# Literature Research

*Leon van Gelder college*

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“Sustainable construction and sustainable development are closely related concepts, to the point that it must be regarded as the way for the construction sector to contribute to it. It is therefore essential to understand the concept of sustainable development, its origin, its necessity and its essence...”

Manuel Soriano “*Sustainable Construction*”

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# 1.0 Preface

Currently, in Europe we are facing three major challenges which will mark a milestone certainly in the development of future generations: the big economic crisis, insecurity of energy supply and climate change caused mainly by increased CO2 concentrations in the atmosphere.

In this context, there is an impact strategy based on large-scale measures to improve the energy efficiency of all processes and activities, and the widespread use of renewable energy.

Indeed, the European Commission has identified some key objectives for the coming years to reduce foreign energy dependence in Europe and to reduce the concentration of CO2 in the atmosphere that cause climate change.

Moreover, it is clear the need for a thorough restructuring of our business activities, based on efficiency and productivity increase. The economic model is based on the consumption of fossil fuels. Right now we are witnessing the twilight of fossil energy sources, where depletion of these energy sources leads to increased oil prices in global markets, and consequently rising inflation in other strategic sectors.

From the point of view of the building, this sector represents 40% of total energy consumption in the European Union. Therefore, reduction of energy consumption in this area is a priority in the framework of the Millennium "20-20-20".

Based on these data and targets for the member states, have been built in the last 10 years new buildings for the future, respecting the requirements and keeping in mind the energy efficiency objective.

Our aim of study is based on one of these buildings that were built with a path towards energy efficiency as a goal, using renewable energies. Currently it has some problems, so it cannot be as energy efficient as they wanted when it was constructed. In addition, it has other issues regarding to the building that have to be solve. So this entail a research and analysis to improve the energy efficiency and at the same time to increase user comfort at the building.

# 2.0Introduction

In general, the energy efficiency means the goal to reduce the amount of energy required to provide products and services.

Energy is the life blood of our society. The well-being of our people, industry and economy depends on safe, secure, sustainable and affordable energy. At the same time, energy-related emissions account for almost 80% of the EU's total greenhouse gas emissions. The energy challenges is thus one of the greatest tests which Europe has to face. It will take decades to steer our energy systems on to a more secure and sustainable path. Yet the decisions to set us on the right path are needed urgently as failing to achieve a well-functioning European energy market will only increase the cost for consumes and put Europe's competitiveness at risk.

Energy efficiency and renewable energy are said to be the twin pillars of sustainable energy policy and are high priorities in the sustainable energy hierarchy. In many countries energy efficiency is also seen to have a national security benefit because it can be used to reduce the level of energy imports from foreign countries and may slow down the rate at which domestic energy resources are depleted.

All the worries that are now come from the world energy consumption, it involves all energy harnessed from every energy source we use. According to IEA (2012) the climate goal of limiting warming to 2°C is becoming more difficult and costly with each year that passes.

Over the next ten years, energy investments in the order of €1 trillion are needed, both to diversify existing resources and replace equipment and to cater for challenging and changing energy requirements. Structural changes in energy supply, partly resulting from changes in indigenous production, oblige European economies to choose among energy products and infrastructures. These choices will be felt over the next 30 years and more. To enable these decisions to be taken urgently calls for an ambitious policy framework. Postponing these decisions will have immeasurable repercussions on society as regards both longer-term costs and security.

The central goals for energy policy (security of supply, competitiveness, and sustainability) are now laid down in the Lisbon Treaty[1]. This spells out clearly what is expected from Europe in the energy area. While some progress has been made towards these goals, Europe's energy systems are adapting too slowly, while the scale of the challenges grows.

Europe cannot afford to waste energy. The EU's Europe 2020 Strategy for smart is based in energy efficiency, sustainable and inclusive growth and of the transition to a resource efficient economy. According to EU Commission the EU needs to act now to get on track to achieve its target while the EU is on course to achieve only half of the 20% objective.

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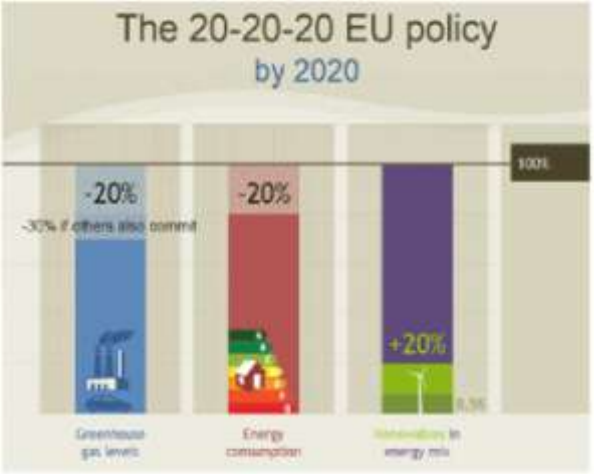
1- *Article 194 of the Lisbon Treaty on the functioning of the European Union (TFUE)*



*Source: European Commission - Communication: 20 20 by 2020. Europe's climate change opportunity*

The European Council in 2008 adopted ambitious energy and climate change objectives for 2020 – to reduce greenhouse gas emissions by 20%, rising to 30% if the conditions are right[2], to increase the share of renewable energy to 20%, and to make a 20% improvement in energy efficiency. The European Parliament has continuously supported these goals. The European Council has also given a long-term commitment to the decarburization path with a target for the EU and other industrialized countries of 80 to 95% cuts in emissions by 2050.

In the building sector , the European Commission adopted Energy Performance of Buildings Directive EPBD - 2002 ( 2002/91/EC ) , consolidated in May 2010 as Directive 2010/31/EU- including a common methodology for calculating energy efficiency of buildings , minimum energy efficiency requirements for new buildings and renovations , systems energy certification of buildings as well as the requirements for regular inspections of boilers and central air conditioning systems .

One of the most important news of the recasting of the EPBD is the emergence of the concept of "building nearly zero energy " . According to the EPBD, Member States shall ensure that all buildings are constructed or rehabilitated in Europe are " building nearly zero energy " from 2018 for public buildings , and from 2020 to the other buildings . EPBD defines "building nearly zero energy "as "that building with a very high level of energy efficiency , determined in accordance with Annex I. The nearly zero or very low energy required should be covered in very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or in the environment.

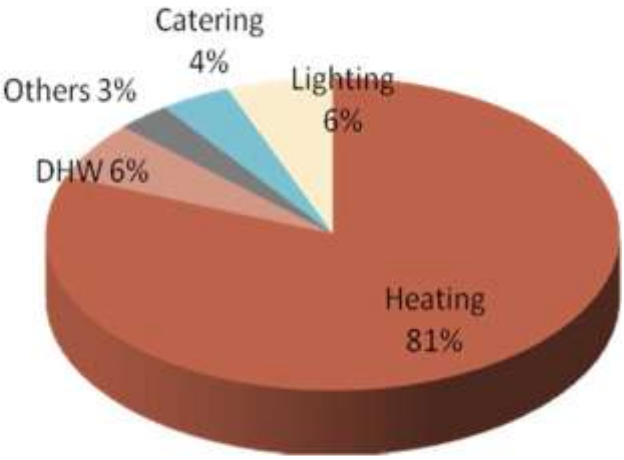
However, in 2011, the European Commission recognized the need to redouble their efforts in terms of energy efficiency, since the aim of reducing energy consumption seemed that he would not be reached and has implemented a new policy that is currently under development: the relative energy efficiency[3], and amending Directives 2004/8/EC and 2006/32/EC repealing directive.

The impact of this new policy will be significant, given the impetus for achieving the objectives of the EU 2020 and help shape legal body and a new business model based on energy savings and build a new sector building in Europe.

2.- *The European Council specified: "provided that other developed countries commit themselves to comparable emission reductions and economically more advanced developing countries to contributing adequately according to their responsibilities and respective capabilities"*

3.- Relative Energy Efficiency: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0370:FIN:ES:PDF

Energy consumption in the building sector, particularly in the service sector of education, Schools.



Through this graph we can see that generally, in public schools, the power consumption is focused on the heating system. So it is understandable to focused on this part, reducing the energy consumption in heating systems in order to achieve sustainable schools and low energy consumption. But also the other parts are important to achieve a energy efficiency building with low level of energy consumption.

Source: Intelligent Energy Europe (UP-RES)2007

# 3.0Energy Efficiency

Energy efficiency is a way of managing and restraining the growth in energy consumption and optimizes the relationship between the amount of energy consumed and the products and services obtained at the end. Something is more energy efficient if it delivers more services for the same energy input, or the same services.

Energy efficiency offers a powerful and cost-effective tool for achieving a sustainable energy future. Improvements in energy efficiency can reduce the need for investment in energy infrastructure, cut energy bills, improve health, increase competitiveness and improve consumer welfare. Environmental benefits can also be achieved by the reduction of greenhouse gases emissions and local air pollution. Energy security – the uninterrupted availability of energy sources at an affordable price – can also profit from improved energy efficiency by decreasing the reliance on imported fossil fuels.

The energy sources are finite, and therefore, its proper use is presented as a necessity of this so we can enjoy them in the future.

Being efficient does not mean giving up our level of well-being and quality of life. It is simply to take a number of responsible actions and investments in technology and management habits.

# 4.0Energy Efficiency Buildings

The concept of sustainable construction is vast, complex and difficult to quantify. In a simple way we can say that sustainable construction is one that is compatible with sustainable development, both in the environmental, and economic and social, if we follow the generally accepted definition of sustainable development.

Regarding the environmental aspects associated with the construction, it is clear that the impact of building activity on the environment is great, and involves different categories, such as water consumption, waste generation, land-use , and emissions of greenhouse gases . It is in this latter aspect, the emissions of CO2, which aspects of energy conservation and efficiency can contribute significantly to improving the environmental quality of buildings way, and thus , sustainability in construction.

But an improvement in the environmental aspects of the construction does not mean that the building is to be sustainable.

An energy efficient building is one that minimizes the use of energy conventional (particularly non-renewable energy ), to save and make wise use of it. The energy efficiency or energy efficiency arises from the ratio of useful energy or used by a system and the total energy consumed:

$$\eta = \frac{E_{\mathrm{util}}}{E_{\mathrm{total}}}$$

It is necessary to establish a criterion to define the total energy. To the extent that energy consumption per unit of product produced or service provided is diminishing, increases energy efficiency. Both the technology available, as responsible habits, enable lower power consumption, improving business competitiveness and quality of life.

The current houses and buildings consume more energy that buildings made 50 years ago, despite more innovations and technologies. In general there are many reasons that explain it, the energy consumption of the buildings increased, the materials for built weren’t sustainable, etc.

In these cases, were created energy reduction goals, with initiatives with advanced technology to be applied to the buildings that stress energy conservation, water conservation, minimization of waste, recycling, indoor air quality, and related measures to minimize environmental impacts and provide a blueprint for a large scale response to climate change. Good building designs need to be at the forefront of any major energy consumption overhaul, but the behavior of building occupants cannot be overlooked.

Moreover, designing and constructing new buildings, to achieve aggressive energy efficiency goals, is much easier and less expensive than retrofitting the existing building stock. While the widespread dissemination of today’s most efficient technologies and practices would fall short of achieving negligible energy consumption, the remaining gap may be overcome by relying on small scale on site distributed renewable energy resources. The cost and physical limitations of renewable energy resources suggest that sole reliance on renewable energy resources to fill the gap could prove impractical, at least in the near term.

The green building and zero net energy building are programs for project that can demonstrate that thoughtful design and construction can improve the performance of new buildings, but it required attention. Also reducing the energy consumption and also reviewing the results of this buildings and recent energy efficiency potential studies it would be required for to reduce the energy consumption in existing buildings.

For make lowered the baseline levels of energy consumptions, the first step involve improved the design and the construction of the new buildings. The significant efficiency gains can realistically and cost-effectively be achieved through today's technologies when supplemented with behavioral changes.

## 4.1 Sustainable Construction of the buildings

Sustainable Construction aims to meet the current needs of the buildings and infrastructure without compromising the ability of future generations to meet their own needs. It incorporates elements of economic efficiency, environmental performance, and social responsibility and contributes to a greater extent while also considering architectural quality, technical innovation and transferability of results.

Sustainable Construction involves matters such as the design and management of buildings, efficiency of materials, techniques and construction processes, energy efficiency (and other resources), operation and maintenance of the building products and technologies, long-term monitoring, respect for ethical standards, (socially viable environment), civic participation, health and safety, innovative financial models, improving environmental conditions, interdependencies of built environment with infrastructures and landscape, flexibility of use, features and changes in the building, dissemination of knowledge in academic, technical and social fields.

Building Performance and Design.

As (previously) stated, the ultimate goal of energy efficiency in buildings is to reduce primary energy consumption and consequently, CO2 emissions to the atmosphere due to the construction activity and above all, the use and operation of buildings. To achieve this goal of reducing energy consumption, it is necessary to understand a concept in which the building exceeds its role as consumer of energy to become an urban energy infrastructure, able to generate, receive, store and distribute electric and thermal energy. The design should incorporate all these aspects without giving up the aesthetics, transparency, or lightness of the traditional technical, spatial and formal constraints of Architecture.

Currently the achievement of an adequate level of comfort in buildings has a little importance to the influence of the architectural form is provided. Energy efficiency in buildings requires changing the order of these strategies and proposing a reverse scheme where most of the comfort is achieved thanks to the shape, proportion, materials and chosen orientation to passive systems which exploit the climatic conditions of the environment; and, finally, to the active high-efficiency systems powered by renewable energy. The design of sustainable buildings should be based on these principles and eco-logic methodology to be energy efficient:

a) A comprehensive study climate with analysis of all variables including hydrothermal temperature, humidity, solar radiation, wind speed, and direction of the prevailing winds where the project/building is involved.

b) The first idea of how to adapt the project and where (placement) should arise from all the information data and other factors. This first phase will come through understanding climate.

c) There on these strategies, the demand reduction achieved with passive measures, with specific bioclimatic solutions to be incorporated in the building design.

d) The next step should be to seek the maximum efficiency through active measures of heating, ventilation and air conditioning systems. This guarantees the minimization of energy consumption of the building.

e) The last step is to analyze the sources or local resources and demands for taking the maximum energy required from renewable sources and by minimizing fossil energy with maximum efficiency criteria.

### 4.1.1 Energy Demand and Consumption

Energy demand of a system is the energy it needs to perform its function. In a building, therefore, the demand for energy would be; the energy required to operate the building, the comfort standards (thermal, lighting) adequately, and achieving all the basic requirements of their role.

This energy is provided by a system with a particular performance, and therefore, the energy supplied to the system does not have to coincide with the energy consumed. Exceptions (heat pumps, condensing boilers, ...) more energy is consumed than is strictly required by the system to supply the demand. Consumption serves as the following relationship between demand and supplier performance power system.

Consumption = Demand / Performance

The ultimate goal of energy efficiency is to reduce energy consumption in buildings. For this we can:

a) Reduce demand,
b) increase system performance and
c) act simultaneously on demand  and systems.

Overall, there are basically three types of energy demand in buildings::

- **Temperature,** to meet the requirements of ACS, heating and cooling,
- **Light,** for lighting comfort requirements,
- **Power,** for applications and systems (different devices).

The energy demand of a building varies greatly depending on several factors that can basically be classified as:

1. Location

The location is key to the performance of a building, as it determines the climatic characteristics that influence in it, affecting demand for heating, cooling or lighting.  Such weather conditions can be divided into macroclimatic and microclimate.

Macroclimatic conditions depend on the area of the planet where the building is, it depends on the latitude, longitude and the specified region is found. The most important are:

- The average, maximum and minimum along the day during the winter and summer temperatures.
- Relative humidity.
- The incident solar radiation (direct and diffuse).

Microclimatic conditions are determined by the geography of the place. The most important are:

- The terrain, which can determine the accessibility plot, and the direction of the prevailing winds.
- The existence of nearby water masses, which reduce sudden variations in temperature and increase humidity.
- The existence of vegetation.

## 2. Feature

The end use of a building logically determines the energy demand of it. An office building will have very different needs in quality and quantity of energy than a house, a hotel, a school or a hospital. The demand will also vary differently throughout the day.

## 3. Design

The building design has a huge impact on energy demand. It is crucial to find solutions that ensure minimum energy demand covered by artificial climate and that make the most solar radiation and natural lighting.

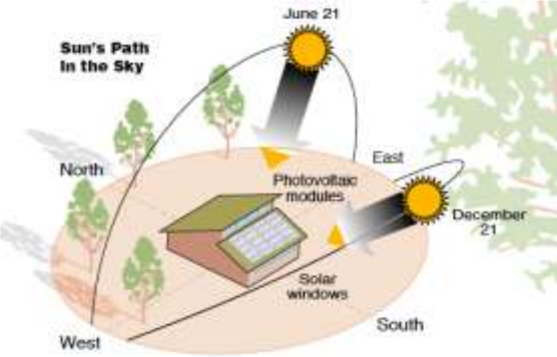
The shape and proportion of the building has a definite impact on:

- The contact area between the building and the outside, which is directly affected for solar radiation and wind exposure. It is definitely an indicator of profit or loss of winner energy outward. Much more contact surface will cause a situation with more heat exchange that is, in principle, favorable in temperate or warm weather and unfavorable in a continental climate.

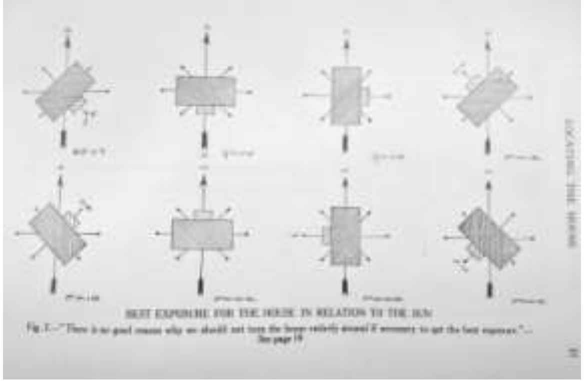
- The resistance to the wind. The larger the building, the greater the wind resistance, except that you avoid obstacles. Increased wind resistance is good in summer as increased ventilation, but bad in winter because it promotes infiltration.

- The position of the windows and doors in the facade and its size, that will allow greater solar gain and reduce energy demand. The designer must find the most appropriate solutions in each case, for example: common ventilated facades, space cap, tank covers, etc

- The building orientation determines the solar energy through glass surfaces. In general, continental climates Worth home better capture the more energy because it helps reduce the consumption of winter heating. During the summer it is necessary to limit this radiation by shading elements, or other techniques so unwanted effects of overheating will not occur. In office buildings is necessary to find a compromise between natural lighting and cooling, because if the light comes, also comes the heat. The generalcharacteristics of the mainlines are:
  - Facing North: Only a few hours to receive solar radiation in summer and none in winter. Belongs to the coldest part of the building.
  - Southern exposure: In winter, the south facade directly receives many hours throughout the day, while in summer the radiation reaches more vertical, and especially gets the cover.
  - The facades facing east and west are 2.5 times more radiation in summer than in winter. The facades of south-east and south-west are a number of very similar throughout the year radiation. The east and west orientations are very controversial during the summer, especially west facing, because from solar noon they recieve a lot of radiation, which is very difficult to control because it impinges perpendicularly on the glass surface. Moreover, during the afternoon in summer, the ambient temperature has already risen considerably, so the outdoor conditions are unfavorable. In this orientation the glazed openings must be protected from the sun during the summer. And the geometric characteristics of the solar incidence, horizontal protection (overhangs, pergolas plants, etc) are ineffective in these guidelines are preferable vertical protections, such as lamas, trees or similar.



*Picture 1*

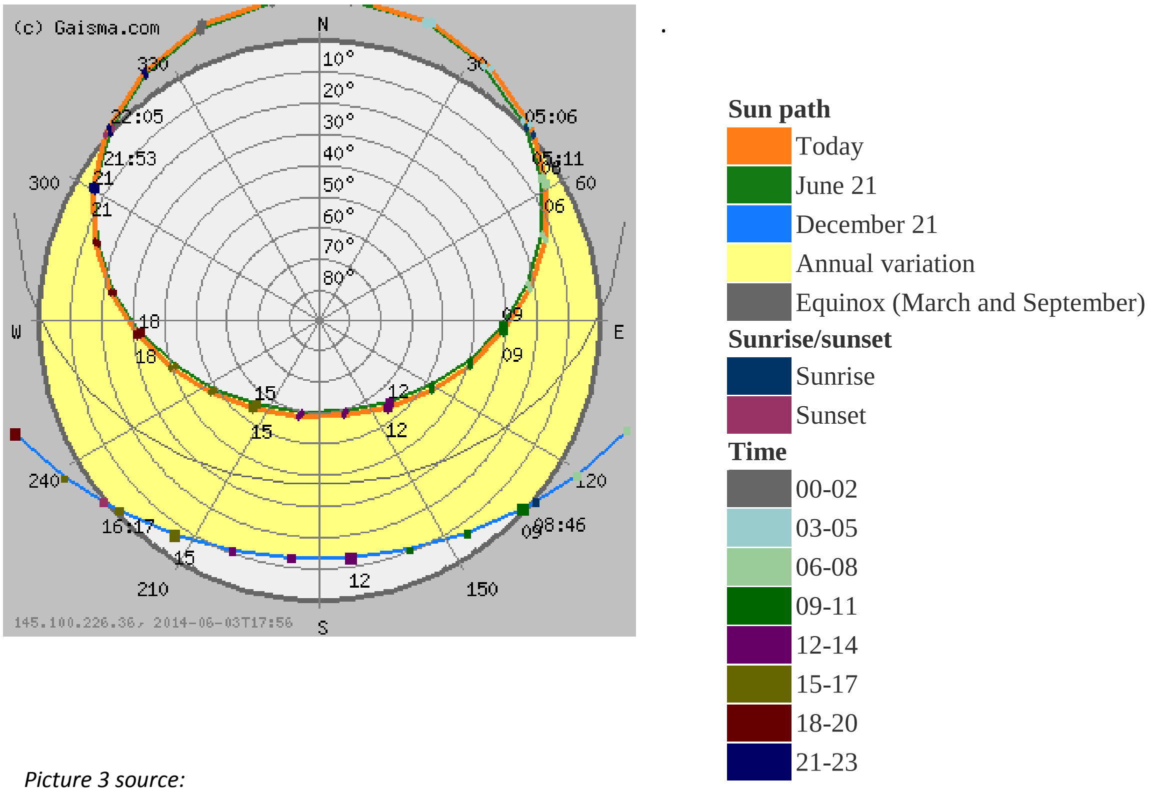


*Picture 2*

In the bellow diagram we can see the Sun path diagram at Groningen city (picture 1). Sun path diagram (also known as "solar path diagram", "sun chart" or "solar chart") is a visualization of the sun's path through the sky. This path is formed by plotting azimuth (left-right) and elevation (up-down) angles of the sun in a given day to a diagram.

To find out the position azimuth = 60, elevation = 30, for example, imagine standing at the center of the diagram heading to the true north. To find the azimuth angle 60, you must turn 60 degrees to the right. Now the altitude angle 30 can be located by raising your head 30 degrees from the horizon.

As we can see, there are big differences between the summer equinox and the winter equinox. Reading this diagram can help a lot for design of the building, to know the elevation of the sun each day and which measure you have to put at the building. For Example, we can see at the orange line (sun path today) that the sun rises from the North-East (azimuth = 60) in Groningen at 05:11 and the sunset happens at 21:5420 when the sun is in the North-West (azimuth = 300). On that day the maximum elevation angle is approximately 60 degrees at noon



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*Picture 3 source:*

http://www.gaisma.com/en/location/groningen.html

In general, a linear building with the direction on East-West axis is the most effective. As much for minimizing the needs for heating in winter, to present a facade to south suitable for solar gain, as to reduce the cooling in summer. The variations of ± 30 ° to the South does not affect significantly the solar gain.

The block buildings, townhouses and in a row orientated to the East-West axis, are more efficient, except extremes positions, because the exposed facades are to the West and to East.

4. The quality of construction

Clearly, the construction quality directly affects the energy consumption. The level of insulation, air tightness, the type of glass used, construction details to avoid thermal, bridges etc.., will determine the energy transfer between the building and the environment, and therefore energy demand. The importance of the laying of the elements and building materials is essential, as even very good and expensive materials can, if badly placed, have very bad thermal behavior, penalizing the entire building in energy consumption.

5. User behavior

The behavior of the users of the building is really important, because the quality of the building after the construction depends on their habits and their way of use. Different user habits may incur enormous differences in energy consumption. Habits such as the temperature at which they are building, performing ventilation, proper use of sun protection systems, etc.., have a huge impact. The optimization of the operation of the building is critical to achieving the energy savings factor, so it is especially important to act in training and awareness in this regard.

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All these factors will make the building energy demand vary considerably in the amount of energy and the time distribution throughout the day. For the thermal conditioning of the building (heating / cooling), considering a conventional building understood as a building built according to constructive behavior every place, the global demands vary depending on all the factors mentioned above.

## 4.2 Heating of the building

Besides heating systems using renewable energy, we can also make use of strategies designed to reducing the heating demand for making the building more energy efficient.

When the goal is to reduce heating demands in buildings, the strategy is to capture the most solar energy. The building must have a design that allows solar radiation to penetrate inside, while on the other hand the thermal envelope must ensure, through the insulation of facades, glazing and sealing suitable joinery that losses of energy through the envelope are the lowest possible.

The most immediate in reducing energy demand action is to maximize solar gains. We have seen during the winter, the southern facades of the buildings are radiated many hours a day. If we take the heat energy of this radiation to heat the interior of the building, we will, of course, require less input from the heating system, and therefore, we will be saving energy. At the report of European Passive Solar Handbook[4] it makes a classification of these passive systems capture, dividing them into direct uptake and indirect uptake.

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*4.- Energy in architecture. "The European Passive Solar Handbook" J.K. Gouling.*

The **direct energy uptake** is the simplest solution. Solar radiation penetrates directly into living spaces through the glazed surfaces, where it is collected and accumulated through the thermal inertia of the floors and walls. A window represents the simplest example of this system.

This concept is such as the **Greenhouse effect.** These direct through glasses contributions are based on: the wavelength of solar radiation reaching the earth is generally between 0.3 microns and 3.5 microns.

Most of the windows are permeable at these short wavelengths, which makes about 80% of the radiation incident on the glass pass there through, while the other 20% is reflected or absorbed by the glass itself.

This radiation that has passed through the glass heats the walls, floor, and in general all surfaces against which it impacts so that these bodies, when heated, re-radiate that energy to the environment, this time is long wave (the order of 11µm) against which the glass acts as an opaque body.

Thus, the glass allows energy input but not the output, heating the outside environment.

For a direct feedback system to be efficient, it must mean the winter heat gain through the glass surface is greater than transmission losses through the glass, not overheating occurs in summer and, finally, that the net contribution to the thermal needs of the building is important. All this implies large glazed surfaces of the walls with southern exposure, double glazing and / or night care, adequate thermal capacity exposed to radiation, and sun protection in summer.

**Indirect uptake** is when between solar radiation and the space desired to heat, there are intermediate elements that store and then distribute energy are placed.

As in the previous case, the only heat transfer phenomenon involved is radiation, but in this case, the conduction and convection are really important. This Is generated between the space to be heated and the outer buffer space that provides additional protection to the building. Some solar radiation enters directly into space, as between the buffer and the interior space there are transparent elements allowing solar gain.

All components have a massive part that stores solar energy captured, emitting this energy in the form of thermal radiation with a lag time (later) that depends on the characteristics of the materials used. There are basically two types of systems: one that only has a massive wall behind glass (which produces the greenhouse effect, favoring the absorption of energy from the wall) and one in which they also combine storage with convection of hot air entering in the space we want to heat.

## Insulation

The influence of thermal insulation is important for energy efficient buildings. With higher levels of insulation from the current policy, we could save a lot of energy in buildings, especially those with significant heating demands.

The insulation materials are those that have a high resistance to the passage of heat. The physical property measuring the insulating capacity is thermal conductivity, λ. The lower the value, more insulating ability the material has. A thermal insulation material that the value of λ is less than 0.06 W / mK is considered at referred 10 ° C. Thermal conductivity is an intrinsic property of each material.

Another feature that is used to evaluate the thermal insulation resistance, is defined as the ratio between the thickness and the thermal conductivity of the material. This property is characteristic of each product (material type and thickness). The higher the value of the thermal resistance is the greater the insulating ability of the product.

Finally, to define the isolation enclosures that a building has, you need to use the thermal transmittance (U value). The walls of the building in contact with the outside air (facade walls, roofs, floors) typically have several layers or products and the U value characterizes the enclosure, which is the inverse of the sum of the thermal resistances of all layers that comprise the enclosure and surface thermal resistances both exterior and interior. When the U value is lower, it would be harder for the heat to go through, therefore more insulation it will contain.

## Reduction of infiltration

The temperature difference between the interior and exterior of a building creates a constant air flow through cracks, joint between materials, etc. The volume of air infiltration into the building depends on the total area of these openings and joint as well as the thermal gradient, and amount of exposure to wind the facade. The injections have a very important role, both in the level of energy efficiency of the building, and in the comfort of its users impact. It is clear that when the outside temperature is low, the income of cold air into the building will increase and the heating loads and the comfort feeling for the users who are close to such infiltrations.

However, the impact of infiltration depends on the climate zone in which the building is located. In cold climates, the infiltration control can become a key factor for energy savings. It is recommended to seal hermetically the buildings and air renovations by mechanical constant flow systems in order to reduce heat losses. It is one of the main strategies of the Passive House standards[5], which bases the energy efficiency of buildings in a maximum control of their infiltration, limiting it at 0.6 air renovations per hour.

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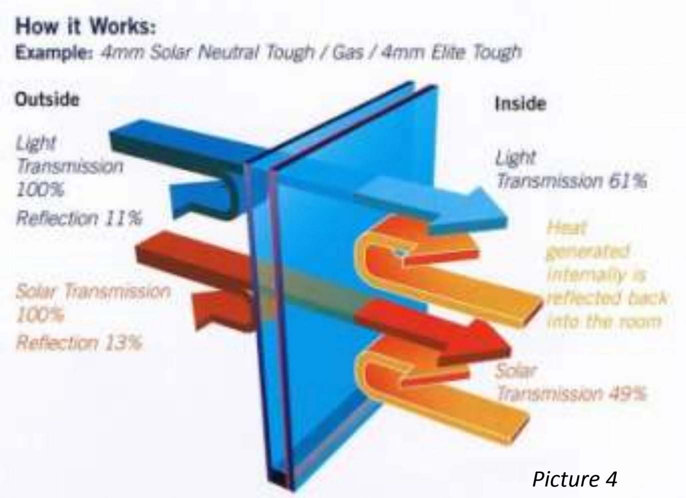
*5.- Reff. PassivHaus Institute [http://www.passiv.de/](http://www.passiv.de/)*

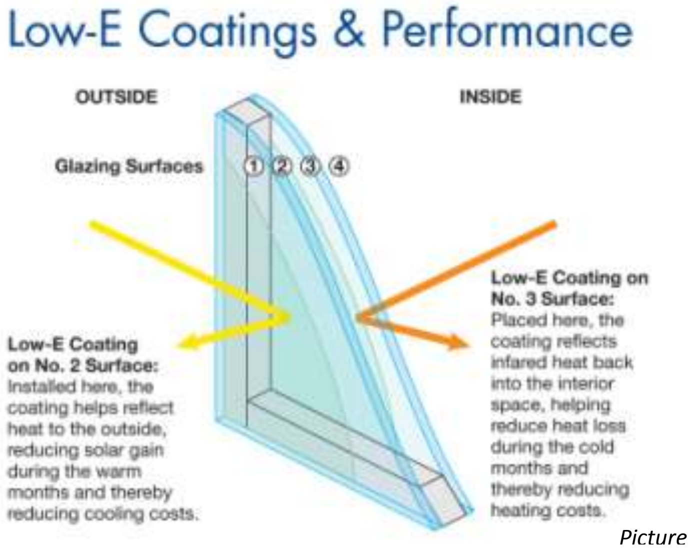
## Low-E Windows

The glass surfaces allow solar gains, allowing solar radiation to pass through them heating the building. However, in the absence of direct sunlight, and when outside temperatures are low, the windows are a sensitive element, because through it a lot of energy losses occur outwards, having logically more constant thermal conductivity (λ) that a massive opaque enclosure, as illustrated in picture 4.



Picture 4

It is therefore interesting to use low emissivity glass in cold climates. The low emissivity glass or low-E, is a glass developed for reducing heat loss from inside. The low emissivity glass is monolithic glass on which is deposited a layer of extremely fine metal oxides, in the nanometer range, giving the glass a reinforced thermal insulation capacity. This layer, in cold climates, absorbed heat conducted inside.



Picture 5

Low emissivity glasses are assembled in a double (or triple) glazing, and the surface on which the bale has been applied metal oxide must be giving the air. This metal layer is the low-e coating, and there are 2 positions for it, at the outside glass or at the inside glass and at the picture 5 we can see that depending on this position, has deferens consequences and solutions.

The glass industry is advancing rapidly, and now we can find low emissivity glass on the market that reaches thermal conductivities below 1, similar to that which could have a cloth enclosure opaque low quality construction.

We do not have to confuse the low-e glasses with the glasses with treatments that prevent the entry of the solar radiation. Their protection is permanent, which in winter they do not let go in the solar radiation and therefore do not allow use of natural heating that the sun gives us. They are not a bioclimatic solution.

**Heat Recovery Systems**

This is a measure that can have a big impact on energy saving especially in cold climates. The heat recovery allows the renewal of the air in a local preserving and recovering the energy used to heat the air.

The heat exchanger works by combining two centrifugal fans of low noise level, where one of them performs the extraction of stale local Interior air to the street, and the other pulls in fresh air from outside to inside. The two circuits cross without mixing in a plate heat exchanger, where heat from the exhaust air is transferred to the fresh air outside and heated.

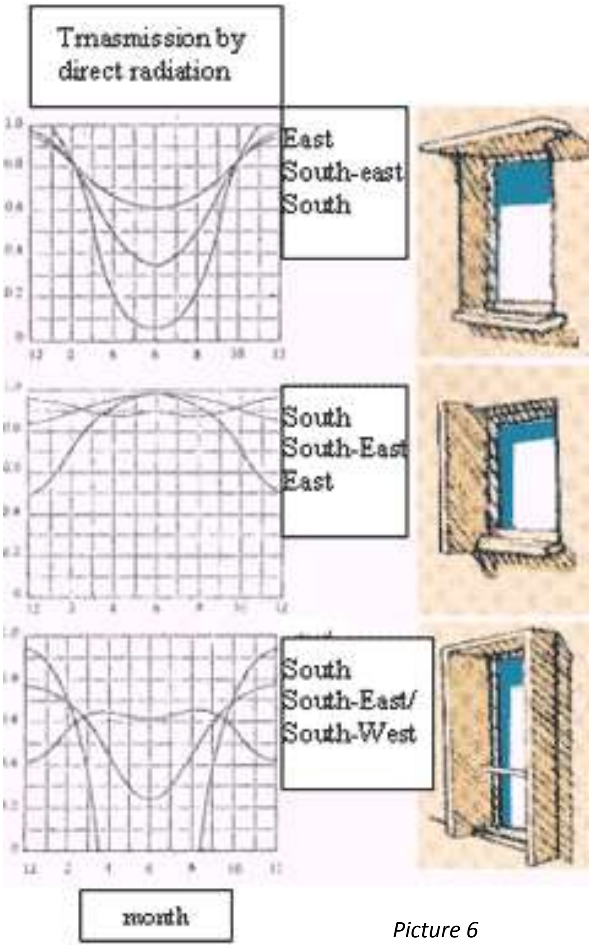
Thus we recover a high percentage of the energy used to heat or cool the air inside the room, and reuse. Without the use of the heat recovery system, this energy would be totally lost. It is also one of the main strategies of the Passive House[5] standard.

## 4.3 Cooling Strategies

Strategies to reduce cooling demand. In winter, the strategy is to capture the most energy, store it and keep it. In summer, the fundamental strategy is to prevent overheating of the building to minimize solar radiation on the glass facade, ventilating and cooling the building when the outdoor temperature falls, and reducing internal loads, especially in the tertiary sector.

**Sunscreens**

In summer, solar radiation penetrates the clear surfaces of the envelope (doors and windows) causing an immediate energy gain which must be removed by the cooling system.



*Picture 6*

The hollow glass sunscreens are undoubtedly the most economically efficient and cost-effective measure to reduce cooling energy demands, especially in office building with a glass ratio / high opaque.

The impact of solar radiation may be reduced by having recourse to different kinds of shading devices:

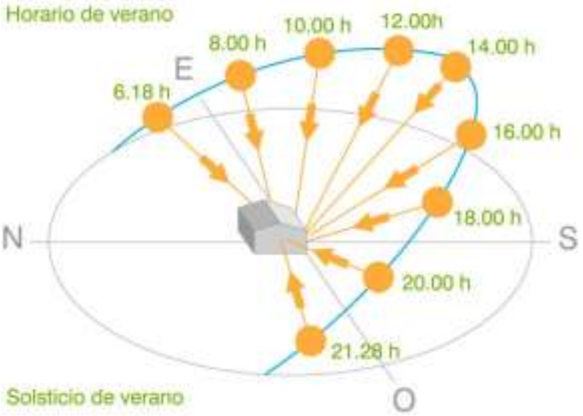
The design of the windows' position is important by designing the project for reduced the cooling by producing shadows on the glass of the windows. For example position the glass of the window at the half of the hollow wall. As we can see in the picture 6, it depends on the orientation and the transmission by direct radiation; we can have different solutions at the windows. Also adding vertical shading devices (for east or west-facing orientations) or horizontal (for south-facing orientations); fixed or adjustable external sun-screens; external awnings ( rolling blinds or Venetian blinds); internal curtains (Venetian blinds or fabric); special glazing.

The sunscreen has to reduce the incident on the gap in summer radiation, but allows energy uptake in winter. This is achieved also using two kinds of external protections: fixed or moveable, but we can also consider the effect of trees or other vegetable items.

External shading devices prove to be the most effective as they prevent solar radiation from beating on clear surfaces.The catalog of solutions is very large.

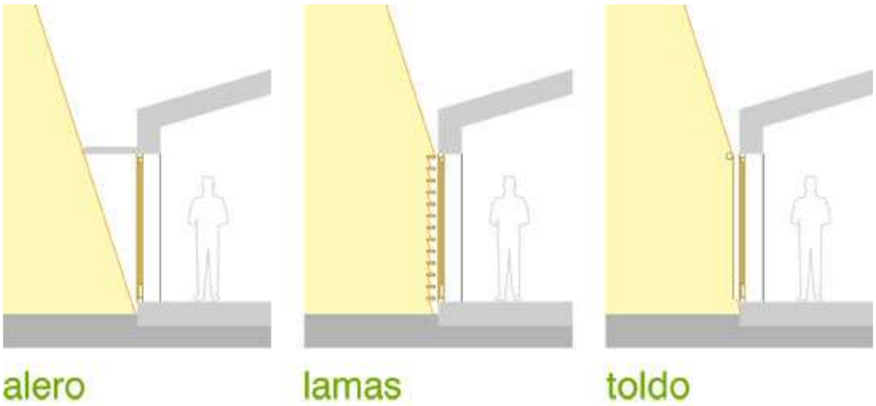
Each kind of protection has its own quirks. You have to know them well enough to know when and for which situation each is better and more indicated.

As we can see in the diagram at the picture 7, we must guard especially in summer sun striking the south orientation between 12.00 and 16.00 and on the west facing between 16.00 and 20.00. This is the worst orientation because the building recieves heating from the sun during the entire day the inside the building because of the lower level of the sun, and enters all through the windows.



*Picture 7sun in  summer*

In the south facing are very effective fixed horizontal elements integrated into the architectural design, such as corbels, horizontal louvers, pergolas, etc. (picture 8) However, such protections are not effective in the east and west orientations. Due to the low solar height in these guidelines, the radiation reaches the very horizontal building, and is not blocked by a horizontal overhang. In these guidelines the most effective protection is to place mobile or fixed as vertical slats.



*Picture 8 corvel – horizontal louvers - awning*

In the below pictures we can see some examples about the solutions for the protection of the south façade.

*Picture 9*

This kind of horizontal sunscreen is mobile so it can have different tilt depending of the season of the year.

As we can see at the previous diagram (picture 8),the corbel sunscreen is that one that more shadow provide the building and the windows.

Also there are some of this corbel sunscreen that could be mobile, so this kind is perfect, because you can use in different positions and facades at the building and you can adjust it depending of the season, the hour at the day and also depending of the situation of the façade. This solution is also useful for the facades orientated to the south-west and south-west.

*Picture 10*

As we saw before, for the façades with east and west orientations is most effective putting the protection with vertical slats.

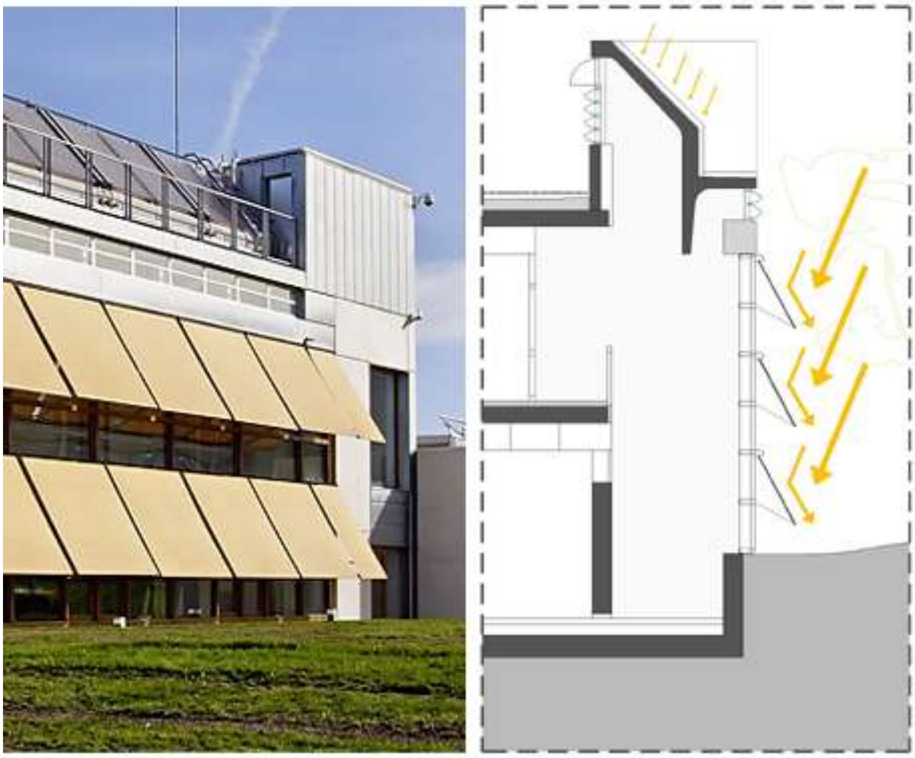
At the example pictures there are fixed and mobile vertical slats. The fixed vertical protection could be already installed at the frames of the windows. Meanwhile the mobile vertical louvers could be outside as a decorative element at the façade and also you can move it depending of the season and the position of the sun.

In general, the sizing of the fixed sunscreens depends on the orientation and latitude of the windows and building.

*Picture 11*

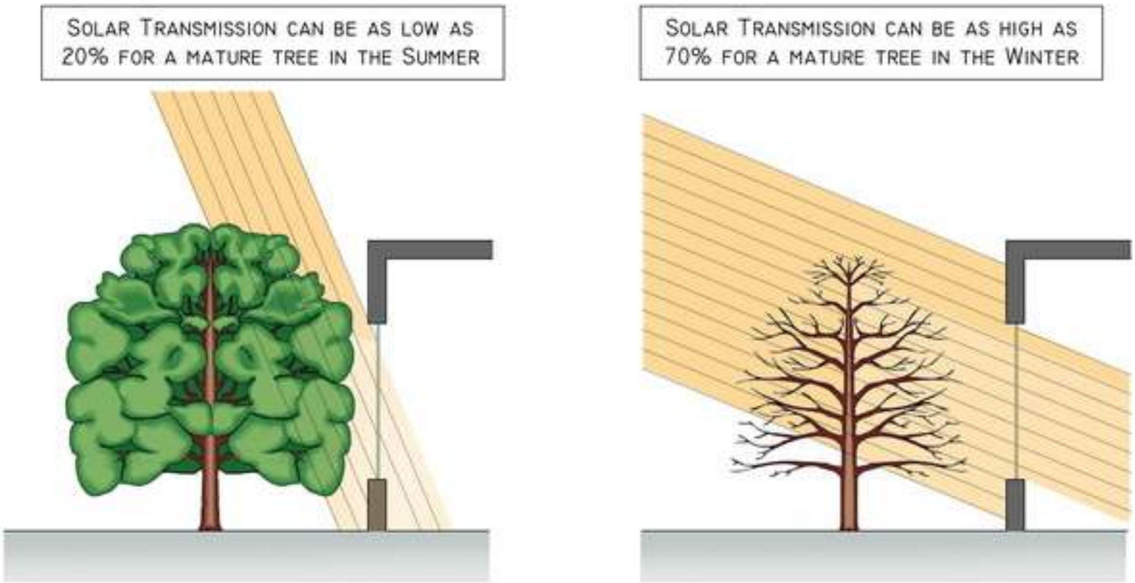
One possibility is to integrate in the elements of sun protection systems of solar energy, so that a single element protects us from solar radiation and time is capturing or generating energy.  (picture 12)

*Picture 12*

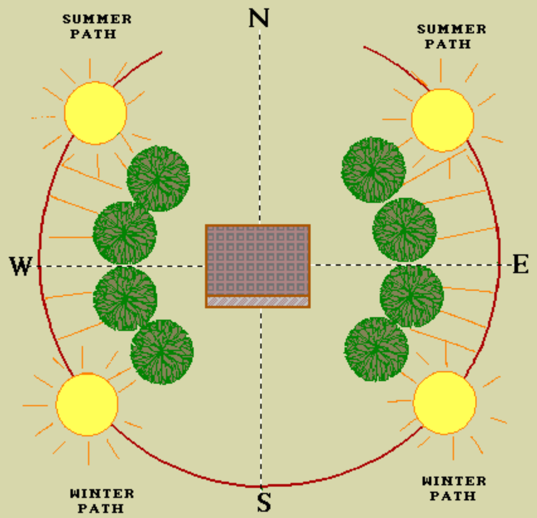


*Picture 13*

Finally, add trees and vegetative organisms as sun protection; the species should be deciduous, so protect from solar radiation in summer but allow solar gain in winter as we can see at the picture 14.



*Picture 14*



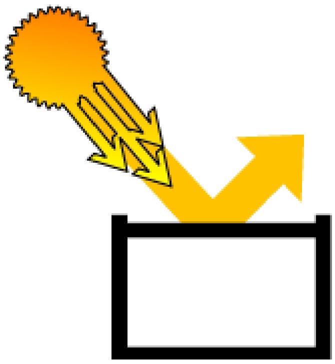
*Picture 15*

In other hand, the roller shutters fixed blades cannot be considered sunscreens because when you take down the shutter block the radiation, but also lighting and natural ventilation. Only the roller shutters with the tilt adjustable are good sunscreens.

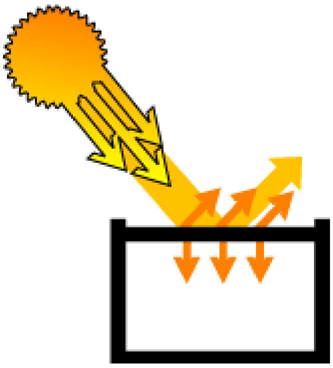
The Interior solar protections are not as efficient as the outside as they do not prevent the radiation through the glass and therefore cannot prevent the greenhouse effect.

Another strategy for keeping the temperature of the building is with the color of the façade surface. Depending of the color of the surface, we will prevent the beating from solar radiation.

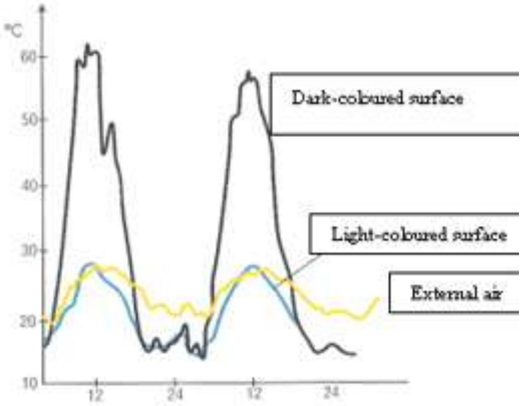
As we can see in the following picture, depending to the thermal impact of solar radiation that we would like to have at the building, will have a relation to the surface color. In the graphic we can see the level of degrees the surface would be reached with different colors.



LIGHT COLOURED SURFACE



DARK COLOURED SURFACE



## Ventilation and cooling strategies

One of the most interesting strategies in reducing cooling loads is the use of ventilation of the buildings. When the entering air has a lower temperature than the comfort temperature, it favors the dissipation of heat accumulated in thermal mass, "dropping" the heat of the building and also acting on the feeling of comfort of the occupants, increasing the evapotranspiration.

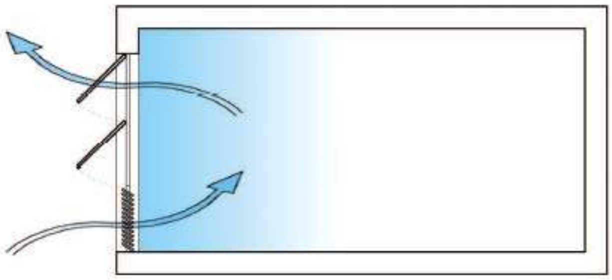
The action of wind on the building envelope generates differences of pressure (positive or negative) by the air flow attempting to overcome the obstacle of the building, and finding a "shortcut" into the openings that the enclosure could have, causing airflow inside the building.

Of course, when would be heating load, ventilation will be desirable only when the outdoor temperature would be below the comfort temperature; when the air moving would be possible internal loads and solar gains or when would be necessary to reduce moisture levels or air pollution.

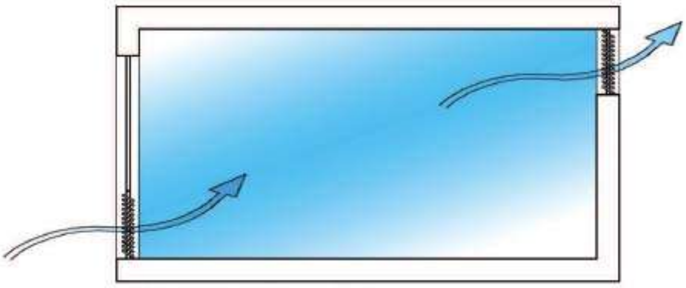
A design parameter that the designer must consider is the location of the points of entry of outside air. The radiation entry incident on each facade, exposure to prevailing winds, the presence of vegetation, water or other areas can significantly vary the temperature of the air ventilation.

There are different types of ventilation. Below we detail the most interesting in the context of sustainable construction:

**Simple ventilation** is produced via a single facade. It is not an efficient strategy, as it is lacking potential for ventilation, absent of any other opening part that allows air go out and therefore the flow air through. In any case, it is preferable to open two hollows at the facade, even if they are smaller than one larger, single hole.



**Cross ventilation:** Cross ventilation is one of the key strategies to reduce cooling loads. It consists in have ventilated rooms with fresh air and an outlet of hot and overloaded air. Therefore, for an energy-efficient building, it has to design spaces providing ventilation flows, and adjust the spaces, openings and vents so that the highest efficiency would be achieved.



It is important to emphasize that at office buildings and service sector in general, the problem becomes more complex, due to the large number of variables that influence the ventilation and the essential the simulation of the effect of the ventilation with fluid dynamics software.

**Mechanical ventilation** is to induce airflow through some kind of mechanical device. This is an important avenue of research to be based on highly effective components for comfort, with great potential for individualization, low cost and minimum consumption.

Mechanical ventilation systems should not be seen as an alternative to natural or artificial systems conditioning. Its integrated design can enable a wide range of possible combinations and coordination between conditioning systems that maximize overall efficiency.

There are mainly two types of systems: those that through ductwork, take outside air and introduce it into each of the spaces and those intended to only recirculate the air inside the rooms and locals.

The first one is usually associated with renewal or indoor air conditioning in order to keep the quality. They consist of fans, filters, ductwork and supply or extract terminals or diffusing elements.

Fans, on the contrary, have the aim to handling the indoor air speed without changing the conditions of temperature and humidity, creating or directing air currents, unstatify bags cool or warm air, increasing the convective exchange between the stream and the inside reducing the temperature and the feeling of the occupants.

**Free Cooling**

The Regulation of Thermal Installations in Buildings orders to incorporate free cooling system based on the injection of outside air into air those systems whose operating range exceeding 1000 hours / year. The energy saving is considerable big systems thanks to the leveraging the powers when this is possible.

How the system works: The outside air intake is based on the comparison of enthalpies. If the energy in the outside air (enthalpy) is much lower than the indoor air, indoor air is completely renovated without energy consumption.

In the case that the outside enthalpy would be less than the interior, it would be forced a partial replacement of air with energy consumption for air conditioning with the minimum necessary.

Night ventilation consists in naturally or mechanically air currents, in order to keep cool the interior during the night taking advantage of the drop in temperature outside.

## 4.4 Strategies of energy efficient fighting

### Natural Lighting

Is mandatory the use of natural light through the installation and use of monitoring and control systems, in areas where daylight supply allows. Therefore, what was once only a choice of the designer is now required by regulations.

Optimizing the use of natural light brings significant energy savings, especially in the tertiary sector and particularly in office buildings, and moreover, their use contributes significantly to lighting comfort and thus the quality of environmental buildings.

The presence of natural light depends on the depth of the room, the size and location of windows and ceiling light, external glazing system and any obstruction. Typically these factors are set in the initial design of the building. Appropriate planning and design at this early stage can produce a building that is more energy efficient.

The orientation of the hollows at the facade is important. The most suitable are oriented exclusively to points that receive the diffuse radiation; generally to the north. If the direct radiation go into areas where it expect to use as natural lighting, the effects of glare will affect very negative and its use would not be possible.

We must find a balance between thermal and lighting aspects between, passive uptake, sunscreen, and natural lighting. In this meaning, it is interesting the design of the mechanisms to transform the direct radiation into diffuse radiation. One way to prevent entry of the direct radiation is protecting it with a hollow element that reflected the radiation towards the interior of the room.

It is also important to understand where elements such as whiteboards and computer screens will be located, in order to avoid reflections which cause glare. This also affects the performance of thermal mass, since an applied reflective surface will prevent absorption.

### Artificial Lighting

An energy efficient lighting system enables a significant reduction in consumption without reducing its quality services and comfort level of illumination.

The buildings should be appropriate to the needs of its users lighting installations yet energy efficient, with a system of controls to adjust the ignition to the actual occupation of the area as well as a lighting system that optimizes use of natural light in areas that meet the right conditions.

The control and regulation systems mandates that the use of basic control systems for each area (explicitly prohibits turning on and off which would made exclusively from the electrical panels), detected the presence in areas of sporadic use and regulate the light in most luminaires close (at a distance of 3 m or less) to the window for of the natural light.

This point is that isis essential to have a lighting management system in the building.

Lightingefficiencyisinfluencedby:

- Energy efficiency of components (lamps, luminaires, auxiliary equipment).
- Using the system (system use, use of regulation and control systems, use of natural light).
- Maintenance (cleaning, relamping).

**Choice of auxiliary equipment**

Auxiliary equipment has a decisive bearing on the energy efficiency in whole. Electronic ballasts offer many advantages with respect to electromagnetic, light comfort as far as concerns energy saving:

- Reduction of 25% of energy consumed, regarding electromagnetic equipment.
- Increasing lamp efficacy.
- Increased lamp life of up to 50%.
- Increased overall comfort, more pleasant light, no flicker or strobe effect and eliminating noise produced by electromagnetic equipment.
- Possibility to connect to light sensors automatically adjust the light intensity of the lamp, and maintain a constant level of light.

**Regulation and control systems**

The regulation and control systems turn off, turn on and regulate the light as switches, with motion and presence detectors, sensitive cells or pre calendars and schedules. They make better use of the energy consumed, reducing energy and maintenance costs, plus provide flexibility to the lighting system. The energy savings achieved by installing such systems can be very relevant.

As not all areas require the same treatment, it is important to control the lights in each zone by separate circuits.

The simplest system of control is the manual switch. Its proper use, switching off the lighting during periods of absence of people, allowing significant savings, especially when in one room there are several areas controlled by different switches so that one may be off but others would be on.

In buildings of the tertiary sector, including office buildings or commercial buildings, where there is a defined schedule, is possible turn on and off automatically by schedule lighting control based on the different days of the week, including free time (meals, etc..), distinguishing between weekends and weekdays, or by incorporating festive period.

In these buildings for multiple uses (offices, hotels, etc..) Is interesting to have a system that allows the energy management and control of lighting systems, similar to those in place for other facilities such as air conditioning. Centralized control, consisting of detectors and a programmable central unit, involves a number of advantages, among which are:

- Possibility of on / off areas through central commands, whether manual or automatic.
- Changing ignition circuits at the central level without electrical works.
- Condition monitoring circuits and consumption thereof.

## 4.5 Sustainable Materials

The market for construction products should be developed into new trends to consider respect for the environment over economic benefits.

The Integrated Product Policy of the European Union, with the aim of developing a market for greener products, promoted the development and implementation of a toolkit for the design of products based on the analysis of the life cycle, as ecolabels and environmental claims, and raised the need to provide incentives to producers.

Since the scope of the users and the demand for more sustainable construction until a few years ago depended exclusively on motivations and issues of personal conscience, but little by little they appear municipal ordinances and decrees level regions and nationally that require and direct the industry to take action to improve the environmental performance of buildings and infrastructure.

### Ecological Materials

UNE 15.301:2003 defines eco design as the one that considers the environmental impacts at all stages of the design process and product development, for attaining that generate the least possible environmental impact throughout their life cycle.

In general, an ecological "green" product is that on that is:

- Environmentally friendly: minimizes pollution of air, ground and water.
- Achieves optimal health and productivity of interdependent communities of plants, animals, and humans
- Produced without the use of synthetic chemical pesticides, fertilizers, medicines.
- Retrieved respecting the growth of plants and animals.
- Prepared without addition of artificial substances additives, colorants, flavors, aromas.

In construction, we define ecological materials to those for manufacturing and placing and to ensure its durability and low maintenance, require operations and activities with low environmental impact and are not a risk to the health of people.

- Natural, with minimal processing and adaptation (soil, adobe, wood, cork, bamboo, straw, sawdust, etc ...), but not altered by light, heat or cold and damp, do not require expensive maintenance, and won't be a potential sources of insects, plague and mould.
- Materials with a high proportion of recycled composition.
- Reused from other buildings, demolition and second hand markets, as has traditionally have been done with bricks and tiles.
- Local materials that do not require long-distance transportation and support the local economy.

Keeping in mind that a more environmentally friendly as it is made lighter construction elements and requiring less material.

**Sustainable Products and Materials Technology**

The sustainable products are those materials that are durable or they can incorporate various technologies: energy harvesting, digesters CO2, eliminate pollution of the cities, and in principle may have a higher cost than a natural material environmental but in the long term provide a greater benefit in all aspects .

## Recycled Materials

Materials using recycled content not only require less virgin resources, they also use less energy and chemicals to process. For instance, recycled (“secondary” aluminum has 90% less embodied energy than virgin (“primary”) aluminum. It is beneficial to both use recycled material and design your constructions to be recycled as well.

Perhaps the easiest way to create a large improvement from recycled content is concrete, because it is used in such large quantities. Concrete can recycle fly ash from coal-fired power plants, and slag form the blast furnaces of steel production, among other materials. However, that these materials may contain toxins like mercury; if so, they should not be directly exposed to occupants.

Some building materials already have recycled content by default. For instance, most structural steel contains 90% recycled content, while sheet steel usually contains around 25% recycled content. Aluminum for curtain walls generally has not recycled content.

To make a recyclable building, the design should be for disassembly. That is, make it easy to separate different kinds of materials from each other. Some strategies for this include using as few different kinds of material as possible, using undoable fasteners and using larger assemblies that have greater value than small pieces.

## Sustainable Harvested Materials

Sustainable harvesting is the practice of harvesting a resource no faster than it can regrow, so that there is no net depletion of the resource or damage to the ecosystem. The most common from of this is “sustainable forestry” for wood products.

The proof of sustainable harvesting is generally in third party certification. The most widely-recognized and credible international standard is Forest Stewardship Council (FSC) certification.

## Local Materials

Local materials are any kind of material grown or manufactured within a certain radius of the building site.  They are also called “regional” materials, because the radius is often large, such as 800km. The goal of local material use is avoid the ecological impacts of transportation and support local economies.

## 4.6 Sustainable Heating Systems for Buildings (heat Pums Geothermal system)

The sun has always provided heat for the earth. Its energy warms the earth directly, but also indirectly. Its heat evaporates water from the lakes and streams, which eventually falls back to earth and filters into the ground. A few meters of surface soil insulate the earth and ground water below. The warm earth and ground water below the surface provide a free, renewable source of energy for as long as the sun continues to shine.

The heat energy taken from the ground is considered low-grade heat. In other words, it is not warm enough to heat your home without being concentrated or upgraded somehow. However, there is plenty of it – the average temperature of the ground just a few meters below the surface is similar to (or even higher than) the average annual outdoor air temperature. Generally speaking, this system works mainly with three main parts: a loop, the heat pump and the distribution system.

Geothermal systems basically consist of a heat pump and a ground loop that warms or cools a circulating fluid, depending on the season. In summer, the heat pump transfers heat extracted from the house into the ground, and returns the cooled air to the house. In winter, it extracts heat stored in the ground and transfers it to the house.

Heat flows naturally from high temperatures to low temperatures. However, the heat pump is able to force the heat flow in the reverse direction using a relatively small amount of work. Heat pumps can transfer this heat from natural sources in the environment at low temperatures (cold source), such as air, water or the earth itself, to the indoor units that are to be heated, or to use it in processes requiring heat in building and industry. It is possible, also, to take advantage of residual heat from industrial processes such as heat sink, which allows a source known and constant temperature which improves system performance.

Therefore, heat pumps can also be used for cooling. In this case the heat transfer is performed in the opposite direction, is from the application required to cool the environment temperature is higher. In some instances, the heat extracted in cooling is used to cover a simultaneous heat demand.

The geothermal heating system is made up of three main parts: a loop, the heat pump and the distribution system.

The loop is built from polyethylene pipe which is buried in the ground either in a horizontal trench (horizontal loop) or through holes drilled in the earth (vertical loop). The loop may also be laid on the bottom of a nearby lake or pond (Lake Loop or pond loop). The heat pump extracts heat from the ground and distributes the heat collected from it throughout the building. The chilled liquid is pumped back into the loop and, because it is colder than the ground, is able to draw more heat from the surrounding soil. These loops are often referred to collectively as a closed loop, as the same liquid circulates through the closed system over and over again.

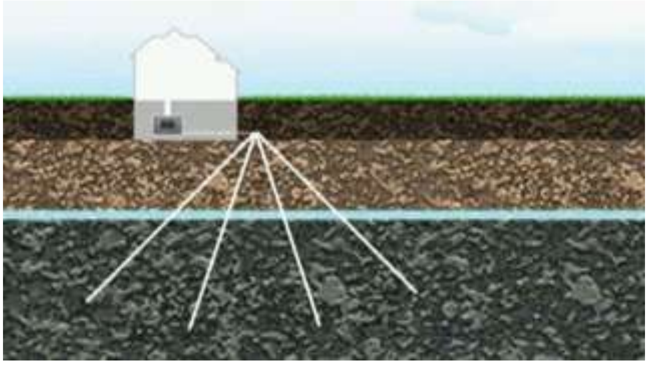
Each of the ground-coupling systems already described utilizes an intermediate fluid to transfer heat between the ground and the refrigerant. Each also requires a pump to circulate water between the heat pump and the ground loop. Direct-expansion systems remove the need for an intermediate heat-transfer fluid, the fluid-refrigerant heat exchanger and the circulation pump. Copper coils are installed underground for a direct exchange of heat between refrigerant and ground. The result is improved heat-transfer characteristics and thermodynamic performance.

There are four types of **closed loops**:

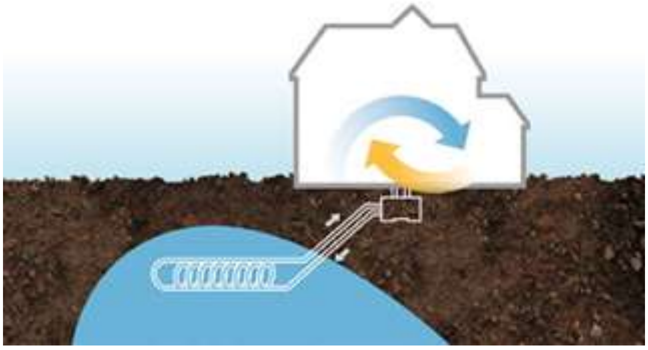
- Horizontal loop

- Vertical loop

- Direct expansion (DX) systemsç



- Lake or pond



Vertical closed loops are the most common, because of their suitability for typical lots. The **direct expansion (DX) systems** areespecially suitable for existing houses. They are good in limited spaces, such as in urban areas, because drilling does not need to be as deep, and can be done by a very small drilling machine. In a DX system, a refrigerant fluid flows through copper piping buried about 30 m underground.

Another way is to pump ground water or well water directly through the heat pump. This is the **open loop** system. This system that uses ground water is often referred to as an open-loop system. The heat pump extracts heat from the well water, which is usually returned to the ground in a return well. To run an open-loop system, you need two reliable wells with water that contains few dissolved minerals that can cause scale build-up or rust over the long term, as it is pumped through the heat pump's heat exchanger.

In both cases, a pump circulates liquid through the loop and the heat pump. The heat pump chills (or collects the heat stored in) the liquid when it is being used as a source of heat, and circulates it back through the loop to pick up more heat. A system for a large home will require a larger heat pump and ground loop, with a circulation pump to match.

After the system has taken the heat energy from the ground loop and upgraded it to a temperature usable in your home, it delivers the heat evenly to all parts of the building through a distribution system. It can use either air or water to move the heat from the heat pump into the building.

A heat pump can heat either air or water, but we are going to base our research in the heating systems by hot water.

Currently the heat pumps just can heat water to no more than about 50°C. This limits your choices for equipment to distribute the heat to the building.

The temperature difference between the ground loop and the hot water distribution system depends on the efficiency of the geothermal system; the greater the difference, the less efficient the system. Typically, the system will extract heat from the earth at about 0°C. If a radiant floor heating system requires a temperature of 50°C to heat your home, the heat pump will produce about 2.5 units of heat for every unit of electricity used to operate the system. If the system can be designed to operate with water at 40°C, it will produce 3.1units of heat for every unit of electricity used to operate it. In other words, it will be about 25 percent more efficient.

For good operation of the system, it needs to take the following factors into account:

- placing your floor pipe 20 cm (rather than 30 cm) apart reduces the water temperature required to heat your home by 4 to 5°C and increases the efficiency of your by about 10 percent;
- laying your floor heating pipe in concrete rather than using aluminum reflective plates with the pipe reduces the required temperature by 12 to 15°C, increasing the efficiency by 25 to 30 percent;
- suspending pipe in the joist space under a floor means that you will need temperatures higher than the system can produce, unless the heat loss in the space is very low;
- placing insulation under a slab-on-grade floor or under a basement floor reduces heat loss to the ground below; and
- Installing a control system that lowers the water temperature pumped through the floor as the outdoor temperature rises increases the efficiency. This type of control is commonly called an outdoor reset control.

This kind of heating system has a lot of benefits; the main is that is good for the environment, because more than two thirds of the energy delivered to your home is renewable energy stored in the ground, and also because there are virtually no toxic emissions. In addition, you can have comfort all the year with low operating costs and also with low maintenance and long service life.

It is important to keep in mind some factors for the correct use and operation of the system, for example:

- The correct location in-ground of the equipment and services
- Correct design of the building for keeping the heating or the cooler inside, with the correct type and level of insulation, ventilation system, type of windows…
- Choose and design the ideal heat pump, keeping in mind the performance and the efficiency for the temperature desired inside of the building.
- The loop size has to meet the requirements of the building, according to the soil conditions in the round area.
- The distribution system of the heating at the building must be designed to match the capacity of the heat pump.
- The system must be monitored by controls such a thermostat for turn on or off the heat pump according to the temperature level inside the building, and a humidifier for maintaining the comfort and it can thus lower or higher the relative humidity to an comfortable level.
- Correct maintenance of the system.

## 4.7 Green Buildings

Green building refers to a structure and using process that is environmentally responsible and resource-efficient throughout a building's life-cycle: from sitting to design, construction, operation, maintenance, renovation, and demolition. The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort.

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

Sustainability may be defined as meeting the needs of present generations without compromising the ability of future generations to meet their needs. Although some green building programs don't address the issue of the retrofitting existing homes, others do. Green construction principles can easily be applied to retrofit work as well as new construction.

Green building programs strive to promote overall resource conservation, through attention to water conservation opportunities, minimization of construction waste, recycling, improvements in indoor air quality, and efficient building operation in addition to energy conservation.

Green buildings, while not ZNEs, are designed to use energy more efficiently and may be able to be modified to use less energy still as technology improves.

The green building certifications do not require a building to have net zero energy use, only to reduce energy use to a level below the minimum required by law.[1] -> The risk is that designers may be tempted to archive only the minimum energy savings necessary or implement strategies inappropriate for a project or site to garner LEED[2] credits.

LEED - certified buildings do generally use resources more efficiently than conventional buildings that are simply constructed to comply with the minimum required by local or state building code. Yet lifetime building performance of green buildings may not actually result in overall energy savings compared to a standard.

Green building practices consider the entire building envelope including semi heated spaces, lighting and electrical systems. The ratings system does require meeting the requirements with extra points given for exceeding these requirements and it can cost significantly more up front to build green, but is a advantage for marketing a project.

1. U.S. Green Buildings Council. LEED for new construction. www.usgbc.org/DisplayPage.aspx?CMSPageID=220
2. Leadership in Energy and Enviromental Design (LEED)

Although green buildings strive to achieve energy efficiency and other sustainability measures, ZNE buildings take the crucial further step of eliminating the need to be connected to an energy grid as well as the need provide a useful bridge to a future where ZNE buildings become the norm, and technologies developed for green buildings such as programmable thermostats and design elements may be easily adapted to ZNE buildings as well.

## 4.8 NET ZERO – Zero Net Energy Efficiency Buildings

Net Zero Energy is quickly becoming a sought after goal for many buildings around the globe - each relies on exceptional energy conservation and then on-site renewable to meet all of its heating, cooling and electricity needs.

Therefore, Net Zero Energy Building are highly energy-efficient building will use over the course of a year, renewable technology to produce as much energy as they consume from the grid. Based on where you place the boundaries for the energy balance, there are several definitions of “Net Zero” buildings: (from NREL)

- Net Zero Site Energy: a site NZEB produces at least as much renewable energy as it users in a year, when accounted for at the site.
- Net Zero Source Energy: a source NZEB produces (or purchases) at least as much renewable energy as it users in a year, when accounted for at the source. Source energy refers to the primary energy used to extract, process, generate, and deliver the energy to the site. To calculate a building’s total source energy, imported and exported energy is multiplied by the appropriate site-to-source conversion multipliers based on the utility’s source energy type.
- Net Zero Energy Cost: In a cost NZEB, the amount of money the utility pays the building owner for the renewable energy the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.
- Net Zero Emissions: A net zero emissions building produces (or purchases) enough emissions-free renewable energy to offset emissions from all energy used in the building annually. Carbon, nitrogen oxides, and sulfur oxides are common emissions that ZEBs offset. To calculate a building’s total emission, imported energy is multiplied by the appropriate emission.

The key to designing net zero energy buildings is first reducing energy demand as much as possible, and then choosing good energy sources. Following there is an example of order of operations:

1) Reduce energy loads
2) Optimize design for passive strategies
3) Optimize design of active systems
4) Recover energy
5) Generate energy on-site
6) By energy/carbon offsets

A Net Zero Energy Building is proof that it is possible to live within our means.For this reason, they should have a certification for prove and to verifies that the building is truly operating as claimed, harnessing energy from the sun, wind or earth to exceed net annual demand. Net Zero Energy Building Certification is a program operated by the International Living Future Institute using the structure of the Living Building Challenge.

Net Zero Energy Building Certification:

- Verifies the building is truly operating as claimed, harnessing energy from the sun, wind or earth to exceed net annual demand. It is one thing to say a building is zero energy; it's another thing to prove it.
- Provides a platform for the building to inform other efforts throughout the world and accelerate the implementation of restorative principles.
- Celebrates a significant accomplishment and differentiates those responsible for the building's success in this quickly evolving market.

To get and have Net Zero Energy Building Certification, the requirements of the following five Living Building Challenge Imperatives must be met:

- Limits to Growth (in part): Curbs the building's contribution to the effects of sprawled development, which undermines the positive impact of achieving net zero energy building operation.
- Net Zero Energy: Serves as the primary focus of Net Zero Energy Building Certification.
- Rights to Nature: Ensures that the building does not preclude another building from achieving net zero energy operation as a result of excessive shading.
- Beauty + Spirit and Inspiration + Education: Underscore the notion that renewable energy systems can be incorporated into a building in ways that are attractive and inspiring.

# 5.0Conclusion- Factors of the level of efficient energy

Now, after the analyses of the energy efficient buildings, and what we need for that a building be sustainable, we can know the main factors that determine the level of energy efficiency.

The most important we can summarize in the following factors:

- Thermal insulation in the envelope (walls, ceilings and windows)
- Reduce heat loss by infiltration in winter
- Proper orientation of the building
- Allow entry of the sun in winter
- Avoid shadows cast by other buildings
- Prevent the entry of the sun in summer
- Designing sunscreens (fixed, mobile, natural)
- Use systems of heating and air conditioning efficient ( energy labeling )
- Use of Low-E glasses at the windows.
- Energy savings in hot water ( drevas System )
- In rule double roofs as insulation thickness and seek to incorporate shade elements.
- Use efficient lighting using low energy lamps.
- Modernization of energy facilities in the building and improving the energy rating of the same.
- Correct waste management.

# 6.0 Indoor Climate Comfort

There are three types of comfort that play a role in the indoor climate; those are the thermal, acoustic and lighting comfort.

## 6.1. Thermal comfort

The human body is prepared to react to climate change, but these reactions consume metabolic energy from the body. The feeling of comfort that comes from the generation of a microclimate that prevents the body's reaction saving energy costs is called natural thermoregulation. On the Contrary to the coat is a phenomenon of artificial thermoregulation.

The normal body temperature is 37 ° C. The human body is very sensitive to increases in temperature inside. An increase of 5 or 6 degrees more can cause severe damage and even death.

While inside buildings, sitting in a room with light clothes and doing light activity, the feeling of satisfaction is reached temperature between 21 ° C and 25 ° C. The relative humidity and moisture, which is usually blamed as the cause of the discomfort is less significant since the tolerance of the body is large, admitting limits between 20 % and 75%.

The body is very sensitive to changes of radiation. If the temperature is below 18 ° C but there is good sun, a human can immediately feel the sensation of comfort increases. This principle is used by the type underfloor heating system and radiators.

To understand what determines the well-being and their relationship to the architecture must be assumed that the human body produces heat that is exchanged with the surrounding atmosphere.

Within the human body are chemical transformations that maintain life, producing heat, produced by homeostasis. For this reason thermodynamics takes place. This constant flow of energy is measured by metabolic rate and varies with the level of activity of people based on age, sex and psychological status.

- Based metabolism: the energy required for maintenance of vegetative life (fasting or resting), approx. 81 Wh for a male of average height.
- resting metabolism : metabolism is minimal because the former is experimental ; 104 Wh
- Metabolism work: in addition to the basic functions of metabolism, this includes driving energy costs. Its level depends on the type of activity, from 104 Wh for an intellectual task to 812 Wh for intense physical effort.

### 6.1.1. Parameters

The comfort is related to the comfort and well being of the body, therefore it is associated in particular with the body functions that may be affected, such as hearing, vision, nervous system or joint problems caused by excess vibration.

Then to talk about "comfort" means to eliminate the possible inconvenience and discomfort generated by different actors involved in the balance of the person.

A thermal ideal environment is one in which the occupants do not express any feeling, hot or cold. The condition is a neutral state in which the body does not need to take any particular action to maintain its own heat balance.

The comfort temperature is recommended that you stay within the following ranges:

| Season | Temperature Cº | Wind velocity (m/seg) | Relative Humidity (%) |
|---|---|---|---|
| Winter | 20-24 | 0.14 | 45 |
| Summer | 23-26 | 0.25 | 65 |

Source: ISO 7730

Comfort parameters are the conditions of environmental, architectural, personal and sociocultural that can affect the feeling of comfort of an individual.

Thermal comfort depends on several external global parameters such as air temperature, the speed of the same and the relative humidity, as well as other specific internal specific parameters as physical activity developed, the amount of clothes or the metabolism of the individual.

Environmental parameters including air temperature, relative humidity, air velocity, radiant temperature, solar radiation, noise levels can be quantified. The architectural parameters are directly related to building characteristics and adaptability of space, the visual and auditory contact that allow occupants.

Some intervals of values of the parameters of external comfort interacting to achieve thermal comfort are:

- Ambient air temperature: 18 to 26 º C
- Mean radiant temperature in surfaces of the local: between 18 and 26 º C
- Air speed: 0 to 2 m / s
- Relativehumidity: between 40 and 65%

The EPBD (Energy Perfonmance of buildings Directive) defines the energy efficiency as “the amount of calculated or measured energy that is needed to satisfy the energy demand associated with normal use of the building, which will include the energy consumed in heating, cooling, ventilation, water heating and lighting.” It means the energy that a building needs to maintain adequate comfort conditions, but how can we” evaluate this comfort?

#### 6.1.1.1. Thermal parameter

Evaluation of thermal comfort is complex, given that the concept of comfort encompasses very diverse factors. These factors should be considered in a holistic manner, assessing how the combination affects the comfort of all.

Owing to psychological variability is practically impossible to get a group of people, whatever the reference ambient conditions would be, to express the same comfortable microclimate feeling in a given situation.

The human body, due to their metabolic activity, produces heat consistently. Our organism needs to remain at a "relatively consistent temperature to be able to operate normally. Consequently, the balance between the heat generated and the heat given to the environment must be null. If our body loses heat faster than it generates, we feel colder . If we give to the environment less heat, our temperature will be rise.

Our body exchanges heat with the environment in several ways:

a) To the air, by convection, depending on the temperature and air velocity
b) By conducting with solids in contact (example the ground)
c) By radiation from the body toward proximal surfaces.
d) By evaporation and transpiration which cools the skin as a function of relative humidity and temperature.

#### 6.1.1.2. PhisicalParaments

The main requirement for thermal comfort in an individual is that their energy balance would be zero or nearly zero. We must pay special attention to the factors and parameters that have the greatest influence on the energy transfer between the individual and the environment:

***Temperature***

Temperature is perhaps the most important parameter in the energy balance. The difference between body temperature and room temperature play an important factor here. It's important to differentiate different concepts related to temperature:

- Dry bulb temperature(DBT): This is the temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture. DBT is the temperature that is usually thought of as air temperature, and it is the true thermodynamic temperature. As a matter of fact, it indicates the amount of heat in the air and it is directly proportional to the mean kinetic energy of the air molecules. Temperature is usually measured in degrees Celsius (°C), Kelvin (K), or Fahrenheit (°F). DBT is indeed an important variable in Psychrometrics, being the horizontal axis of a Psychrometric chart.

- Radiant temperature: Two bodies that are at different temperatures exchange energy by radiation. The mean radiant temperature is the temperature that incorporates the average effect of cooling or heating by electromagnetic radiation environment. The radiant temperature is a key parameter in assessing the thermal comfort and thermal sensation. For example, a job next to a glass surface will lead to discomfort probably cold when the outside temperature is low, since the person is radiating energy to the window.
- Operating temperature: This isthe arithmetic average between the dry air temperature and the radiant temperature of the walls of the room. This Integrates the feeling of comfort generated by the air temperature and the radiant temperature. When the humidity is between 45 and 60% and air velocity below 0.2 m/s the equivalent temperature is the value most used. The RITE generally limits the operating temperature between 21°C and 23°C in winter and 23°C and 25°C in summer. However, in public buildings, the air temperature in the heated enclosures shall not exceed 21° C or below 26° C in refrigerated spaces.
- Chill temperature: This isan arbitrary index that characterizes the greatest feeling hot or cold a person feels on your skin when exposed to an environment with certain specific conditions of temperature, wind and humidity.

### ***Relative humidity***

The relative humidity is the percentagebetween the vapor of the water that the air content, and it would need to contain for be saturated at the same temperature is defined. For example, a relative humidity of 65% means that all water vapor (100%) which may contain air at this temperature, in this instance contains 65% humidity.

The UNE-EN 7730 regulation indicates that relative humidity should be maintained in the range of 30-70%. The importance of relative humidity has little effect on comfort while between 40% and 60%, although outside of this range, is a variable that significantly affect thermal comfort.

The relative humidity (RH) by the air temperature will indicate in a psychometric diagram the in thermal conditions inside a local. This is indicated in the following point 7.1.2.

### ***Air Velocity***

The air velocity is, with the temperature and humidity, one of the key values of comfort. All conditioning systems, either passive or active, obtained the comfort by modulating these three factors.

The cooling effect of air movement is due to two phenomena. The first is evaporative and is caused by the increase of the rate of sweat evaporation on contact with the air stream. Evaporation cooling absorbs the energy from the body cooling it. The second phenomenon occurs to increase the heat transfer by convection between the body and the air.

It is customary to place the maximum rate in office buildings at 0.8 m/s (to prevent the flight of papers and cold drafts which cause discomfort Local).

### 6.1.1.3. Heat transfer

The key parameter in achieving thermal comfort is temperature. In a building, we should know which types for the heat transfer are in order to control them when designing a building. In this case we can benefit from their free energy boost when needed, and know protect a excessive profit when we need it.

There are three mechanisms of heat transfer: conduction, convection and radiation. In the interaction between building and occupant come into play outside the three mechanisms. But the most important for this research the heat transfer by radiation, so we are going to emphasize in this part.

**Conduction**

Conduction is the way for transmitting heat in solid bodies. When a body is heated, the molecules that directly receives the heat increases their vibration and collide with the surrounding . These in turn do the same with their neighbors until all the molecules in the body are shaken.

The resistance heat that flows passing through a material is calculated based on **the thermal conductivity (λ): the quantity of energy passing through a surface area of 1 m2 and 1 m in thickness when the temperatures on both sides differ by 1 ° C** . Its units at the International System are W / m ° C. In the case of multilayer walls, the equivalent resistance is calculated according to the properties and thickness of each material is composed.

The thermal resistance (R) of a material is indicative of the difficulty encountered when the heat transmitted through the interior of the material. Through a homogeneous medium, the thermal resistance is directly related to the material thickness of the form:

$$R = e / \lambda$$

Where: R: thermal resistance [m2 • °C/W] e: material thickness [m], λ: thermal conductivity [W/ m • °C]

**Convection**

Convection consists of a heat exchange between air and a solid (or vice versa) when they are at different temperatures. The difference of the temperature between the face of a solid and the fluid with which contact has produced movements in the fluid due to density differences that are created. This type of movement, due solely to the difference in temperature of the fluid is called convection.

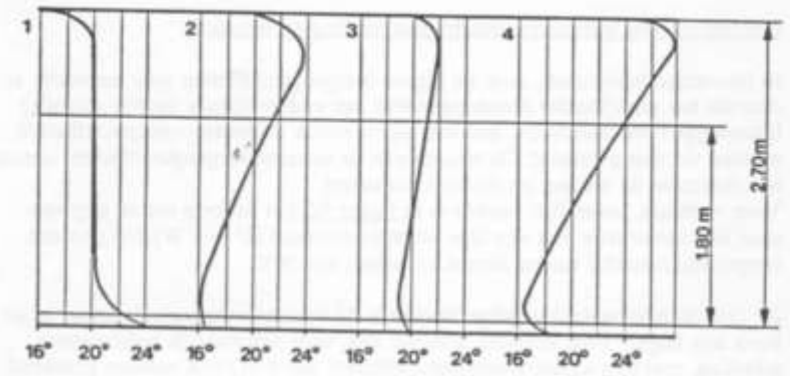
**Radiation**

The radiation transfers the heat between two bodies which are not in contact with each other and between themthere is a difference of temperature. All bodies with temperature above 0 K emit electromagnetic radiation, and its intensity is dependent on the temperature and the wavelength considered.

Radiation energy is an electromagnetic movement similar to that of light and electricity, but with very small wavelengths (about 10 µm). The distance between bodies has virtually no significance and the emitted energy can be absorbed by another body or reflected.

As we have seen before, the Radiant temperature is the uniform temperature of an imaginary black enclosure which would produce in the same loss of heat by radiation on people as the real local.

Diagram of radiant temperature:



Figuur 5.8: temperatuurstratificatie in een vertrek

1 vloerverwarming
2 radiatorverwarming met radiator aan binnenmuur
3 radiatorverwarming met radiator aan buitenmuur
4 luchtverwarming

## Incidence of solar radiation in enclosures

Solar energy is an input only by radiation. Solar radiation can manifest in three ways depending on how the elements are radiated:

- Direct radiation: coming directly from the sun.
- Diffuse Radiation received from the atmosphere due to the scattering of sunlight into this.
- Albedo radiation: one that is reflected on the surface.

The solar radiation can fail on a building, in general, on an opaque, or a glass surface area. When falling on the opaque surface of the enclosure, the heat energy is transmitted into the building by conduction.

## The heat transfer coefficient U

The total thermal resistance (Rt) measures the opposition that shows how an enclosure can transmit heat, considering its behavior in the conduction according to the thermal resistance of each of the materials that make up the enclosure of the building, and the effect of convection of their outer surfaces (exterior and interior) in contact with surrounding environments. Convection effect is quantified by its superficial thermal resistances, which include the effect of radiation.

$$R_t = \frac{1}{h_e} + R_1 + R_2 + \ldots + \frac{1}{h_i}$$

The inverse of the total thermal resistance is defined as thermal transmittance (U) units W/m2•°C. Its meaning is the amount of heat passing through 1m2 of material when the temperatures on both sides differ by 1 ° C.

The values and *hi* and *he* are calculated by the addition of the rates of change to keep in mind the outside and inside of the material (depending on the heat transfer mechanisms that act on each of the two sides).

## The thermal inertia

Thermal inertia is the property that indicates the ability of a body to keep heat energy received and giving it gradually. Thermal inertia depends on mass, density and specific heat. The buildings of high thermal inertia have more stable thermal variations, as the heat accumulated during the day is released at night time, this means that the higher thermal inertia higher thermal stability.

This property is a key factor in bioclimatic and sustainable architecture, as it can keep the temperature inside the most stable throughout the day, with high-mass walls residential premises. During the day warm, and at night, colder, they are giving heat to the atmosphere its place. In summer, during the day, absorbing heat from the air ventilation and during the evenings become cool with adequate ventilation, to prepare for the next day. Proper use of this property can avoid the use of artificial indoor climate systems.

However, it is a common mistake to assert that the thermal inertia is always positive for the buildings energy performance. Depending on the type, climate area and usage profile of the building could be interesting not keep thermal energy, and in return get a quick change in temperatures.

**Solar radiation through glass.**

The wavelength of the radiation that reaches the Earth falls mainly between 0.3 and 3.5 microns. Glass windows are permeable to shortwave radiation (wavelengths <2.5 microns) which is most of the radiation (approx. 97%).

It must be said that not all shortwave solar radiation incidents on a glass through it, because some is reflected and some is absorbed by the glass. The reflected radiation is a function of angle of incidence and the iron content of the glass. As we already saw in the point 5.2 at *Low-E glasses*, this depends to the proprieties of the glass.

The energy absorbed by the glass is transferred both to the outside environment and the interior, by radiation and convection. Generally it (transferred more energy outwards due to a bigger temperature difference between the glass and foreign objects and no with interior ones and the higher coefficient of heat transmission convective.

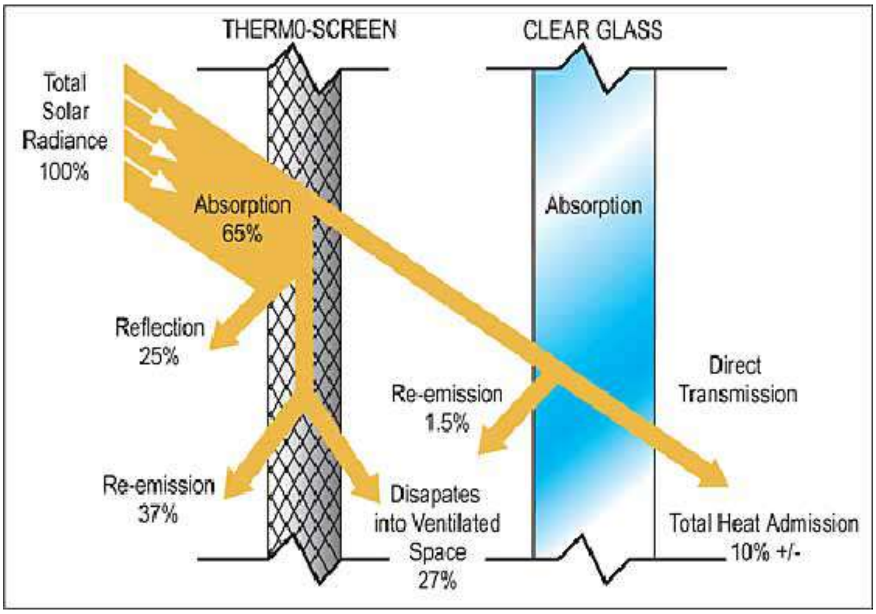


*Figure : Effect of solar radiation through glass*

The rest of the heating radiation goes into the materials, walls, floor, etc., and although it not heats directly the air, it ends heated by convection for contact with hot bodies. All these hot bodies, besides lending convective heat, radiate energy with a wavelength for which the glass is opaque. Thus, the glass becomes a system that allows input of energy but not its output, making it constantly warm indoor environment (greenhouse effect). This is only the effect for solar radiation, although it does not always have the same effect with glass radiation, we will describe in the following points the radiation temperature through the grasses from inside.

First, the long wavelength radiation emitted from the inside, by impinging on the glass, but does not pass through it, it heats up, giving the possibility for the energy to be lost by convection or by the radiation of hot glass outwards. On the other hand, the way that the most amount of energy is lost is by heat transfer as a function of the difference in temperature between the air inside and outside, and the transmission coefficient of the heat air of the glass.

**Solar Factor**

A relationship between the energy that transcends the material glass (transmitted more energy absorbed and radiated part inside the glass) and the total solar energy incident on it is called Solar Factor (Fs).

The solar factor is therefore a function of transmission factors, and energy absorption. This is a variable depending on the magnitude of solar incidence angle and the external conditions of natural convection and wind speed.

#### 6.1.1.4 Thermal Bridge

### 6.1.2. Measurement of termal comfort

The individual thermal comfort parameters relate to the person. This includes clothing, metabolic rate, age, sex, etc.
These factors are less important than the physical parameters described above, but you can not ignore its impact at all, especially in specific types or uses as nursing homes, sports arenas, hospitals, etc..

To evaluate the thermal comfort ranges buildings you can choose between the following options:

- *The method of Fanger* , based on the PMV model (Predicted Mean Vote), which nowadays is the most widely used for the estimation of thermal comfort, or
- *Comfort adaptive model* (Humphreys, Auliciems, Griffins, etc.,), which takes into account the ability of the occupant to adjust the outside climate.

In general, the Fanger model is suitable for mechanically conditioned buildings while the adaptive model is the most appropriate to evaluate comfort in air-conditioned buildings with passive heating and ventilation strategies.

The Fanger's method is calculated from relating data like clothing, metabolic rate, air temperature, mean radiant temperature, relative air velocity and relative humidity, two indexes named PMV-Predicted Mean Vote and PPD-Predicted Percentage Dissatisfied values that both provide clear and concise information on the thermal environment. The PMV is an index that reflects the positive or negative comfort of the votes from a large group of people with respect to the thermal sensation of 7 levels scale (cold, cool, slightly cool, neutral, slightly hot, hot very hot), based on the heat balance of the human body (internal body heat production equals their loss to the environment).

The PMV predicts the mean value of the chill temperature. However, individual votes are distributed around this mean value, so it is useful to estimate the percentage of people dissatisfied by feeling too cold or heat.

**Adaptive** comfort **model** proposes a correlation between the temperature of comfort for building users and outside air temperature. The underlying concept is the process by which the human body adapts to seasonal and local weather. Therefore, users will considered different temperatures inside considered as satisfactory comfort temperatures, depending on the outer climatic conditions at the time.

Compared with Fanger model, the adaptive model considers a wider range of temperatures as "acceptable temperatures" and therefore allows easier integration of passive cooling technologies.

### 6.1. 3 Psychrometrics

Psychometrics  is the branch of physics on the measure of determining atmospheric conditions, particularly regarding to humidity and the effect of atmospheric moisture on the materials and human comfort. It is the essential method to measure the effect of air conditioning on environmental atmospheric conditions.

Dry air is a mixture of several gases. Its general composition is as follows:

Nitrogen: 77%
Oxygen: 22%
Carbon dioxide and other gases: 1%

| Name | Symbol | Dry air % in weight | Dry air % in volume |
|---|---|---|---|
| Nitrogen | $N_2$ | 75,47 | 78,03 |
| Oxygen | $O_2$ | 23,19 | 20,99 |
| Carbon Dioxide | $CO_2$ | 0,04 | 0,03 |
| Hydrogen | $H_2$ | 0,00 | 0,01 |
| Other gases | - | 1,3 | 0,94 |

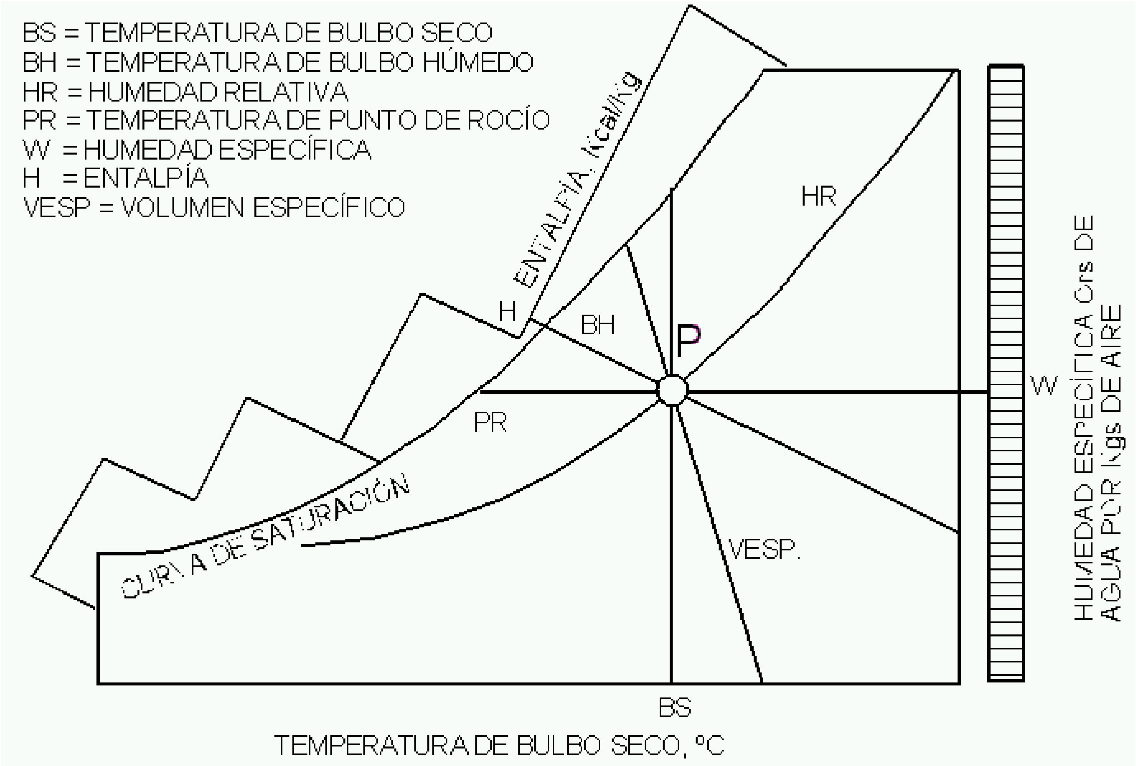
As we can see in the previous table, the atmospheric air is a mixture of oxygen, nitrogen, carbon dioxide, hydrogen, water vapor, and very small percentage of rare gases such as argon, neon, ozone, etc.

Regarding the temperature, air has the property of retaining a certain amount of water vapor. With lower temperature, it has fewer amounts of vapor, and vice versa; with higher temperature, more water vapor, if it is kept at constant atmospheric pressure.

Although the principles of psychrometry apply to any physical system consisting of gas-vapor mixtures, the most common system of interest is the mixture of water vapor and air because of its application in heating, ventilating, and air-conditioning and meteorology. In human terms, our thermal comfort is in large part a consequence of not just the temperature of the surrounding air, but (because we cool ourselves via perspiration) the extent to which that air is saturated with water vapor. Many substances are hygroscopic, meaning they attract water, usually in proportion to the relative humidity or above a critical relative humidity.

### 6.1.2.1. Psychrometricdiagrams

The psychrometric tables offer great precision, since their values are up to four decimal; however, in most cases not much accuracy is required, and the use of the psychrometric chart can save much time and calculations.



- Determining relative humidity: The percent of relative humidity can be located at the intersection of the horizontal dry bulb and diagonally down sloping wet bulb temperature lines. Metric (SI): Using a dry bulb of 25°C and a wet bulb of 20°C, read the relative humidity at approximately 63.5%. In this example the humidity ratio is 0.0126 kg water per kg dry air.
- Determining the effect of temperature change on relative humidity: For air of a fixed water composition or *moisture ratio*, find the starting relative humidity from the intersection of the wet and dry bulb temperature lines. Using the conditions from the previous example, the relative humidity at a different dry bulb temperatures can be found along the horizontal humidity ratio line of 0.0126, either in kg water per kg dry air.

- Determining the amount of water to be removed or added in lowering or raising relative humidity: This is the difference in humidity ratio between the initial and final conditions times the weight of dry air.

## 6.2. Acoustic Comfort

Acoustic comfort is the noise level, which is below the legal standards that can potentially cause damage to health, and also must be accepted as comfortable for the workers concerned.

Acoustic comfort is the sound level that does not disturb, do not disrupts and does not cause direct harm to health.

The first noise annoyance causes this discomfort we feel when we interfere with the activity we are doing or when our rest stops.

Among the conditions that can cause this pollutant are:

Interference in communication: The loud noises that would normally prevent the communications, forcing us to raise our voice.

Loss of attention, concentration and performance: A sudden noise will make distractions that will reduce performance in many types of jobs, especially those that require a certain level of concentration.

Sleep Disorders: Noise has a negative effect on sleep, in varying degrees according to individual peculiarities, from 30 decibels.

Levels of acoustic comfort according to activities (desirable values):

| ACTIVITIES | dB |
|---|---|
| Garages and repair shop | 60 – 70 dB(A) |
| Mechanized offices | 50-55 dB(A) |
| Gyms, sports halls, swimming pools | 40-50 dB(A) |
| Restaurants, bars, cafes | 35-45 dB(A) |
| Offices, libraries, courtrooms | 30-40 dB(A) |
| Theaters, hospitals, small churches, conference halls | 25-35 dB(A) |
| Classrooms, television studios, big conference rooms | 30-20 dB(A) |
| Concert halls, theater | 25-20 dB(A) |
| Clinics, audiometric places | 20-10 dB(A) |
| Ventilation system | 30-35 dB(A) |

Source: ISO R-1996/ UNE 74-022

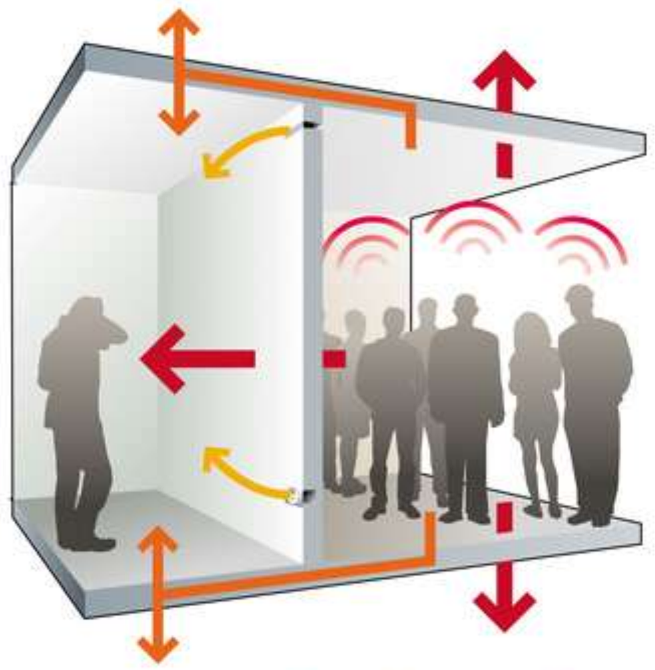
Besides the equivalent noise level, we must consider a number of other physical parameters such as frequency and timing noise, room acoustics (reverberation produced by the reflection walls, floors, ceilings and objects, etc...)

In terms of acoustics, there are two major sources to be considered: the reverberation of noise from inside the classroom; and the transmission of noise from outside to inside, and between classrooms.

The problems that frequently have the buildings as to lack of acoustic comfort for excess noise can be summarized in two typical situations:

- Sound proofing

Is the set of actions aimed at the protection of enclosures against the outside noises. We should keep in mind the noise transmitted by air or structural path between the enclosures in a local and building.



Transmission du bruit : → directe / → indirecte ou latérale / → parasite

The isolation depends on the characteristics of the materials, constructive solutions adopted and architectural context in which it is integrated.

In terms of physical quantity of sound insulation, this is the ratio of sound energy that is attenuated by the sound transmitted between a transmitter enclosure and a receiver enclosure.

- Acoustic fitting-out

This is the action destined to improve the sound quality and acoustics in an enclosure acoustically isolated from external noise. Unlike soundproofing involves a single enclosure, the sound is generated and collected in the same enclosure.

The acoustic treatment is directly related to the reverberation of the room. This reverb is related to the acoustic absorption of the enclosure according to the following expression:

$$T=0.16\ V/A$$

where:

T - is the reverberation time of the enclosure.
V - is the volume of the enclosure.
A - is the area of absorption of the compound

The acoustic fitting-out in an enclosure is also related to the choice of the lining material of the finish surfaces.
The construction materials most employed are:

- Porous materials, where sound absorption is produced by the dissipation of acoustic energy by friction between the air in the interior pores that vibrates to the incident waves and the material itself". To function well acoustic absorbing these pores must be interconnected, these materials are known as open cell. Examples of absorbent materials are carpets, textile floor coverings, panels of mineral acoustic wool, plasters and acoustic mortars, etc ...

- Resonator panels used in specific applications because the absorption is selective in a frequency range. Among the most used in construction include:

    - Membrane resonators based in separate wall panels, ceiling, etc. the camera may be filled wholly or partially of flexible absorbent material such as mineral wool. An example is plywood panels anchored to a structure or frame.

    - Perforated panels, separated of the wall with a distance, the camera can be fully or partially filled of the absorbent material. Is one of the construction options most used, if the perforation percentage is higher than 12% then the panel is transparent and the absorption is the same as the material disposed in the chamber. One example is the perforated ceiling for acoustic treatment.

Thinking of the design of classrooms or meeting rooms as a first objective of the following recommendations, should be considered:

- The cubic enclosures are to be avoided or those in which the main dimensions are integers.
- For similar absorption sound values of the elements of the compound is more appropriate a central corridor that two lateral access for people.

## 6.3. Lighting Comfort

For lighting a number of variables are used that are essential to a proper understanding. These figures are:

- The luminous flux, which is the light power emitted by a light source.
- The light intensity, which is how the light is distributed in one direction.
- The lighting level, which is the level of light striking an object.
- La luminancia, es la cantidad de luzqueemiteunasuperficie, esdecir, el brillo o reflejo.

Proper lighting allows the shapes, colors, objects, and that this is easily done without causing eyestrain. When designing a suitable light environment for viewing, what needs to be addressed is the distribution of light as it provided the most appropriate. An inadequate distribution of light can cause headaches, visual discomfort, errors, visual fatigue, confusion, accidents and especially the loss of vision.

Order to ensure visual comfort we must take into account three basic conditions: the level of illumination, glare and contrast.

A good lighting system should ensure adequate levels of lighting in the workplace and in their environments.

Workplaces must be illuminated preferably with natural light, but if it is not enough or does not exist, should be supplemented with artificial light. It will be a general lighting, supplemented in turn by localized light when the job requires it.

Workplace minimum lighting levels (lux)

| Work places | Lighting levels (lux) |
|---|---|
| Low visual requirements | 100 |
| Moderate visual requirements | 200 |
| High visual requirements | 500 |
| Very high visual requirements | 1000 |
| Local areas of occasional use | 50 |
| Local areas of habitually use | 100 |
| Circulation roads/ways occasional use | 25 |
| Circulation roads/ways habitually use | 50 |

Light intensity or quantity of light energy incident on a surface is measured in lux (= 1 lumen / m²). Although the human eye can see illuminance between 3 and 100,000 lux, comfortably to develop an activity requires between 100 lux and 1000 lux.

The distribution of the light sources is a factor that must be addressed particularly because the poor distribution of light levels can cause bright or glares. Glare is produced by impinging a light beam on the eye, producing discomfort and decrease the visual perception.

The light distribution should be as uniform as possible. The way to reduce the glares will be covering the lamps with diffusers, louvres or other systems to regulate the light avoiding the direct view of the light at the source.

Other factors to keep in mind the contrast balance between the luminance of the object and surfaces that the user has in their visual field. Strong contrasts spaces with weak contrasts should be avoided, as well as. The aim is to achieve a balance across the workspace.

# 7.0 Conclusions – Factors that play role in a comfortable indoor climate

An indoor climate in a space, and the way the users are assessing the comfort ability is influenced in some aspects.

Based on the above, we can identify the factors that are important defining the comfort within a local. These factors are divided according to which comfort we would like to make reference: Thermal, acoustic and lighting comfort. Therefore the combination of these 2 types, will determine a correct comfort in a room.

Regarding the thermal comfort we can see the following factors as the most importants:

- Humidity - Relative humidity
- Temperature
- Ventilation
- Filtration and air cleaning
- Psychrometrics
- Building Design
- Construction parameters, cold or hot materials used.
- Chill temperature / felt air temperature / air temperature apparent
- Air Velocity
- Heat transfer - radiation heat

Regarding acoustic comfort, the following factors will define a correct comfort:

- Correct acoustics and noise levels
- Sound proofing
- Acoustic conditioning
- frequency and temporal distribution of sound

Finally, in reference to lighting comfort, we can determine it by the following factors:

- Daylighting
- Light intensity
- Lighting level
- Proper distribution of light sources
- Contrasts
- Luminous Balance

# 8.0 Energy efficient Certificate for Existing Buildings.

The building sector can play a critical role in achieving the transition to a low-carbon economy.

Energy certification of buildings is a key policy instrument for reducing the energy consumption and improving the energy performance of new and existing buildings.

This policy pathway documents the elements, steps and milestones (i.e. the pathway) necessary to successfully implement energy certification of buildings. Its aim is to help countries implement effective programmes within the context of their national policy frameworks by offering advice and opportunities to benefit from the experience of others.

While the focus, methodology, application, output and impact of certification may differ for new and for existing buildings, both require robust, transparent procedures that are accurate, reproducible and cost-effective:

- For new buildings, energy certification can demonstrate compliance with national building energy regulations and provide an incentive for achieving a better standard compared with buildings of the same type.
- For existing buildings, energy certification attests to the energy performance of the building, and provides information that may increase demand for more efficient buildings, thereby helping to improve the energy efficiency of the building stock in the country.

Energy performance certification provides a means of rating individual buildings – whether they be residential, commercial or public – on how efficient (or inefficient) they are in relation to the amount of energy needed to provide users with expected degrees of comfort and functionality. The degree of efficiency depends on many factors including: local climate; the design of the building; construction methods and materials; systems installed to provide heating, ventilation, air condition or hot sanitary water; and the appliances and equipment needed to support the functions of the building and its users.

Clearly, certification is a complex procedure, requiring in-depth knowledge of building components. It also reflects increasing recognition of the need to think of buildings as "integrated systems", rather than simply the sum of their parts.

Energy certification of buildings typically involves three main steps:

- The assessment of the energy performance of a building by a competent assessor using a nominated methodology.
- The issuance of a certificate rating the building’s energy performance which includes, in some cases, information on possible improvements likely to yield energy savings.
- The communication of this information to stakeholders through publication of the certificate.

In order to prepare an energy certificate, it is first necessary to undertake an energy performance assessment of the building’s characteristics and systems. This is carried out by a qualified assessor who collects information on the building’s characteristics and components, as well as its energy systems and energy consumption. An assessment generally includes, as a minimum, an analysis of:

- The form, area and other details of the building.
- The thermal, solar and daylight properties of the building envelope and its air permeability.
- Space heating installation and hot water supply, including their efficiency, responsiveness and controls.
- Ventilation, air-conditioning systems and controls, and fixed lighting.
- Fuel and renewable energy sources.

Other elements, such as lighting systems and installed equipment and appliances, may also be included in the assessment.

Assessment methodologies generally use software tools to calculate energy performance and ratings, which will often be based on annual energy use in specific terms, such as the number of kilowatt hours used per square metre (kWh/m2/year).

They may also measure related CO2 emissions, measured in kilograms of CO2 per square metre (kgCO2/m2/year). A comprehensive software system can also help provide recommendations for upgrading the building to improve efficiency.

Building certificates may be issued for new and existing buildings. The timing of issuance is important because it can determine the effectiveness of the certification and its potential to have a positive impact on the building's energy performance level.

Energy certification in existing buildings: This is a significant tool for improving the overall efficiency of the entire building stock. As buildings have long life spans, turnover is low and it will take a long time before new building codes, policies and certification schemes for new buildings have any significant impact on the building stock as a whole. For existing buildings, certification and particularly the advice on options to improve energy performance help to raise awareness of energy efficiency opportunities when renovating and/or refurbishing. This is, after design, the most cost-effective time to implement energy efficiency upgrades.

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# 10.0 Attachments

Are only showed the new attachments. The other attachments are the same as in our first document

1- Energy efficient
2- Energy efficient buildings
3- Geothermal Energy Elements
4- Lighting in energy efficiency
5- Elements for the indoor climate
6- Energy Performance Certification of Leon van Gelder Building.
7- Energy performance Certificate Report

# Green Building Insulation: The Environmental Benefits

To meet green building standards for better thermal protection and energy performance from longer-lasting, environmentally benign building materials, more projects employ closed-cell spray polyurethane foam (ccSPF) insulation, which provides significant benefits contributing to green building performance and LEED certifications..

## Executive Summary: The Use of Advanced Insulating Technology in High-Performance Green Building

For commercial and institutional buildings, sustainability has become an overarching and highly important project driver. Key attributes associated with high-performance green building – including high energy efficiency, occupant comfort, material durability and increased property values – have led to the adoption of best practices in construction materials and methods. Among those is the use of more efficient insulation systems, air barriers, and seamless monolithic roofing systems. One such system, closed-cell spray polyurethane foam (ccSPF) is the subject of this white paper. Closed-cell spray polyurethane foam has been shown to offer improved life-cycle analysis and environmental performance, in addition to superior control of the building enclosure and the indoor environment.

This paper reviews the current state of high-performance, advanced green insulation technology, and the key factors to consider when selecting, specifying and designing a green building insulation system. Attention is given to the selection criteria used for green building, including life-cycle analysis (LCA) and the U.S. Green Building Council's LEED systems.

After a discussion of the features and advantages of ccSPF insulation in this context, an overview is given on closed-cell spray foam products for use in the commercial building enclosure, including the roof, walls, floor slabs and foundation. Two case studies demonstrate the practical application of ccSPF in green building. The technical white paper concludes that ccSPF insulation provides significant benefits contributing to green building performance and LEED certifications.

## Table of Contents

## Green Building Drivers

Volatile and increasing energy prices, concern over environmental impact, and occupant health and comfort – these are the drivers of green building today. In fact, these trends have become of paramount importance for commercial and institutional building owners.

Many experts in building performance believe that the current state of energy consumption and carbon emissions in the United States requires a stark redirection of current design and construction approaches. "In the whole field of energy conservation and greenhouse gas emission, our industry has to stop, hold on, and see what we're doing wrong, as opposed to running to fix small things," says Dr. Mark Bomberg, a research professor in the Building Energy and Environmental Systems Laboratory at Syracuse University. "You really have to look where you can save energy – work on the demand side – before you address the supply side, and that's through the rehabilitation of existing buildings."

Industry's response to rising energy prices and increased environmental impact of building construction is apparent. The American Institute of Architects reports that although five years ago, less than half of architects were incorporating green building practices, it is estimated that 90 percent of architects will incorporate sustainable elements by 2012, and 88 percent have received some training in green building. In addition, the 2006 McGraw Hill Construction Survey noted that corporate respondents to the survey are willing to pay an average of 4 percent more for LEED certified buildings, with 31 percent willing to pay more than 5 percent more.

Despite increased demand for energy and environmental performance, quantifying the green building benefits of specific technologies and strategies is a complex process. It requires the evaluation of a long list of criteria in a full life-cycle analysis (LCA) to determine overall product performance (related to manufactured products) and full system performance (related to buildings as a whole).

### The LCA for ccSPF

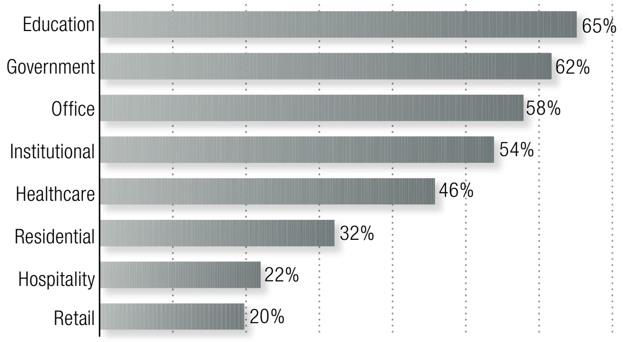
Organizations such as Green Globes, owned and operated in the United States by the Green Building Initiative, have created tools to perform LCA for products. These methods include consideration of a complete range of environmental performance factors that impact overall product selection and application. These factors include: climate change potential; embodied energy; pollution and waste production; health factors; and other environmental risks.

A number of LCAs have been performed to date on specific formulations of closed-cell spray polyurethane foam (ccSPF), and all have reported favorable outcomes, in part because:

- **Installed performance.** Once installed, ccSPF materials are highly durable, energy-efficient, and protect buildings and their occupants from such issues as mold and poor indoor air quality (IAQ).
- **Manufacturing efficiencies.** The production and installation of ccSPF uses less or equivalent energy and raw materials to produce, transport and install as traditional insulation products. For example, one truckload of ccSPF material is equal to three

**Significant market growth is projected for green building.**

**Projected market growth in green construction**



*Source: 2006 McGraw-Hill Construction Survey*

A study by Franklin and Associates published in 1992 - The Comparative Energy Evaluation of Plastic Products and Their Alternatives for the Building and Construction Industry – performed a pioneering life-cycle analysis of plastic products that concluded that in the building and construction industry, plastics use less energy from all sources than alternate materials. The study concluded that polyurethane foam insulation saved 3.4 trillion BTUs in manufacturing energy in 1992, as compared to fiberglass insulation. This is equivalent to 3.3 billion cubic feet of natural gas, or 580,000 barrels of oil.

to four truckloads of board stock insulation.

- **Material sourcing and transport.** In addition, some formulations use locally-sourced and both pre and post consumer recycled products, adding to the sustainability of the system.

## Green Building Standards and Certifications

The practice of green building is becoming institutionalized by organizations such as the U.S. Green Building Council through their LEED Rating Systems. LEED stands for the Leadership in Energy and Environmental Design (LEED) Green Building Rating System™, which includes such categories as New Construction (LEED-NC) and the renovation of Existing Buildings (LEED-EB). These rating systems are highly influential, though they have only certified a small portion of the national building stock – roughly more than 1,250 buildings to date.

While it is not the only method employed to evaluate the sustainability of buildings, LEED provides a model that covers the significant issues associated with green building. These green building drivers – as they relate to the application of ccSPF – focus on:

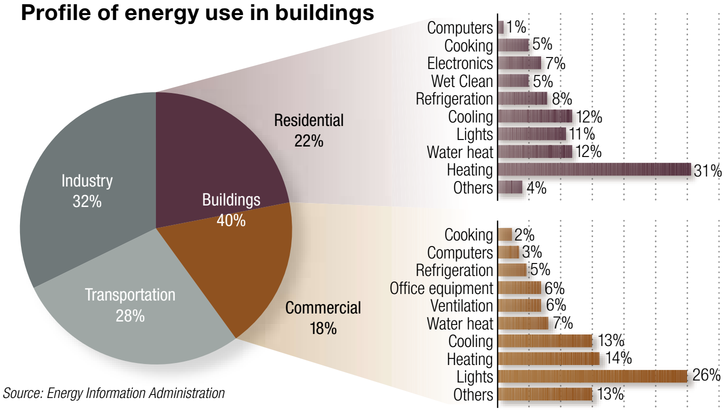
**Energy efficiency.** According to the U.S. Department of Energy (DOE), buildings demand a growing and significant amount of energy – the total is about 40 quadrillion Btu (quads) per year, with commercial buildings accounting for more than 40 percent of overall energy use. In addition to energy consumption, buildings account for more than 40 percent of all CO2 emissions in the United States – primarily because of their reliance on coal-fired electrical plants for electricity supply. (See Figure 1 on page 3)

These two factors, coupled with the rising cost of operating commercial and industrial buildings, makes energy efficiency a critical driver in sustainable design and construction – as well as in building operations. Green building criteria address energy efficiency by requiring significant energy improvements in existing buildings, and high performance ratings on new buildings. The LEED-NC rating system, for example, requires that buildings be built to meet the provisions of ASHRAE/IESNA Standard 90.1-2004 as a minimum level of energy performance. (ASHRAE is the American Society of Heating, Refrigerating and Air-Conditioning Engineers, and IESNA is the Illuminating Engineering Society of North America.)

**Site selection and sustainability.** In addition to general considerations about the building site – including the redevelopment of brownfields, the density of buildings and developments, availability of mass transit, and pollution reduction – green building drivers

**Figure 1**

**Profile of energy use in buildings**



*Source: Energy Information Administration* include the reduction of the heat island effect. According to the U.S. Environmental Protection Agency (EPA), this phenomenon describes "urban and suburban temperatures that are 2 degrees F to 10 degrees F hotter than nearby rural areas" due to the heating of buildings, roads, and other developed lands. "Elevated temperatures can impact communities by increasing peak energy demand, air conditioning costs, air pollution levels, and heat-related illness and mortality," the EPA adds.

Strategies to reduce heat island effects include the use of ccSPF highly reflective, or ccSPF vegetated, roof systems. The LEED-NC rating system requires that roof surface area be covered with at least 75 percent of material that has a Solar Reflectance Index (SRI) of at least 78 for low-slope roofs, or an SRI of 29 for steep-sloped roofs. (See Figure 2 on page 4)

**Material and resource use.** According to the Environmental Protection Agency in 1996, more than 78 million tons per year of waste was generated from commercial building renovation and construction, accounting for more than 57  percent of overall construction and demolition debris. To significantly reduce the amount of material diverted to disposal, LEED-NC criteria allot credits for buildings that reuse a large  percentage of the existing structure, rather than demolishing and reconstructing the building. Closed-cell SPF systems, particularly roofing systems, allow for recoating in lieu of complete system replacement, reducing demolition and reconstruction. Credit is also given for use of recycled, regional, and rapidly renewable materials. Some ccSPF formulations utilize recycled content, including the reuse of existing roof system materials, and qualify for this credit.

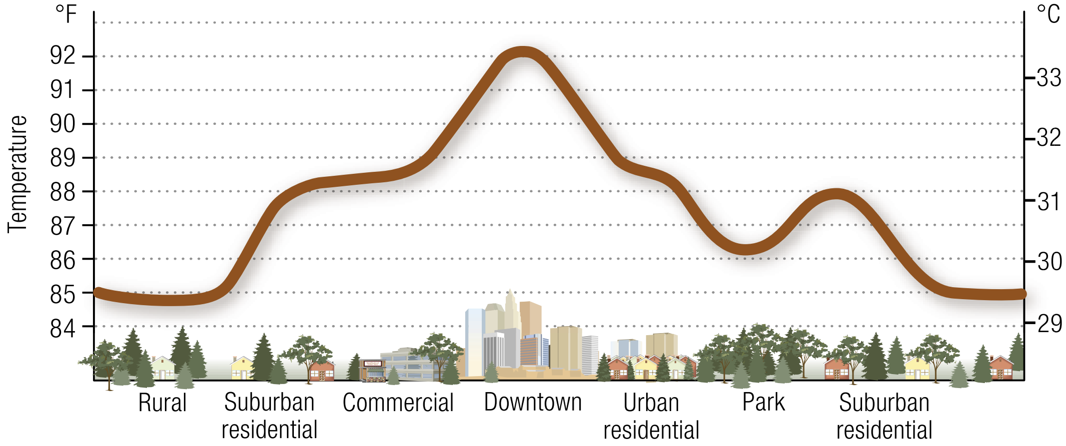
**Indoor environment.** Indoor environmental quality, or IEQ, is of paramount concern in green building, particularly in large buildings where occupant health and workplace productivity is critical. Issues in the indoor environment include indoor air quality (IAQ), comfort, effective operation and control of thermal and lighting systems, and adequate occupant exposure to daylight.

The importance of controlling these variables is crucial for green building. Some studies show a direct correlation between indoor pollutants and the accuracy of certain tasks, such as typing; they also show a certain correlation between perceived indoor pollutants and the performance of work tasks. Among other notable statistics from IEQ studies performed by Lawrence Berkeley National Laboratory (LBNL):

- By doubling ventilation rates in office buidlings, occupants showed a decrease in short-term absences of more than one-third.
- Buildings with above-average ventilation rates show significantly less sick-building syndrome (SBS) symptoms in workplace occupants, with reductions of

**Figure 2**

Urban heat island profile



*Source: U.S. Environmental Protection Agency*

10 percent to 80 percent.

- Workplace performance decreases significantly in speed and accuracy when interior temperatures climb above, or fall below, 71 degrees Fahrenheit.
- Workplace performance increases in speed and accuracy when ventilation rates increase.

To address these concerns, green building criteria require that HVAC systems and the building envelope (insulation and airtightness) be designed to allow for optimal thermal control according to ASHRAE Standard 55-2004, which includes the factors of humidity, air temperature and speed, and radiant temperature. Adequate ventilation rates are required according to ASHRAE 62.1-2004 Ventilation for Acceptable Indoor Air Quality. In addition, low-emitting materials, including adhesives, sealants, paints, coatings, carpets, and wood or fiber products are required.

Fundamentally, in order to adequately control ventilation rates, indoor temperature and humidity, the building envelope must be tightly sealed to prevent uncontrolled air infiltration. A ccSPF system allows for superior air sealing, improving the controllability of the indoor environment.

## How ccSPF Stacks Up to Green Building Criteria

Closed-cell spray polyurethane foam (ccSPF) insulation systems are self-adhering, two-component products that are spray-applied on site. The material is a rigid insulation system that, once cured, fills cracks, voids, and gaps and tenaciously bonds to most construction material substrates, including metal, wood, plastic, masonry, and the like.

In addition, ccSPF has been shown to provide superior thermal insulation performance – the highest among all commonly used insulation products. Typically, 2 lb/ft3 foam is used for walls and 3 lb/ft3 foam is used for roofs to provide increased strength. CcSPF performance shows a design R-value of 6.2 for ccSPF wall insulation with a density of 2-pounds per cubic foot at 75 degrees F. Similarly, at a mean temperature of 75 degrees, a design R-value of 6.7 is observed for ccSPF with a density of 3 pounds per cubic foot (lbs/cu. ft.), according to the standard ASTM C 518 04.

Excellent thermal performance, added structural strength, nearly zero air permeability and integral vapor retarding function makes ccSPF a superior green building product. The expansion of the product once it's sprayed on a surface – nearly thirty times the original volume – allows it to conform to the many irregular spaces that traditional materials cannot.

**Overall, ccSPF systems are an excellent choice for green building, as ccSPF systems provide:**

- Superior R-value as compared to all other insulation products.
- A complete air barrier, eliminating air infiltration, thus improving energy performance significantly beyond basic R-value and radically improving control of the indoor environment.
- Improved building durability because it is seamless and monolithic, reducing water and moisture intrusion and improving overall building strength.
- An overall favorable life-cycle analysis, thanks to: reduced manufacturing energy used; up to 40 percent operational energy savings; durability and long installed life span; and minimal waste of about 1/2 cubic yard per 10,000 square feet of application.
- Many green building rating system (such as LEED) credits for energy performance, reduced energy use in transport, recycled and renewable material content (see *Green Benefits of Spray-applied Barrier Systems* for more details).

### Life-Cycle Analysis

The building systems incorporating ccSPF have been shown to provide superior performance in life-cycle analysis (LCA). Many manufacturers have commissioned LCAs for their specific products, and results vary based on the product formulation. However, generally speaking, LCAs performed show that ccSPF in comparison to other insulation systems:

- Increased energy efficiency by providing twice the R-value of traditional materials, along with an integrated air barrier and protection against thermal bridging commonly found in commercial buildings; energy consumption over the life of the building, which has been quantified as up to 40 percent lower than with other materials.

- Reduced landfill diversion and cost, as installation of ccSPF produces little waste to be diverted to landfill. This attribute also addresses requirements for reduced construction waste.
- Reduced transportation cost, as ccSPF is transported as the liquid precursors and is therefore compact and lightweight to transport.
- Increased durability when compared to traditional systems, as ccSPF provides superior protection against moisture and water vapor, as well as increased racking strength and wind resistance.
- Reduced health and risk potential, as less material must be produced and transported, less flammable primers are used, and there is less irritant potential than with many other common material choices.

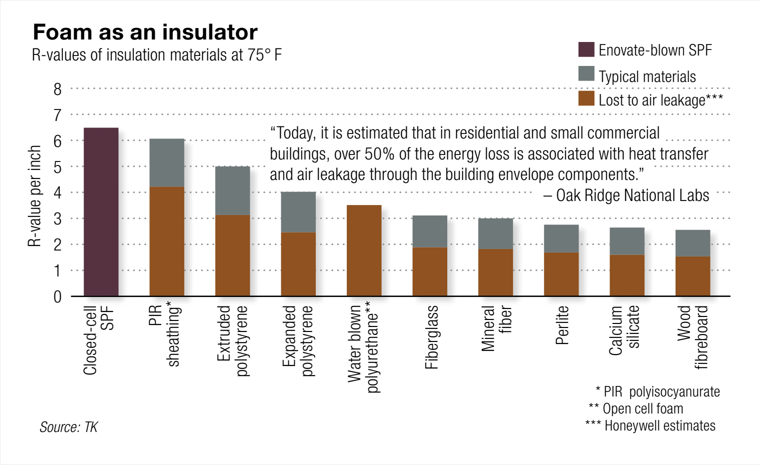
Dick West, President of West Roofing Systems and West Development Group, who has been producing and installing SPF roof systems for decades notes an important point in relation to the overall environmental impact of SPF systems. “When we send out a truckload of ccSPF,” says West, “it’s a truckload of drums. Let’s say a truckload is 40,000 pounds of product per truckload. A truckload is equal to 120,000 board feet of insulation. It would take 3-4 truckloads of board stock to provide insulation for the same project that takes one truckload of ccSPF. The overall carbon footprint of a ccSPF roof is substantially lower than a comparable roof assembly simply because we’re shipping it out as a fluid and it expands 30 times upon application.”

## Energy Efficiency – and the Building Envelope

Energy efficiency is a complex issue that involves nearly every individual system in a building, as well as consideration for the entire building as a whole system. However, engineers and designers versed in energy-efficient construction agree that efficiency begins with building envelope performance. A high-performance building envelope involves two significant factors: high levels of effective insulation, and a superior and consistent air-barrier system.

Not only does ccSPF provide the highest R-value per inch of any insulation system, but it also acts as an integral air barrier. In commercial buildings, this performance is particularly significant. “Oftentimes in commercial buildings you’re dealing with steel studs, and steel conducts energy and heat about 1,000 times faster than wood or vinyl,” says Steve Easley, a California-based building-science consultant specializing in the commercial sector. According to the Denver American Association of Architects Committee on the Environment, thermal bridging in steel framed buildings can reduce the effectiveness of insulation systems by 30-50 percent. The reduced insulation effectiveness can lead to lower wall cavity temperatures, which, in turn, can lead to condensation and building envelope moisture problems. The Department of Energy recommends using “thermal blocks” to eliminate issues with thermal bridging, which can be done by utilizing ccSPF as an insulation system, as ccSPF will continuously cover existing thermal bridges. In addition, because ccSPF

**Figure 3**



**Foam as an insulator**

R-values of insulation materials at 75° F

“Today, it is estimated that in residential and small commercial buildings, over 50% of the energy loss is associated with heat transfer and air leakage through the building envelope components.”
– Oak Ridge National Labs

* PIR polyisocyanurate
** Open cell foam
*** Honeywell estimates

*Source: TK*

systems don't require fasteners, thermal bridging is naturally eliminated. (See Figure 3 on page 6)

## Site Selection and Sustainability

According to LBNL's Heat Island Group, the urban heat-island effect is a considerable issue in metropolitan areas, where the lack of vegetated ground cover can lead to temperature differentials of 6-8 degrees Fahrenheit. This temperature increase dramatically impacts energy use, mechanical system operation, IAQ, and comfort. LBNL studies to reduce heat island effect have focused largely on cool roofs – systems that use light colored, reflective roof coatings that can reduce energy use by up to 40 percent and, if widely used, can greatly reduce the increase in temperatures in urban areas.

Roofing systems using ccSPF provide an excellent commercial cool-roof solution because they can be combined easily with high reflectivity, low-emissivity (low-E) roof coatings. They can also be used effectively under vegetated roofs to reduce roof surface temperature and increase building performance. In addition, because ccSPF roofing applications are an extremely effective strategy for re-roofing over existing standing seam metal and other (built-up, modified bitumen, or single-ply) roof systems, the material provides a sustainable solution for existing buildings.

## Material and Resource Use and Durability

A significant factor in green building is reducing or diverting construction waste, and with this comes the issue of durability of materials. The EPA has estimated that construction- and renovation-related waste generated in the United States accounts for 25 percent to 40 percent of the country's solid waste. Because ccSPF is applied on site by qualified professionals who use only as much material as is needed, construction waste is eliminated or significantly reduced.

More significantly, increasing the life of a building system reduces the need for new resources to replace it. Surveys conducted by Dr. Dean Kashiwagi, a teaching professor at the Del E. Webb School of Construction at the University of Arizona, have documented the exceptional durability of ccSPF roofing systems. The studies have evaluated thousands of ccSPF roofing systems in six U.S. climate zones and concluded that of all the roofs:

- 97.6 percent did not leak
- 93 percent had less than 1 percent deterioration
- 55 percent were never maintained
- 70 percent were applied over existing roofs.

The oldest performing roofs were more than 26 years old. Fundamentally, the studies proved that the physical properties of the roofs did not diminish over time. This conclusion highlights the sustainability of ccSPF roof systems.

## Indoor Environment

HVAC system design and performance, human activities, and off-gassing of toxic compounds from building components and furnishings have a dramatic effect on the quality of indoor air. The performance of the building envelope is paramount to good air quality. A poorly insulated, leaky envelope creates the perfect conditions for condensation and mold growth, as well as the invasion of outside contaminants into the conditioned space – not to mention reductions in energy efficiency.

The use of ccSPF helps to improve IAQ because it acts as an integral air barrier, reducing air infiltration to provide a more controllable conditioned space. This also reduces the incidence of moisture intrusion and moisture-related damage, even providing an insulation value that reduces condensation within the wall cavity or on building surfaces. These features reduce the growth of mold and mildew and allow for improved ventilation and mechanical system operation, improving indoor air quality.

Finally, ccSPF is considered a low-emitting material by LEED-NC because it doesn't produce toxic contaminants that affect the indoor environment. As critical to indoor air quality is control of space conditioning. The high R-value of ccSPF – and its performance as an air barrier – allows HVAC systems to work to the best of their expected performance.

## Selection Criteria and Industry Standards for Green Building

The past decade has seen a huge need to measure and quantify the performance of green products, and green buildings. "I use the term high-performance buildings," says Syracuse University's Dr. Mark Bomberg, "because nobody understands what the word 'green' means." In fact, the advertising and publicity associated with green building and sustainable design in the construction and remodeling industry is seen as nebulous, ill-defined, and unregulated by experts. In response, the Federal Trade Commission held a working group to determine how to provide concrete guidance on the acceptable use of marketing terms associated with green building. These recommendations will be incorporated into the FTC's Green Guides in 2009, making it unlawful to market using unsubstantiated (and unmeasured) claims about building or building product performance.

The technical standards to which a "green building" must be built have also long been in contest. This need has driven the development or adaptation of a variety of standards for commercial construction by organizations such as ASHRAE, the Green Building Initiative (GBI), and the U.S. Green Building Council (USGBC). Recently, the USGBC and GBI both became accredited as Standards Developing Organizations (SDO) by the American National Standards Institute (ANSI), and they both have developed standards that apply to buildings and building systems.

- **The U.S. Green Building Council:** USGBC's LEED for New Construction and LEED for Existing Buildings provide a comprehensive certification program. In addition, LEED provides a LEED for Core & Shell rating system that focuses specifically on the performance of the structure, envelope, and HVAC system only.
- **Green Building Initiative:** The Green Globes Assessment and Rating System and associated tools provide a comprehensive rating system for new and existing buildings, a certification process and analysis tools. Their software tools allow for building and full life cycle analysis.
- **GreenGuard:** Created by the GREENGUARD Environmental Institute, GREENGUARD certification assures that products and buildings that go through frequent testing to ensure particle and chemical emissions that meet guidelines for acceptable indoor air quality.
- **Green Seal:** Run by a not-for-profit group, Green Seal tests and certifies products that have been evaluated over their full life cycle, starting from material extraction through manufacturing and consumer use, all the way to disposal and recycling.

## Green Insulation Choices and Tradeoffs

Based on the industry-accepted standards and criteria for high-performance, sustainable buildings outlined above, a number of attributes, including full product life-cycle analysis, must be weighed when selecting sustainable insulation materials. In addition to using an LCA for product evaluation, effective energy performance and overall air barrier effectiveness must be considered critically.

**Effective energy performance.** In addition to choosing a system with the highest possible effective R-value based on the field performance of commonly installed insulation products, the overall energy performance of a building is significantly affected by issues associated with insulation system selection and installation. It is important to note that studies have shown that the real-world (effective) performance of insulation systems simply doesn't match up to labeled R-value. Installation errors, wind drift/wash, mechanical fasteners, joints and gaps along with other factors radically reduce thermal performance of insulation as measured in commonly installed scenarios.

Because the effective performance of insulation systems is so critical to the performance of the entire building system, Oak Ridge National Laboratory (ORNL) conducted a study in 1998 to evaluate the actual R-value performance of insulation products when installed, as compared to the labeled R-values. Striking results showed that fiberglass batt insulation labeled at an R-value of 19, showed an R-value of 17 when correctly installed. When installed as commonly found in walls after installation, the R-value was 13.7 (ORNL 1998). (See Figure 4 on page 9)

As demonstrated in Table T.K on page T.K., reflecting research by the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) and the Oak Ridge National Laboratories (ORNL), fasteners alone can reduce the effective insulation value between 1.5 percent to 31.5 percent, depending on the number and type of fasteners.

SPF eliminates thermal bridging by providing a continuous, fully adhered layer of insulation over existing thermal bridges in the roof deck and/or assembly.

**Significant impacts on energy performance.** Thermal drift, thermal bridging, air movement, and moisture all dramatically impact whole building performance.

- **A thermal bridge** is an assembly or component in the building envelope that transfers heat at a significantly higher rate than the surrounding insulated area. Thermal bridging is created by fasteners, joints, and gaps. Thermal bridging can be a significant cause of heat loss and underperformance of insulation assemblies in commercial buildings, particularly in metal-framed buildings and decking systems.
- **Air movement** (infiltration and exfiltration) account for a significant amount of energy loss in commercial buildings. According to a 2005 study by the National Institute of Science and Technology (NIST), an energy savings of up to 62  percent can be realized by undertaking specific measures to improve airtightness. In addition to energy loss, infiltration reduces occupant comfort, interferes with efficient operation of mechanical systems, reduces indoor air quality and contributes to condensation and moisture damage in the building envelope system. Air movement can be most effectively limited by the use of ccSPF as compared to other type insulation systems.

**Moisture considerations.** Issues related to moisture penetration and

**Figure 4: Labeled R-value vs. Installed R-values** Attic Thermal Testing at Oak Ridge National Laboratory

| Insulation | Test Number | Insulation Temerature | Labeled R-Value | Tested R-Value (C 1363) | % Labeled |
|---|---|---|---|---|---|
| Blown Fiber Glass @ 14 incehes | 1a (low temp) | 38.01 | 38 | 17.7 | 47 |
| | 1b (low temp) | 38.03 | | 17.7 | 47 |
| | 1c (avg temp) | 51.75 | | 29.0 | 76 |
| | 1d (high temp) | 88.97 | | 20.2 | 53 |
| Low-Density SPF @ 5.5 inches | 2a (low temp) | 32.61 | 19.8 | 14.7 | 74 |
| | 2b (low temp) | 32.73 | | 14.7 | 74 |
| | 2c (avg temp) | 48.49 | | 13.6 | 69 |
| | 2d (high temp) | 93.00 | | 12.1 | 61 |
| High-Density SPF @ 4.0 inches. | 3a (low temp) | 32.89 | 27 | 22.8 | 84 |
| | 3b (low temp) | 33.01 | | 22.7 | 83 |
| | 3c (avg temp) | 48.79 | | 19.8 | 73 |
| | 3d (high temp) | 93.07 | | 18.1 | 67 |
| *Source: Oak Ridge National Laboratory, 1998* | | | | | |

## R-value Loss Due to Fasteners in Metal Roof Deck Assemblies

| **Board Insulation** | **1 fastener per 4 sq ft** | | | **1 fastener per 2 sq ft** | | | **1 fastener per 1 sq ft** | | |
|---|---|---|---|---|---|---|---|---|---|
| Insulation Thickness | Comparison Results: Assumed System Resistance & U-Value vs. Actual System Resistance and U-Value | | | | | | | | |
| | R-Value | | Loss % | R-Value | | Loss % | R-Value | | Loss % |
| | Assumed | Calculated % | | Assumed | Calculated % | | Assumed | Calculated % | |
| 1. 0 in. | 5.85 | 5.18 | 11.5 | 5.85 | 4.66 | 20.27 | 4.7 | 3.45 | 26.49 |
| 1.5 in. | 8.35 | 7.34 | 12.08 | 8.35 | 6.57 | 21.3 | 6.62 | 4.75 | 28.19 |
| 2.0 in. | 10.85 | 9.51 | 12.4 | 10.85 | 8.48 | 21.86 | 8.54 | 6.05 | 29.13 |
| 3.0 in. | 15.85 | 13.83 | 12.73 | 15.85 | 12.29 | 22.44 | 12.39 | 8.66 | 30.13 |
| 4.0 in. | 20.85 | 18.16 | 12.9 | 20.85 | 16.11 | 22.75 | 16.24 | 11.26 | 30.66 |
| 5.0 in. | 25.85 | 22.49 | 13.01 | 25.85 | 19.92 | 22.94 | 20.08 | 13.86 | 30.98 |
| 6.0 in. | 30.85 | 26.81 | 13.08 | 30.85 | 23.74 | 23.06 | 23.93 | 16.46 | 31.20 |
| 7.0 in. | 35.85 | 31.14 | 13.13 | 35.85 | 27.55 | 23.15 | 27.77 | 19.06 | 31.36 |
| 8.0 in. | 40.85 | 35.47 | 13.17 | 40.85 | 31.36 | 23.22 | 31.62 | 21.67 | 31.48 |
| *According to research by ASHRAE and ORNL, fasteners alone can reduce the effective insulation value of metal buildings between 1.5% to 31.5%, depending on the number and type of fasteners.* | | | | | | | | | |

control go hand in hand with improving energy performance in buildings. The reason is that systems improving energy performance in the building envelope can prevent bulk water and water vapor from entering and damaging building assemblies. Insulation, moisture barriers, and air barriers are critical parts of the high-performance building envelope. These systems are instrumental to energy performance, but also to helping prevent water vapor from entering the envelope assembly, where it can condense and turn into liquid water – a key ingredient in corrosion and mold growth. The properties of ccSPF address the functions of all of these systems, combined.

**Air barrier performance.** Generally speaking, air barriers are intended to keep air from moving through building assemblies – walls, roofs, foundations – throughout the entire building envelope. Although air-barrier and insulation systems often involve several components and installations, the entire air-barrier assembly, fully installed and connected, must be tested for air leakage to quantify the performance of the installed system. This testing is done using ASTM E 2357 guidelines, and the results reflect the total amount of air that passes through the envelope. The acceptable air leakage of assemblies, components, and the entire building envelope is the same, and cannot exceed 0.2 liters per second per square meter (L/s/m2) at 75Pa, or 0.004 cubic feet per minute per square foot (cfm/ft2) at 1.57 psf. In relation to individual air barrier materials that may comprise an air barrier system or assembly, the material must have the requisite air leakage rate when measured in accordance with ASTM 2178.

In addition to evaluating the performance of specific systems in a laboratory-testing environment, overall performance targets for the entire building must be considered. Though many building codes do not contain adequate language to govern the design and construction parameters for air barriers in commercial buildings, new standards are being developed and implemented. For example, ASHRAE is in the process of making revisions to Standard 90.1 that will require the inclusion of a continuous air barrier. As previously stated, the material must have the requisite air leakage rate when measured in accordance with ASTM 2178.

**Figure 5: R-Values of common Insulation Materials**

| Insulation Type | R-Value per inch of thickness |
|---|---|
| Fiberglass blanket or batt | 2.9 to 3.8 (avg. 3.2) |
| High performance fiber glass blanket or batt | 3.7 to 4.3 (avg. 3.8) |
| Loose-fill fiber glass | 2.3 to 2.7 (avg. 2.5) |
| Loose-fill rock wool | 2.7 to 3.0 (avg. 2.8) |
| Loose-fill cellulose | 3.4 to 3.7 (avg. 3.5) |
| Perlite or vermiculite | 2.4 to 3.7 (avg. 2.7) |
| Expanded polystyrene board | 3.6 to 4 (avg. 3.8) |
| Extruded polystyrene board | 4.5 to 5 (avg. 4.8) |
| Polyisocyanurate board, unfaced | 5.6 to 6.3 (avg. 5.8) |
| Polyisocyanurate board, foil-faced | 7 |
| Spray polyurethane foam | 5.6 to 6.3 (avg. 5.9) |

*Source: U.S. Department of Energy/Oak Ridge National Laboratory, July 2007*

For more information on air barriers, see Insulation Energy Saving: Key Issues and Performance Factors [ADD LINK TO BD+C PAPER HERE, as follows:] (www.ncfionline.com/uploads/Insulation percent20Energy percent20Savings percent20Final.pdf).

## Green Insulation Options for Commercial Construction

The Insulation Contractors Association of America (ICAA) recognizes the following categories of insulation in their publication Recommended Design Considerations and Guide Specifications for Commercial Building Insulation:

- Rigid and semi-rigid foam board insulation.
- Thermal batt and blanket insulation.
- Spray applied polyurethane foam insulation.
- Spray applied fibrous insulation.
- Loose fill insulation.

Many products within these categories can be used to achieve green building guidelines, but as seen in the sections above, foam board and spray foam insulation provide significantly higher R-values than other insulation types, and ccSPF provides an integral thermal, moisture and air barrier that dramatically improve actual energy savings performance.

In addition to energy, moisture and air barrier considerations, GREENGUARD lays out the following emissions criteria for a product to be labeled under their GREENGUARD Indoor Air Certification Program for Low-emitting Products (see Figure using minimal additional resources and diverting very little material to landfills.

- Provides superior thermal performance, including unparalleled air-sealing which, in turn, improves overall building envelope thermal performance and reduces energy used by HVAC systems. Lower energy use in buildings in turn reduces carbon emissions.
- Provides moisture protection, reducing IAQ issues and increasing durability.
- Adds structural integrity to the building, further increasing building durability.
- Is renewable, particularly in applications like commercial roofs where ccSPF can be recoated vs. tear-off and replacement of traditional roof system every 10-20 years.
- Is durable, as ccSPF has a serviceable life of more than

### Figure 6: GreenGuard Emission Criteria

For use with GreenGuard Certification Program$^{SM}$ for Low Emitting Products

Insulation-Applicable to: Building insulation, Basic mechanical insulation and Air handling (HVAC) insulation

| Properties | ASTM Test | Value |
|---|---|---|
| Individual VOCs[1] | < 0.1 TLV | < 0.1 TLV |
| Formaldehyde | < 0.05 ppm | < 0.025 ppm |
| Total VOCs[2] | < 0.5 mg/m$^3$ | < 0.25 mg/m$^3$ |
| Total Aldehydes[3] | < 0.1 ppm | < 0.05 ppm |
| Respirable particles (for HVAC ductwork) | < 0.5 mg/m$^3$ | < 0.5 mg/m$^3$ |
| Listing of measured carcinogens and reproductive toxins as identified by California Proposition 65, the U.S. National Toxicology Program (NTP), and the International Agency on Research on Cancer (IARC) must be provided. | | |
| Any pollutant regulated as a primary or secondary outdoor air pollutant must meet a concentration that will not generate an air concentration greater than that promulgated by the National Ambient Air Quality Standard (U.S. EPA, code of Federal Regulations, Title 40, Part 50). | | |

[1] *Any VOC not listed must produce an air concentration level no greater than 1/10 the Threshold Limit Value (TLV) industrial work place standard (Reference: American Conference of Government Industrial Hygeinists, 6500 Glenway, Building D-7, Cincinnati, Ohio 45211-4438).*

[2] *Defined to be the total response of measured VOCs falling within the* $C_6$-$C_{16}$ *range, with responses calibrated to a toluene surrogate.*

[3] *Defined to be the total response of a specific target list of aldegydes (2-butenal; acetaldehyde; benzaldehyde; 2.5-dimethylbenzaldehyde, 2-methylbenzaldehyde; 3-and /or 4-methylbenzaldehyde; butanal; 3-methylbutanal; formaldehyde; hexanal; pentanal; propanal), with each individually calibrated to a compound specific standard.*

*Source: GreenGuard Environmental Institute*

30 years and can be recoated easily, at a minimal cost, using minimal additional resources and diverting very little material to landfills.

- Is sometimes made with recycled materials, and with materials that are “locally sourced” and manufactured.
- Rates very well in life-cycle analysis.

Joseph Lstiburek, Ph.D., P.Eng., a principal of Building Science Corporation and an internationally renowned building scientist believes that insulation products capable of achieving green building standards need to handle water, air, vapor and thermal control in one material. “All of these factors,” says Lstiburek, “are very important in the fundamental performance of a building. You want a water, air, and vapor control layer coupled with a thermal control layer. A lot of technologies are able to collapse three of those four functions, whereas ccSPF can actually collapse all four into one application. In other words, normally you have a water control membrane that’s also an air and a vapor barrier and you install insulation over it. With ccSPF, that one layer of foam sprayed on the outside of the building actually does all four things. It’s a product that’s unique like no other – the only product available in the industry that can provide four of the major fundamental control functions of the building enclosure.”

> **“It’s the only product available in the industry that can provide four of the major fundamental control functions of the building enclosure.”**

This fundamental fact is the cornerstone and unique value of ccSPF to green building – ccSPF systems address all of the core issues associated with energy, moisture, and durability performance of buildings in one system, in addition to providing added benefits that can be used to achieve other points in green rating systems.

### Achieving USGBC LEED for New Construction credits using ccSPF

Closed-cell spray polyurethane systems provide benefits that can allow designers to qualify for points in the USGBC LEED rating systems. The following table outlines the areas where it may be possible to achieve points using ccSPF:

## Closed-Cell Spray Polyurethane Foam: Green Attributes and Applications

For those wanting more detail, following is an overview of the attributes and applications of ccSPF. Briefly, ccSPF is an insulating foam that is sprayed in or onto construction assemblies. When it contacts the application surface, it immediately increases in volume by as much as 30-40 times.

The Spray Polyurethane Foam Alliance (SPFA) notes that the various SPF formulations provide a broad range of physical properties that are suitable for a variety of applications and climates. Closed-cell SPFs (ccSPFs) are suitable for both interior and exterior insulation because of significantly higher structural integrity and waterproofing characteristics. Foam

| | |
|---|---|
| **Sustainable Sites** | |
| SS Credit 6.1-6.2: Storm water Design: Quantity and Quality Control | Use of vegetated roof systems over ccSPF roof systems can qualify projects for points by minimizing impervious surfaces. |
| | |
| SS Credit 7.2: Heat Island Effect: Roof | Use of highly reflective roof coatings over ccSPF roofs, in addition to vegetated roof systems, can qualify for points by reducing roof surface temperatures and thereby decreasing the urban heat island effect. |
| **Energy and Atmosphere** | |
| EA Prerequisite 2: Minimum Energy Performance Required | Use of ccSPF significantly increases energy performance in buildings through superior R-value and air barrier performance. Points may be gained for overall building energy performance because of improved building envelope performance. In addition, ccSPF is a non-Ozone depleting technology, ccSPF roofs can to integrated into photovoltaic solar energy systems , and there is reduced energy in manufacturing ccSPF as compared to traditional systems. |
| EA Credit 1: Optimize Energy Performance | |
| **Materials and Resources** | |
| MR Credit 1.1 - 1.2: Building Reuse: Maintain 75% - 95% of Existing Walls, Floors & Roof | Use of ccSPF roof systems allows for application of new coatings instead of complete roof tear-off once the system's useful life is reached. Points may be gained for reuse and recoating of the existing roof structure. |
| MR Credit 4.1-4.2: Recycled Content | Some ccSPF formulations utilize recycled content and may qualify for points. |
| MR Credit 5.1 -5.2: Regional Materials | Some ccSPF formulations utilize regionally sourced and produced materials and can qualify for points. |
| MR Credit 6: Rapidly Renewable Materials | Some ccSPF formulations utilize agricultural products, such as soy, and sugar based polymers that are rapidly renewable. |
| **Indoor Environmental Quality** | |
| EQ Credit 4.1: Low-Emitting Materials: Adhesives & Sealants | CcSPF is not considered a volatile organic compound (VOC) by the U.S. government, and its use reduced the use of caulks and adhesives. |
| EQ Credit 7.1: Thermal Comfort: Design | CcSPF can help building envelopes meet the requirements of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy |
| ID Credit 1–1.4: Innovation in Design | CcSPF foam can contribute to innovation credits for acoustical performance, reducing construction waste while being sustainable and durable. |

used in exterior applications must be covered for both UV and protection from the weather.

Because ccSPF shows little degradation over time, SPF roofing systems have been in place for as long as 30 years and are easily renewable after that time by just re-coating the surface which provides UV protection. Cracks or punctures in ccSPF roof systems up to 3 inches in diameter can be fixed using simple elastomeric sealants or caulk; damage of a larger size can be resolved with reapplication of the spray foam in the affected area. The combination of ccSPF roof insulation and waterproofing system with elastomeric, aggregate, or vegetated coverings to protect the ccSPF against UV ratings provide and highly desirable green-roof solution.

Several types of ccSPF are used for building envelopes – *high-density closed-cell SPF* that is extremely resistant to water intrusion and foot traffic, *medium-density closed-cell SPF* for interior applications.

## Views on Spray-Foam Insulation by Green Building Experts

Bill Rose, a research architect at the University of Illinois at Urbana-Champaign's Building Research Council, has conducted significant research into thermal and moisture performance of buildings, and served as a consultant on historic buildings and museums. For obvious reasons, his work in museum projects has focused on the critical building performance factor of indoor temperature and humidity control. According to Rose, "There is simply no way to control temperature and particularly humidity in a building that's leaky. Especially for larger museums, the effort to improve the indoor climate and make it more stable hinges on the ability to prevent air leakage."

Rose's experience shows that existing buildings can have significant issues in air leakage that can't be solved using traditional materials. These leaks pose significant problems to energy and indoor environmental performance. "As far as I can tell," says the research architect, "there really isn't any product that compares to spray-applied urethane foams for blocking air leakage. The first thing we do is look at the wall roof junction. Often where the wall goes up the roof engages the parapet continues up from that – it's just a giant chimney for air leakage. The question of making the indoor environment workable or not comes down to the question – can we foam these holes shut?"

Syracuse University's Dr. Mark Bomberg believes that spray foam will play a significant role in reducing energy demand and environmental impact of buildings. Bomberg's decades of experience with buildings and building performance research, as well as the spray foam industry, has made him passionate about systems that behave as a system, rather than component products and materials. "Spray foam is a material for now and the future, not for the past, because in the past we were dividing building and materials and everyone was selling miraculous solutions called product A, B, or C. Now because we are looking at energy, durability, sustainability – all these green things – we have to deal with building as a system. Spray foam's future is secure because it allows tailoring to whatever needs you have in your system."

## Related Green Benefits of SPF

Though not directly measured by commonly accepted green building criteria, the following related benefits of using ccSPF systems should be considered in any green building or remodeling project:

- **Safety:** ccSPF insulation and waterproofing systems add structural integrity to any building – particularly in roof systems that are impacted by wind uplift in severe weather areas. In fact, a 2007 study at the University of Florida's Department of Civil and Coastal Engineering showed that ccSPF roof systems have the potential to increase wind uplift capacity by more than three times that of traditional construction using a continuous layer of ccSPF on the underside of the roof deck.
- **Highly reflective (cool) roof surface:** Heat on a low-slope black roof surface can surge to 190 degrees Fahrenheit in the summer. Much of the heat generated in summer months is absorbed into the building, radically impacting efficiency by impact to heating and cooling loads. Highly reflective, low-E roof coatings and membranes are now widely available for the U.V surfacing of ccSPF roof systems, and have proven to reduce roof temperatures to a few degrees above ambient temperature on common roof assemblies. In addition, highly reflective ccSPF roof systems have been shown to reduce the energy needed

to cool a commercial building by as much as half. As an alternate green-roof strategy, a vegetated-roof system can be installed on top of a ccSPF roof system.

- **Solar photovoltaic roof SPF systems:** Once energy conservation measures are employed and the building consumes as little energy as possible, generating power onsite from renewable energy sources is an excellent green building strategy. A ccSPF roof system that employs highly reflective coatings, coupled with roof-mounted photovoltaic (PV) panels can provide efficient operation and offset energy costs. The ccSPF roofing systems create a waterproof, monolithic, and lightweight roof structure that allows for the addition of PV systems without concerns about roof weight.
- **Vegetated roof systems:** Vegetated or "true green" roof systems employ vegetative roof cover to replace a bare membrane, gravel, shingle, or tiles. A vegetated roof system can provide significant benefits, including stormwater runoff management and urban heat island effect reduction. Although a vegetated roof system can be installed on any type of low-slope commercial roof, ccSPF systems are ideal, because they:
    - Provide significant insulation value, reducing the likelihood of water on the roof from cooling the building during the winter or heating it during the summer.
    - Are lightweight. Any additional systems placed on the roof of a building add weight to the structure, and the lightweight nature of ccSPF may allow designers to specify vegetated roof systems without the need to reinforce the roof to account for additional weight.
    - Are continuous, monolithic, self-flashing and are easily tapered to slope and drain properly ensuring that water from the vegetated roof system doesn't enter the building envelope.
    - Are durable and have a compressive strength of (45-50psi) - double that of polyisocyanurate board stock at (20-25psi). This added durability improves the roof's ability to withstand foot traffic and abuse.
    - Adhere to irregular surfaces and fill penetrations unlike any other product, ideal when a vegetated roof system design uses stanchions or other structural assemblies.

A critical note for green building systems such as solar photovoltaic and vegetated roof systems is made by Dick West. "You're taking a part of a building that's basically designed to insulate and waterproof the structure, that's it. Anything you put on that roof is detrimental to that goal – so when you start putting rooftop mounted equipment up there and you have penetrations going through the roof to support the solar collectors – each one of those penetrations is a vulnerable point for water intrusion. Because ccSPF is self-flashing and conforms very easily to irregular shapes and penetrations, the cost of the roof assembly doesn't go up as a result of all of the additional assemblies and penetrations needed to support a PV system. The other reason that ccSPF lends itself to these additional systems is the fact that ccSPF is probably the lightest weight roof assembly you can install on a building. A building's roof capacity is limited. If you want to make the load capacity greater, you have to beef up the structure itself, which is expensive. If you're going to add PV or vegetated roof systems, thus adding weight and can add a lighter weight roof system instead of reinforcing the building, that's a clear benefit."

## Green Building Case Study: Mississippi Coast Coliseum

**Building: Mississippi Coast Coliseum**
**Location: Biloxi, MS**
**Profile:** Biloxi, Mississippi is a tough place to be a building, particularly a roof. Since 1979, Biloxi has been hit by more than 15 hurricanes, with high wind speeds between 110 mph and 115 mph. According to the National Oceanic and Atmospheric Administration (NOAA), 28 significant hail events with golf-ball-sized hail, 28 tornadoes, and 100 high-wind storms have braced the area. All told that equates to more than 175 days of severe weather since 1979.

Built in 1977, the Mississippi Coast Coliseum was constructed with an ccSPF roof. After Hurricane Katrina, the coliseum was still standing with little damage to the SPF roof system. Contractors removed a ½ inch of the SPF and replaced it, along with a new elastomeric coating. A NIST report titled

> **“A number of spray polyurethane foam (SPF) roofing systems were observed … Some of these roofs were estimated to be about 20 years old. With one minor exception, all were found to have sustained Hurricane Katrina extremely well without blow-off of the SPF or damage to flashings.”** *– NIST*

Performance of Physical Structures in Hurricane Katrina and Hurricane Rita: A Reconnaissance Reports showed that SPF roofs performed significantly better than average in hurricane conditions.

The increased durability of SPF roof systems provides a sustainable solution for commercial buildings, reducing the need for replacement or significant maintenance and maintaining building performance attributes over time.

According to sources such as the Oak Ridge National Laboratory and Franklin & Associates, durability is a key component of life-cycle analysis, or LCA – a key component of green building. Providing good wind uplift resistance and enhanced structural strength of building assemblies, ccSPF has been shown to contribute to sustainability over the long term.

## Green Building Case Study: Texas A&M University

**Building(s): Texas A&M University**
**Location: Biloxi, TX**
**Profile:** With over 7 million square feet of ccSPF roofing system on their buildings, Texas A&M may be the best example of proven sustainability and energy efficiency of SPF systems.

In the 1970s, the university’s physical plant department was looking for alternatives to their traditional built-up roof systems, which had suffered significant leaks after only a few years of service.

SPF roof systems were used on many of the Texas A&M buildings, with energy savings being monitored on 27 buildings that had been retrofitted with SPF roofs between 1980 and 1984. Results showed a payback in energy savings of an average of 4.5 years.

The systems, many still in place today, boast high energy savings, low maintenance and replacement costs, and minimal disruption in occupant productivity, as the systems can be applied without disrupting the building interior.

## Action Plan: Using ccSPF for Green Building – New Construction and Renovations

Use of ccSPF systems for green buildings will become more commonplace as building designers and owners seek cost-effective means to achieve new building codes and green building program requirements. For that reason, we recommend the following:

**1. Focus research and solutions development and measurements on whole-systems solutions, rather than component parts.** Syracuse University’s Bomberg believes that the industry should strive for systems solutions that are measured and verified as whole systems, rather than component parts.

**2. Understand and evaluate the application and performance of different ccSPF formulations for specific applications.** There are many different types of foams and applications and building teams must evaluate the performance of each formulation and application. As Bomberg reflects, “A tailor can use very different textiles to make different pants. He’s not saying I use only one textile to make all pants. The foam industry needs to look at their products in a similar way.”

**3. Further verify the performance of ccSPF systems according to traditional LCA models.** While life-cycle analysis has been performed on ccSPF systems that reflect good performance, additional evaluations are forthcoming that will further strengthen the case. Clearly, in such areas as energy conservation and durability, ccSPF is a good life-cycle choice.

**4. Push the requirement of high thermal and air-barrier performance in the design and construction of all buildings.** Fundamentally, building codes and standards are not stringent enough to create a solution to building-related contributions to greenhouse gas emissions, unsustainable energy consumption, and significant negative environmental impact. New codes and legislation should be developed and enacted that reduce consumption and improve positive environmental impact.

## Sources and References

**The following groups have been cited or quoted in the development of this White Paper. Building Design + Construction thanks these groups for their work.**

Mark Bomberg, Syracuse University
BASF
Steve Easley, Steve Easley & Associates
Environmental Protection Agency
Green Building Initiative
Honeywell
Lawrence Berkeley Laboratory
National Institute of Standards & Technology
National Oceanic and Atmospheric Administration
Oak Ridge National Laboratory, Buildings Technology Center
Bill Rose, University of Illinois at Urbana-Champaign
Spray Polyurethane Foam Alliance
U.S. Department of Energy
U.S. Green Building Council

**Corporate Sponsor Honeywell**

Honeywell has been a key supplier of fluorocarbon insulation for more than 40 years. Throughout this time, Honeywell has been a global leader in developing and commercializing products that meet the needs of the global foam market, as well as the most comprehensive technical, regulatory, health, safety, and environmental support, which is critical in ensuring safe and effective use of these products.

Honeywell

# Passive Design Toolkit

CITY OF
VANCOUVER

# City of Vancouver — Passive Design Toolkit

## Message from the Mayor

Vancouver City Council has taken an important first step toward our goal of becoming the greenest city in the world, as the first jurisdiction in North America to go beyond green building codes and use architecture itself to reduce greenhouse gases (GHGs).

More than half of all GHG emissions in Vancouver come from building operations, so the City has set a target that all new construction will be GHG neutral by 2030, through carbon-neutral measures in areas such as lighting and heating technologies.

The Passive Design Toolkits will serve as a resource to the development industry, and as a framework for the City's Planning department to review and update its design guidelines. Passive design elements, when evaluated in terms of relative cost and effectiveness, have been shown to reduce a building's energy demand by as much as 50 percent.

The new Toolkits will help us create a more sustainable architectural form across the city, while improving the comfort of the people who live and work in new buildings.

**Gregor Robertson**

## Message from BC Hydro

BC hydro
powersmart

BC Hydro is a proud supporter of the Passive Design Toolkits for the City of Vancouver.

We recognize that part of providing clean energy for generations is helping British Columbians build *Power Smart* high performance buildings.

We thank you for using this Toolkit in your project, and congratulate the City of Vancouver for providing leadership in helping designers create the buildings of tomorrow in BC today.

**Lisa Coltart, Executive Director Power Smart and Customer Care**

**Prepared by:**

July 2009

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# Contents

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# 1. Executive Summary

## 1.1 Purpose

This document presents best practices for the application of passive design in Vancouver. It is intended to establish a common vision and definition of passive design and support decision making for new developments[1] that will maximize occupant health and comfort and minimize energy use by relying less on mechanical and electrical systems. Furthermore, it is intended to move the Vancouver design community toward a new, higher standard of energy efficiency without sacrificing thermal comfort.

This document is not prescriptive, but rather discusses and analyzes recommended design approaches and the energy saving opportunities each presents. Additionally, the modeling results shown are useful and valid but do not replace project-specific modeling.

## 1.2 Navigating this Toolkit

This toolkit is organized into three main sections:

1. Context
2. Passive Design Strategies
3. Passive Design Elements

Context provides the fundamental frameworks for understanding and implementing passive design. The Passive Design Strategies lay out the overarching strategies that will optimize comfort and minimize energy requirements for new developments in Vancouver. Each strategy is made up of several design elements. Each element is addressed in further detail in Passive Design Elements.

Finally, the appendices provide supporting information, including detailed energy modeling analysis.

## 1.3 Summary of Recommendations

When building in Vancouver, it is recommended that designers adopt a passive design approach that uses the building architecture to maximize occupant comfort and minimize energy use. Design teams that understand the basic concepts and implement the strategies recommended in this toolkit will optimize passive performance and achieve the many spin-off benefits of energy efficient, thermally comfortable buildings. Of course, the application of passive design must be carefully considered within the specific constraints and opportunities of each project.

The key passive design recommendations for buildings in Vancouver are summarized below. (See Appendix E for energy modeling to support statements.)

- ☐ Design each facade specific to its orientation.
- ☐ Where possible, minimize east and west exposures to avoid

☐ When building in Vancouver, it is recommended that designers adopt a passive design approach that uses the building architecture to maximize occupant comfort and minimize energy use.

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[1] This toolkit is intended for Part 3 buildings, as per the National Building Code of Canada (2005).

Design for cooling by natural ventilation.

unwanted solar gains.

- For better energy performance, attempt to limit windows to 50% on any facade (for best performance, limit windows to 30% ), taking into account other aesthetic and livability criteria. If higher window to wall area ratios are desired, incorporate high performance windows or a double facade and optimize shading.
- Target overall wall assembly RSI values between 2.3 (ASHRAE minimum) and 2.9. Use modeling to assess project-specific benefits, as the impact of insulation depends greatly on window to wall area ratio.
- Use an air-tight envelope to minimize uncontrolled infiltration.
- Use heat-recovery ventilation during heating season only, and design for natural ventilation and cooling by natural ventilation throughout the rest of the year.
- For residential buildings, use clear glass with good insulating value (low U-value with low-e coating). Mitigate unwanted solar gains with external shading and allow for passive cooling by natural ventilation.
- For commercial buildings, use either clear glass with effective external shading elements or dark or reflective glass (low shading coefficient) to control unwanted solar gains. Regardless of shading option, the glass should have good insulating value (low U-value with low-e coating). Remove internal heat gains with other passive elements (e.g., natural ventilation).
- Incorporate overhangs providing shading angles of 20°-30° off vertical (measured from the bottom window sill to the edge of the overhang) on south-facing windows.
- Incorporate operable external shading on east-, south- and west-facing windows.
- Use thermal mass that is exposed to the conditioned space and combine it with other passive elements to achieve its full energy-savings and comfort potential.
- Incorporate buffer spaces on all exposures whenever possible to optimize comfort and reduce both peak load and overall heating and cooling energy requirements.
- Design for cooling by natural ventilation in all building types.
- Optimize the effects of passive heating and cooling strategies by strategically combining passive elements.
- Incorporate as many passive design elements as possible to optimize comfort and minimize overall energy use.

# 2 Context

## 2.1 Definition of Passive Design

"Passive design"[2] is an approach to building design that uses the building architecture to minimize energy consumption and improve thermal comfort. The building form and thermal performance of building elements (including architectural, structural, envelope and passive mechanical) are carefully considered and optimized for interaction with the local microclimate. The ultimate vision of passive design is to fully eliminate requirements for active mechanical systems (and associated fossil fuel-based energy consumption) and to maintain occupant comfort at all times.

Even though we may not achieve the ultimate passive design vision on every building, implementing the passive design approach to the fullest extent possible will lower building energy use. Building shape, orientation and composition can improve occupant comfort by harnessing desirable site-specific energy forms and offering protection from undesirable forms of energy. Through properly applied passive design principles, we can greatly reduce building energy requirements before we even consider mechanical systems.

Designs that do not consider passive thermal behaviour must rely on extensive and costly mechanical HVAC systems to maintain adequate indoor conditions, which may or may not even be comfortable. Furthermore, even the most efficient technologies will use more energy than is necessary with a poorly designed building.

To successfully implement the passive design approach, one must first accomplish the following:

1. Understand and define acceptable thermal comfort criteria.
2. Understand and analyze the local climate, preferably with site-specific data.
3. Understand and establish clear, realistic and measurable energy performance targets.

## 2.2 Thermal Comfort

Proper understanding of the parameters around thermal comfort is a critical component of successful building and system design. It is especially important in passive design, where buildings must maintain thermal comfort without the aid of active mechanical systems for as much of the year as possible.

Thermal comfort refers specifically to our thermal perception of our surroundings. The topic of thermal comfort is a highly subjective and complex area of study. Through passive design, we can impact four indoor environmental factors that affect thermal comfort:

☐ "Passive design" is an approach to building design that uses the building architecture to minimize energy consumption and improve thermal comfort.

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[2] Also known as "climate adapted design" or "climate responsive design"

*Thermal comfort is a very subjective term thus making it difficult to model.*

- Air temperature
- Air humidity
- Air velocity
- Surface temperatures

Each factor affects thermal comfort differently. The factors most commonly addressed in the conventional design process, air temperature and air humidity, in fact affect only 6% and 18% of our perception of thermal comfort, respectively. To take a more effective comfort-focused approach, we must also consider the temperature of surrounding surfaces and the air velocity, which account for 50% and 26% of thermal comfort perception, respectively.

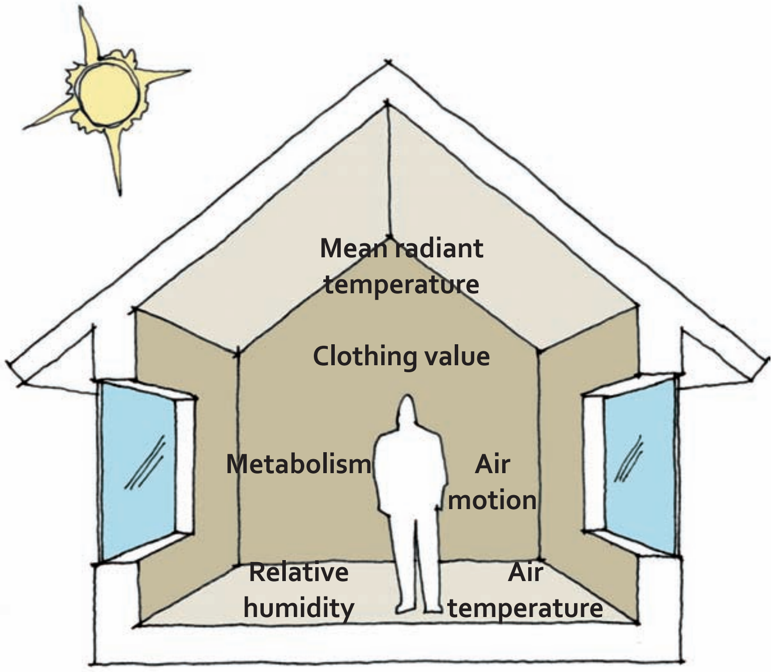
The effectiveness of passive strategies depends on the range of acceptable thermal comfort parameters set for the project.

### 2.2.1 Thermal Comfort Models

As human thermal comfort perception is extremely complex and subjective, defining acceptable comfort parameters is particularly challenging. Despite these difficulties, several models for quantitatively measuring occupant comfort have been widely used. The two most relevant in this case are the Fanger and Adaptive Models.

The Fanger Model is most commonly used for typical buildings that rely solely on active mechanical systems. It defines comfort in terms of air temperature and humidity because these parameters are easy to measure and control. It prescribes a relatively narrow range of acceptable levels which, in common practice, do not vary with outdoor conditions on a daily or yearly basis.

Figure 1: Key Thermal Comfort Parameters



This suits the conventional approach which has heavy reliance on active mechanical systems regardless of the outdoor climatic conditions. But this can also lead to unnecessary energy consumption. Furthermore, this simplification does not account for the temperature of surrounding surfaces, the dominant factor affecting thermal comfort.

The complexity of human thermal comfort, particularly in passively designed buildings, can be better described by the lesser-known Adaptive Model.

The Adaptive Model correlates variable outdoor conditions with indoor conditions and defines comfort with a wider range of thermal parameters, making it more suited to buildings with passive features and natural ventilation. In the mild Vancouver climate, passive buildings can maintain acceptable thermal comfort within the parameters of the Adaptive Model for the majority of the year, with the exception of the coldest outdoor temperatures during winter.

Using the passive design approach and the Adaptive Model can significantly reduce a building's reliance on energy-intensive active mechanical systems.

The required strategies to achieve such passive performance are discussed in Section 3 of this toolkit. See Appendix B - Thermal Comfort for further details on both thermal comfort models.

### 2.2.2 Resultant Temperature

Resultant temperature[3] is the average of the air temperature and temperature of the surrounding surfaces (i.e., Mean Radiant Temperature or MRT). Surface temperatures affect occupant comfort by radiant heat transfer, the most dominant factor of human comfort perception, and air temperature affects comfort by convection and conduction, less dominant factors.

As long as the resultant temperature of the space remains within the targeted comfort range, occupants will feel comfortable, even as the air temperature fluctuates outside the comfort range. Conversely, when the resultant temperature of the space is outside the defined comfort range because of a cold or hot surface (e.g., a hot window on a sunny day), occupants will feel uncomfortable even if the desired air temperature set point is maintained.

The resultant temperature and MRT can be controlled by passive design strategies, which are discussed in Section 3 of this toolkit.

### 2.2.3 Free Run Temperature

Free Run Temperature (FRT) represents the natural temperature variation inside a building operating in an entirely passive mode, that is, without the involvement of active mechanical systems. An annual FRT

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[3] Also known as operative temperature; RT = (Average Air Temp + Mean Radiant Temp)/2

Understanding the local climate is the foundation of passive design.

profile is a very effective tool for understanding a building's passive response to its local climate. Once generated with building simulation software, an FRT profile can be used to test passive strategies. Effective passive strategies keep the FRT within the comfort range (or close to it) for most of the year. Optimizing the FRT minimizes the amount of energy required of the mechanical system.

See Appendix B.4 - Free Run Temperature for further details.

## 2.3 Vancouver Climate Characteristics

Understanding the local climate is the foundation of passive design. It guides the selection of appropriate passive design strategies and affects the extent to which mechanical systems are needed to maintain comfort.

Vancouver (49.18° N, 123.17° W) is located at sea level on the southwestern Pacific coast of British Columbia. In general, Vancouver has a temperate climate with mild temperatures and moderate humidity levels year round. Summers are pleasantly warm and dry and winters are relatively mild with high levels of precipitation. This weather pattern is due to the combination of the nearby ocean and the protection from the cold continental winter offered by the Coast Mountains rising abruptly from the ocean immediately to the north of the city.

The following table shows the average minimum and maximum air temperatures for Vancouver during the coldest month (January) and the hottest month (August).[4]

### Table 1: Vancouver Average Temperatures

| January | | August | |
|---|---|---|---|
| Average Minimum | Average Maximum | Average Minimum | Average Maximum |
| 0.5 °C | 6.2 °C | 13.2 °C | 21.9 °C |

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[4] Source: http://www.climate.weatheroffice.ec.gc.ca

Because Vancouver is on the Pacific Northwest coast and it rains frequently, we often refer to Vancouver as "humid." However, only Vancouver's relative humidity is consistently high, not its absolute humidity. When high relative humidity coincides with low temperatures, the absolute amount of moisture in the air is still low. See Appendix C.2 for a more detailed discussion of humidity in Vancouver.

Vancouver receives moderate levels of solar radiation during spring, summer and fall.

The prevailing wind direction is from the east, followed in frequency by westerly winds. Due to the protection of the Coast Mountains, north winds are marginal.

The outdoor design temperatures for Vancouver as defined by the BC Building Code (2006) and ASHRAE 90.1 v.2007 are shown in Table 2.

## 2.4 Energy Performance Targets

Minimum energy performance is defined by current North American standards in indirect, non-energy-specific terms. The standards fall short of what is being achieved in other parts of the world and what is possible in our Vancouver climate.

Both North American standards address only two passive building components: envelope insulation and window performance. Neither standard addresses other crucial passive design parameters affecting energy performance such as building shape, compactness, orientation, layout, and thermal storage effects of building mass.

The currently prescribed methodology does not provide clear, measurable energy performance targets. It is not possible to compare energy performance between buildings or determine how a building compares to the best energy performance in a given climate.

Establishing building energy performance targets in clear and measurable terms is a fundamental prerequisite of successful passive design. This new methodology has already been successfully

### Table 2: Vancouver Outdoor Design Temperatures

| | BCBC | ASHRAE |
|---|---|---|
| Winter Dry Bulb Temperature, 99.6% | -9°C | -8°C |
| Summer Dry Bulb Temperature, 1% | 26°C | 23°C |
| Summer Wet-Bulb Temperature<br>(max coincident with 23°C dry-bulb) | 19°C | 18°C |

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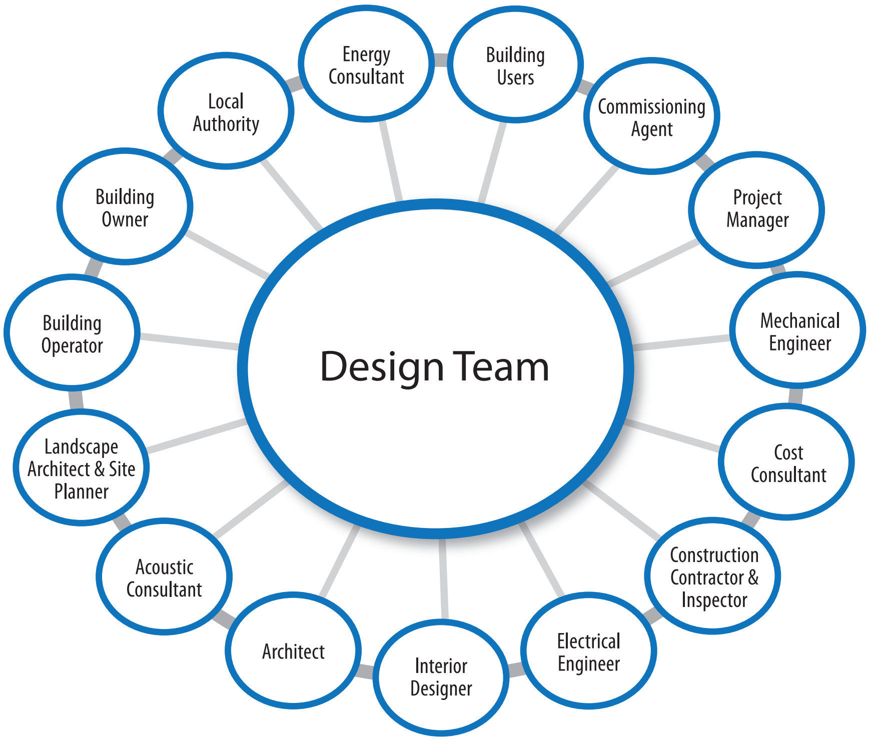
5 In general, ASHRAE 90.1 is used in the US, and the Model National Energy Code of Canada for Buildings (MNECB) is used in Canada. However, local Canadian jurisdictions can choose to supersede MNECB, as Vancouver has done by adopting ASHRAE 90.1 v.2007.

implemented in most of Europe.[6] Minimum building energy performance is prescribed in terms of energy intensity, kWh/m²·year, for a specific building type in a specific climate. Maximum allowable energy intensity targets can either be determined from the historical building energy consumption data or derived from fundamental laws of physics such as with the free-run temperature methodology.

Figure 2: Integrated Design Process Team



It is recommended that the City of Vancouver adopt maximum allowable energy intensity targets for specific building types. At present (late 2008), the City of Vancouver is working with BC Hydro and Terasen Gas to gather energy intensity data on existing buildings. Once an adequate and accurate data set has been collected, the City will be able to set energy intensity targets appropriate to the Vancouver climate and building market.

## 2.5 Integrated Design Process

Optimized building design requires the integration of many types of information from diverse sources into a comprehensive whole throughout the project. The Integrated Design Process (IDP) ensures all issues affecting sustainable performance are addressed throughout the process, from conception to occupancy. It is most critical to implement the IDP early on in the design activities, when issues can be addressed with minimal disruption. Active, consistent and coordinated collaboration between all team members and disciplines is critical to a successful IDP.

When implementing a passive design approach, many disciplines must collaborate to have the building and its surrounding site working together as a passive system. Figure 2 illustrates some of the many possible members of an IDP team.

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[6] European Energy Performance of Buildings Directive, MINERGIE (originated in Switzerland), Passive Haus (originated in Germany), etc.

# 3 Passive Design Strategies

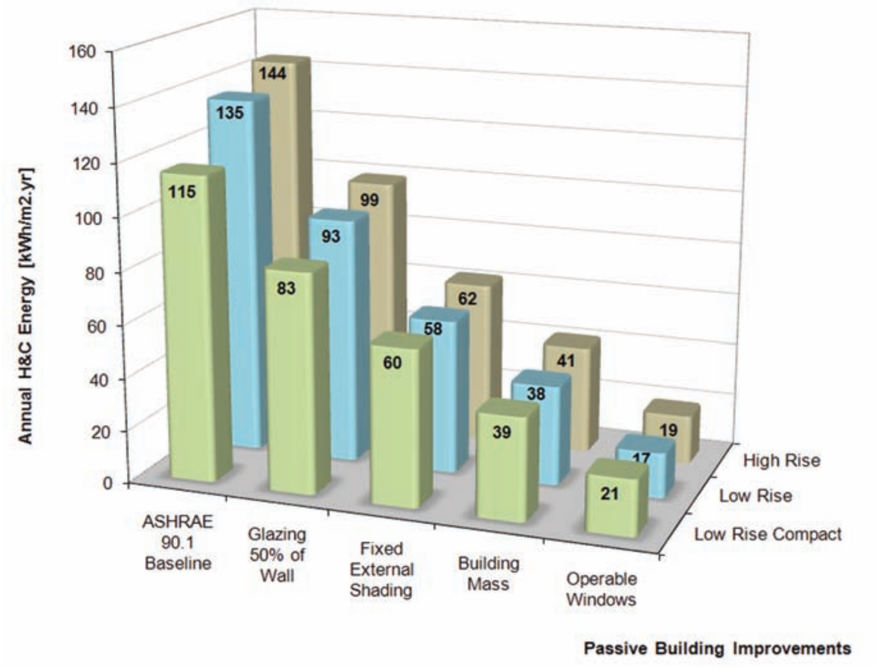
Certain passive building elements have inherent synergies and can be combined to produce different and potentially greater improvements in comfort and building energy performance.

However, combining elements incorrectly or using certain elements in isolation can negatively impact thermal comfort and building energy efficiency. For example, large south and west facing windows beneficial for passive solar heating must be implemented in combination with high performance windows and external shading to protect the interior from excessive solar heat gains during summer in order to achieve the desired overall building efficiency gains.

It is important to note that these guidelines distinguish between cooling and ventilation. In a conventional forced-air HVAC system, ventilation and space temperature control functions are combined. However, there are great advantages to separating the function of space temperature control from the function of ventilation, especially when designing for optimal passive performance. This separation allows the choice of a hydronic heating and cooling system, using water instead of air for energy transfer. Water has over 3,000 times the energy carrying capacity of air, so hydronic systems can achieve dramatically increased system efficiency. The separation also allows the use of an independent ventilation system providing 100% fresh air.

Figure 3 below shows an example of the compounding effect of combining various passive elements on a typical building in Vancouver as thermal comfort is held constant. The baseline meets the minimum requirements of ASHRAE Standard 90.1. As each additional element is incorporated, the annual energy consumption is further reduced, finally achieving a high level of efficiency that would be impossible using any single measure in isolation. The passive design measures essentially build upon and improve the requirements and results of most commonly used North American energy standards methodologies.

Figure 3: Effect of Passive Design on Energy Intensity



**CASE STUDY**

Turn to page 102 to learn how the Millennium Water development takes advantage of cross-ventilation.

With many passive strategies, there is a trade-off between heating performance and cooling performance. The building type and operation determine which strategies will have the best overall impact on energy performance. In all cases, building energy modeling specific to the project should be conducted. Once again it is important to note that the simulation results presented in this report are parametric comparisons only; they do not replace the value of project-specific modeling.

## 3.1 Passive Heating

Using building design to harness solar radiation and capture the internal heat gains is the only passive way to add free thermal energy to a building. Passive solar heating combines a well-insulated envelope with other elements that minimize energy losses and harness and store solar gains to offset the energy requirements of the supplemental mechanical heating and ventilation systems. Elements that contribute to passive solar heating include the following:

- Orientation
- Building shape
- Buffer spaces and double facades
- Space planning
- High-performance windows (clear, low-e)
- Mixed-mode heat recovery ventilation (HRV)[7]
- Low window to wall area ratio (N/E)
- High window to wall area ratio (S/W)
- Operable external shading
- High-performance insulation
- Thermal mass
- Minimized infiltration

## 3.2 Passive Ventilation

Passive ventilation strategies use naturally occurring air flow patterns around and in a building to introduce outdoor air into the space. Wind and buoyancy caused by air temperature differences create air pressure differences throughout occupied spaces. Buildings can be designed to enhance these natural air flows and take advantage of them rather than work against them.

Passive ventilation must be considered during the design process because many architectural features affect air flows through a building, including the building shape, layout of interior walls, floors and even furniture. Design features must strike a balance between privacy/noise attenuation needs and the desired path of least resistance for air distribution. Ventilation rates will also be affected by prevailing wind direction.

There are three common approaches to passive ventilation. The simplest form is single-sided ventilation with operable windows, where ventilation air enters and exhausts through the same window(s) on the same side of

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[7] HRV is an active system; however, due it its effective synergies with passive ventilation, we are mentioning it here. See Appendix E for modeling results on the efficiency of this mixed-mode system.

the occupied space. There are design limitations on how large a space can be effectively ventilated this way: single-sided ventilation does not achieve a significant result unless ceilings are very high.

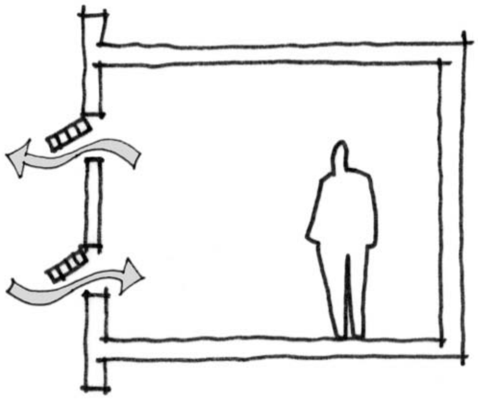
More effective is cross-ventilation, where operable windows on adjacent or opposing walls draw ventilation air across the occupied space. Designs should strive for at least two exposed walls per residential or commercial unit to allow for cross-ventilation.

Finally, in larger buildings with significant core spaces, induced ventilation with high spaces such as atria, stacks and wind towers may be necessary to provide adequate ventilation by strictly passive means. These strategic architectural features create optimized pathways for natural, passive ventilation.

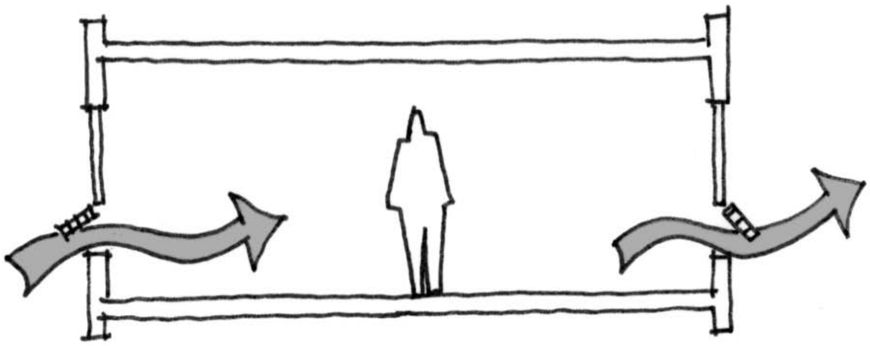
The passive elements that contribute to natural ventilation include the following:

- Operable windows
- Buffer spaces and double facades
- Building shape
- Space planning
- Orientation
- Strategic architectural features
- Openings to corridors and between otherwise separated spaces
- Central atria and lobbies
- Wind towers

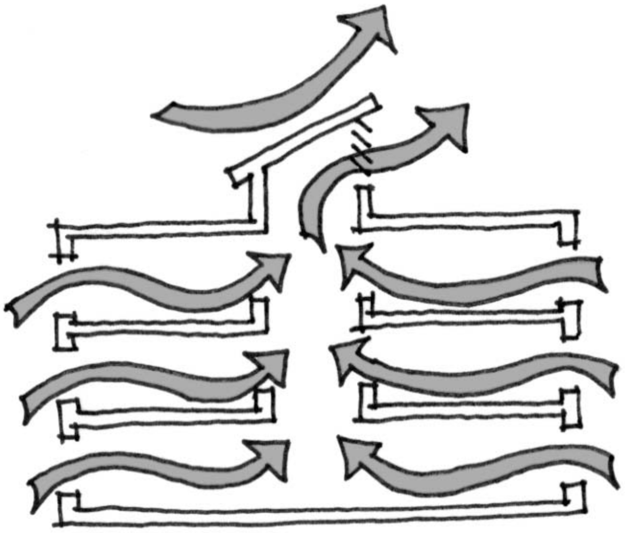
## Figure 4: Single-Sided Ventilation



## Figure 5: Cross Ventilation



## Figure 6: Stack Effect Through an Atrium



Careful design is required to avoid overheating from direct solar gains and to minimize glare.

## 3.3 Passive Cooling

Passive cooling strategies prevent the building from overheating by blocking solar gains and removing internal heat gains (e.g. using cooler outdoor air for ventilation, storing excess heat in thermal mass).

Passive cooling strategies are often coupled with passive ventilation strategies, and the cooling function is achieved by increased passive ventilation air flow rates during periods when the outdoor air temperature is low enough to flush heat from the building.

Elements that contribute to passive cooling include the following:

- Fixed/operable external shading
- Thermal mass
- Low window to wall area ratio (S/W)
- Passive ventilation
- Nocturnal cooling
- Stacked windows
- Passive evaporative cooling
- Earth-tempering ducts

Nocturnal cooling uses overnight natural ventilation to remove heat accumulated in the building mass during the day. The cooler night-time air flushes and cools the warm building structure/mass.

Stacked windows allow cool air in at a lower window, creating an upward-moving vacuum that forces warm air out a high-placed window.

Evaporative cooling uses heat from the spaces to convert water from a liquid to a vapor, which changes the air from warm and dry to cool and moist. In order to cool a space by evaporative cooling, moisture must be added to an airstream. This can be achieved by drawing air across or through existing water (e.g., a water feature located within the building, a natural exterior body of water, a hydroponic living wall, etc.).

Earth tempering takes advantage of the relatively constant temperature of the ground at depths exceeding 1.5 m to provide tempering for building ventilation air. This requires burying a ventilation air intake path, also called an earth tube.

## 3.4 Daylighting

Daylighting maximizes the use and distribution of natural diffused daylight throughout a building's interior to reduce the need for artificial electric lighting. Careful design is required to avoid overheating and to minimize glare, and to complement passive heating and cooling strategies such as shading. In order to maximize energy savings , advanced electrical control systems like sensors should be integrated. The features which contribute to a daylighting strategy include:

- Space planning
- High ceilings paired with tall windows
- Window size and placement (window to wall area ratio)
- Interior surface colours and finishes
- Strategic architectural features
- Light shelves
- Skylights and light tubes
- Clerestories

The key energy savings benefit of daylighting is straightforward: daylighting reduces energy requirements for electrical lighting. Indirectly, daylighting can also reduce energy requirements for space cooling.

Daylighting strategies are highly project-specific: detailed building modeling and analysis is required to achieve an effective design and to estimate energy savings. As such, daylighting is not included in the parametric simulations of this study.

## 3.5 Applying the Strategies: Residential

In the Vancouver market, the vast majority of residential developments are medium- and high-rise towers. Residential spaces have night-time occupancy and relatively low internal heat gains (aside from intermittent cooking), which results in a heating-dominant residential energy profile in the Vancouver climate.

Specific passive approaches that will improve the overall energy performance of residential buildings in Vancouver include:

- Carefully detailed and constructed high-performance insulation in the envelope with minimal thermal bridging, including exterior walls and roofs.
- Clear, low-e, high-performance windows in combination with operable external shading to block solar gains during summer and admit solar gains during shoulder seasons and winter
- Note: any building in which the window to wall area ratio is greater than 50% will be challenged to achieve higher energy performance
- Unconditioned, enclosed buffer spaces (not regularly occupied) that cover the perimeter of the space, fitted with operable windows to provide natural ventilation from the exterior to the interior space when desired.
- Thermal mass on the interior side of the insulation, located in the floors, external walls, and walls between adjoining units (i.e., party walls).
- Compact and simple form.
- Air- and moisture-tight envelope.
- Mixed-mode ventilation using HRV during the winter only and passive ventilation throughout the rest of the year.

The following table displays the elements that positively contribute to the various passive design strategies for residential buildings.

| | Relative Impact (★) | Passive Heating | Passive Cooling | Passive Ventilation | Daylighting |
|---|---|---|---|---|---|
| High-performance insulation | ★★★ | • | • | | |
| High-performance windows | ★★ | • | • | | • |
| Window to wall area ratio <50% | ★★★ | • | • | | • |
| Buffer spaces | ★★★ | • | • | • | • |
| External shading | ★★★ | | • | | • |
| Thermal mass | ★★ | • | • | | |
| Compact form | ★ | • | | | |
| Air- and moisture-tight envelope | ★★ | • | | | |

These features were added to the parametric model one at a time to clearly illustrate the compounding benefit of each. Refer to modeling results in Appendix E.

## 3.6 Applying the Strategies: Commercial

Commercial buildings have different characteristics from residential buildings, such as greater internal heat gains from equipment and lighting, higher ventilation requirements, and different occupancy trends. Commercial buildings benefit from passive cooling, but in the Vancouver climate, design must strike a balance between heating and cooling performance.

Specific passive approaches that will improve the overall energy performance of commercial buildings in Vancouver include:

- Carefully detailed and constructed high-performance insulation in the envelope with minimal thermal bridging, including exterior walls and roofs.
- Solar gain control using either high-performance windows with low shading coefficient (tinted or reflective) or clear high-performance windows with a low-e coating in combination with operable external shading to block solar gains during summer and shoulder seasons and admit solar gains during winter.
- Window to wall area ratio limited to <50%.
- Double facades with operable shading elements and operable windows to act as thermal buffer spaces, preheat ventilation air in the winter, and block solar gains and provide natural ventilation in the summer.
- Building shape and massing that enhances natural ventilation and daylighting, ideally with central atria and ventilation towers.
- Thermal mass on the interior side of the insulation, located in the floors, external walls, and walls between adjoining units (i.e., party walls).
- Passive cooling strategies, such as nocturnal ventilation to pre-cool spaces during summer and ventilation air intakes located in cool areas and delivered to the building using earth tubes.
- Air- and moisture-tight envelope.

The following table displays the elements that positively contribute to the various passive design strategies for commercial buildings.

| | Relative Impact (★) | Passive Heating | Passive Cooling | Passive Ventilation | Daylighting |
|---|---|---|---|---|---|
| High-performance insulation | ★★ | • | • | | |
| High-performance windows | ★★★ | • | • | | • |
| Window to wall area ratio <50% | ★★★ | • | • | | • |
| Double facades | ★★ | • | • | • | • |
| External shading | ★★★ | | • | | • |
| Narrow forms | ★ | | • | • | • |
| Thermal mass | ★ | • | • | • | |
| Nocturnal ventilation | ★★ | | • | • | |
| Pre-cooled ventilation air | ★★ | | • | • | |
| Air- and moisture-tight envelope | ★★ | • | | | |

These features were added to the parametric model one at a time to clearly illustrate the compounding benefit of each. Refer to modeling results in Appendix E.

## 3.7 Modeling Summary

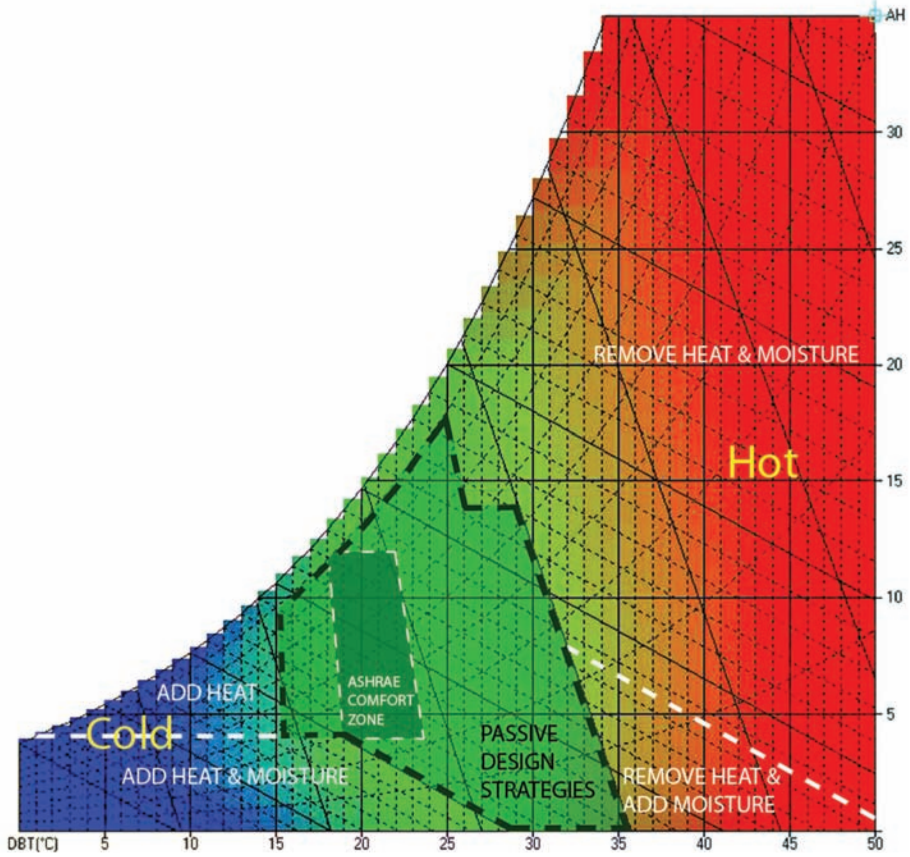
Our modeling results indicate that incorporating passive elements and strategies effectively expands the range of outdoor conditions under which buildings can remain comfortable without active systems.

The figure below shows this effect of passive design strategies relative to the ASHRAE Comfort Zone. When outdoor conditions fall within the extended passive zone, a building that incorporates all of these passive strategies will be comfortable without mechanical heating or cooling; when conditions fall outside of the zone, the building must rely on active systems to maintain thermal comfort.

In conclusion, passive design enables buildings to maintain occupant comfort throughout more of the year using less energy.

For the quantitative impact of individual passive elements and strategies, refer to Appendix E.

**Figure 7: ASHRAE Comfort Zone and Achievable Extended Comfort Range by Passive Design Strategies in Vancouver Climate**



Liu Institute for Global Issues Photo: Stantec/Arthur Erickson

# 4 Passive Design Elements

The primary objective of passive design strategies is to reduce or even eliminate the need for active mechanical systems while maintaining or even improving occupant comfort. The passive design strategies discussed in Section 3 integrate the complementary passive design elements that follow to minimize heating and cooling loads. Performance of each individual passive element is discussed here in Section 4. They are presented in the general order a designer would encounter them throughout a design.

- Site and Orientation
- Building Shape and Massing
- Landscape Considerations
- Space Planning
- Buffer Spaces
- Windows
- Solar Shading
- Thermal Mass
- Thermal Insulation
- Air and Moisture Tightness

## 4.1 Site and Orientation

### 4.1.1 Overview

Many site considerations can affect the passive design approach, including urban design opportunities and constraints, building orientation on the site, shade from other buildings, wind patterns, proximity to industry, noise, and urban character. These all need to be considered to optimize the integration of passive design strategies and some may pose design conflicts. On the other hand, the integration of site considerations such as landscaping, wind and microclimate can influence the local architectural expression of a building.


*$O^2$ in Vancouver  Photo: Merrick Architecture*

Building facade orientation is one of the key elements for many passive design strategies. Facade orientation affects the energy and comfort implications of solar shading, window to wall area ratio, window position and performance, and choice of exterior colour.

A building's orientation determines the amount of solar radiation it receives. The roof surface receives the greatest intensity, but it is normally opaque and well-insulated. Building facades, which can have a significant window to wall area ratio, also receive sun in various amounts. The south facade will capture desirable solar gains during winter when the sun angle is low, making it ideal for passive solar heating during winter. On the other hand, window should be carefully placed on the east and west facades since they receive the second highest radiation intensities. Excessive solar heat gains on the west side can be particularly problematic as maximum solar intensity coincides with the hottest part of the day.

☐ The primary objective of passive design strategies is to reduce or even eliminate the need for active mechanical systems while maintaining or even improving occupant comfort.

Figure 8: Vancouver's Two Distinct Grid Orientations

Figure 9: Seasonal Sun Paths

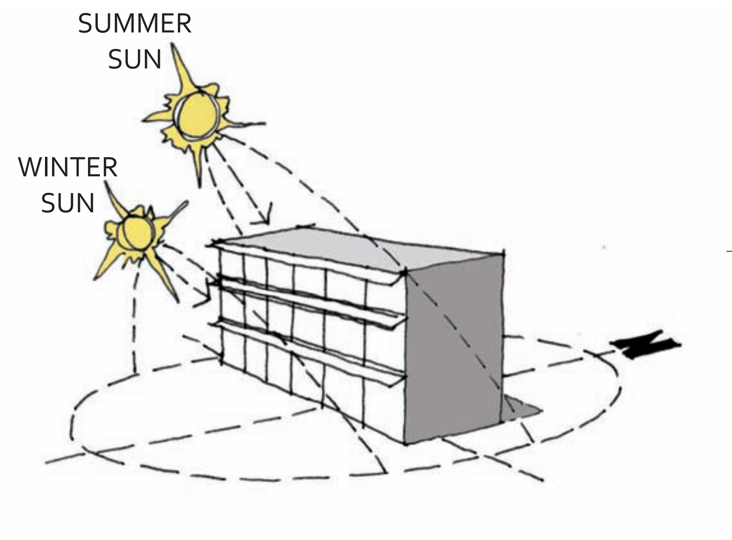
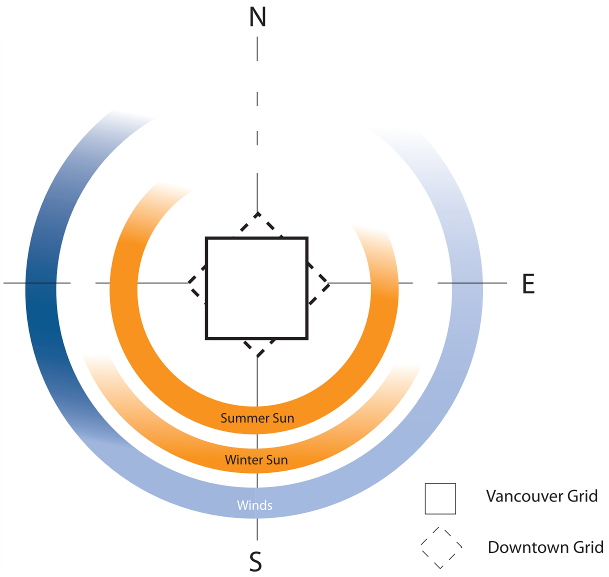


Figure 10: Facade Considerations



### 4.1.2 Benefits

- Can greatly improve heating and cooling performance when optimized.
- Can greatly improve daylighting when optimized.

### 4.1.3 Limitations

- Designing to optimal orientation is not always possible, and can be limited by roads, existing development, urban design context, lot size, and lot orientation.

- Heritage conditions and related design guidelines may create opportunities for unique responses in the delivery of a passive design solution.

### 4.1.4 Synergies

Since many passive design strategies are affected by orientation, responding to the different conditions of each facade is the most fundamental design decision a project team can make to passively design a building. For example, orientation and daylighting are very much linked. Optimum orientation will provide adequate daylight without glare or excessive solar gain.

### 4.1.5 Vancouver Applications

Orientation that allows winter solar gains is desirable; therefore south-facing orientation is appropriate provided that it is well-shaded during summer.

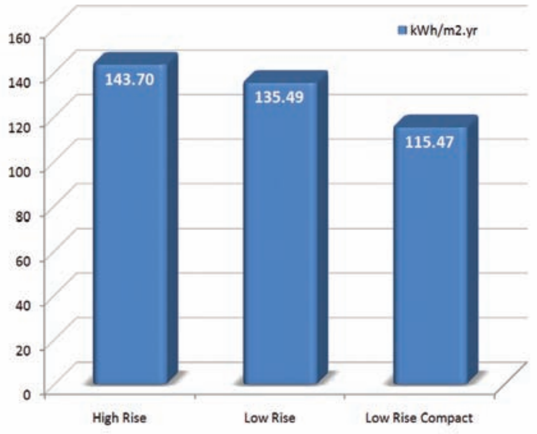
Orientation will often not be optimum in the downtown grid. However, responding to the various facade conditions will significantly increase thermal comfort and decrease active mechanical system requirements.

## 4.2 Building Shape and Massing

### 4.2.1 Overview

Building shape and massing[8] have great potential to reduce building energy intensity, but they often fall under the influence of a complex array of factors (planning considerations, building type and use, feasibility and initial cost). Certain common building shapes greatly increase envelope area to volume ratio (e.g., thin high-rise towers), which can decrease building energy performance in heating dominant buildings. With a similar square footage, buildings with a smaller exterior envelope area will achieve better energy-efficient performance. A compact building shape significantly reduces the building's energy intensity and reduces the need for active mechanical systems as demonstrated in the modeling results shown below in Figure 11.

Figure 11: Energy Intensity and Building Shape



**CASE STUDY**

Turn to page 103 to learn how the Pacific Institute for Sports Excellence's unique building shape provides solar shading.

☐ Building shape and massing have great potential to reduce building energy intensity.

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[8] "Massing" is used in this section to describe the overall geometry of the building. It is not to be confused with "thermal mass" (see Section 4.8).

Massing optimization can significantly improve passive performance, often without increasing the capital cost.

As one of the first design considerations, the massing of a proposed building must account for orientation and other site-specific conditions. Section 4.1 discusses orientation and its critical effects on massing and other passive design elements.

### 4.2.2 Benefits

- Reduced heating and cooling energy consumption.
- Reduced peak heating and cooling loads.

### 4.2.3 Limitations

- Must be carefully considered so as to not compromise the livability of the interior spaces provided (e.g. compromised daylighting; see Synergies).
- Must consider potential urban design conflicts related to street conditions, view corridors and other urban planning considerations.

### 4.2.4 Synergies

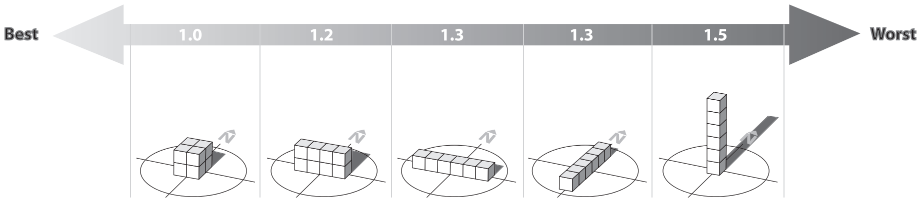
Building massing functions in close relationship with other basic architectural passive design parameters such as orientation, envelope performance (including window location) and solar shading.

Massing must also be considered alongside daylighting needs and natural ventilation, which tend to improve in buildings with narrower profiles, courtyards and other features that increase envelope area.

### 4.2.5 Vancouver Applications

- Heating-dominant residential buildings should be as compact as possible to improve their energy performance.
- Cooling-dominant commercial buildings should favour a longer shape along an east-west axis with more potential for passive cooling strategies.
- Buildings with compact form can be designed with features such as light wells and atria to facilitate natural ventilation and daylighting.

**Figure 12: The Effect of Envelope to Volume Ratio on Energy Efficiency**



## 4.3 Landscape Considerations

### 4.3.1 Overview

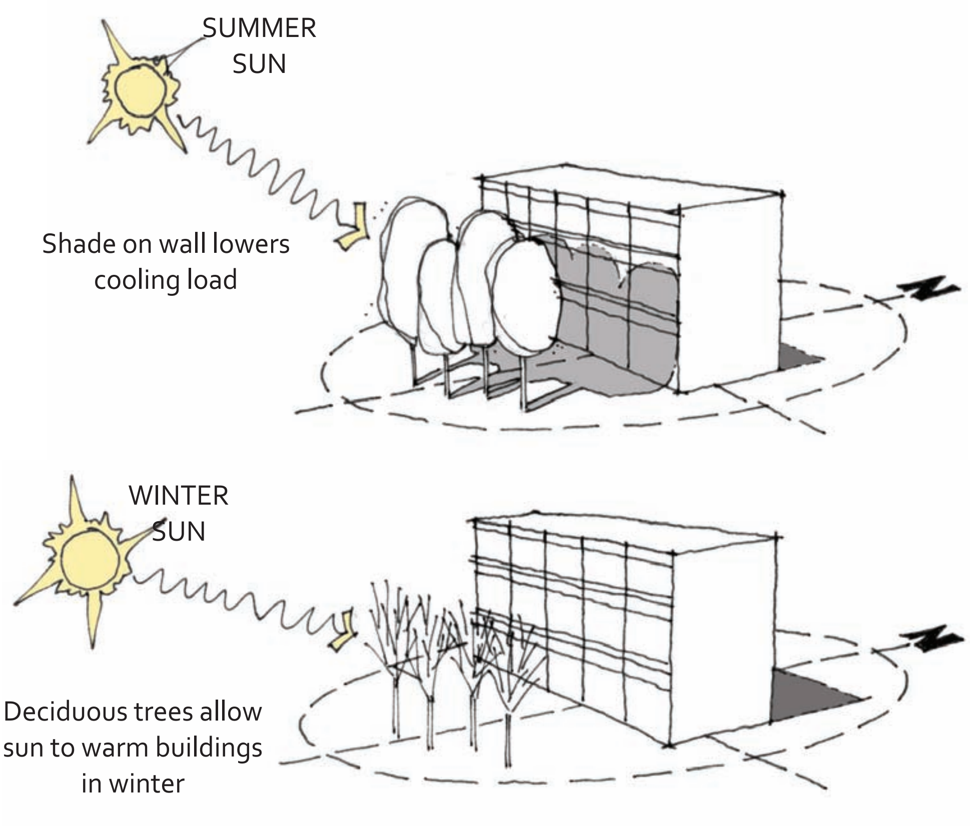
Many landscape considerations happen very early on in the design process. Set backs, street trees, street alignment and use of landscape buffer zones can be guiding elements of many site planning decisions. Therefore, careful consideration of landscaping is critical to successfully implementing the passive approach at the early stages of design. The integration of landscape strategies requires an active IDP where energy and thermal comfort goals are discussed and understood within the design team. Vegetation can help in many ways:

- Reducing ambient temperature and limiting the heat island effect around buildings, thus reducing the cooling load.
- Protecting the building from sun, wind and precipitation.
- Reducing solar intensity by introducing vegetated 'green' roofs and walls.

**CASE STUDY**

Turn to page 108 to learn how the new Butchart Gardens Carousel building will take advantage of its surrounding landscape.

Figure 13: Landscape Strategies for Passive Solar Heating and Daylighting Control



☐ Deciduous trees provide cooling shade in the summer and after shedding their leaves allow for warm sun to enter the building in the winter.

Photo: cobalt engineering

Figure 14: Reducing Solar Intensity with a Green Wall (Aquaquest at Vancouver Aquarium)

### 4.3.2 Benefits

- Deciduous planting provides desirable shading during summer and allows desirable solar gains during winter while adding aesthetic appeal.

- See Synergies.

### 4.3.3 Limitations

- Landscaping strategies are often limited by the available space.

- Many landscaping strategies require maintenance and irrigation.

- Incorporating landscaping strategies in higher buildings can be challenging due to maintenance and increasing challenges such as weight, wind pressure and irrigation.

### 4.3.4 Synergies

- Landscaping strategies can assist mechanical ventilation systems by contributing to ventilation air pre-cooling.

- Landscaping strategies can contribute to daylighting controls by reducing glare.

- Landscaping strategies can facilitate passive heating by allowing solar heat gain during winter and providing shade during summer.

### 4.3.5 Vancouver Applications

- Vancouver's mild, seasonal climate is very conducive to deciduous trees whose leaves provide desirable shading during summer and fall to allow desirable solar gains during winter.

## 4.4 Space Planning

### 4.4.1 Overview

Matching the program requirements with orientation and massing (building geometry) can further decrease energy use and increase thermal comfort. Building functions with particular thermal requirements should be placed in areas of the building that can provide those conditions (or come closest) without mechanical intervention. For example, computer labs or other rooms that have large internal heat gains and thus require mostly cooling should be placed on north or east-facing facades to minimize energy use from mechanical cooling.

By accounting for the thermal comfort requirements of a particular space use and matching them to suitable building characteristics, the design team can use passive design strategies to reduce building energy demand and maintain occupant comfort.

### 4.4.2 Benefits

- Locating spaces in their ideal thermal location in the building reduces mechanical heating and cooling energy by taking advantage of the building's natural thermal responses.
- Strategic space planning can reduce glare and improve comfort.

### 4.4.3 Limitations

- In many cases, such as residential units facing only one direction, it may be difficult to program the building to avoid having uses that will be negatively affected by solar gain.

### 4.4.4 Synergies

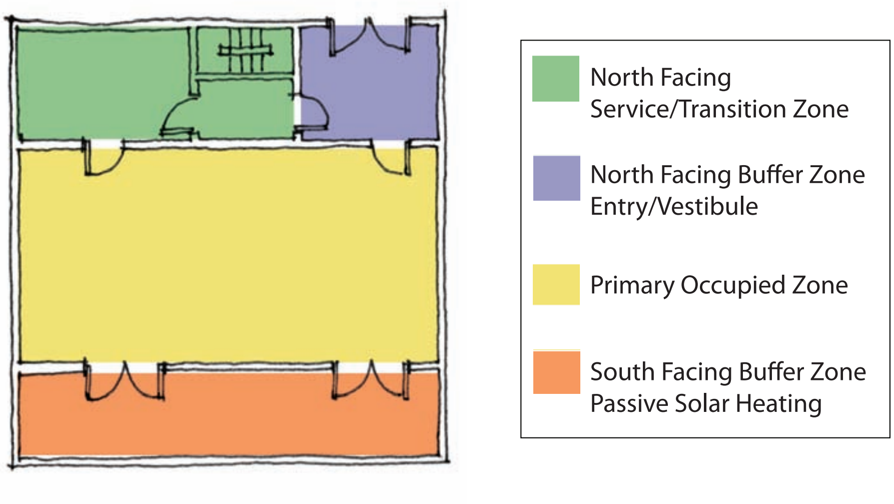
- Space planning considerations are directly linked to orientation and massing and the ability of the design team to provide, when possible, appropriate thermal conditions within the buildings.

**CASE STUDY**

Turn to page 105 to learn how careful space planning helps Surrey's Revenue Canada building.

Locating spaces in their ideal thermal location in the building reduces mechanical heating and cooling energy.

Figure 15: Example of Strategic Space Planning

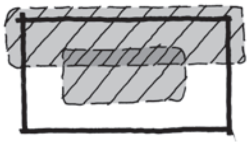


- When possible, incorporating buffer spaces to increase thermal conditions of the program areas should influence space planning decisions.

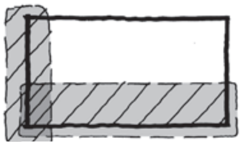
### 4.4.5 Vancouver Applications

Dockside Green Photo: Busby Perkins+Will

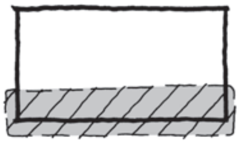
In the Vancouver climate, space planning should target the following conditions:



- Locate cooling dominant spaces on the north or in the centre of the building away from any perimeter solar gain.



- Locate heating dominant spaces on the south or west, avoiding over-exposure to west solar radiation.



- Locate residential spaces on the south exposure whenever possible.

## 4.5 Buffer Spaces

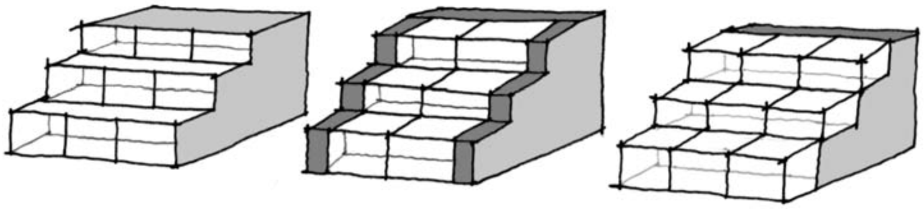
### 4.5.1 Overview

Buffer spaces such as double facades and sunspaces are located along the building perimeter and can be occupied or unoccupied, as well as semi-conditioned or unconditioned. They improve building energy performance by widening the range of outdoor temperatures in which thermal comfort can be maintained in the building with low mechanical energy consumption. Especially helpful during winter, buffer spaces create another insulation layer in front of the envelope, slowing the rate of heat loss between the outdoors and the indoor conditioned space. Ideally, they should be convertible to fully exterior space during summer to aid in ventilation and cooling of the adjoining occupied space.

Buffer spaces are a key component of many passive solar designs when they are oriented on the sunny side of the building.

South- and west-facing buffer spaces can be designed to act as occupied sunspaces, providing both passive solar heat gain and a functional occupied space. Sunspaces function like passive solar collectors, trapping solar gains like a greenhouse. Thermal storage is most effectively provided in the thermal mass of the floor and/or walls of the sunspace structure itself. Stored heat can either reach the building passively through the walls between the sunspace and the interior, or be distributed by an active mechanical system. The design and construction of sunspaces varies widely. In general, they can have open or closed ends, single or multiple slopes, and various arrangements of storage mass in the floor and walls.

## Figure 16: Examples of Possible Sunspace Configurations



In passive heating applications, sunspaces must be designed so the solar gains are greater than the heat losses through the windows.

Integrating occupied buffer spaces as transition spaces is ideal because a wider thermal comfort range is acceptable in spaces like corridors and entryways, as opposed to other, more tightly conditioned spaces such as residential, classroom or office areas. Entryway vestibules, a mandatory requirement for many buildings under the Vancouver Building Bylaw, are also maintained at wider thermal comfort ranges, which also help to reduce the mechanical system energy consumption by limiting the loss of heated air during winter and cooled air during summer. They also improve comfort in the adjacent space by reducing or even eliminating drafts.

Unoccupied buffer spaces, such as double facades or Trombe walls, are cavities between an exterior window layer and a secondary wall or window layer, typically with controllable openings between the outdoors and the interior spaces. The openings are adjustable to either ventilate the cavity, or to transfer air between the indoors and outdoors. Double facades can also be designed to induce stack effect and passively ventilate the occupied space. During winter the cavity can preheat ventilation air. During summer, the cavity openings can be adjusted to draw exhaust air out of the building. In the shoulder seasons, a double facade can increase the amount of time that natural ventilation can satisfy occupant comfort requirements.

### 4.5.2 Benefits

- Energy savings with reduced heat losses, infiltration at entries, and/or preheated ventilation air.
- Improved thermal comfort due to more stable interior space surface temperatures, reduced draft, and increased application of natural ventilation.
- Protects interior wall surface from the elements.
- Reduces building heating energy requirements via passive heating.

### 4.5.3 Limitations

- Buffer spaces increase the area of the building, but the space is not always usable for occupants.

- Buffer spaces may increase capital costs.

### 4.5.4 Synergies

Many synergies are possible with buffer spaces such as double ventilated facades. Buffer spaces in south facing double ventilated facades can be used to aid natural ventilation for example. Other passive building strategies can also work well with these types of facades such as night cooling and solar shading.

### 4.5.5 Vancouver Applications

Vancouver's temperate climate makes buffer spaces an excellent design option, because they could potentially eliminate the need for mechanical cooling and dramatically reduce the amount of time the mechanical heating system operates. In addition, they can serve as seasonally convertible habitable spaces. Buffer spaces can also provide additional rain screen protection for the building envelope resulting in longer life and fewer moisture problems for the external wall assembly.

Buffer spaces create another insulation layer in front of the envelope.

**Figure 17: Example of Double Facade as Buffer Space (Summer Performance)**

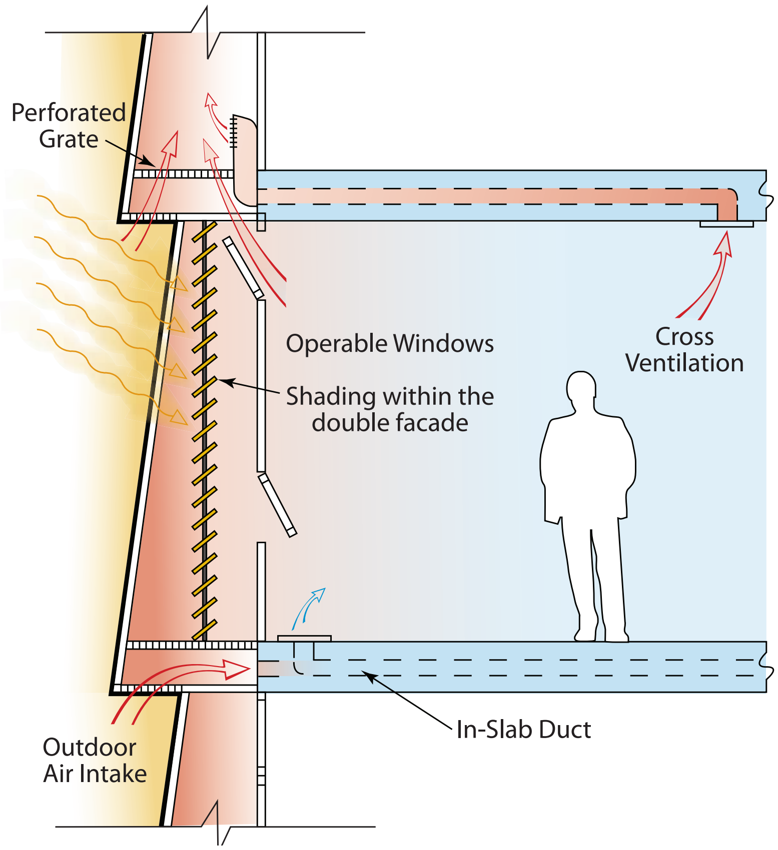
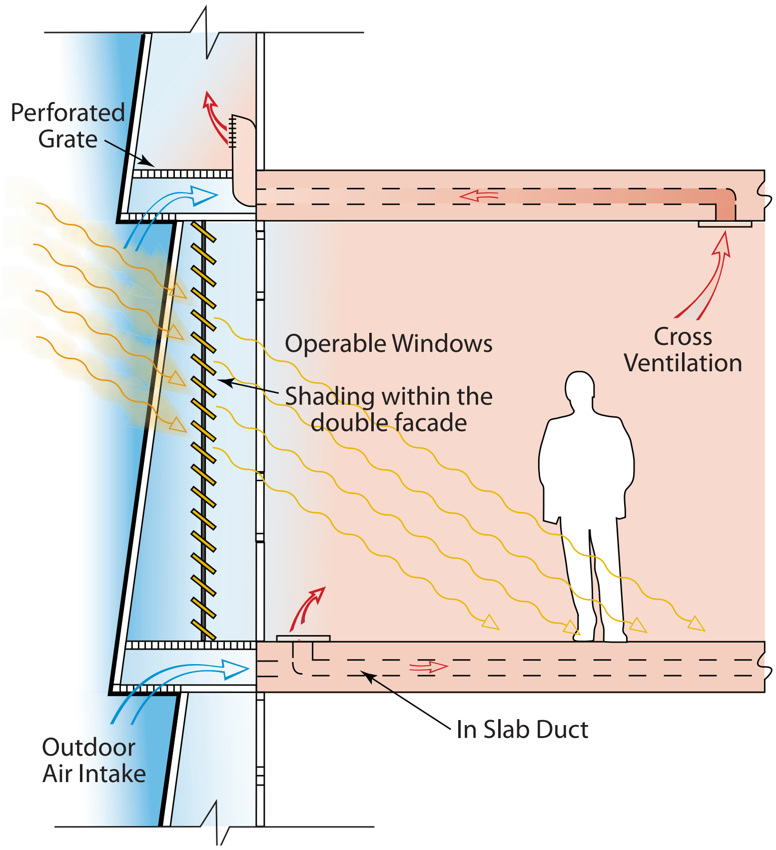


Figure 18: Example of Double Facade as Buffer Space (Winter Performance)



☐ Window assemblies are the weakest thermal links in a building's insulated envelope.

## 4.6 Windows

### 4.6.1 Overview

Windows (glazing) are necessary envelope elements in any building as they provide access to views and daylight and can be used for natural ventilation. However, window assemblies are the weakest thermal links in a building's insulated envelope, and the window design approach has a significant impact on occupant thermal comfort and building energy consumption.

In general, windows affect a building's thermal state by transmitting solar radiation directly into the conditioned space, where it stays trapped inside and heats the interior surfaces (i.e., the greenhouse effect). This heat gain is beneficial during winter and undesirable during summer when it can overheat the space.

With respect to windows, the design requirements of heating, cooling, aesthetics and daylighting often conflict; an energy efficient design uses window materials, sizes and framing design that balance aesthetics and overall energy performance. Annual building simulations can help to identify

**CASE STUDY**

Turn to page 106 to learn how the White Rock Operations Centre uses different window to wall area ratios on different facades.

this optimal combination; however they cannot replace a proper understanding of how window characteristics affect the building.

Window design characteristics fall into two categories: thermal and optical.

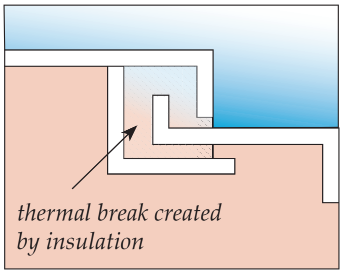
The thermal characteristics are the insulation or U-value, the framing type, overall area of windows, and the amount of framing.

- The number of panes of glass and the gas or vacuum void between them defines the amount of insulation provided by the windows, referred to as U-value. The U-value affects the amount of heat that is transferred between the interior and exterior, as well as the window interior surface temperature. Glass that insulates better traps more heat in the building and keeps a higher internal surface temperature, which is beneficial during winter and undesirable during summer.

- The overall window to wall area ratio is the window characteristic with the most significant impact on building energy consumption. Even the best performing glass insulates poorly when compared to an insulated wall. On east, south, and west exposures, greater window areas will admit more solar gain during winter. However, in the Vancouver climate, the net annual effect of any window to wall area ratio greater than 10% is still a thermal energy loss, even with the higher level of solar gains (see simulation results in Appendix E).

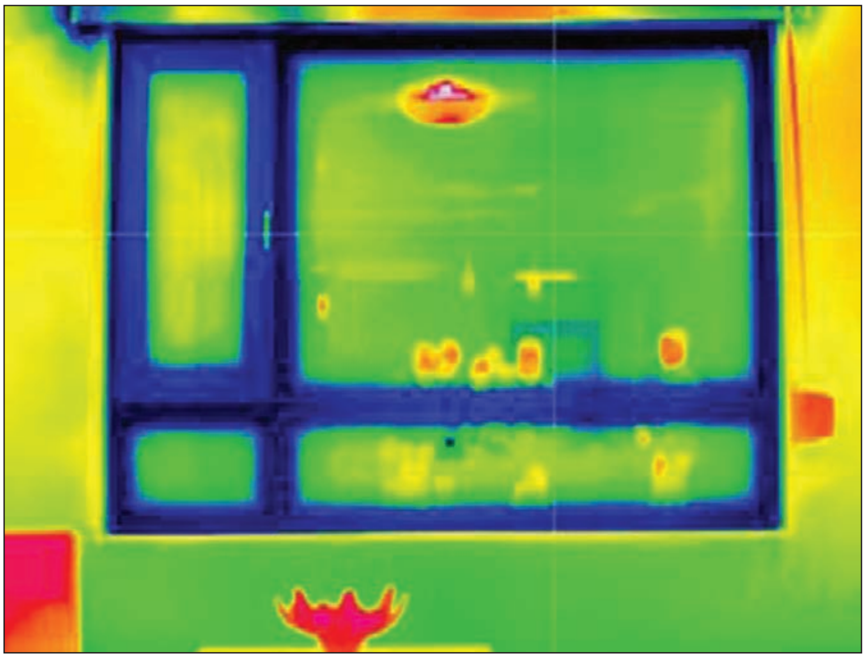
- Frames hold the glass panes and link them with the wall. They are usually made of highly conductive metal, creating thermal bridges between the interior conditioned space and the outdoors, further speeding heat loss through the window assembly. Frames can be made of less conductive materials, such as wood and vinyl. "Thermally broken" frames have an insulating spacer to slow the rate of heat transfer through the frame. However, even with a thermal break, frame material and design always limits the thermal performance of the overall window assembly. The minimum amount of framing structurally required is directly proportional to the area of windows; in addition to the minimal structural requirements, framing design is also guided by the envelope aesthetic, sometimes resulting in more framing than is necessary. The effects of thermal bridging should be minimized by reducing the amount of framing wherever possible. The thermal photo in Figure 20 demonstrates the effect of thermal bridging in window framing.

**Figure 19: Thermal Break**



"Thermally broken" frames have an insulating spacer to slow the rate of heat transfer through the frame.

## Figure 20: Thermal Image Showing Thermal Bridging in Window Framing



The optical characteristics of windows are defined by the glass material and the location of surface treatments such as coatings, tinting or colours. The overall optical performance of windows is typically described by the shading coefficient or solar heat gain coefficient, representing the amount of light and heat the window transmits, absorbs, and reflects. (A window with a low shading coefficient value blocks a high amount of solar radiation.) As these are fixed characteristics that can not be modified with the seasons, they have to strike a balance between the desirable shading during summer and the benefits of solar gains during winter.

The size, location, type and detailing of windows affects the thermal comfort and supplemental heating and cooling energy consumed by the building. Therefore, window design must consider and balance the desire for floor to ceiling glass and the ongoing energy consumption that will be created by such window area and material characteristics.

### Benefits

- Good insulation values reduce heating energy consumption.
- Optimized shading properties reduce cooling loads in commercial building.
- Optimized insulation values and framing design reduce heat losses and condensation in residential and high-humidity applications (i.e. food preparation).

- Optimized window to wall area ratios result in greater levels of thermal comfort from smaller cold/hot surface areas.

- Optimized window to wall area ratios can reduce both heating and cooling energy demands.

- Smaller window areas make better quality windows more feasible economically.

### Limitations

- Higher capital cost of high performance glass.

- Window to wall area ratios of greater than 50% (including floor-to-ceiling glass) will greatly challenge the energy efficiency of a building. Buffer spaces should be explored in this design scenario.

### Synergies

- High performance windows should be combined with natural ventilation strategies to relieve heat gains.

- Window to wall area ratio impacts decisions on shading, window performance, thermal insulation, thermal mass, orientation and programming.

### Vancouver Applications

For residential buildings the most effective combination involves a double-pane window assembly with a low-e coating for good winter performance in combination with external shading elements (rather than windows with a low shading coefficient) for good summer performance.

Commercial buildings with high internal heat gains will benefit from double pane windows with a low shading coefficient and a low-e coating.

From a building energy perspective, windows should be located to admit solar radiation during winter to aid the mechanical heating system and be designed to limit the amount of heat lost due to the poor insulating value of glass.

## 4.7 Solar Shading

### 4.7.1 Overview

Solar shading elements can be applied to the exterior or interior side of the windows.

External solar shading is the use of overhangs, blinds, louvers, trellises, or anything else that blocks the sun's rays from heating the building envelope and entering the building through windows.

Internal solar shading features, typically internal blinds, are any material that blocks the sun's rays at the perimeter but inside the building.

The distinction between internal and external shading is important because, although both systems block solar radiation, they have

**CASE STUDY**

Turn to page 107 to learn how the Dockside Green development uses exterior solar shading.

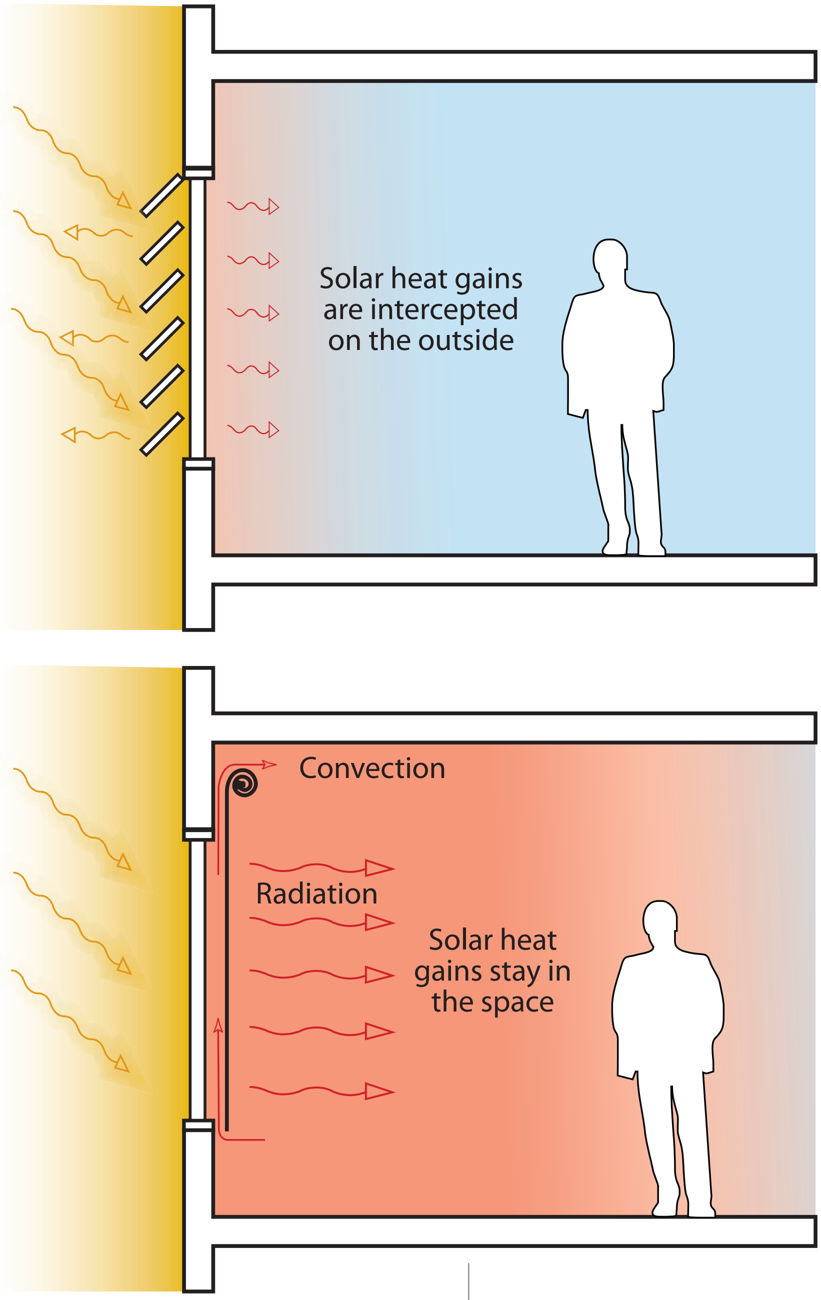
different effects on the building aesthetic, day lighting, comfort, and building energy system requirements.

**External shading** devices intercept, absorb and/or reflect solar radiation before it reaches the exterior surface of the building envelope. When used in front of opaque envelope assemblies, external shading results in lower external surface temperatures and less heat gain through the envelope. When used on transparent envelope assemblies (i.e., windows), shading reduces the amount of direct solar gain in the space, reduces both the external and internal surface temperatures of affected windows, floors and walls, and reduces glare in the space.

**Internal shading** also blocks solar radiation from penetrating into the conditioned space; however the solar energy is still transmitted through the window assembly. Once inside, it heats the internal surface of the glass and the blinds. These warm surfaces will heat the interior space and occupants through radiant and convective heat transfer (i.e., greenhouse effect). If mechanical cooling is used, this heat gain needs to be removed by the system.

Effective shading design requires a balance between admitting desirable solar gains during winter and blocking undesirable solar gains during summer. The optimal shading strategy would be adjustable for different times of the year. Fixed features such as horizontal overhangs are designed to admit low-angle winter sun and block high angle summer sun.

Figure 21: Effects of Internal and External Shading



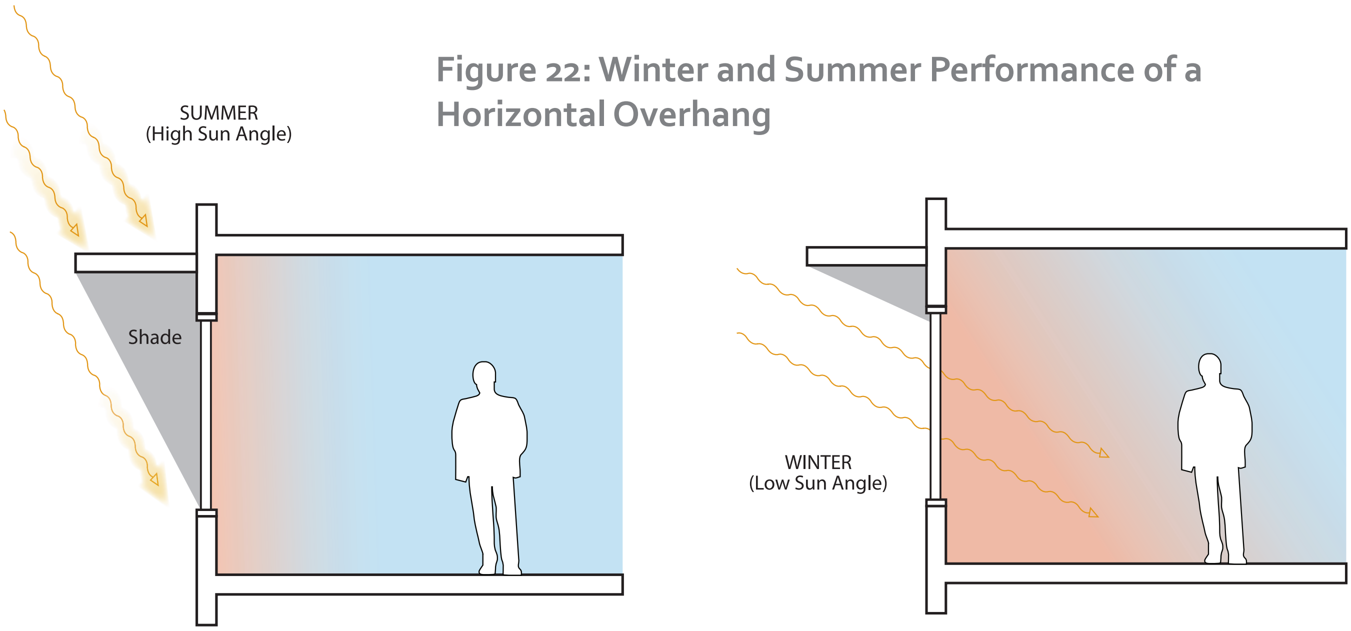


Figure 22: Winter and Summer Performance of a Horizontal Overhang

**CASE STUDY**

Turn to page 104 to learn how UBC's Liu Institute for Global Issues takes advantage of thermal mass.

### 4.7.2 Benefits

- Reduced demands on, and potentially eliminates the need for, active cooling systems.
- Reduced glare and improves thermal comfort by blocking direct solar gains.

### 4.7.3 Limitations

- The benefit of blocking direct solar gains in summer must be balanced with the desired benefit of solar heat gains in winter.
- Designers must consider practical issues such as window washing.

### 4.7.4 Synergies

- Building Orientation
- Daylighting

### 4.7.5 Vancouver Applications

- Shading elements should be designed according to their particular facade orientation and keeping in mind seasonal temperature variations and the changing angle of the sun.
- When designing fixed shading devices, it is important to consider how they will provide the appropriate performance to meet both winter heating and summer shading/cooling requirements.

## 4.8 Thermal Mass

### 4.8.1 Overview

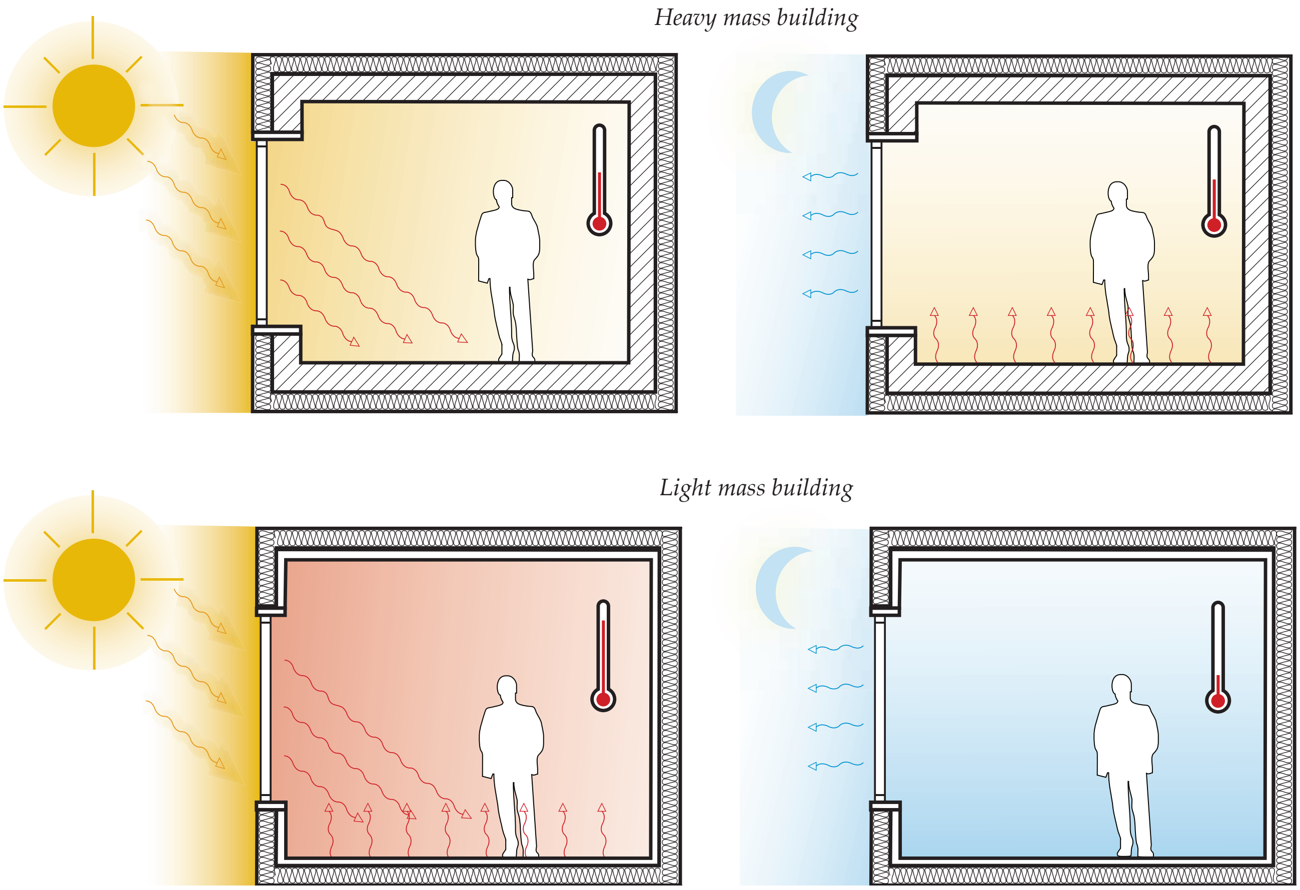
All matter has thermal mass, however when used in reference to a building, thermal mass generally means materials capable of absorbing, holding, and gradually releasing heat (thermal energy). Thermally massive materials absorb heat and slowly release it when there is a temperature difference between the mass and the surrounding space. When incorporated in a wall, for example, the mass acts as a heat sink, absorbing the heat and slowing its transfer through the wall.

Heavy, dense building materials with high specific heat like stone, concrete, brick, or adobe have high thermal mass. Lightweight, porous materials such as wood, insulation, and glass have low thermal mass.

During summer, thermal mass exposed to the interior absorbs heat from the space, including solar gains, and lowers the load on the mechanical cooling system. A thermally massive floor in a day-occupied building, for example, can be cooled overnight with cooler outdoor air. In the morning the cool mass will absorb solar and other heat gains from the space, providing the sensation of coolness from the floor. This has been shown to delay the onset of daily mechanical cooling and in some cases reduce or even eliminate the peak cooling demand. This delay is referred to as "thermal lag."

☐ Thermally massive materials absorb heat and slowly release it when there is a temperature difference between the mass and the surrounding space.

**Figure 23: Effects of Thermal Mass**



Thermal mass can have a negative impact on energy performance in some cases, where there is no opportunity to release heat into ambient air (in climates with no diurnal swing) or there is no opportunity for solar gains to be absorbed and stored (in climates with cold temperatures and low solar incidence).

### 4.8.2 Benefits

- Reduced annual energy use.
- Reduced peak demand.
- Maintains a more stable internal environment.
- Increased acoustic insulation of assemblies.
- Improved fire ratings of assemblies.

### 4.8.3 Limitations

- Without adequate direct solar radiation (i.e., on north-facing facades), thermal mass can result in increased energy consumption from the mechanical system when compared with lightweight construction.

### 4.8.4 Synergies

- Passive solar heating.
- Passive ventilation.
- Passive cooling and shading.

### 4.8.5 Vancouver Applications

- Thermal mass construction, when applied to the interior side of the insulation and exposed to the occupants and solar gains, will reduce heating energy requirements in the Vancouver climate.
- Thermal mass construction, when exposed to natural ventilation air flows and the occupants, will reduce cooling energy requirements in the Vancouver climate.
- Thermal mass can allow for natural, controlled moisture absorption and release in the Vancouver climate.

## 4.9 Thermal Insulation

### 4.9.1 Overview

Thermally insulating materials are poor thermal conductors that slow the rate of heat losses and gains to and from the outside. Effective thermal insulation is one of the most critical design parameters of building envelope.

This reduction of heat transfer is commonly expressed in terms of R-Value (and the metric equivalent, RSI-Value) and U-Value. Minimum R-Values and maximum U-values for key building envelope components are prescribed by current ASHRAE 90.1 building energy standards.

Thermal insulation also impacts the surface temperature on the

**R-Value / U-Value**

**R-Value and the metric equivalent RSI-Value:**
*Thermal resistance*

How well the material slows down the transfer of thermal energy.

**U-Value:**
*Heat transfer rate*

The intensity of heat transfer through the material.

**R ≈ 1/U**

envelope interior, which directly impacts thermal comfort. Interior envelope surface temperatures must remain high enough during winter to avoid condensation and maintain occupant comfort. Cold surface temperatures (i.e., windows) affect occupant comfort by both radiation and convection.

To achieve consistent thermal insulation of the building envelope, assemblies must be carefully detailed with continuous thermal breaks. Thermal breaks use non-conductive materials to separate conductive materials to avoid degrading the envelope's thermal insulation, a common problem called thermal bridging.

### 4.9.2 Benefits

- Reduces heating and cooling losses/gains and energy consumption.
- More stable interior surface temperatures increases thermal stability in the conditioned spaces.

### 4.9.3 Limitations

- Rate of diminishing returns, best investigated with building simulations.

### 4.9.4 Synergies

- Infiltration and air tightness.
- Window performance.

### 4.9.5 Vancouver Applications

- Thermal insulation must be better than the current standard (ASHRAE 90.1 v.2007) in order to maintain comfort with window to wall area ratios optimized for heating and cooling.
- Minimize thermal bridging to ensure the targeted overall R-values (RSI-Values) and U-values of envelope assemblies are achieved.

## 4.10 Air and Moisture Tightness

### 4.10.1 Overview

The air and moisture tightness of a building's envelope is a critical factor in its thermal performance and durability. It is also indirectly related to the building's ventilation system.

Undesirable air movement through the envelope can occur in either direction: infiltration is movement of exterior air into the building, and exfiltration is leakage of interior air to the exterior. Infiltration and exfiltration can occur at the same time through different unintentional paths such as cracks around windows and doors or improperly sealed construction joints. They are caused by air pressure and temperature differences across the building envelope due to differences in air density between warm and cold air. Greater differences in pressure and temperature cause greater rates of infiltration and exfiltration.

Indoor air and outdoor air are not only different temperatures most of the time, but they also contain different amounts of moisture in the form of water vapour, which diffuses with the air. In the Vancouver climate this diffusion is predominantly from the warmer, more humid interior side (due to internal moisture gains) toward the cooler, less humid exterior side. If moisture is allowed to diffuse through the envelope, it will eventually reach the colder portion of the envelope assembly, where it will condense as the envelope temperature drops below the dew-point temperature (see Appendix C.2).

An incorrectly detailed building envelope with undesirable air and moisture diffusion typically has the following negative effects:

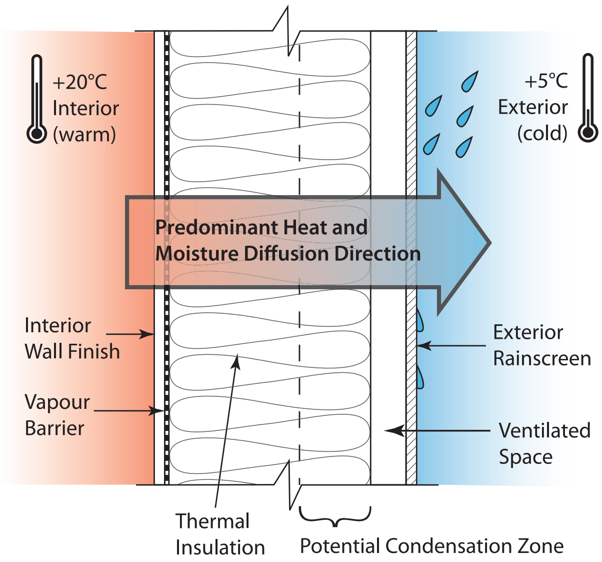
- Reduced thermal insulating value of the envelope resulting in excessive heat losses and increased heating energy requirements.
- Uncontrolled air and moisture exchange between the exterior and interior.
- Potential condensation within the envelope.
- Physical damage of the envelope components from condensation (e.g., corrosion of metals, rotting of wood).
- Potential occupant health impact associated with mildew and fungus growth resulting from the trapped moisture within the envelope.

To avoid these negative impacts, a building's envelope must be completely air- and moisture-tight. Depending on the envelope type, different approaches to achieve air and moisture tightness are required:

### 1. Lightweight envelope

For most conventional lightweight envelope assemblies (e.g., steel or wood frame), air and moisture tightness is best achieved by applying both a continuous vapour barrier on the interior side of the envelope, at or just behind the finished surface layer, and a continuous rain screen on the exterior face of the envelope with a narrow, vented air gap separating it from the insulation. This configuration keeps the moist air in the space and precipitation on the outside. (The interior moisture is removed by proper ventilation.) Provided the continuity of the vapour barrier and rain screen is achieved (by careful design and installation), the resulting envelope is completely air- and moisture-tight and thus avoids negative impacts such as the risk of condensation and reduced thermal insulation value.

Figure 24: Air- and Moisture-tight Envelope (Conventional, Lightweight Assembly)



## 2. Heavy-weight envelope

High-performance heavy-weight envelopes should have "sandwich-like" assemblies with a relatively thick layer of concrete or masonry facing the interior and a layer of thermal insulation with a protective vented rain-screen facing the exterior.
The dense and massive concrete or masonry layer is sufficiently air tight to keep infiltration and exfiltration at acceptable levels. Unless the interiors have consistently high humidity levels, as might be the case in a commercial kitchen, vapour barriers (e.g., waterproof coating, membrane, ceramic tile, etc.) on the interior surface may not be essential. As massive materials are also porous to a certain degree, they can absorb and release moisture from the indoor air. When combined with continuous exterior thermal insulation to keep the mass temperature above the dew point, the massive layer can absorb and release moisture safely without risk of condensation and its related negative impacts. This continuous thermal insulation on the exterior side is critical to both improving energy performance and avoiding condensation. (Proper application of air and vapour barriers must be considered with a qualified building envelope consultant on a project-specific basis.)

Insulating heavy mass envelope from the inside requires a vapour barrier, since the potential condensation zone extends all the way to the insulation. Inside insulation also creates undesirable thermal bridges at floor-to-wall interfaces that are prone to condensation and compromise the thermal insulation value of the envelope.

Traditional non-tight envelopes had high infiltration/exfiltration rates (often more than 1 air change per hour, or ACH) that were actually—and unintentionally—high enough to meet ventilation requirements. However, this undesirable, uncontrolled ventilation increased heating energy requirements and often caused condensation and its related negative impacts. Although in Vancouver's mild climate the energy penalty for a non-tight envelope is not as severe as in the rest of Canada, uncontrolled air and moisture diffusion through the envelope is still undesirable. Properly designed and built air- and moisture-tight envelopes typically limit uncontrolled air exchange to less than 0.2 ACH. As a result, the space ventilation must be provided by separate means to provide sufficient fresh air for building occupants.

☐ Buildings in Vancouver should have properly detailed and constructed air- and moisture-tight envelopes.

Space ventilation can be fully active with fans and heat recovery ventilation (HRV) units, fully passive with operable windows, or a mixed-mode system that combines the two. Most locations at Vancouver's latitude have harsher climates with much greater heating-dominant requirements. In these climates, year-round reliance on fully active HRV is typically recommended as the most energy-efficient means of providing ventilation in air-tight buildings. However, in Vancouver's milder climate, the most energy-efficient solution is the mixed-mode ventilation approach, relying on HRV during heating season only and relying on passive ventilation strategies for the rest of the year. (See Appendix E - Energy Modeling for modeling results that illustrate the greater efficiency of a mixed-mode system in the Vancouver climate.)

### 4.10.2 Benefits

- A properly detailed and installed air- and moisture-tight envelope improves building energy performance and mitigates the risk of condensation and its related negative effects.

### 4.10.3 Limitations

- Tighter envelopes require greater care to avoid leaks from face seals.
- An inadequately detailed and/or installed air- and moisture-tight envelope can result in cumulative moisture and condensation buildup within the envelope. This will result in compromised energy performance and other negative effects.

### 4.10.4 Synergies

- Passive and mixed-mode ventilation strategies.
- Certain shading devices can also serve as additional rain protection for the envelope.

### 4.10.5 Vancouver Applications

van:app

Buildings in Vancouver should have properly detailed and constructed air- and moisture-tight envelopes. Passively designed buildings should also incorporate a mixed-mode ventilation approach, relying on HRV during heating season only and relying on passive ventilation strategies for the rest of the year.

# Appendix A – Glossary of Key Terms

| | |
|---|---|
| Annual Heating Plant Energy | The annual total of the heating energy consumed by the heating plant, measured in kWh. |
| Annual Space Heating Energy | The annual total of the heating energy delivered to the space, measured in kWh. |
| Annual Ventilation Heating Energy | The product of the instantaneous ventilation heating loads (kW) and the duration for which it is required (h), measured in kWh. |
| Annual Ventilation Cooling Energy | The product of the instantaneous ventilation cooling loads (kW) and the duration for which it is required (h), measured in kWh. |
| Computational Fluid Dynamics (CFD) | Complex numerical analysis using fluid mechanics theory to analyze fluid flow and heat transfer conditions within the defined space boundaries. In many cases results are available in a graphical display. |
| Cooling Design Temperature | The outdoor temperature equal to the temperature that is exceeded 1% of the number of hours during a typical weather year. |
| Distribution System Energy | The energy consumed by all the equipment making up a mechanical system, excluding the heating and cooling generating equipment. This value is the product of the rated power of each piece of equipment (kW) and the operating duration (h) and is measured in kWh. |
| Efficiency | The ratio of the quantity of useful energy generated by a system to the quantity of energy put into the system. |
| Energy Intensity | A normalized unit to measure the amount of energy used per unit area, allowing energy performance comparisons between different buildings, usually measured in $kWh/m^2$ year. |
| Free Run Temperature | The natural space temperature inside the building operating in an entirely passive mode with no mechanical systems to heat, cool, or ventilate. |
| Heat Transfer | Heat energy moves in one direction - from hot to cold. Heat transfer occurs in three ways; conduction, i.e., touching a stove element; convection, i.e., warm air flows up from the stove element; or radiation, i.e., the heat you feel next to the stove element. In a building, all three modes of heat transfer occur and impact the comfort level inside. |
| Heating Design Temperature | Outdoor dry bulb temperature equal to the temperature that is exceeded at least 99.6% of the number of hours during a typical weather year. |
| Mean Radiant Temperature | A measure of an occupant's perception of radiant temperature from all surfaces in the space. |
| Peak Operating Efficiency | All mechanical equipment has an efficiency curve that is dependent on the capacity that is required. For example, a boiler is designed to provide 100 kW of heating. The boiler will be most efficient when 100 kW of heating are required. If only 20 kW of heat are required, the boiler will operate at a reduced efficiency and will consume excess fuel energy for the amount of heat it can produce. |
| Peak Space Heating Load | The instantaneous amount of heat the building will require during the coldest time of the year in order to maintain a specific indoor temperature, measured in kilowatts, kW. This is the amount of heat that the system must be able to provide to the space to make up the heat loss through the windows, walls, floors and roof. |

| | |
|---|---|
| Peak Ventilation Load | The instantaneous amount of heat energy required to bring ventilation (outdoor) air to the temperature required for delivery to the occupied space, measured in kW. |
| Resultant Temperature | The average of the mean radiant temperature and the air temperature. This measurement is the best indication of the temperature perceived by an occupant. Also known as Operative Temperature. |

# Appendix B – Thermal Comfort

## B.1 Parameters

### Table 3: Factors Influencing Thermal Comfort Perception

| Environmental Factor | Heat and Mass Transfer Process | Portion of Total Perception of Thermal Comfort |
|---|---|---|
| Air temperature | Conduction (direct contact) | 6% |
| Temperature of the surrounding surfaces | Radiation (rays) | 50% |
| Air velocity and air movement distribution | Convection (movement of a fluid) | 26% |
| Air humidity | Evaporation (heat removed in phase change from liquid to gas, e.g., sweat) | 18% |

There are other factors influencing comfort which are just as important as the factors listed above, however, they are seldom considered during building and system design.
They include radiant asymmetry, vertical air temperature gradient, and thermal stability. Radiant asymmetry refers to uncomfortable conditions caused by two nearby surfaces having very different temperatures. Too large a vertical air temperature gradient, the difference in temperature from head to toe, can also cause discomfort. Finally, comfortable conditions require thermal stability (i.e., relatively constant thermal conditions over time).

If neglected, these factors can result in perceived discomfort and unnecessary energy consumption even though the building fully meets the primary conditions. For example, the localized radiant effects of a cold or hot window surface (winter/summer) cause thermal discomfort even though the space air temperature is maintained within the design comfort range by the mechanical system. This condition cannot be corrected by simply adjusting the space air temperature. Instead, it requires careful design of the building fabric to better control the surface temperatures.

## B.2 Fanger Model

The Fanger Thermal Comfort Model (named after Danish researcher Ole Fanger) is the most widely used model. It determines comfort as a function of a limited set of parameters: air temperature, relative humidity and air motion in relation to the occupant's activity level (i.e., metabolic rate) and clothing.

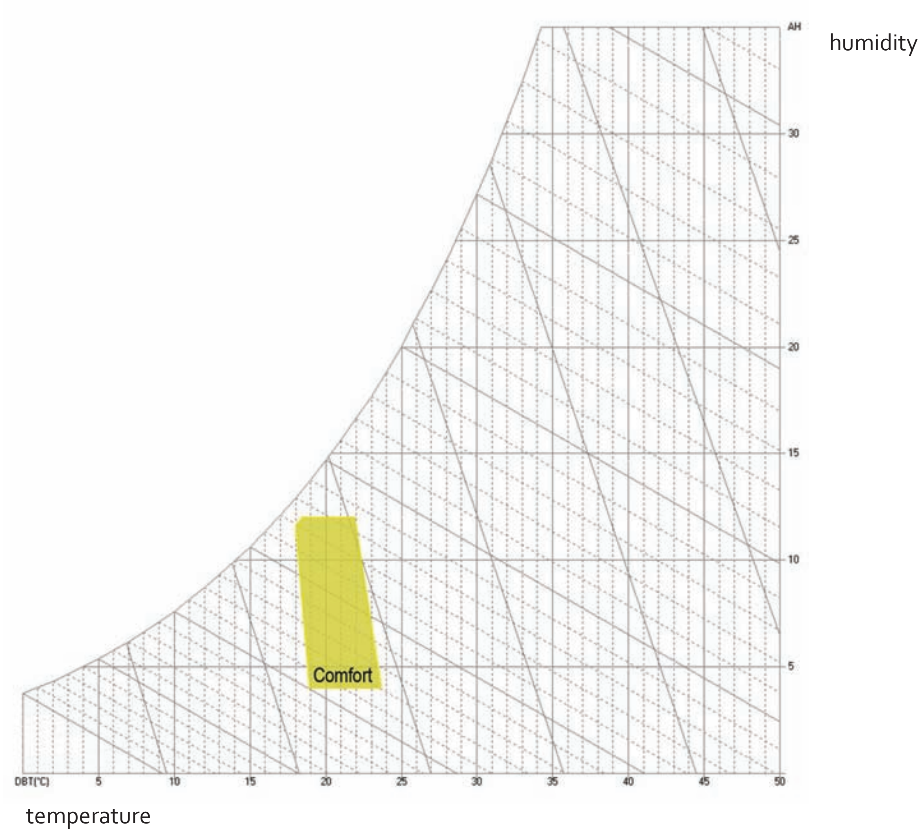
The Fanger Model was developed from the results of controlled laboratory experiments. It prescribes a relatively narrow range of acceptable thermal comfort parameters, most often defined in a further simplified relationship between only two parameters; the operative temperature and relative humidity (see Figure 25 below). The acceptable indoor conditions do not vary with outdoor conditions on a daily or yearly basis. The prescribed range of acceptable conditions falls within a relatively narrow range (i.e., 20°C at 30% RH for heating, and 22°C at 60% RH for cooling year round). This results in heavy reliance on active mechanical systems regardless of the outdoor climatic conditions, which can lead to unnecessary energy consumption.

Although this comfort model clearly identifies two separate comfort regions for heating and cooling seasons, respectively, the majority of current buildings are designed to a fairly narrow comfort zone representing the winter performance, which is maintained by mechanical systems year round.

## B.3 Adaptive Model

While the Fanger Model is widely used and it is appropriate for mechanically conditioned and ventilated buildings, it does not adequately define thermal comfort when passive conditioning and natural ventilation are introduced.

**Figure 25: ASHRAE Comfort Zones as Defined by the Fanger Model**



As such, it eliminates many passive systems from the design. Furthermore, it does not always reflect occupant comfort perfectly. Therefore, another model; the Adaptive Thermal Comfort Model, has been developed from surveys of acceptable thermal comfort conditions in actual buildings. The Adaptive Thermal Comfort Model correlates outdoor conditions with indoor conditions and allows a wider range of acceptable thermal parameters within its definition of comfort, making it more suited to buildings with passive conditioning and natural ventilation.

The conditions defining human perception of thermal comfort are not fixed, but are subject to gradual drift in response to changes in both outdoor and indoor thermal environment. The human body is able to adjust its metabolic rate in response to changes in climate throughout the year, and as a result, occupants' definition of comfort actually changes based on the season and location. For example, a sudden change of temperature is likely to provoke discomfort and complaint, while a similar change, occurring gradually over several days or longer, would be compensated by a gradual corresponding change of clothing and adaptation to the new thermal conditions and would not provoke a complaint. For passively designed and operating buildings the observed comfort temperature proved to be almost linearly dependent on the past outdoor temperature.

The fundamental assumption of the adaptive approach to thermal comfort is expressed by the adaptive principle: "If a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort". People will make adjustments to their activity, clothing, posture, and/or adjust required elements of their surrounding (i.e., open or close windows, pull down blinds, etc.) to improve their thermal comfort. In addition to these adjustments, they acclimatize to the new thermal conditions. Therefore, in addition to the optimized passive building design, adequate provisions and ways for occupants to adjust their thermal environment need to be provided.

In a well-designed passive building operating in Free Running mode (see Section 2.2.3 and Appendix B.4), indoor thermal conditions change only gradually in response to changes in the weather. In the mild Vancouver climate, it is possible to achieve a passive building design that would be able to maintain acceptable thermal comfort conditions within the parameters of the Adaptive Model for the majority of the year, with the exception of the coldest outdoor temperatures during winter. With the proper passive design, the building's reliance on active mechanical systems and resulting energy requirements can be significantly reduced.

The required strategies to achieve such passive performance are discussed in Section 3 of this toolkit.

## B.4 Free Run Temperature

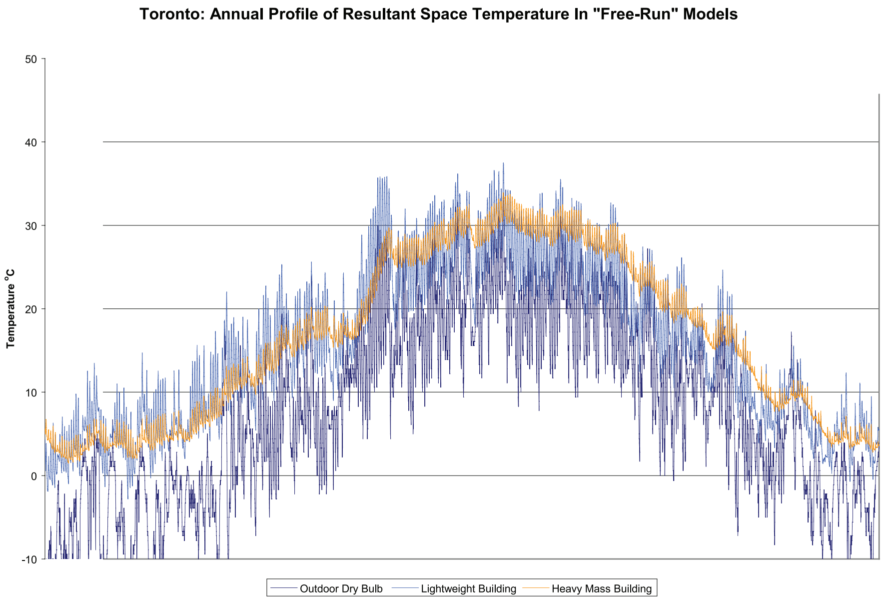
The original FRT methodology was developed at the Swiss Federal Institute of Technology. It is based on the notion that "any building in any climate develops its own temperature behaviour pattern under the influence of its passive building components and the climate alone".

The FRT methodology can serve as a valuable tool during the early stages of building design. Widespread availability and use of powerful advanced building energy simulation tools make generating a detailed FRT profile relatively easy.

The FRT methodology is one of the most effective and accurate means for optimizing passive building design strategies.

Figure 26 below displays an example of FRT profile results. In this case, the two simulated buildings were identical except for the amount of mass in their building constructions. The temperature difference during peak summer conditions represents the potential energy savings from reduced peak load. That is, by lowering the temperature the building reaches on its own, without any mechanical systems, the peak demand on the mechanical systems is lowered.

## Figure 26: Example of a FRT Profile



# Appendix C – Vancouver Climate Characteristics

## C.1 Overview

Detailed weather data is necessary for the concept analysis of shading, envelope, passive and active solar heat gain, building system energy and plant capacities. Comprehensive hourly data, required for envelope, building system energy and plant capacity analysis, is only available for Vancouver International Airport, which is located just southwest of the city, on the shore of Georgia Strait.[9]

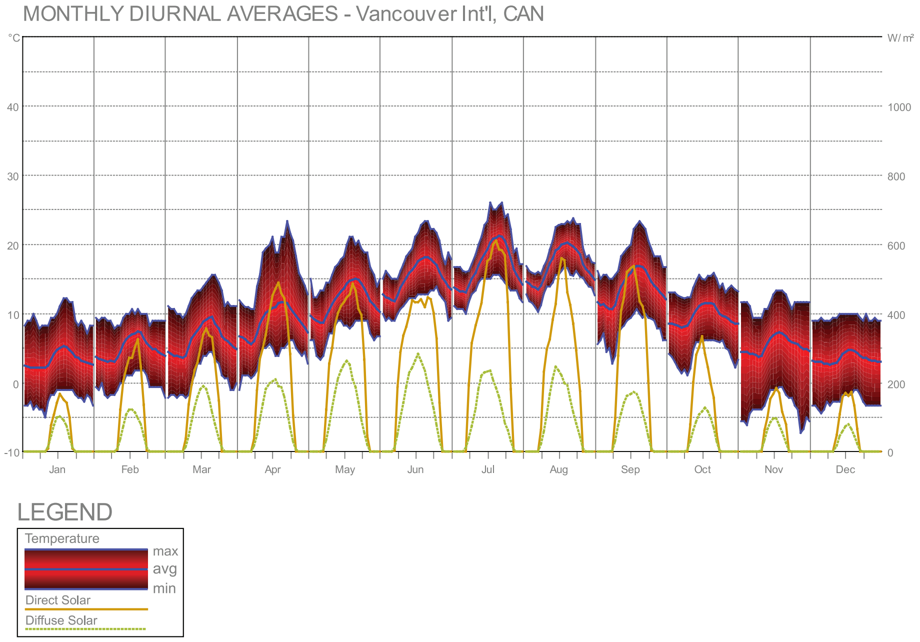
The following graph shows the typical daily weather profile for each month from the Vancouver weather file.

## C.2 Air Temperature and Humidity

There are several ways to express the moisture properties of air. The psychrometric equations relate dry bulb temperature, absolute humidity (moisture quantity in the air expressed in grams of water per kilogram of air), relative humidity, wet-bulb temperature and dew point.

The relative humidity, expressed as a percentage, is commonly used when discussing the moisture content of air. However, this parameter is easily misinterpreted, especially in cold

Figure 27 : Monthly Diurnal Averages



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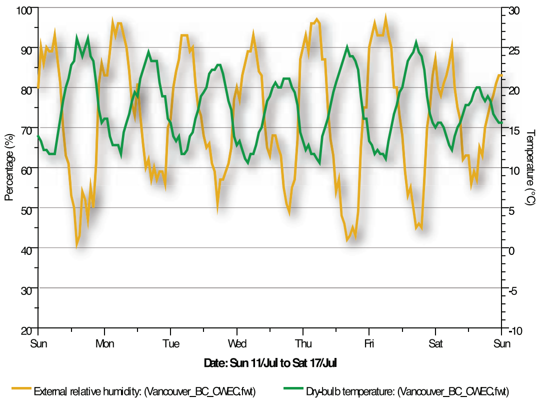
[9] Energy simulations and any hourly analysis done with computer software require a weather file containing various data sets, such as air temperature and wind speed. The file from Canadian Weather for Energy Calculations (CWEC) is used throughout this analysis. It is publicly available and is a derived file covering 30 years of historical data.

conditions. High relative humidity is often mistaken for high humidity under any conditions, but this is not the case. For example, 10°C air with 80% relative humidity has a humidity ratio of 7 g water/kg air, whereas 30°C air with 80% relative humidity has a humidity ratio of 22 g water/kg air – more than three times greater. This is especially relevant to Vancouver; our high relative humidity levels at our corresponding low air temperature represent only mild levels of absolute moisture quantity in the air.

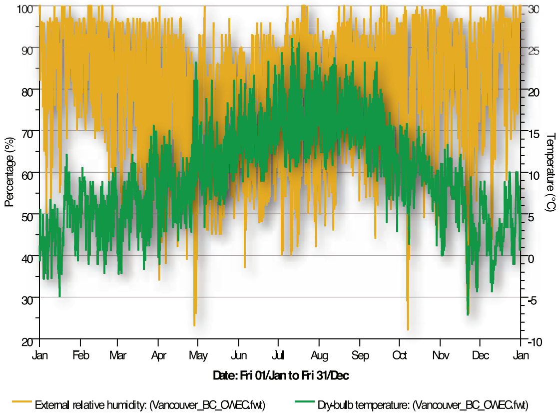
Furthermore, cold outdoor air with high relative humidity becomes dry indoor air once passed over sensible heating coils; the amount of moisture remains constant, but the volume of the air increases and therefore the relative humidity percentage drops. For this reason, the relative humidity of the ambient outdoor air is not always the best indicator of indoor air conditions for this climate.

With the detailed relative humidity and dry bulb temperature data in the weather file, other air moisture properties can be calculated using the psychometric relationships. In this report, we use the dew point temperature to help guide the passive design process, not the relative humidity. Dew point temperature represents the temperature at which condensation occurs. Dew point temperature is important when assessing building envelope construction, internal surface temperatures, ventilation air humidification/dehumidification, and mechanical systems such as radiant cooling. The annual dew point temperature profile was generated using weather data from Vancouver International Airport. The annual maximum dew point temperature is 18°C, and occurs early in September, because Vancouver summers are relatively warm and dry.

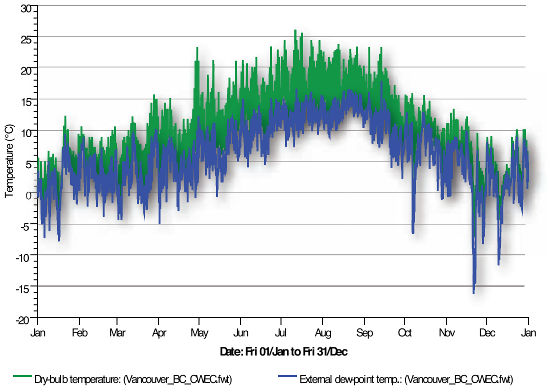
## Figure 28: Summer Dry Bulb Temperature and Relative Humidity Profile



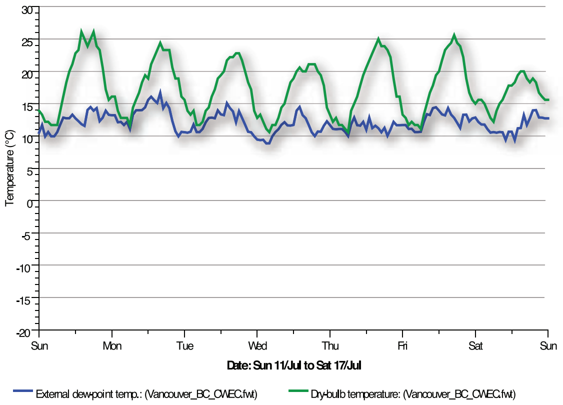
## Figure 29: Annual Dry Bulb Temperature and Relative Humidity Profile



## Figure 30: Annual Dry Bulb Temperature and Dew Point Temperature Profile



## Figure 31: Dry Bulb Temperature and Dew Point Temperature Profile: Second Week of July



## Figure 32: Dry Bulb Temperature and Dew Point Temperature Profile: Last Week of November

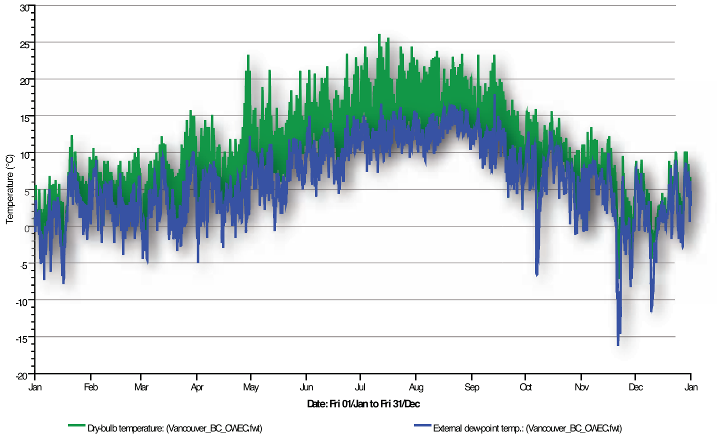
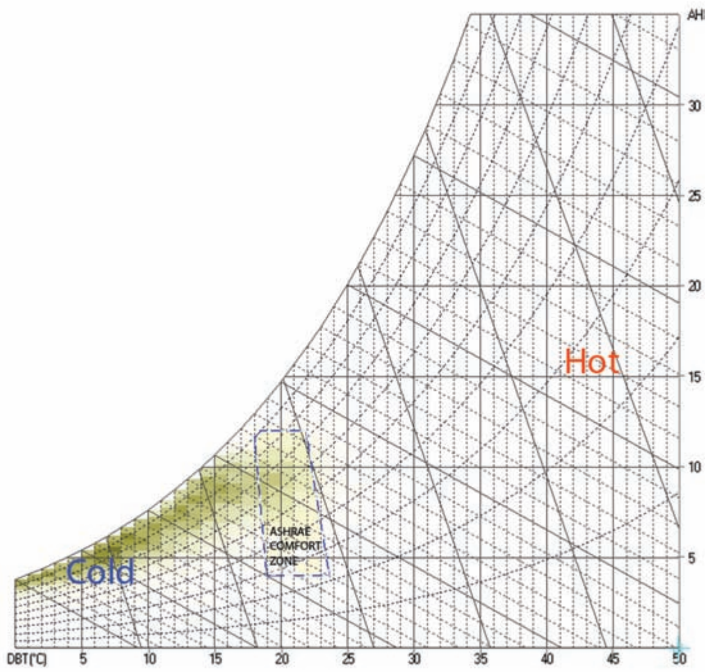


Figure 33 below shows the annual and seasonal outdoor air conditions in Vancouver on a psychrometric chart. The blue box indicates the ASHRAE standard 55 comfort range. Data points to the left and below this range indicate times when outdoor air is cooler than the desired operating temperature. Data points to the right and above are times when the air is warmer.

## Figure 33: Annual Cumulative Frequency of Outside Air Conditions in Vancouver



When no passive design features are implemented, the data points outside the comfort range (i.e., the blue box) represent times when mechanical heating or cooling is required.

Incorporating passive design features expands the range of outdoor conditions during which indoor comfort conditions can be maintained without mechanical heating or cooling. (See also Figure 7.)

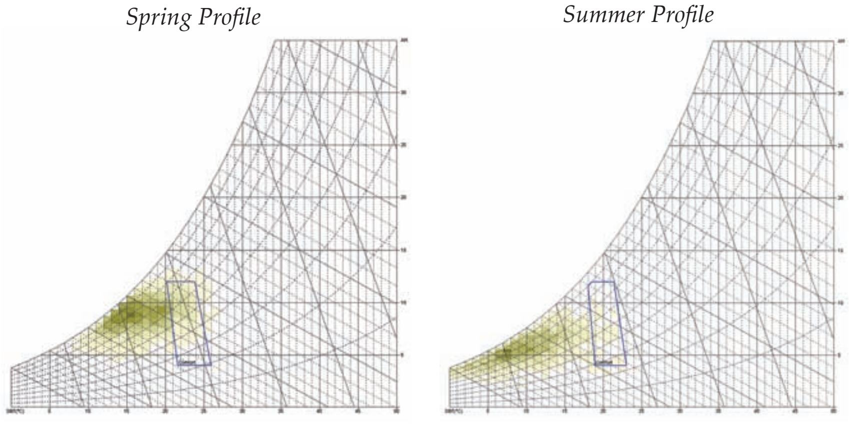
## C.3 Solar Radiation

Many days during spring receive up to 450 W/m$^2$ of global radiation (on a horizontal flat plane), and the maximum value during summer is 880 W/m$^2$.

Solar radiation affects the design of thermal mass, solar shading, window parameters, and active solar energy systems (i.e., photovoltaics and hot water heating).

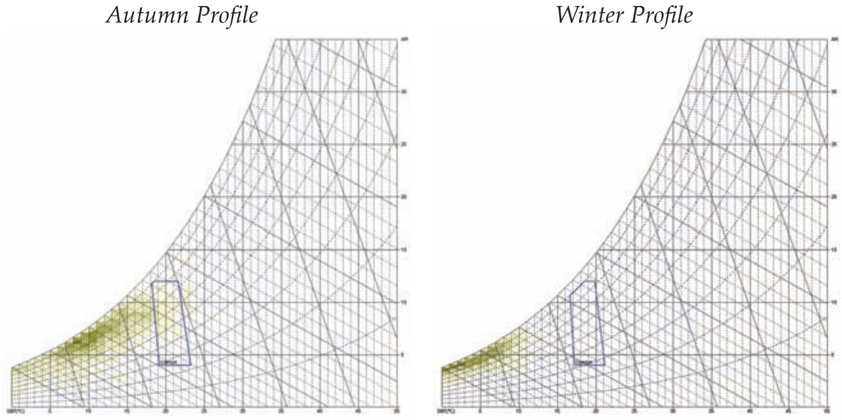
The average daily solar radiation profile for each week in the year is shown in Figure 35, extracted from the Vancouver weather file.

**Figure 34: Seasonal Cumulative Frequencies of Outside Air Conditions in Vancouver**



*Spring Profile*

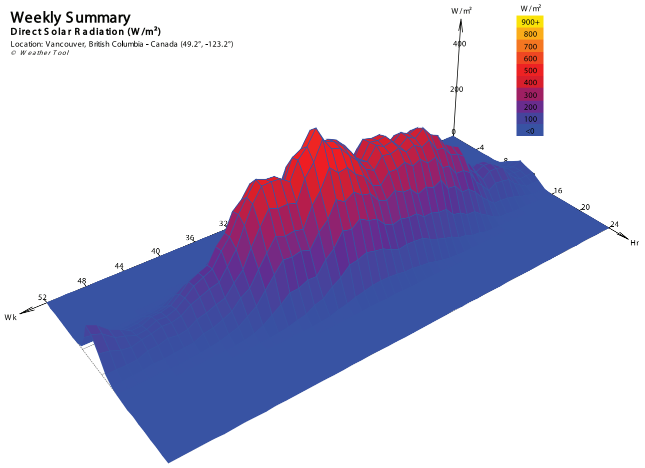
*Summer Profile*



*Autumn Profile*

*Winter Profile*

## Figure 35: Direct Solar Radiation (W/m²)



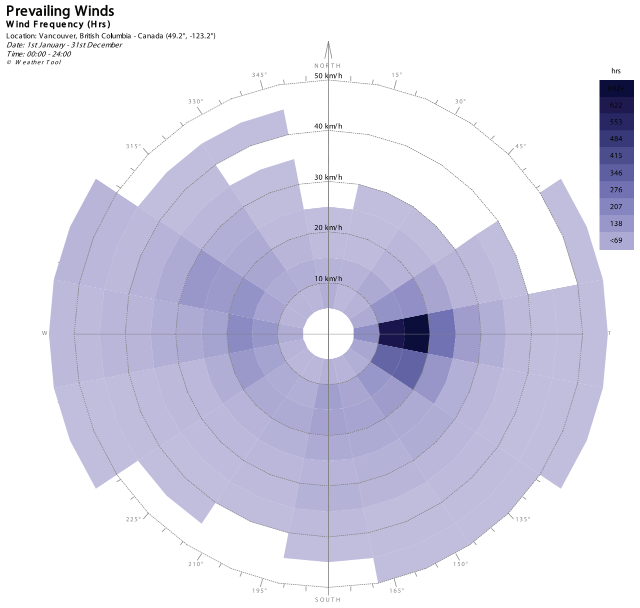
*Sun Up/Down December 21st: 8:05 PST to 4:17 PST (8 hours and 12 minutes of daylight)*
*Sun Up/Down June 21st: 5:07 PSD to 21:22 PSD (16 hours and 15 minutes of daylight)*

## C.4 Wind

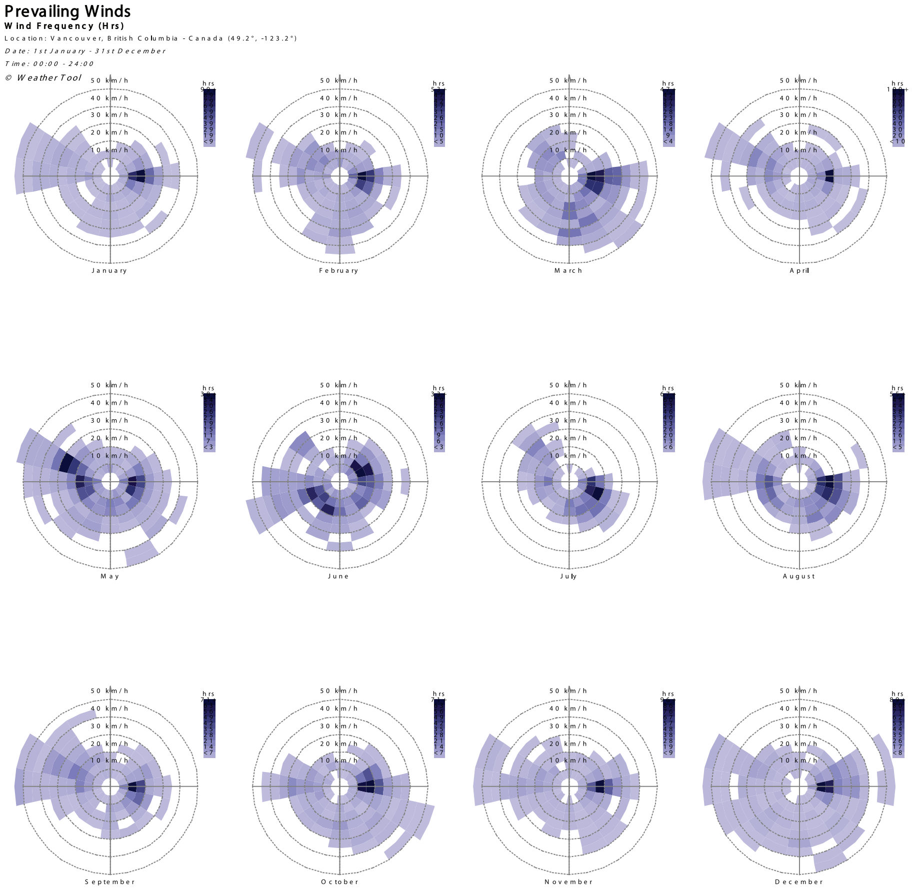
Wind data is important when designing naturally ventilated buildings, operable window and louver placement, and local wind power generation.

Wind is specific to a site's surroundings and is strongly influenced by adjacent buildings and terrain, open fields or bodies of water, and even parking lots and trees. If advanced natural ventilation designs are pursued, a weather station is set up on the site as early as possible to collect real, site-specific wind conditions and patterns for use in design and energy simulations.

## Figure 36 : Annual Wind Cumulative Frequencies



## Figure 37 : Monthly Wind Cumulative Frequencies



## C.5 Precipitation

The average total precipitation in Vancouver ranges from a low of 39 mm in August to a high of 180 mm in November. The average monthly total rainfall is 96 mm, and most of the annual rainfall occurs between October and March. Considering rainfall is important when assessing rainwater harvesting and storm water management.

Vancouver receives an average of 48 cm of snow per year, with a maximum depth accumulated in January averaging at 16.6 cm deep. Snowfall is an important consideration when exploring active solar systems using solar collector panels.

## C.6 Outdoor Design Temperatures

Historical weather data for Vancouver indicates an extreme minimum temperature of -17.8°C in 1950 and an extreme maximum temperature of 33°C in 1960. Site microclimate will also influence outdoor air temperatures, and it is possible that a particular site could experience even higher air temperatures during summer. However, when establishing heating and cooling design temperatures for a building, it is not reasonable to design to these extremes, as the resulting systems and equipment will be dramatically oversized and operate at low efficiency most of the time. Rather, it is common practice to use established design conditions as defined by the BCBC and ASHRAE Standard 90.1. The published Vancouver design conditions appear in Section 2.3.

# Appendix D – Energy Performance Targets

Neither of the common North American building standards defines building energy performance targets in measurable energy units. Instead they establish the energy performance of active components such as HVAC equipment (not systems), service water heating efficiency and lighting power density in terms of equipment efficiencies.

This methodology essentially creates a non-existent target for energy performance. There is no established benchmark of energy performance in easily comparable energy units. With no clear target to aim for, it becomes difficult for the proposed design to achieve its low-energy goals.

The modeling protocol required by the standards further complicates the situation by requiring detailed data on active systems before any energy analysis can be performed. These parameters are seldom clearly defined at early design stages, so the focus tends to shift to optimizing the active system components without adequate consideration for first optimizing passive features.

Millennium Water Photo: Merrick Architecture

# Appendix E – Energy Modeling

## E.1 Introduction

Advanced building energy simulation software was used to calculate the effects of the passive building design elements discussed in this toolkit. Each element was simulated on a control building to find the amount of energy needed to maintain comfort in the occupied space year round. The models were set to isolate the interaction between the building and climate from other variables. These results represent parametric ideal situations useful for demonstrating the thermal principles and relative energy performance of each measure.

In a realistic building multiple elements may be installed and often the elements will interact with each other. Both the potential synergies and complications are discussed in the relevant element's results discussion. Also, to further explore this interaction, passive heating and cooling strategies comprised of multiple elements were simulated.

The assumptions, simulation inputs, results and analysis are provided in this appendix. The study conclusions are summarized in the main body of the report.

## E.2 Study Cases

Calculate the annual heating and cooling energy required at the space level in a control building to demonstrate the effect of the following passive building elements and strategies:

**Passive Building Elements**

1. Building Orientation
2. Space Planning
3. Window to Wall Area Ratio
4. Window Performance
5. Solar Shading
6. Thermal Mass
7. Thermal Insulation
8. Infiltration and Air tightness

**Passive Building Strategies**

9. Passive Heating
10. Passive Cooling
11. Residential Applications
12. Commercial Applications

### E.2.1 Assumptions and Inputs

The baseline parametric model is a 3 storey square building with 9 square spaces per floor and in all cases is simulated using the same Vancouver CWEC weather file.

This geometry was selected to provide equal comparison between facades and to provide simulation result data in all three typical floor scenarios: floors in contact with the ground; floors that have roof surfaces exposed to the outdoors; and, the most typical arrangement in Vancouver's high rise market, both floor and ceiling in contact with an adjacent occupancy.

The building is aligned square north-south in all of the element and strategy simulations, with the exception of the orientation study.

As this study investigates the passive response of the building features the variable and subjective simulation parameters of internal heat gains and mechanical systems were intentionally omitted. Results are presented in terms of the energy intensity in kWh/m² yr and represent the space heating and cooling energy requirement at the space level. Other building energy flows such as domestic water heating, fan and pump power were also omitted from the analysis and no systems or efficiencies were included.

Ventilation air tempering in the baseline model is generally omitted from the analysis where passive envelope features are studied.

Where the performance of the passive element has an effect on, or may be affected by ventilation a separate base case with ventilation was created and the presented results include the energy required to temper the ventilation air.

In cases where it is believed the internal heat gains will play a role in the interpretation of the results and application of the measure a commercial office building schedule was assigned. Those cases are noted as commercial schedule and a separate base case with the commercial schedule was created.

Tables outlining the modeling inputs for the baseline, as well as the passive element and strategy studies, are presented in the following sections.

### E.2.2 Methodology

The overall study methodology consists of the following steps:

1. The baseline model was simulated for one year and was calibrated by comparing the results with published energy use data for actual buildings in British Columbia as well as previous modeling experience.
2. Each passive element was simulated independently on a copy of the baseline building. Iterations were conducted on several of the measures to produce data ranges to identify trends and patterns.
3. The results of each element were analyzed and potential combinations of elements were identified.
4. These element combinations defined the strategies proposed for the Vancouver climate and those strategies were simulated to demonstrate the compounding effect as each measure was added.

Additional notes on the methodology for the simulating each of the elements and strategies are noted in the respective sections.

### E.2.3 Results and Conclusions

The simulation results and conclusions are presented in the following sections. Results for all spaces in each simulation are available; however only results for specific spaces were presented for the purpose of this study.

Typically results are presented for the most relevant extreme spaces, however the entire data set could be provided upon request.

## E.3 Baseline Model

The baseline model is the simplest model and is simulated for comparison between passive envelope elements. The settings represent current market practice in Vancouver with envelope assemblies meeting the Vancouver Building By-law (2007) requirements. Internal heat gains and ventilation air tempering are not included to isolate the passive building behaviour.

### E.3.1 Assumptions and Inputs

| | | |
|---|---|---|
| Wall RSI value: | R2.3 (ASHRAE 90.1)<br>exterior wall with 100mm concrete outside | m²K/W |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | m²K/W |
| Window U value: | U2.3<br>double pane windows | W/m²K |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 60% | |
| Infiltration | 0.5 | ACH |
| Room resultant temperature set points : | 21 - 24 | °C |
| RH: | 0-100<br>not controlled | % |
| Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |

### E.3.2 Methodology

1. Simulate the baseline model for one full year.

2. Extract and record the annual heating and cooling results.

### E.3.3 Results

The baseline results were not generated to act as a prescriptive energy target because the variable and subjective inputs of internal gains, ventilation rates and mechanical systems were not included. Rather, the results are intended to be used in the relative comparison of the effects of the

While most of Vancouver is aligned to a north south grid, downtown Vancouver is aligned at a 45° angle from north-south.

various passive measures and are presented as such in the following sections.

## E.4 Orientation

This set of simulations compared four spaces on the middle floor of the parametric model in two different orientations. The first orientation represents most of Vancouver, oriented with the street grid aligned north south.

The second orientation represents the downtown peninsula aligned at an angle roughly 45° from north-south. The simulation results represent an identical space with one external wall in 8 different orientations.

### E.4.2 Methodology

1. Simulate the baseline model aligned square to the north.
2. Simulate the baseline model aligned 45° from north.
3. Extract results for the mid-facade space of the middle floor in each model, for a total of 8 sets of results.

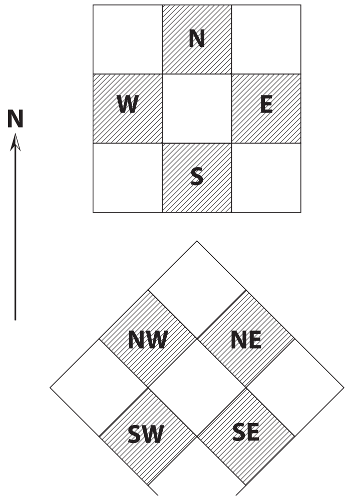


*Figure 38: Model orientation for the north-south aligned model, at top, and the 45° aligned model to represent Vancouver's downtown peninsula.*

### E.4.1 Assumptions and Inputs

| | | |
|---|---|---|
| Wall RSI value: | R2.3 (ASHRAE 90.1)<br>exterior wall with 100mm concrete outside | m²K/W |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | m²K/W |
| Window U value: | U2.3<br>double pane windows | W/m²K |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 60% | |
| Infiltration | 0.5 | ACH |
| Room resultant temperature set points : | 21 - 24 | °C |
| RH: | 0-100<br>not controlled | % |
| Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |

## E.4.3 Results

*Figure 39: Annual heating and cooling energy intensity for mid-wall spaces on the middle floor, each space has one external wall exposed to the direction noted (Building aligned north-south).*

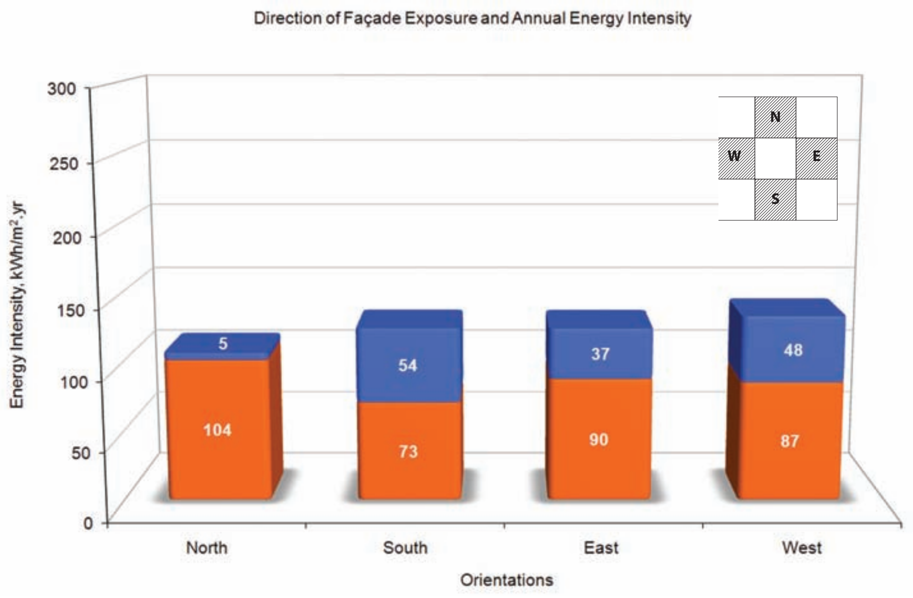
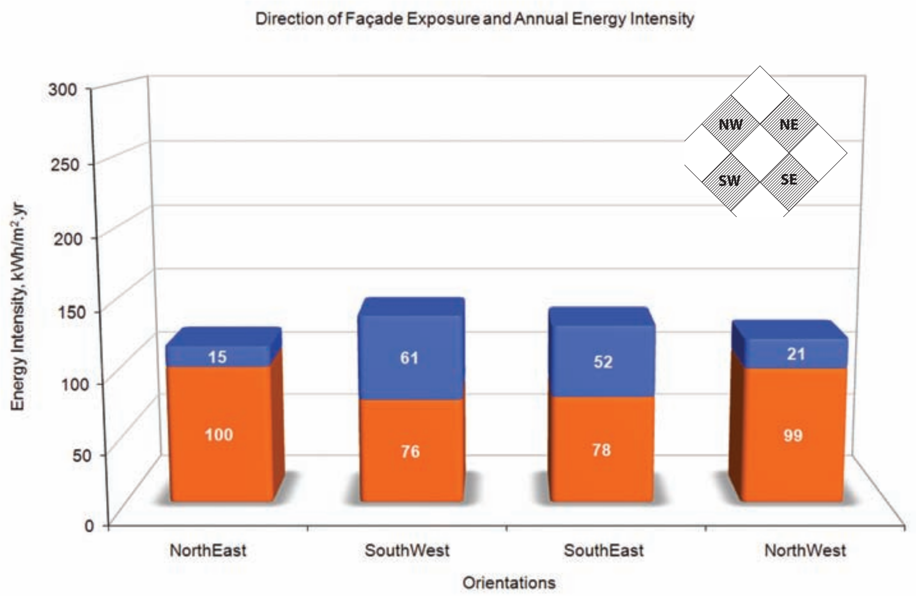


*Figure 40: Annual heating and cooling energy intensity for mid-wall spaces on the middle floor, each space has one external wall exposed to the direction noted (building aligned 45 degrees from north).*



### E.4.4 Conclusions

- Spaces with southwest exposure have the highest total energy requirement; however they have the lowest heating energy requirement as the direct effect of the solar gain.
- North, northeast and possibly northwest exposures can be designed to be sufficiently comfortable without space cooling, especially if additional passive cooling elements such as natural ventilation are provided.
- All facades were simulated with the same window to wall area ratio. The energy consumption could be more evenly distributed in the building if different window to wall area ratios were applied to the different exposures.
- Internal heat gains and orientations do interact as discussed in the programming section of this report. No simulations were conducted for programming as the discussion is sufficient for the purpose of this toolkit and programming is highly building specific. Building specific modeling must be conducted to assess the building energy performance of programming layouts with respect to facade exposure.
- Though it appears that the downtown pattern has generally higher energy requirements than the north-south alignment, corner space results are not presented. When the whole building annual energy use is compared between the two orientations the results show that the difference is negligible (0.04%) as the parametric building is symmetrical. Buildings which are not symmetrical would produce different results.

### E.4.5 Recommendations for Orientation

- Design each facade specific to its orientation.
- Minimize east and west exposures to avoid unwanted solar gains.
- The 45° vs. 90° orientation makes little difference on overall energy performance on a symmetrical building with identical facades.

## E.5 Balcony Buffer Space

In this study the baseline parametric model was adjusted to have enclosed, unconditioned balconies on all the exterior facades. Apertures were assigned to ventilate the balconies and to allow air transfer between the balcony space and conditioned space. The buffer space aperture controls were optimized to relieve heat gains from the buffer zone in order not to induce a cooling load in the adjacent space. Also, apertures between the balcony and adjacent space were opened when the air temperature was sufficient to passively offset the need for heating or cooling.

The balcony concept provides an additional level of insulation between the conditioned space and the exterior when closed, preheats ventilation air, or relieves solar heat gains before they negatively affect the conditioned space. Balconies and their openings can be configured to increase the total building surface area to enhance cooling with the windows open and maintain a more compact form to minimize envelope surface area with the windows closed.

Dockside Green - Photo: Enrico Dagostini / Busby Perkins+Will

## E.5.1 Assumptions and Inputs

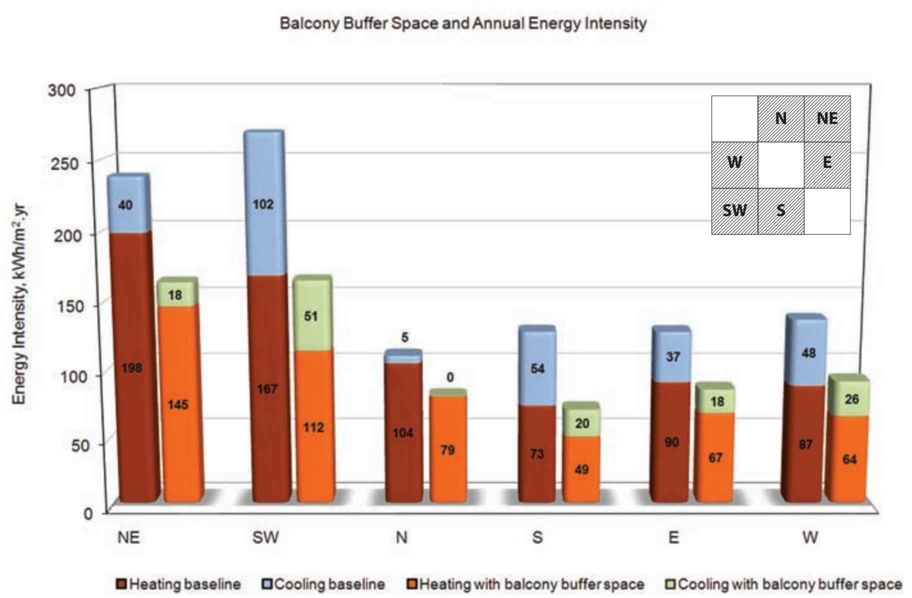
| | | |
|---|---|---|
| Wall RSI value: | R2.3 (ASHRAE 90.1)<br>exterior wall with 100mm concrete outside | m²K/W |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | m²K/W |
| Window U value: | U2.3<br>double pane windows | W/m²K |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 60% with 50% of windows operable | |
| Infiltration | 0.5 | ACH |
| Room resultant temperature set points : | 21 - 24 | °C |
| RH: | 0-100 (not controlled) | % |
| Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |
| Balcony Depth: | 915mm | |
| Balcony Windows: | 100% glass wall with 50% operable single pane glass | |
| Window Controls: | Buffer space open to occupied space when the outdoor air temperature greater than 19 °C less than 21 °C;<br>Balcony exterior window controlled by balcony air temperature > 20 °C | |

## E.5.2 Methodology

1. Revise a copy of the baseline model to have 915mm deep exterior balconies on all facades and maintain external wall and glass properties in the wall dividing the balcony from the conditioned space. Corner spaces have two balconies, one on each facade. Assign single pane windows to balcony exterior wall and typical floor construction to the balcony floors/ceilings. Assign the opaque external wall construction to the partition walls between balconies.
2. Add operable windows to both the balcony exterior walls and the wall between the balcony and the adjacent space.
3. Extract the results for both extreme corner spaces as well as the mid-facade spaces facing each of the four cardinal directions on the middle floor of the model.

## E.5.3 Results

*Figure 41: Annual heating and cooling energy intensity with balcony buffer spaces as compared with the baseline building fully sealed without buffer, shown for the middle floor SW and NE corners and mid-facade rooms in all four cardinal directions.*



### E.5.4 Conclusions

- The buffer space effectively reduced both the heating and cooling energy in all cases. The corner spaces have higher demands because they have greater envelope exposure areas, and for the same reason see the greatest reduction in energy consumption with the addition of the buffer space.

- The buffer space reduces the cooling energy by half in most of the spaces and completely eliminates the cooling energy in north facing spaces. In absolute values, the buffer space has the greatest impact on the southwest corner, south, west and northeast corner spaces.

- The buffer space reduces the heating energy in all spaces by values ranging between 24% in the north and 33% in the south facing spaces.

- The balcony floor, ceiling, and partition walls were simulated with opaque constructions. These elements also act as fixed shading blocking solar gains from entering the conditioned space when compared with the baseline. This shading effect is embodied in the overall results and analysis.

- The results show that significant energy savings can be achieved though the application of unconditioned buffer spaces to the building facade.

- Though comfort conditions are not extracted from the simulations, the reduced heating and cooling energies indicate more stable internal temperatures in the conditioned space. The unconditioned balcony would be comfortable during most of the year for most activities with the exception of sleeping.

- Buffer spaces were not simulated with a commercial schedule however the overall effect is expected to be similar. With internal heat gains a buffer space would expand the range of outdoor temperatures during which natural ventilation could be applied, thus reducing the cooling energy demands. In commercial applications a buffer space would most likely consist of a double facade or atrium spaces.

### E.5.5 Recommendations for Buffer Space

- Incorporate buffer spaces on all exposures whenever possible to optimize comfort and reduce both peak load and overall heating and cooling energy requirements.

## E.6 Window to Wall Area Ratio

One of the most significant passive building features affecting Vancouver's building energy consumption is the extensive use of windows in place of exterior walls.

This study iterates through various window to wall area (GWA) ratios on the baseline building and presents the trends in annual space heating and cooling energy required for the north-east corner and south-west corner rooms.

Note on ASHRAE Standard 90.1: Section 5.2 states that for a building to comply with the standard the prescriptive values can only be applied to buildings with 50% window to wall area ratio, or less. Envelopes with greater window to wall area ratios must comply with the standard through the building envelope trade-off method of Appendix C. Section C3.3 states that the baseline building will have a window to wall area ratio that is the same as the proposed building, or 40%, whichever is less. Therefore any building with a GWA greater than 50% is measured against the performance of a building with 40% window to wall area ratio and often the trade-off calculation results in lower U-value requirements (high performance windows).

---

## E.6.1 Assumptions and Inputs

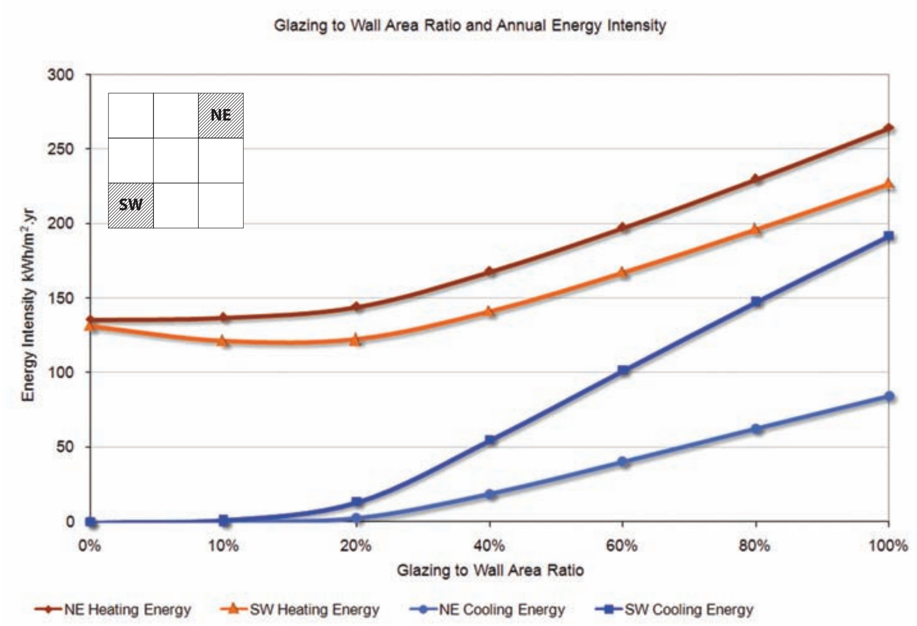
| | | |
|---|---|---|
| Wall RSI value: | R2.3 (ASHRAE 90.1)<br>exterior wall with 100mm concrete outside | $m^2K/W$ |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | $m^2K/W$ |
| Window U value: | U2.3<br>double pane windows | $W/m^2K$ |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 0%, 10%, 20%, 40%, 80%, 100% | |
| Infiltration | 0.5 | ACH |
| Room resultant temperature set points : | 21 - 24 | °C |
| RH: | 0-100 (not controlled) | % |
| Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |

## E.6.2 Methodology

1. Adjust a copy of the baseline model for a range of window to wall area ratios. In each case apply the window ratio to all four facades.
2. Extract results for the northeast and southwest corner spaces on the top floor of the model.

### E.6.3 Results

*Figure 42: Annual heating and cooling energy intensity with varying window to wall area ratios in the SW and NE corner spaces.*



### E.6.4 Conclusions

- Significant heating and cooling energy consumption begins occurring after the 40% window to wall area ratio threshold. Heating energy is increased because although the greater window area allows more solar heat to enter the space, the overall insulation value provided by the envelope (window plus wall) is low and the heat loss overwhelms the solar heat gain.

- Little to no cooling energy is required below the 20% window to wall area ratio in this model because there are no internal heat gains. If there were internal heat gains a slight cooling energy requirement may be observed.

- In the southwest corner space GWA ratios between 10% and 30% result in lower heating energy consumption that the same space without any windows, showing that annually the solar heat gain offsets the heat losses through the envelope on this exposure. Note that this trend is not the same for the northeast corner space, where any amount of windows increases the annual heating energy consumption.

- The southwest corner space cooling energy requirement increases dramatically beyond 30% window to wall area, and the heating energy increases as well, thus showing that window areas greater than 30% on this type of exposure have an adverse effect on the energy performance. The lowest total heating and cooling energy requirement in the southwest space occurs between 10% and 20% window to wall area ratio.

- The resulting trend is not unique between different building types; it is a consistent trend that the extent of windows being used currently in Vancouver is resulting in unnecessarily high energy consumption in all building types, those with heating only as well as those with both heating and cooling systems.
- Any building proposed to have a window to wall area ratio greater than 50% must prove overall energy consumption at or below that of the ASHRAE standard building at 40%. In the southwest corner space, for example, the cooling energy doubles when the ratio increase from 40% to 60% and the heating energy increases as well. This increased energy consumption must be compensated for in other areas of the building envelope and systems, and would likely require higher insulating values in the windows and other envelope components.

### E.6.5 Recommendations for Window to Wall Ratio

For optimum passive performance, do not exceed 50% windows on any facade and limit windows to 30% whenever possible, taking into account other aesthetic and livability criteria.

If higher window to wall area ratios are desired, incorporate high performance windows or double facade and optimize shading.

## E.7 Window Performance

Window assemblies are specified by several factors which describe their insulating effect and the amount of solar heat and light it transmits and reflects. In this study a range of window insulation values were simulated in both a residential and commercial schedule (without and with internal gains, respectively). The selected values represent greater and poorer performance than the value prescribed by ASHRAE 90.1. The shading coefficient was also studied, but on the residential schedule only.

*Note on ASHRAE Standard 90.1: Section 5.2 states that for a building to comply with the standard the prescriptive values can only be applied to buildings with 50% window to wall area ratio, or less. Envelopes with greater window to wall area ratios must comply with the standard through the building envelope trade-off method of Appendix C. Section C3.3 states that the baseline building will have a window to wall area ratio that is the same as the proposed building, or 40%, whichever is less. Therefore any building with a GWA greater than 50% is measured against the performance of a building with 40% window to wall area ratio and often the trade-off calculation results in lower U-value requirements (high performance windows).*

### E.7.1 Assumptions and Inputs

| | | |
|---|---|---|
| Wall RSI value: | R2.3 (ASHRAE 90.1) exterior wall with 100mm concrete outside | m$^2$K/W |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | m$^2$K/W |
| Window U value*: | 3.5 and 0.8<br>double pane and 4-element pane windows | W/m$^2$K |
| Window total shading coefficient: | 0.3 and 0.5<br>clear glass | |
| Window to wall area ratio: | 60% | |
| Infiltration | 0.5 | ACH |
| Room resultant temperature set points : | 21 - 24 | °C |
| RH: | 0-100 (not controlled) | % |
| **Residential**<br>Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |
| **Commercial** | 7am to 8pm, with night thermostat setback to | |
| Internal heat gains: | 15 - 28 | °C |
| People: | 7 | people/100m$^2$ |
| Lighting: | 11 | W/m$^2$ |
| Equipment: | 5 | W/m$^2$ |
| Ventilation: | 10 | L/s/person |

** Note that the lower U-value has a higher insulating value. Properly applied low-e coatings decrease the U-value thereby increasing the insulation value.*

### E.7.2 Methodology

1. Test the effect of window insulation by adjusting a copy of the baseline model for two window performance cases representing: a low quality, double pane window assembly with U=3.5 W/m$^2$K, and a very high performing 4-element window assembly with U=0.8 W/m$^2$K. Maintain the baseline shading coefficient at 0.7 to represent clear glass. Apply the same parameters to all facades.

2. Extract and compare the results for the northeast and southwest corner spaces.

3. Generate a commercial baseline model that has the commercial occupancy schedule.

4. Repeat steps 1 and 2 with the commercial occupancy schedule.

### E.7.3 Results: U-value

*Figure 43: Annual heating and cooling energy intensity with various window insulation values for residential schedule with no heat gains.*

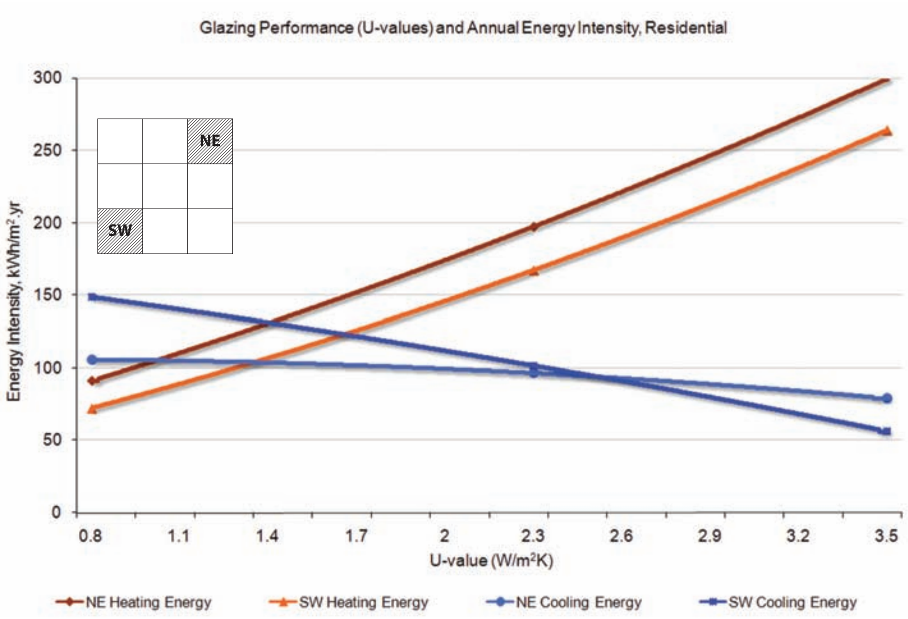
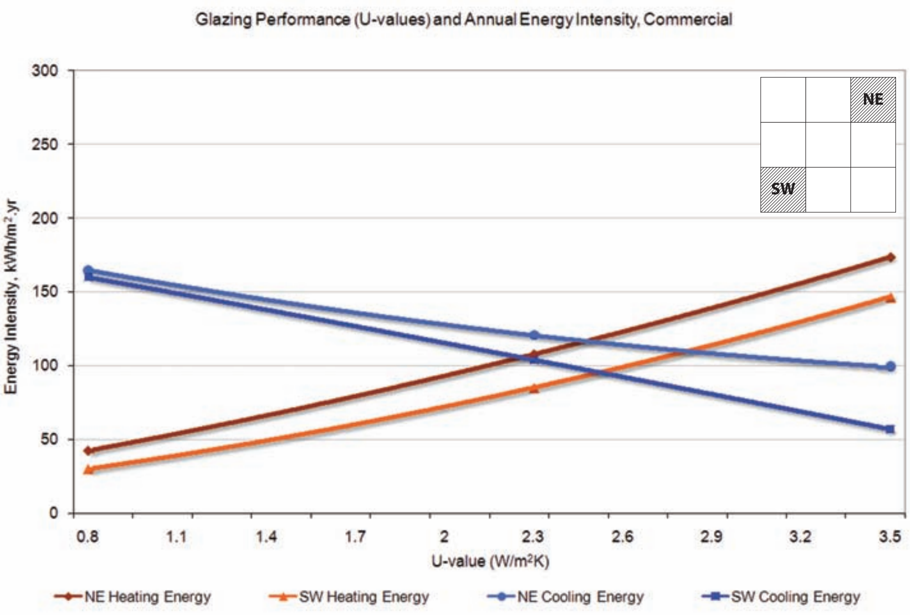


*Figure 44: Annual heating and cooling energy intensity with various window insulation values for commercial building schedule.*



### E.7.4 Conclusions: U-value

- When the U-value is low (high insulating value) the heating energy intensity is low and the effect of lowering the window performance is significant because of the extent of windows on the building (60% window to wall area ratio).

- When the heating energy performance is optimized the cooling energy performance is adversely effected because this study assumes a sealed building and the heat accumulated during the day does not leave the building as quickly as with a glass with higher U-value. Passive cooling strategies such as natural ventilation and operable external shading should be used to counteract this effect instead of reducing the thermal performance of the windows.

- This effect on the relative heating and cooling energy is more pronounced with the commercial schedule because there are internal heat gains and night setback on the thermostat, thus lower heating energy demands and higher cooling energy demands overall.

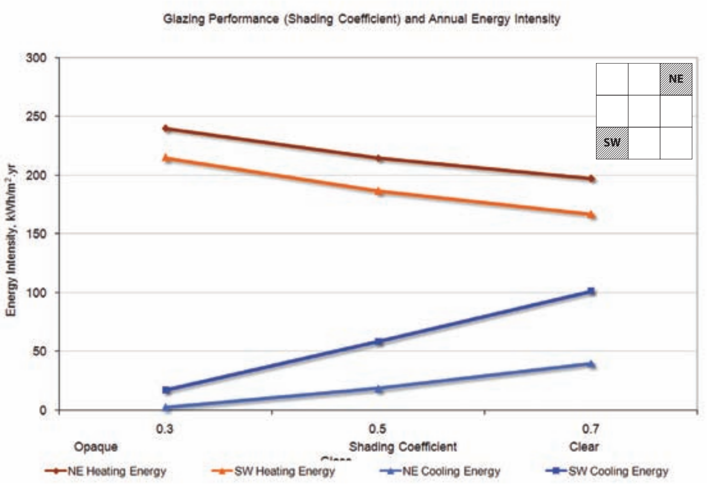
- This result suggests that in a commercial building if no passive cooling features can be applied, a life cycle costing analysis[2] may be required to determine an optimal window U-value which results in the minimum total primary energy used for space heating and cooling.

- Even the highest performing glass assemblies have relatively poor thermal performance when compared with a built up insulated wall, and cannot compensate for large GWA ratios.

- In buildings with greater than 50% window to wall area ratio, lower U-value window (higher insulating value than the standard) and passive cooling features will be required to compensate for the increase in total energy consumption associated with the high window areas.

### E.7.5 Results: Shading Coefficient

*Figure 45: Annual heating and cooling energy with various shading coefficients on the windows with no internal heat gain schedule.*



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[2] Life cycle cost analysis requires building energy simulations and system level calculations to determine the amount of primary energy used and accounts for system and plant energy conversion efficiencies, which are not factored into the passive results analysis in this study. The results presented in this study represent the space level heating and cooling demands as discussed in the Introduction to this appendix.

### E.7.6 Conclusions: Shading Coefficient

- The low shading coefficient glazing (dark tinted) blocks solar radiation all year long which reduces the cooling energy intensity in the building but increases the heating energy intensity.

- In a residential application the impact of the low shading coefficient on the heating energy performance is not preferred over the resulting benefit in cooling. High shading coefficients (less tinted glass) are preferred and can be coupled with passive cooling strategies to optimize energy consumption and comfort.

- In commercial applications where the cooling energy represents a greater proportion of the overall energy consumption, a low shading coefficient may reduce the annual total primary energy consumption, and building specific energy simulations should be used to determine the appropriate glazing product for the project.

- ASHRAE 90.1 prescribes shading coefficients for window to wall area ratios up to 50%. The Canadian MNECB does not prescribe shading coefficients in recognition of the fact that this permanent passive feature has an inverse effect on the building in heating mode, and instead allows the designer to determine which is most suitable for the project application.

### E.7.7 Recommendations for Window Performance

For residential buildings, use clear glass with good insulating value (low U-value with low-e coating). Mitigate unwanted solar gains with external shading and passive cooling by natural ventilation.

For commercial buildings, use either clear glass with effective external shading elements or dark or reflective glass (low shading coefficient) to control unwanted solar gains. Regardless of shading option, the glass should have good insulating value (low U-value with low-e coating). Remove internal heat gains with other passive elements (e.g., natural ventilation).

## E.8 Solar Shading

In this study two different shading approaches were tested. In the first set of simulations the baseline case was compared with fixed exterior overhangs of various lengths. In the second simulation the baseline case was compared with an operable external blind that can be opened to admit solar gains when they can offset heating energy and be closed to block solar gains when cooling is required.

## E.8.1 Assumptions and Inputs

| | | |
|---|---|---|
| Wall RSI value: | R2.3 (ASHRAE 90.1)<br>exterior wall with 100mm concrete outside | $m^2K/W$ |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | $m^2K/W$ |
| Window U value: | U2.3<br>double pane windows | $W/m^2K$ |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 60% | |
| Infiltration | 0.5 | ACH |
| Room resultant temperature set points : | 21 - 24 | °C |
| RH: | 0-100 (not controlled) | % |
| Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |
| **Fixed External Overhangs**<br>Window Height:<br>Overhang Depth: | 2,400mm<br>300mm, 900mm, and 2,400mm<br>7°, 21°, and 45° angle between the bottom of the window and edge of overhang | |
| **Operable External Blinds**<br>Description:<br>Controls: | 50% transparent blind<br>Blinds closed when space resultant temperature exceeds 22 °C | |

## E.8.2 Methodology

1. Generate 3 copies of the baseline model and add fixed exterior overhangs at the top edge of the 2,400mm high glazing on the east, south and west facades. Simulate 3 models with 300mm, 900mm and 2,400mm overhangs respectively. These cases represent shade angles of 7°, 21 °, and 45° angle measured between the bottom of the window and edge of overhang.
2. Generate an additional copy of the baseline model and assign 50% transparent operable external blinds to the east, south, and west windows. Control the blinds to reduce the cooling energy consumption with minimal effect on the heating energy consumption.
3. Extract and compare the results for northeast and southwest corner spaces on the top floor of the model.

### E.8.3 Results: Fixed External Overhangs

*Figure 46: Annual heating and cooling energy with fixed external shading of various depths in the top floor northeast and southwest corner spaces. Shade angle is measured from the bottom edge of the window to the outer edge of the overhang.*

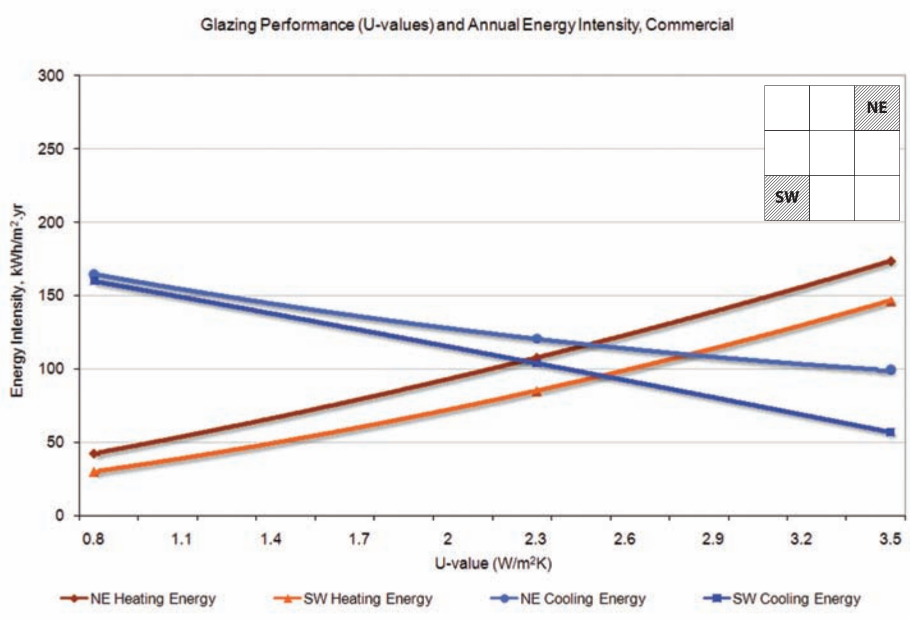
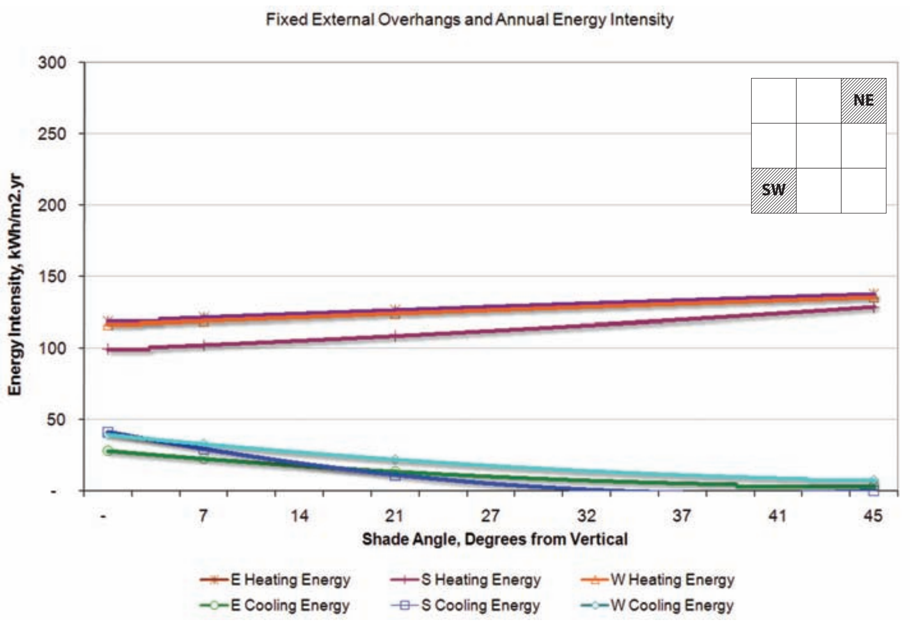


*Figure 47: Annual heating and cooling energy with fixed external shading of various depths in the top floor east, south and west mid-facade spaces. Shade angle is measured from the bottom edge of the window to the outer edge of the overhang.*



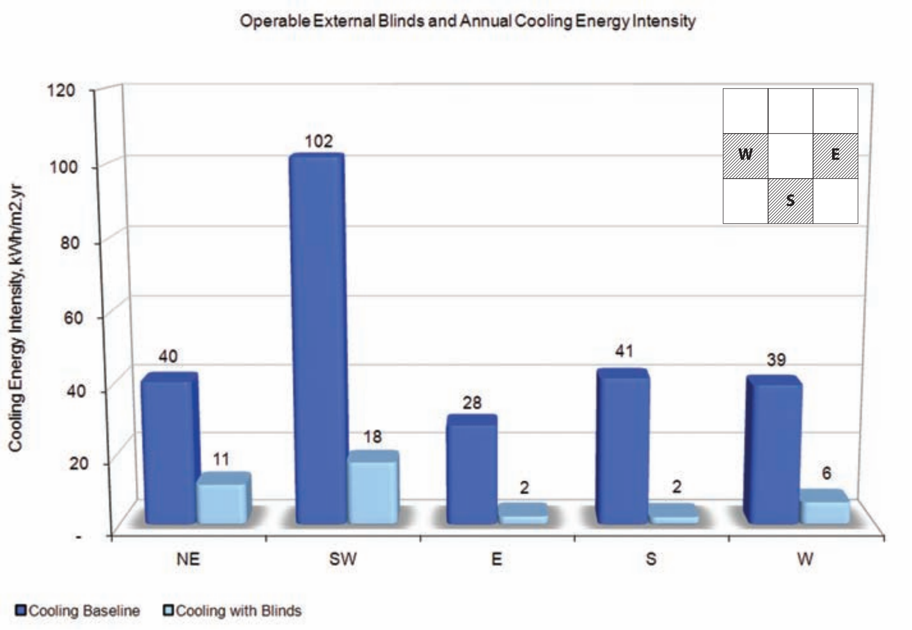
## E.8.4 Conclusions: Fixed External Overhangs

- The external overhangs have the greatest impact on the southwest corner and the south mid-facade space.
- Overhangs with shade angles less than 10º (shade depths less than 300mm) have little impact on the space cooling energy overall and in the mid-facade spaces increase the heating energy by about the same amount as the cooling is reduced.
- Overhangs with shade angles greater than 35º eliminated the cooling energy requirement in the south mid-facade space with a marginal increase in space heating energy.
- When the shade angle is between 7º and 15º (depth between 300mm and 600mm) the cooling energy is reduced with minimal impact on the space heating energy in all cases.
- At depths between 21º and 45º(depth between 900mm and 2,400mm) the cooling energy is dramatically reduced in the corner and south mid-facade space, however the annual heating energy consumption increases.

Revenue Canada Offices
Photo: Busby Perkins+Will

## E.8.5 Results: Operable External Blinds

*Figure 48: Annual heating and cooling energy with operable external blinds controlled to close when the space temperature exceeds 22°C in the northeast and southwest corner spaces, S, W, E mid facade spaces on the top floor.*



Dockside Green - Photo: Enrico Dagostini / Busby Perkins+Will

### E.8.6 Conclusions: Operable External Blinds

- The external blinds effectively reduce cooling energy consumption on all three facades and nearly eliminate the cooling energy consumption in the east and south mid-facade spaces.

- External blinds are more effective than overhangs on the east and west facades because they successfully block low angle sun (early morning and evening) where no length of fixed overhang is effective.

- The external blind control can be optimized in a way that has no impact on the annual heating energy.

### E.8.7 Recommendations on Shading

- Incorporate overhangs providing shading angles of 20°-30° off vertical (measured from the bottom window sill to the edge of the overhang) on south-facing windows.

- Incorporate operable external shading on east-, south- and west-facing windows.

## E.9 Thermal Mass

This set of simulations investigated the effect of thermal mass construction on the annual heating and cooling energy of the passive, residential space with no internal heat gains. The baseline case has thermal mass in the exterior wall construction; however it is exposed to the environment and not the conditioned space. The baseline building was adjusted to create two new massing cases. The first case maintained the baseline concrete floor thickness with a lightweight external wall construction. The second case had increased concrete thickness in the floor and external wall with the location revised to the interior side of the insulation. Each case was tested with two window to wall area ratios, 60% as per the baseline model and 40% to demonstrate and discuss the synergy between these two passive elements.

## E.9.1 Assumptions and Inputs

| | | |
|---|---|---|
| Wall RSI value:<br>Baseline<br>Lightweight<br>Heavy Mass | R2.3 (ASHRAE 90.1)<br>exterior wall with 100mm concrete outside<br>exterior wall, steel frame with batt insulation<br>exterior wall with 200mm concrete inside | $m^2K/W$ |
| Floors:<br>Baseline & Lightweight<br>Heavy Mass | 100 mm concrete<br>200 mm concrete<br>- | |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | $m^2K/W$ |
| Window U value: | U2.3<br>double pane windows | $W/m^2K$ |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 60% and 40% | |
| Infiltration | 0.5 | ACH |
| Room resultant temperature set points : | 21 - 24 | ºC |
| RH: | 0-100 (not controlled) | % |
| Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |

## E.9.2 Methodology

1. Generate two copies of the baseline model to test the two construction weights with 60% window to wall area ratio. Assign both construction weights to both models, respectively.

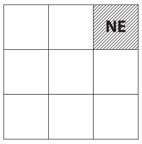
2. Generate a copy of each construction weight model and adjust the window to wall area ratio to 40%.

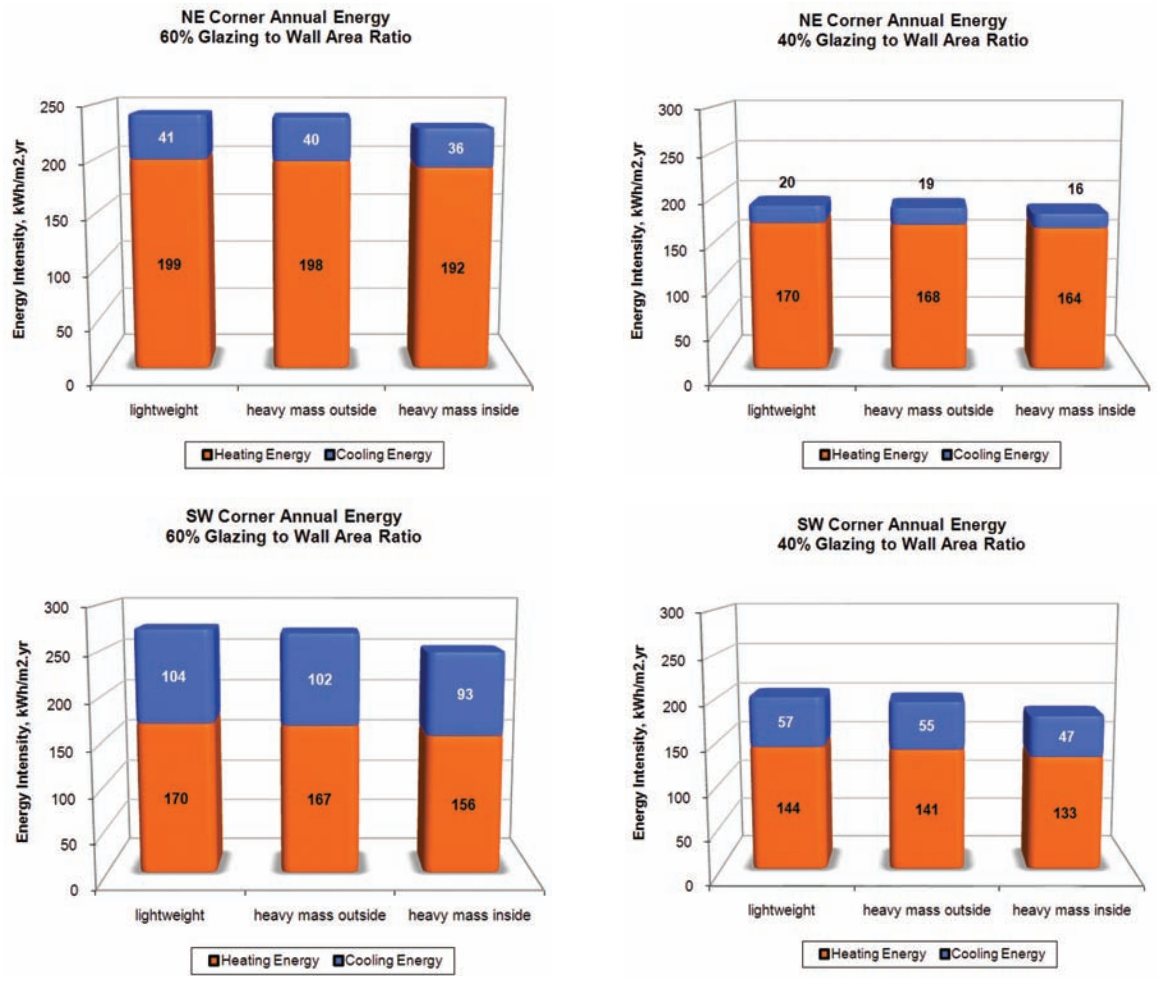
3. Extract and compare the results for northeast and southwest corner spaces on the top floor of the model.

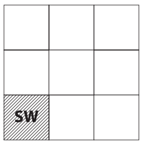
*Leigh Square Photo: Boldwing Continuum*

## E.9.3 Results

*Figure 49: Annual heating and cooling energy for various construction weights, in the northeast corner space with a) 60% and b) 40% window to wall area ratios and the southwest corner space with c) 60% and d) 40% window to wall area ratios.*







## E.9.4 Conclusions

- Thermal mass in the external wall is more effective at reducing both heating and cooling energy consumption when exposed to the interior conditioned space in all cases.

- The overall impact is greater with the lower window to wall area ratio, because there is more total external wall surface area and, therefore, more thermal mass.

- Even in the southwest corner space the benefit of increased window area and resulting additional solar heat gain does not exceed the negative impact of the greater window area's heat loss showing that lower window ratios result in better energy performance.

### E.9.5 Recommendations on Thermal Mass

Use thermal mass that is exposed to the conditioned space and combine it with other passive elements to achieve its full energy-savings and comfort potential.

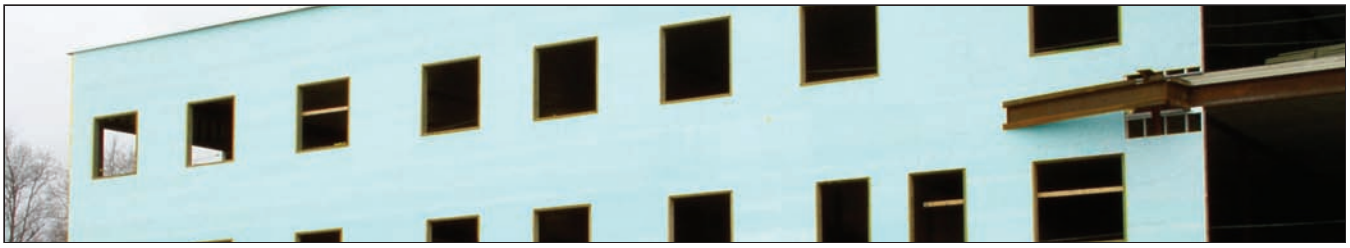
## E.10 Wall Insulation

This study tested a range of insulation thicknesses within the exterior wall assembly. The minimum case tested consisted of 100mm concrete with 15mm gypsum wall board (RSI 0.4 m$^2$oK/W) and no insulation. Insulation was added between the concrete and wallboard at various thicknesses up to 175mm to provide an overall RSI value of 7 m$^2$oK/W. The simulation results are presented for the northwest corner spaces and the southeast corner spaces. This study was conducted without internal heat gains

### E.10.1 Assumptions and Inputs

| | | |
|---|---|---|
| Wall RSI value: | RSI 0.4, 0.9, 5.3, 7<br>exterior wall with 100mm concrete outside various insulation thickness | m$^2$K/W |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | m$^2$K/W |
| Window U value: | U2.3<br>double pane windows | W/m$^2$K |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 60% | |
| Infiltration | 0.5 | ACH |
| Room resultant temperature set points : | 21 - 24 | °C |
| RH: | 0-100 (not controlled) | % |
| Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |
| **Commercial**<br>Internal heat gains:<br>People:<br>Lighting:<br>Equipment | 7am to 8pm, with night thermostat setback to<br>15 - 28<br>7<br>11<br>5 | °C<br>people/100m$^2$<br>W/m$^2$<br>W/m$^2$ |
| Ventilation: | 10 | L/s/person |

*Detailed commercial schedule provided at the end of this appendix.*



## E.10.2 Methodology

1. Copy the baseline model which has an exterior wall assembly consisting of 100mm concrete, insulation, and 15mm of gypsum wall board.
2. Adjust the insulation thickness in each case as required to provide a range of insulating values, from RSI 0.4, which has no insulation to RSI 7 which has 175mm insulation.
3. Compare the results with the baseline case which meets the minimum prescriptive requirement of ASHRAE 90.1 which is RSI 2.3 m$^2$oK/W.
4. Generate a commercial baseline model with the commercial occupancy schedule.
5. Repeat steps 1 to 3 with the commercial occupancy schedule.
6. Extract and compare the results for northeast and southwest corner spaces on the top floor of the model.

---

## E.10.3 Results

*Figure 50: Annual heating and cooling energy intensities for the NE and SW corner spaces with varying insulation thicknesses for a residential building.*

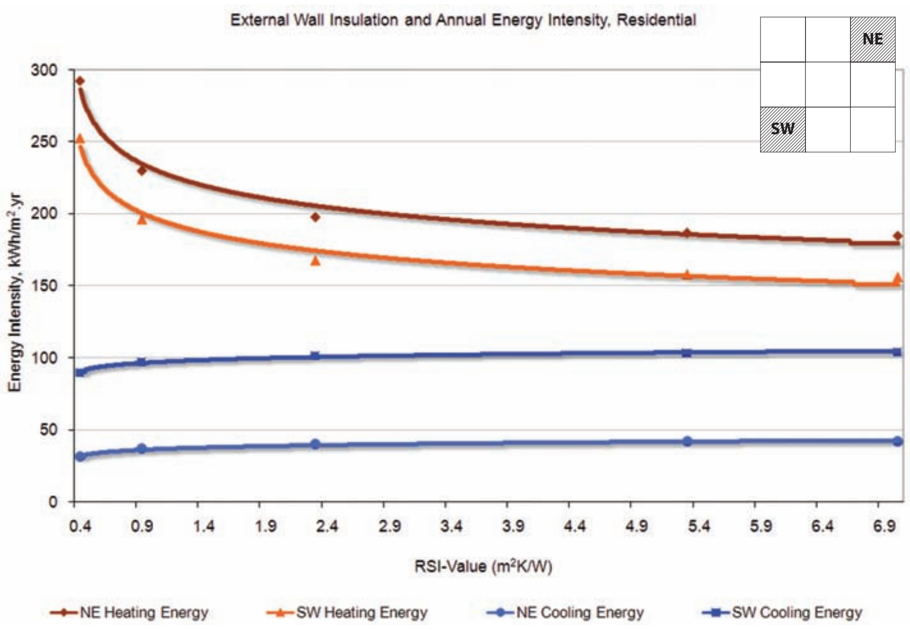
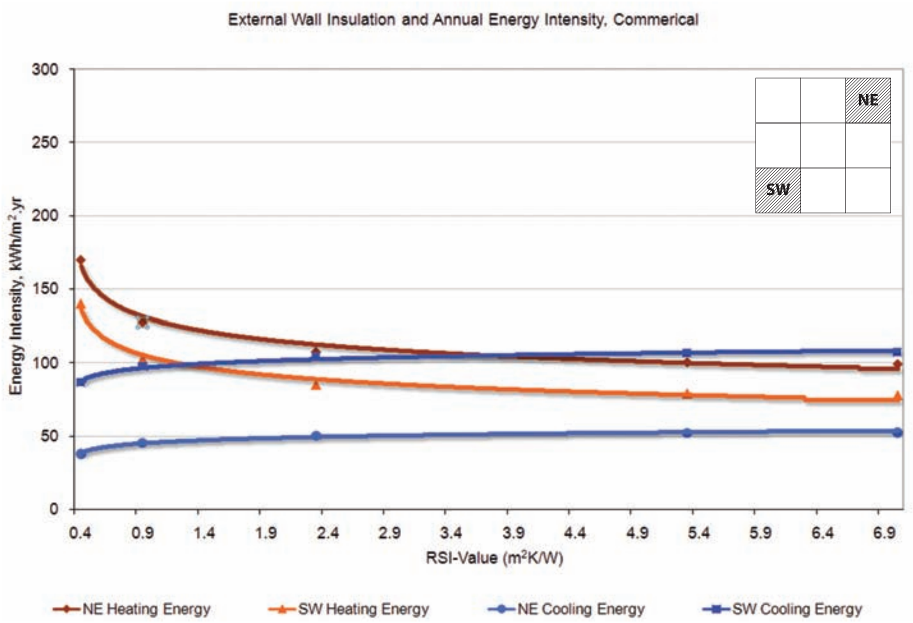


*Figure 51: Annual heating and cooling energy intensities for the NE and SW corner spaces with varying insulation thicknesses for a commercial building.*



## E.10.4 Conclusions

- Wall insulation values below the RSI 2.3 value prescribed by ASHRAE significantly increase the space heating energy required in both residential and commercial spaces.

- Values between RSI 2.3 and RSI 5.3 yield some energy benefits and should be explored in building specific simulations. The curve between these two points indicates that significant energy benefits could be achieved even up to RSI 3.8.

- Increasing the wall insulation value beyond RSI 5.3 results in little to no net energy benefit.

- The increased insulation value increases the amount of cooling energy required in both space types, however the impact is greater in the commercial space because there are internal heat gains. This result is because the added insulation slows the rate of heat loss through the envelope during the summer in the cooler evening hours when the air temperature is lower than the space temperature. This result is unique to an airtight building, and should be counteracted with other passive cooling strategies.

- These results were generated with a 60% window to wall area ratio to represent the baseline for the Vancouver current market. ASHRAE standard 90.1 prescribes wall insulation values up to and including a 50% window to wall area ratio. Beyond that point, the building envelope trade-off method must be used to prove compliance, in which other energy features must be improved to offset the negative effects of large window areas. In this case, wall, roof and window insulation values greater than the prescribed value would likely be required.

### E.10.5 Recommendations on Insulation

Target overall wall assembly RSI values between 2.3 (ASHRAE minimum) and 2.9. Use modeling to assess project-specific benefits, as the impact of insulation depends greatly on window to wall area ratio.

## E.11 Infiltration

This portion of the study isolated the effect of the building construction air tightness. The baseline model was adjusted twice, to represent a well constructed air tight building with 0.2 Air Changes per Hour (ACH) infiltration rate and to represent a leaky building with 1.0 ACH. The simulation software calculates the infiltration rate hourly based on temperature differentials and wind speeds. The settings represent the amount of air infiltration at peak conditions as determined in the simulation.

### E.11.1 Assumptions and Inputs

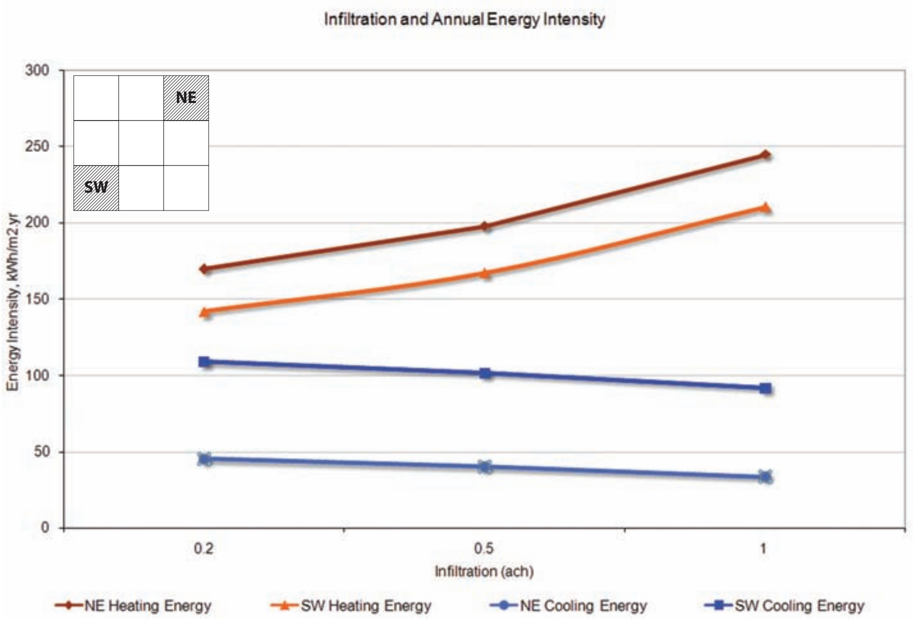
| | | |
|---|---|---|
| Wall RSI value: | R2.3 (ASHRAE 90.1)<br>exterior wall with 100mm concrete outside | $m^2K/W$ |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | $m^2K/W$ |
| Window U value: | U2.3<br>double pane windows | $W/m^2K$ |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 60% | |
| Infiltration | 0.2, 0.5, and 1.0 | ACH |
| Room resultant temperature set points : | 21 - 24 | °C |
| RH: | 0-100 (not controlled) | % |
| Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |

### E.11.2 Methodology

1. Create two copies of the baseline model and adjust the infiltration rate in each to 0.2 ACH and 1.0 ACH respectively.
2. Extract and compare the results in the top floor northeast and southwest corner spaces.

### E.11.3 Results

*Figure 52: Annual heating and cooling energy for top floor northeast and southwest corner spaces with various rates of infiltration. 0.2 ACH represents a well constructed airtight building, 0.5 ACH represents average construction and 1.0 ACH represents a building.*



### E.11.4 Conclusions

- Increased infiltration rates increase the heating energy consumption and reduce the cooling energy consumption.
- The infiltration rate has a greater effect on space heating than on space cooling due to the temperature difference between the Vancouver climate and the indoor air set point.
- In this model the effect of infiltration is the same regardless of exposure (both SW and NE corner trends are consistent with each other). However, wind

*Example of an HRV unit*

pressure affects infiltration and spaces that have exterior surfaces exposed to high wind pressures may experience increased heating energy demands depending on the quality of construction. In the case of infiltration the space orientation is relevant to the prevailing winds rather than the solar angles.

- Increased infiltration rates reduce the cooling energy because the air exchange provides free cooling. However, this is not a recommended approach because the air leakage is uncontrolled and could be perceived as uncomfortable drafts for occupants as well as increase heating energy demands. Other passive cooling elements should be applied to reduce cooling energy consumption.

### E.11.5 Recommendations on Infiltration

Use air-tight envelope to minimize uncontrolled infiltration.

## E.12 Heat Recovery Ventilation

This part of the air tightness study compared the combined effects of infiltration rates, heat recovery ventilation and natural ventilation. One well recognized energy saving approach in North America is to maintain an airtight envelope year round and rely entirely on heat recovery ventilation equipment to provide energy savings. The energy performance of the parametric building with this strategy is compared with a case without the heat recovery system as well as a case that includes the HRV during the winter months only and has a less airtight envelope during the summer months with natural ventilation openings.

As this study includes ventilation air tempering energy in the results interpretation, a revised baseline model was generated to include ventilation throughout the year. The presented results include both space tempering and ventilation air tempering energy requirements.

### E.12.1 Assumptions and Inputs

| | | |
|---|---|---|
| Wall RSI value: | R2.3 (ASHRAE 90.1)<br>exterior wall with 100mm concrete outside | $m^2K/W$ |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | $m^2K/W$ |
| Window U value: | U2.3<br>double pane windows | $W/m^2K$ |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 60% | |
| Infiltration | 0.2, 0.5 | ACH |
| Room resultant temperature set points : | 21 - 24 | °C |
| RH: | 0-100 (not controlled) | % |
| Internal heat gains from people, lighting, or equipment: | Not included | |
| Ventilation: | Not included | |
| **Residential Schedule** | 24h/day | |
| Internal heat gains: | 2 | people/room |
| People: | 0 | $W/m^2$ |
| Lighting: | 0 | $W/m^2$ |
| Ventilation: | 10 | L/s/person |
| Heat Recovery Efficiency: | 55% | |

### E.12.2 Methodology

1. Generate a ventilation baseline model with 2 people per space, 10 L/s/person operating 24 hours per day. This baseline is referred to as Case A.

2. Copy this ventilation baseline model and adjust the infiltration rate to represent a well constructed air tight envelope with 0.2ACH; Case B.

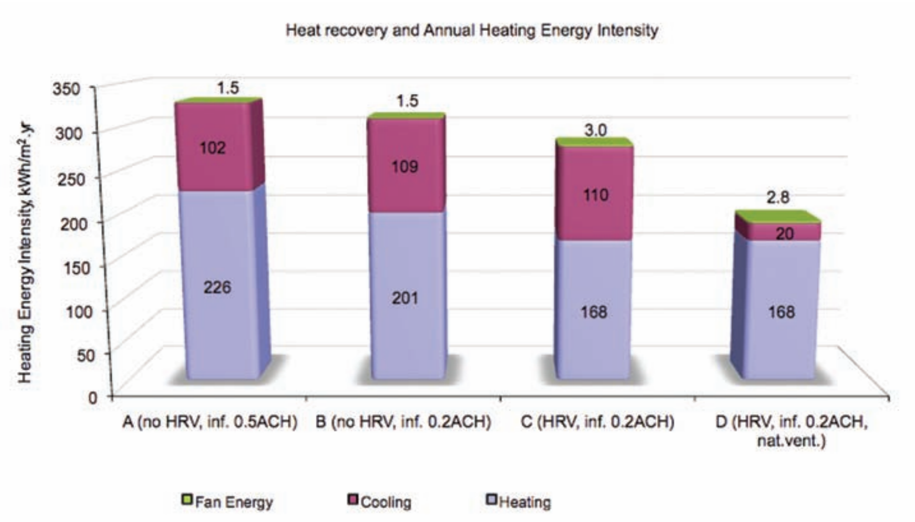
3. Copy the Case B model and add heat recovery to calculate the amount of heat energy that can be recovered from the ventilation air flow rate as it is exhausted from the space, Case C. The heat recovery unit seasonal efficiency is conservatively assumed to be 55% and no allowance is made for bypassing the heat exchanger during summer conditions, the resulting heat transfer increases the ventilation air cooling load.

4. Copy case C and add natural ventilation apertures and control to provide ventilation air to the space when outdoor air conditions are within the desired temperature range and/or can provide space cooling, Case D.

5. Extract and compare the results for the top floor southwest corner space.

### E.12.3 Results

*Figure 53: Annual heating and cooling energy for both space and ventilation air tempering for the southwest corner space on the top floor with various applications of air tightness and heat recovery ventilation.*



### E.12.4 Conclusions

- The simple HRV system (without summer bypass) reduces the total ventilation air heating energy consumption but slightly increases the ventilation air cooling energy.

- Increased air tightness decreases the space heating energy and increases the space cooling energy.

- The combined effect of increased air tightness and simple HRV reduces the total annual energy consumption when compared with the base case, and this result (Case C) represents a standard approach to energy savings.

- Case D shows that the combination of all three factors results in the best energy performance overall. Not accounted for in this case is also the wider range of acceptable comfort conditions in spaces with natural ventilation as discussed in the natural ventilation section below, which would further reduce the energy consumption of Case D.

- So far in the studies mechanical systems and electrical energy have been omitted from the analysis to isolate the passive building response. However, fan energy must be addressed when discussing HRV. An HRV unit has an additional return fan when compared with a basic air handling unit system where ventilation air is exhausted by small distributed fans or by exfiltration. The annual fan energy consumption is therefore higher with an HRV system over the basic alternative.

- Natural ventilation reduces the number of hours the fans operate and thus reduces the annual fan energy consumption as well as the space cooling energy. Natural ventilation also bypasses the HRV unit eliminating the unwanted summer heat exchange that would occur otherwise.

- Fan energy was calculated for the parametric model based on the ventilation air volume and though the HRV cases consume more electric fan energy, the absolute values are very low compared with the space heating and cooling energy consumption and were omitted from the charts.

### E.12.5 Recommendations on Heat Recovery Ventilation

For optimum passive performance, use heat-recovery ventilation during heating season only, and design for natural ventilation and cooling by natural ventilation throughout the rest of the year.

## E.13 Natural Ventilation

To simulate a simple natural ventilation strategy operable windows and controls were added at the external walls of all the spaces. The corner spaces have two facades and are cross ventilated with no model adjustments. To cross ventilate the mid-facade spaces the core was connected on all three levels and extended above the roof to represent a wind tower or an atrium. Apertures were added between the core and mid-facade spaces, as well as on the external walls of the core above the roof level. All of the apertures were controlled by the comfort conditions in the occupied spaces and the windows were closed when supplemental mechanical heating or cooling was needed to temper the space.

*Hesquiat School*
*Photo: Marceau Evans Johnson Architects*

The thermostat settings in the occupied spaces were adjusted to a wider deadband when natural ventilation was simulated. This assumption is based on ASHRAE Standard 55 Figure 5.3 and the adaptive comfort model approach which states that occupants will be comfortable in a wider range of temperatures, which are more closely related to outdoor conditions, when they have access to operable windows.

As ventilation energy is relevant to the natural ventilation discussion, ventilation base cases were generated for both residential and commercial occupancy. The natural ventilation model was simulated with both schedules.

## E.13.1 Assumptions and Inputs

| | | |
|---|---|---|
| Wall RSI value: | R2.3 (ASHRAE 90.1) exterior wall with 100mm concrete outside | m$^2$K/W |
| Roof RSI value: | R2.6 (ASHRAE 90.1) | m$^2$K/W |
| Window U value: | U2.3<br>double pane windows | W/m$^2$K |
| Window total shading coefficient: | 0.7<br>clear glass | |
| Window to wall area ratio: | 60% | |
| Infiltration | 0.2 | ACH |
| Room resultant temperature set points : | 19 - 26 | °C |
| RH: | 0-100 (not controlled) | % |
| **Residential**<br>Internal heat gains:<br>People:<br>Lighting: | 24h/day<br>2<br>0<br>0 | <br>people/room<br>W/m$^2$<br>W/m$^2$ |
| Ventilation: | 10<br>6am to 6pm | L/s/person |
| **Commercial**<br><br>Internal heat gains:<br>People:<br>Lighting:<br>Equipment | 7am to 8pm, with night thermostat setback to<br>15 - 28<br>7<br>11<br>5 | <br><br>°C<br>people/room<br>W/m$^2$<br>W/m$^2$ |
| Ventilation:<br>*Detailed commercial schedule provided at the end of this appendix* | 10 | L/s/person |
| Window Opening Controls: | Windows open based on outdoor air temperature<br>18°C < outdoor air < 23°C | |
| Window Operable Area: | 50%<br>(1/2 of the 60% window area is operable) | |
| Core Ventilation Tower:<br>Cross Ventilation | Core space connected and extended above roof surface by 2.7m to act as ventilation shaft<br>Apertures added between mid-facade spaces and core dimension 1.5m x 6m | |

## E.13.2 Methodology

1. Generate a residential ventilation baseline model with the inputs noted in the table above.

2. Copy the residential ventilation baseline model and provide operable windows and controls at all of the exterior wall windows.

3. Connect the core spaces vertically and extend beyond the roof to simulate a ventilation shaft or wind tower.

4. Add apertures and controls to the wall between the mid-facade perimeter spaces and the new core ventilation shaft. Also add apertures and controls to the exterior walls of the ventilation shaft above the roof level.

5. Extract and compare the cooling energy results for the middle floor southwest and northeast corner spaces, which have corner cross ventilation within the space as well as all 4 mid-facade spaces, which have cross ventilation through to the core ventilation shaft.

6. Repeat steps 1 through 5 with a commercial baseline and the commercial schedule assigned in all spaces.

---

## E.13.3 Results

Note: Mechanical ventilation is accounted for in all cases.

*Figure 54: Annual cooling energy intensity with and without natural ventilation on the middle floor for the northeast and southwest corner spaces as well as mid-facade spaces in each cardinal direction with residential occupancy.*

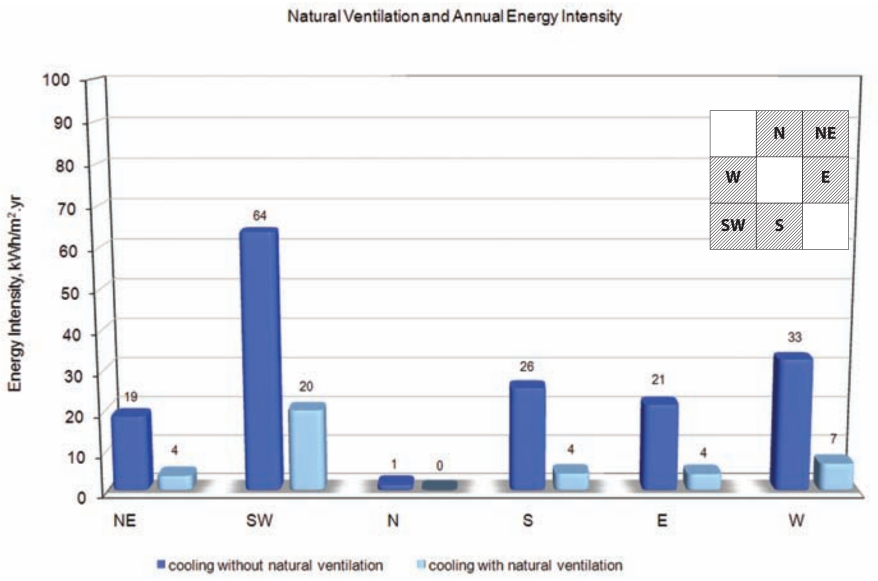
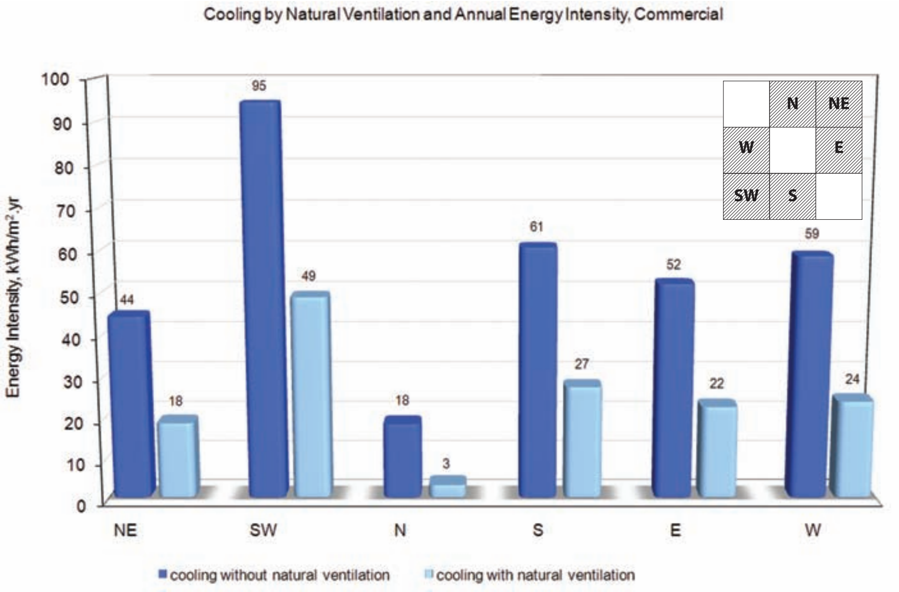


*Figure 55: Annual cooling energy intensity with and without natural ventilation on the middle floor for the northeast and southwest corner spaces as well as mid-facade spaces in each cardinal direction with commercial schedule.*

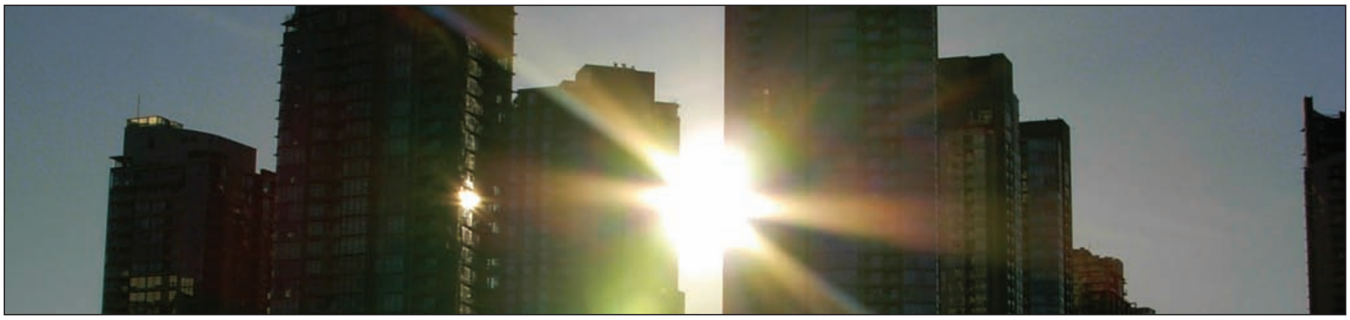


## E.13.4 Conclusions

- Natural ventilation reduces the annual cooling energy in all cases, and by a significant amount.
- In the residential spaces cooling energy is reduced by 69% to 100%, 82% on average across the middle floor.
- In the commercial spaces cooling energy is reduced by 48% to 83%, 60% on average across the middle floor.
- In the residential occupancies the space cooling energy is very low in most of the spaces with the exception of the west and southwest corner spaces. These spaces could be treated with other passive cooling elements, such as shading, to reduce or even eliminate the need for mechanical cooling.
- Space and ventilation air heating energy was calculated but is omitted from the chart to focus the discussion on the passive cooling effect. Well controlled natural ventilation has very little impact on heating energy and in the simulations the value remained constant between cases.
- The corner spaces have different type of cross ventilation than the mid-facade spaces, and both strategies are effective, the corner spaces energy savings are only slightly lower than the floor average.

## E.13.5 Recommendations on Natural Ventilation

Design for cooling by natural ventilation in all building types.



## E.14 Strategy: Passive Heating

This study combined the passive heating elements in a series of simulations to demonstrate their combined effect in an application with no mechanical cooling system. Each measure was added to the baseline model incrementally to demonstrate the compound effect. The simple baseline model was used with no internal heat gains or ventilation energy to isolate the passive thermal response. HRV was not simulated as it does not affect the passive building response or space heating and is adequately addressed in section 12.0.

Two cases were simulated; Case 1 and Case 2, with different combinations of elements and the presented results are the sum of the heating energy requirements in all the perimeter spaces on the middle floor of the model.

---

### E.14.1 Assumptions and Inputs

The following lists the passive element inputs applied to the baseline model as described in the methodology below.

| Passive Building Element | Case 1 | Case 2 | Settings |
|---|---|---|---|
| Building Orientation | √ | √ | North-south |
| Buffer Space |  | √ | 3ft deep balconies |
| Window to Wall Area (GWA) | √ | √ | 40% |
| Window Performance<br>Insulation<br>Shading Coefficient | √ | √ | U=0.81 W/m²°C<br>clear glass |
| Solar Shading |  |  |  |
| Thermal Mass | √ |  | 200mm floor & 200mm interior side of the external wall |
| Thermal Insulation | √ |  | RSI 5.3 |
| Infiltration | √ |  | 0.2 |
| Natural Ventilation |  |  |  |

*Leigh Square Community Arts Village Photo: Boldwing Continuum*

## E.14.2 Methodology

**Case 1**

The passive heating elements were added to the baseline model in the following order. Each element was added to the previous model, and the simulation results were extracted at each step.

1. Simulate baseline model.
2. Reduce window to wall area ratio to 40%, simulate and record results.
3. Improve window U-value to U=0.81 W/m$^2$°C, simulate and record results.
4. Increase wall insulation value to RSI 5.3, simulate and record results.
5. Revise floor and wall construction to heavy mass with 200mm concrete inside the insulation, simulate and record results.
6. Improve air tightness to 0.2ACH, simulate and record results.

**Case 2**

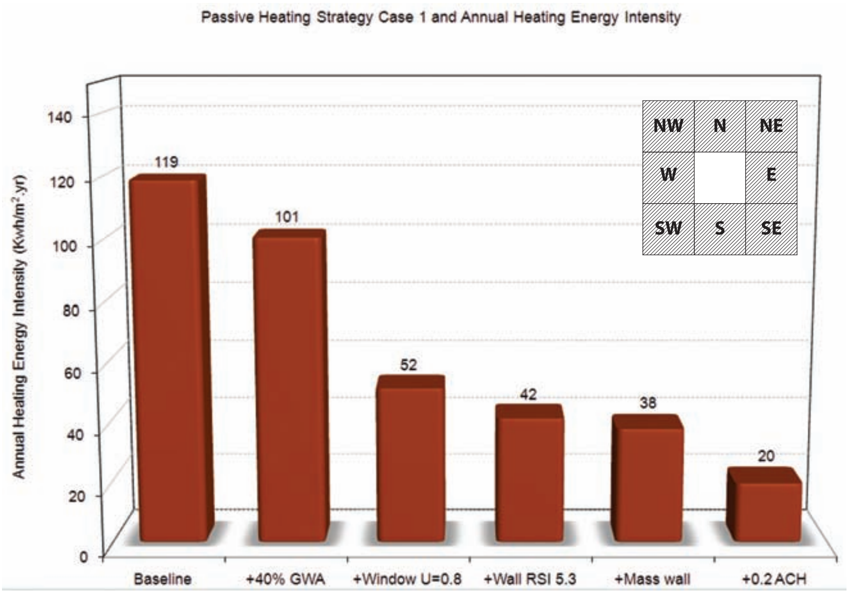
The passive heating elements were added to the baseline model in the following order. Each element was added to the previous model, and the simulation results were extracted at each step.

1. Simulate baseline model.
2. Reduce window to wall area ratio to 40%, simulate and record results.
3. Revise floor and wall construction to heavy mass with 200mm concrete inside the insulation, simulate and record results.
4. Add an enclosed balcony buffer space with no window openings, simulate and record results.
5. Add window openings to the enclosed buffer space, simulate and record results.

## E.14.3 Results

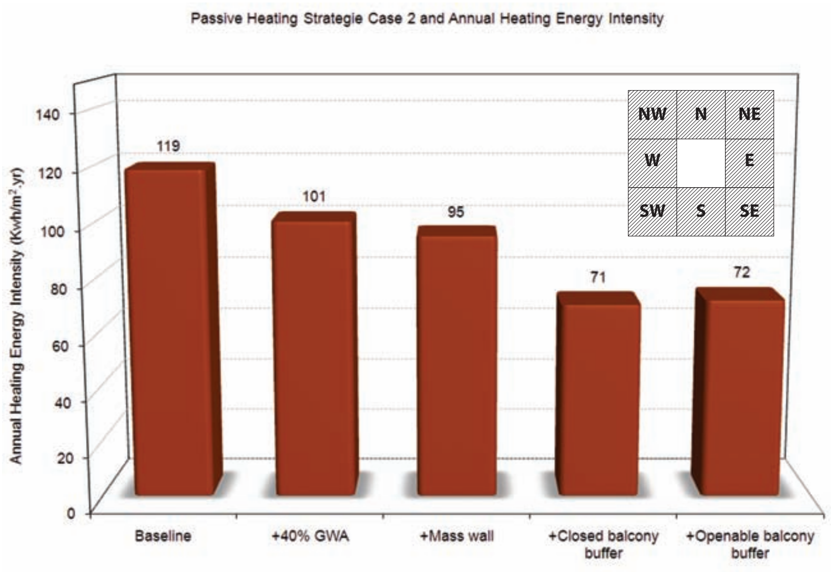
### Case 1

*Figure 55: Incremental, cumulative effect of the passive heating elements on the annual heating energy intensity summed over all the perimeter spaces on the top floor in the passive heating strategy Case 1.*



### Case 2

*Figure 56: Incremental, compound effect of the passive heating elements on the annual heating energy intensity summed over all the perimeter spaces on the top floor in the passive heating strategy Case 2.*



### E.14.3 Conclusions

- The elements assigned in Case 1 resulted in significant heating energy savings. The greatest contributions came from the window to wall area ratio, the window U-value and increased air tightness. However, the final result of 20 kWh/m$^2$year is a function of all the elements interacting.

- The elements assigned in Case 2 produced heating energy savings as well, however fewer elements were implemented and the overall savings are not as impressive as in Case 1.

- Two cases were run because when the buffer space was added at the end of Case 1 it was found that the buffer increased the heating energy consumption. This result was investigated and it was found that with the high envelope insulation the buffer space had minimal effect on the heating energy because heat gained via the buffer space was offset by the reduction in solar heat gains resulting from the shading effect created by the balcony.

- The benefit of the enclosed balcony was demonstrated in Case 2 assuming that wall and window insulation improvements were not applied in lieu of the enclosed buffer space, which is a realistic trade-off in actual construction practice.

### E.14.4 Recommendations on Passive Heating

- Optimize the effect of passive heating by strategically combining passive elements. (See specific recommendations for each passive element above.)


*Millennium Water*
*Photo: Merrick Architecture*

## E.15 Strategy: Passive Cooling

This study combined passive cooling elements in a series of simulations to demonstrate their combined effect. A heating system was simulated but the results are not presented in this section as the interaction is discussed in each measure, and the focus of this study is passive cooling only. Each measure was added to the baseline model incrementally to demonstrate the compound effect. The simple baseline model was used with no internal heat gains or ventilation energy to isolate the passive thermal response.

## E.15.1 Assumptions and Inputs

| Passive Building Element | | Settings |
|---|---|---|
| Building Orientation | √ | North-south |
| Buffer Space | | 3ft deep balconies |
| Window to Wall Area (GWA) | √ | 40% |
| Window Performance<br>Insulation<br>Shading Coefficient | √ | U=0.81 W/m2°C<br>SC=0.3 |
| Solar Shading | √ | External operable blinds |
| Thermal Mass | √ | 200mm floor & 200mm interior side of the external wall |
| Thermal Insulation | | |
| Infiltration | √ | 0.5 |
| Natural Ventilation | √ | Refer to inputs in Section 13.0 |

## E.15.2 Methodology

The passive cooling elements were added to the baseline model in the following order. Each element was added to the previous model, and the simulation results were extracted at each step.

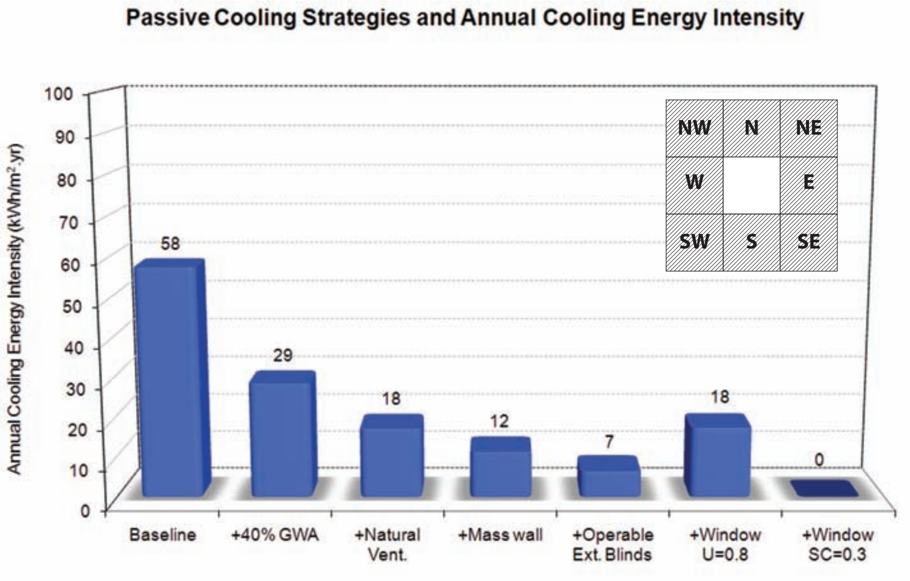
1. Simulate the baseline model.
2. Reduce window to wall area ratio to 40%, simulate and record results.
3. Add natural ventilation strategies in the same way as in the element study; simulate and record results.
4. Revise floor and wall construction to heavy mass with 200mm concrete inside the insulation, simulate and record results.
5. Add external operable blinds in the same way as in the element study; simulate and record results.
6. Improve window U-value to U=0.81 W/m²°C, simulate and record results.
7. Reduce window shading coefficient to 0.3, simulate and record results.

*Regent College*
*Photo: Clive Grout Architects*

The Regent College Library wind tower takes advantage of the natural stack effect to passively provide 100% outdoor air to this underground facility.

### E.15.3 Results

*Figure 57: Incremental, cumulative effect of the passive cooling elements on the annual cooling energy intensity summed over all the perimeter spaces on the top floor in the passive cooling strategy Case 2*



### E.15.4 Conclusions

- Increasing the window U-value even with operable windows increases the annual cooling energy.
- With all the passive measures applied the cooling load is eliminated; note that this model has no internal heat gains from occupants, equipment or lighting. Internal gains and heating loads are discussed in the commercial approach.
- Depending on the amount of internal heat gains the cooling energy may not be entirely eliminated, however, the passive features successfully eliminate the environmentally induced cooling loads and therefore the cooling system size could be dramatically reduced and be designed to deal with the internal gains only.

### E.15.5 Recommendations for Passive Cooling

- Optimize the effect of passive cooling by strategically combining passive elements. (See specific recommendations for each passive element above.)

## E.16 Strategy: Residential Approach

Passive building elements were selected that would improve the annual heating and cooling energy performance for a residential building in the Vancouver climate. Each measure was added to the baseline model incrementally to demonstrate the compound effect. The simple baseline model was used with no internal heat gains or ventilation energy to represent a simple residential occupancy.

Cooling energy results are presented even though in many cases residential buildings do not have mechanical cooling systems. However, even if a cooling system is not applied the cooling energy results provide insight on anticipated comfort levels. High annual cooling energy consumption indicates that such a space would overheat more often than a space with low cooling energy consumption.

The results are summed over the perimeter spaces of the middle floor of the parametric model, which represents the majority of residential development in Vancouver.

### E.16.1 Assumptions and Inputs

| Passive Building Element | | Settings |
|---|---|---|
| Building Orientation | √ | North-south |
| Buffer Space | | |
| Window to Wall Area (GWA) | √ | 40% |
| Window Performance<br>Insulation<br>Shading Coefficient | √ | U=0.81 W/m²°C<br>clear glass |
| Solar Shading | √ | External operable blinds |
| Thermal Mass | √ | 200mm floor & 200mm interior side of the external wall |
| Thermal Insulation | √ | RSI 5.3 |
| Infiltration | √ | 0.2 |
| Natural Ventilation | √ | Refer to inputs in Section 13.0 |

### E.16.2 Methodology

The passive elements were added to the baseline model in the following order. Each element was added to the previous model, and the simulation results were extracted at each step.

7. Simulate baseline model.

8. Reduce window to wall area ratio to 40%, simulate and record results.

9. Improve window U-value to U=0.81 W/m²°C, simulate and record results.

10. Increase wall insulation value to RSI 5.3, simulate and record results.

11. Revise floor and wall construction to heavy mass with 200mm concrete inside the insulation, simulate and record results.

12. Improve air tightness to 0.2ACH, simulate and record results.

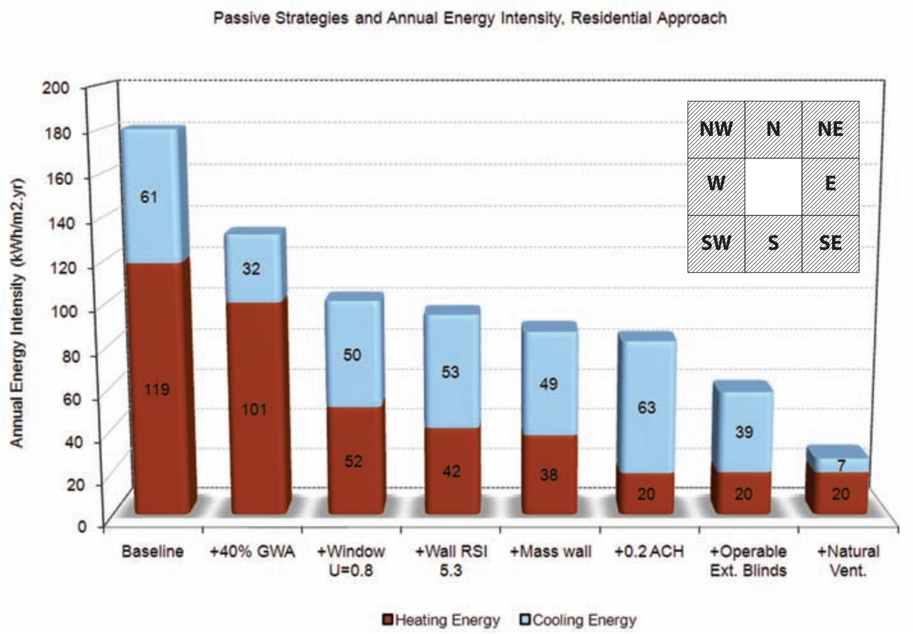
13. Add external operable blinds in the same way as in the element study; simulate and record results.

14. Add natural ventilation strategies in the same way as in the element study; simulate and record results.

---

### E.16.3 Results

*Figure 58: Incremental cumulative effect on the annual heating and cooling energy intensity for the all perimeter spaces on the middle floor for the passive residential approach.*



### E.16.4 Conclusions

- The simulation shows that the passive measures successfully reduce the total heating and cooling energy consumption of the residential building.

- The measures which increase the cooling energy, window and wall insulation and improved air tightness, decrease the heating energy and in each case the total energy consumption is lower with the added element. The operable blinds and natural ventilation strategies successfully reduce the cooling energy to be well below that of the baseline.

- The trends follow the results found in the individual element simulations and the combined effect is a dramatic reduction in energy consumption compared with the baseline case.

### A.16.5 Recommendations on Residential Approach

- Incorporate as many passive design elements as possible to optimize comfort and minimize overall energy use.

## E.17 Strategy: Commercial Approach

Commercial buildings typically operate with higher internal heat gains, greater ventilation requirements and different thermostat controls than residential buildings. As such, commercial buildings typically have higher cooling energy requirements and therefore the passive elements affect their energy performance differently than residential buildings. To demonstrate the effect of passive building elements on both heating and cooling energy performance on this type of building a commercial approach was simulated.

Passive elements were selected with a priority to reduce the annual cooling energy consumption of the building. The results are summed over the perimeter spaces of the middle floor of the parametric model.

---

### E.17.1 Assumptions and Inputs

| Passive Building Element | | Settings |
|---|---|---|
| Building Orientation | √ | North-south |
| Buffer Space | | |
| Window to Wall Area (GWA) | √ | 40% |
| Window Performance<br>Insulation<br>Shading Coefficient | √ | U=0.81 W/m²°C<br>clear glass |
| Solar Shading | √ | External operable blinds |
| Thermal Mass | √ | 200mm floor & 200mm interior side of the external wall |
| Thermal Insulation | √ | RSI 5.3 |
| Infiltration | √ | 0.2 |
| Natural Ventilation | √ | Refer to inputs in Section 13.0 |

### E.17.2 Methodology

The passive elements were added to the baseline model in the following order. Each element was added to the previous model, and the simulation results were extracted at each step.

1. Simulate the baseline model.
2. Reduce window to wall area ratio to 40%, simulate and record results.
3. Add natural ventilation strategies in the same way as in the element study; simulate and record results.

4. Revise floor and wall construction to heavy mass with 200mm concrete inside the insulation, simulate and record results.

5. Add external operable blinds in the same way as in the element study; simulate and record results.

6. Improve window U-value to U=0.81 W/m²°C, simulate and record results.

7. Reduce window shading coefficient to 0.3, simulate and record results.

8. Increase wall insulation value to RSI 5.3, simulate and record results.

9. Improve air tightness to 0.2ACH, simulate and record results.

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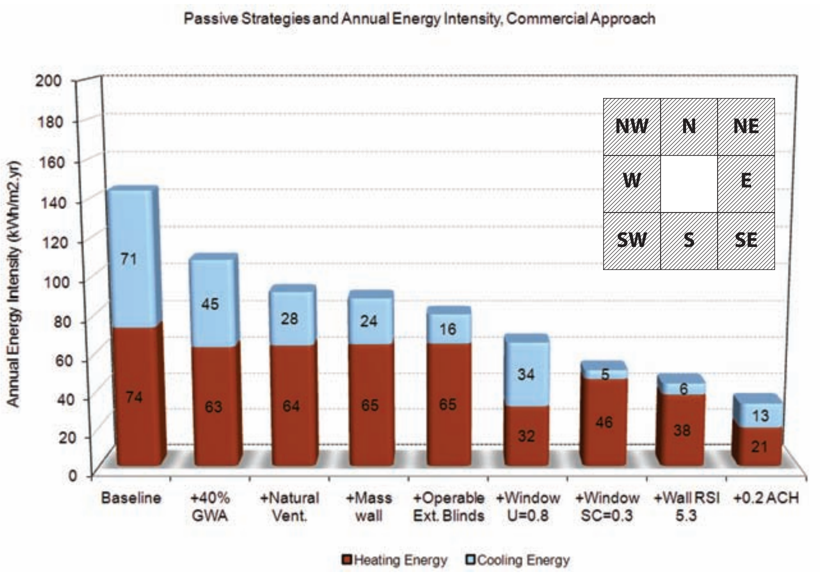
## E.17.3 Results

*Figure 59: Incremental cumulative effect on the annual heating and cooling energy intensity for the all perimeter spaces on the middle floor for the passive commercial approach*



## E.17.4 Conclusions

- The passive elements reduce the total annual heating and cooling energy consumption in the commercial building significantly.

- Although the shading coefficient, and mass wall increase the heating energy consumption compared with the previous case, the element's effect on space cooling results in reduction in net annual energy consumption.

- The final result is a significant reduction in both space heating and space cooling energy consumption for the commercial building.

### E.17.5 Recommendations on Commercial Approach

Incorporate as many passive design elements as possible to optimize comfort and minimize overall energy use.

## E.18 Commercial Schedule

**Room set points**

| | Summer | Winter |
|---|---|---|
| Resultant Temp.: | 24-28(setback) | 15(setback)-21 |
| RH: | 0-100% | 0-100% |

Conditioning schedule (on ☐ off ■) Set back system setback during weekends

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| On/off | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ☐ | ☐ | ☐ | ☐ | ☐ |
| hr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |

People(no people during weekends)

| | | |
|---|---|---|
| People density: | 14.3 | m² / person |
| OA requirements: | 10 | l/s/person |
| Sensible gain: | 73 | W / person |
| Latent gain: | 59 | W / person |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| hr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |

Lighting (10% safety lighting during weekends)

| | | |
|---|---|---|
| Lighting power density: | 11 | W/m² |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % | 10 | 10 | 10 | 10 | 10 | 10 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 1t0 | 10 | 10 | 10 | 10 | 10 |
| hr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |

Plug load (no plug load during weekends)

| | | |
|---|---|---|
| Installed power density: | 5 | W/m² |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| hr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |

O² Photo: Merrick Architecture

# Appendix F – Case Studies

## O²

*Vancouver, BC*

**Provided by Merrick Architecture**

The O² project was conceived as the convergence of earth, air and water. O² is a residential mixed use project that integrates and responds to the natural elements within the densely populated urban context of Vancouver's West End.

O²'s natural ventilation recalls the proximity of the ocean and takes advantage of the corresponding sea breezes. The building form and strategically placed operable windows assist in optimizing natural cooling and ventilation through the suites.

Passive cooling is also achieved through the use of south- and west-facing shading that controls and reduces excessive solar heat gain. Natural daylighting is maximized through the careful consideration of the depth and layout of the units, integration of interior glazing, and location of external glazing systems.

## Millennium Water – Vancouver's Olympic Athlete's Village

*Vancouver, BC*

**Provided by Merrick Architecture**

Vancouver's Olympic Village development demonstrates a number of passive design strategies that significantly reduce building energy loads. South facades feature horizontal shading while western exposures feature mechanized external vertical shading devices to control daylighting and solar heat gains. Deep balconies provide shading to the suites below.

Access stairwells are pulled to the perimeter of the building and encased in glass to maximize natural daylighting, encourage the use of stairs, discourage elevator use, and draw light into the public corridors. Natural ventilation is optimized with operable windows. Suites are designed as through-units to allow cross-ventilation with unconditioned exterior hallways. Evaporative cooling ponds located in the courtyards between buildings cool the air as it circulates between the external and interior environments.

## Pacific Institute for Sport Excellence, Camosun College

*Victoria, BC*

**Provided by Cannon Design**

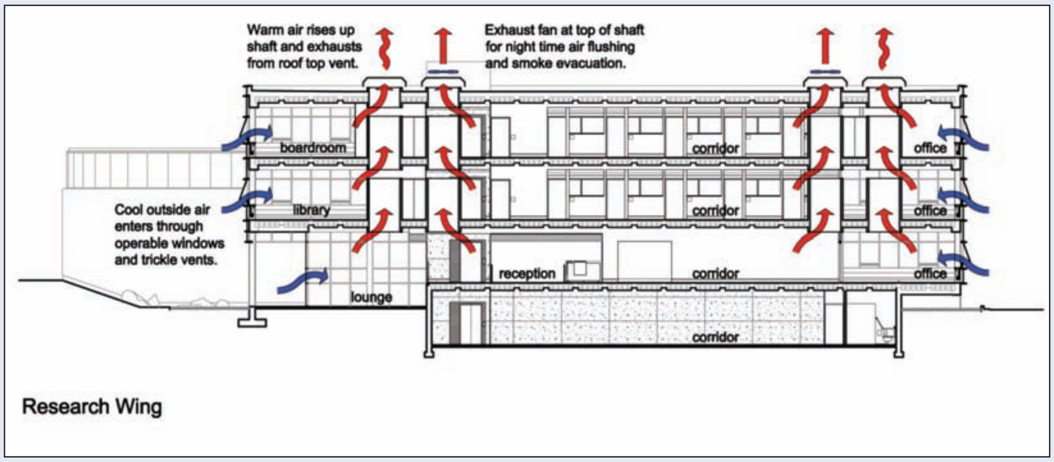
The Pacific Institute for Sport Excellence (PISE) accommodates a complex program of sport education, sport medicine and wellness, and high-performance athletic research and training. It is located on the outer edge of Camosun College's semi-rural Interurban Campus and will ultimately become an important urban landmark within the college's master plan.

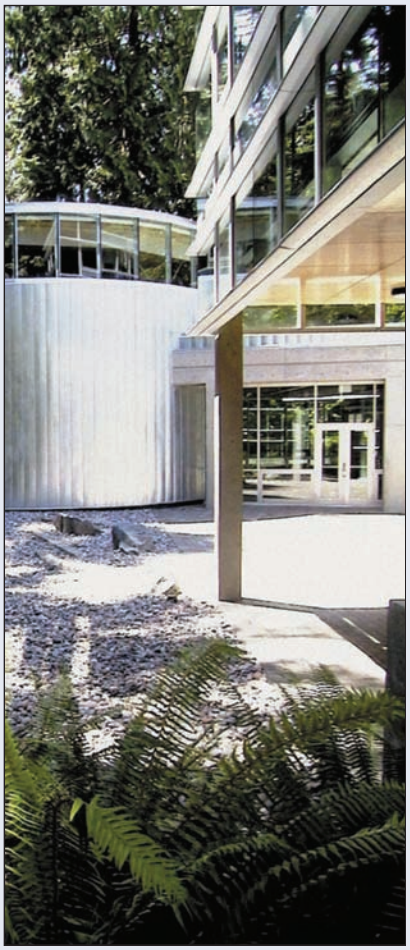
PISE's greatest energy-saving factors are its site orientation and building shape. Tucked into the slope of the hill, first floor service spaces and change rooms are earth-sheltered under an urban plaza. The building's east-west oriented shape maximizes southern exposure on the long, highly glazed 3-storey facade. East and west facades are minimized and have reduced window areas.

A constrained construction budget precluded the implementation of exterior shading devices on the south facade. Instead, the design called for the south facade to slope outward 15 degrees, providing 'self shading' for the interior during summer. This strategy cost only nominally more than a vertical facade, and considerably less than exterior shading devices. This provided a dynamic and highly imageable form to the institution and worked well to accommodate different program areas on the three floors. Most importantly, this strategy helped reduce energy consumption by approximately 45% compared to a conventional facility of this kind.

## Liu Institute for Global Issues, UBC

*Vancouver, BC*
**Provided by Stantec**





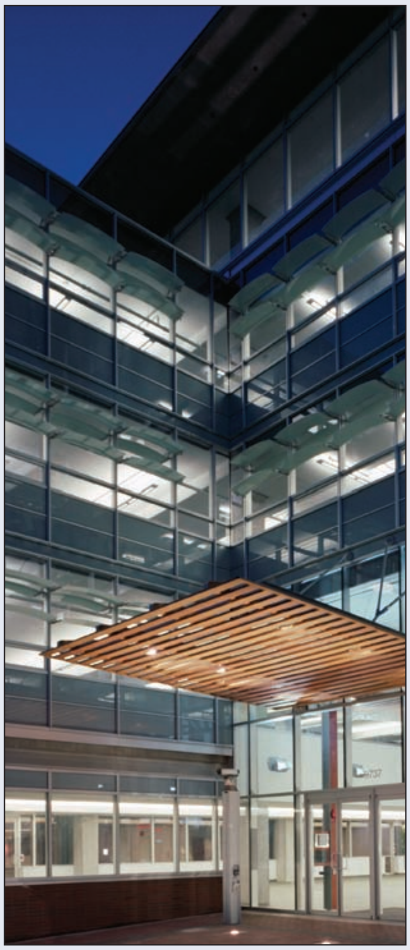
The Liu Institute has two distinct elements: one wing with offices and research and administration space for 72 participants, and one wing with meeting space including a case room, a multi-purpose room, and two seminar rooms. The building site was chosen carefully to maximize the quality of indoor light and take advantage of its natural forest setting. A rare Katsura tree stands in the entry courtyard to the north, while the south courtyard opens to a Zen garden and the forest backdrop beyond.

Passive design strategies include thermal mass in the form of exposed concrete surfaces. The pre-cast concrete is featured as both a structural element and a finish. The building spaces are naturally ventilated through operable windows, trickle vents and stack effect from four thermal chimneys. The adjacent forest provides passive shading for the interior spaces while allowing for extensive daylighting. The forest canopy offers occupants protection from direct solar glare.

## Revenue Canada Offices

*Surrey, BC*

**Provided by Busby Perkins+Will**



Completed in 1998, the Revenue Canada office building was one of the first to demonstrate the rational and economic benefits of green building and passive design strategies in office buildings. The office spaces are organized around a central core that contains all shared heat-generating equipment, such as printers and photocopiers. This concentration of heat assists in creating the stack effect necessary to draw in fresh air from the perimeter windows for natural ventilation. For the first time, a 100% shading coefficient was implemented, with a two-tier system of exterior shading to block direct summer sun from entering the building. The upper sun shade is paired with an interior light shelf that reflects daylight off white-painted exposed concrete ceilings, allowing the daylight to reach deep into the office space. Through natural ventilation, a raised floor system, thermal mass from concrete flooring, and external solar shading, air-conditioning was minimized and is only used in the height of summer.

Adapted from Busby: Learning Sustainable Design, Janam Publications Inc., March 2007.

Photos: Martin Tessler

## City of White Rock Operations Centre

*White Rock, BC*

**Provided by  Busby Perkins+Will**

Completed in 2003, this 600 m$^2$ facility houses the public works departments for the City of White Rock, including administration, meeting rooms, lockers and changing rooms for municipal operations field crews. Each facade responds to the natural environment on that side of the building. To the east, a roof overhang and a row of deciduous trees provide summer shade and allow for winter sun penetration. To the south, the roof overhang continues and a projecting horizontal sun shade is added to protect the lower areas of windows. To the west, an exterior horizontal trellis (made of salvaged telephone poles) is supported on projecting fin walls that together provide afternoon protection from solar penetration. In contrast with the other elevations, the north facade is almost entirely solid, with windows covering only 5% of the wall area.

## Dockside Green

*Victoria, BC*

**Provided by Busby Perkins+Will and Hughes Condon Marler : Architects**

Dockside Green is a 1.3 million ft$^2$ mixed-use development including residential, office, retail and industrial spaces on fifteen acres of former industrial land. The finished development will be greenhouse gas neutral and on site energy generation may exceed on site demand, turning the development into a net energy provider.

### Dockside Green Phase R1: Synergy

Provided by Busby Perkins+Will

Completed in March 2008, Dockside Green's Synergy phase represents 95 residential units in 9,344 m$^2$, 351 m$^2$ of commercial space, and 6,876 m$^2$ of underground parking. Among Synergy's many passive features, exterior shading on the west and south facades minimizes solar heat gain in the residential suites.

### Dockside Green Phase CI-3: Evolution

Provided by Hughes Condon Marler : Architects

The Evolution phase at Dockside Green is designed to meet the LEED® Platinum rating for Core and Shell under the Canadian Green Building Council (CaGBC). In order to achieve Platinum, the mechanical and electrical systems are designed to optimize passive solar and ventilation principles. Operable windows combine low (desk height) and high (ceiling height) air intakes and exhausts, and elongated floor plates optimize cross-ventilation. Narrow floor plans maximize daylighting potential and view access.

A retractable, vertical venetian blind system shades the south facade, and two-storey vertical fins shade east-facing windows from the late morning sun. Energy modeling shows that Evolution will consume approximately 48% less energy than the reference building. In addition, all hot water and heating energy will come from the Dockside biomass plant.

## Butchart Gardens Carousel Building

*Victoria, BC*

**Provided by Hughes Condon Marler : Architects**

A traditional 32-figure wooden carousel will be housed within a concrete, wood and glass carousel pavilion at the base of an existing mature forest at The Butchart Gardens. The building consists of two main elements: a 90m long serpentine wall made of board-formed concrete and a glass drum with exposed timber structure. In some locations the wall creates cave-like rooms for children's parties, concession and service spaces, while in other instances it forms the retaining wall at the rear of the main circular carousel room. The circular roof over the carousel will be constructed of exposed glue-laminated ("gluelam") beams with a blue stain pine ceiling infill and a 4m diameter glazed oculus at the centre. The roof hovers over the curving wall on pairs of tilting gluelam columns. The upper domed roof will be covered in a thin layer of native mosses, sedums and Corsica mint. The lower roofs will be a continuation of the forest understorey; snow berry, ferns, salal.

By placing the building to the north of an existing hillside forest, solar overheating is avoided. In addition, by locating the building against the hillside, the planted roofs and thick concrete walls all improve the thermal performance of the interior spaces.

Fresh air is tempered by the earth's relatively constant temperature as it passes through a large earth tube in the hillside. Air is supplied at low levels and exhausted at high levels through operable windows. The operable windows and low velocity supply fan are automatically controlled via the DDC system.

The radiant slab heating/cooling system utilizes the existing main irrigation line running past the site. The irrigation line remains at a relatively constant temperature, and heat is removed using a water to water heat pump.

## Hillcrest Community Centre

*Vancouver, BC*

**Provided by Hughes Condon Marler : Architects**

The Hillcrest Community Centre is designed to achieve LEED® Gold under the Canadian LEED® standard. This unique facility, which will serve as the curling venue for the Vancouver 2010 Olympic Games, is oriented carefully on its site to optimize solar gains. The strategic location of window and solar shading also contributes to energy savings. The facility features natural ventilation through operable windows, providing fresh air from the adjacent Queen Elizabeth Park and further reducing energy costs.

The preliminary estimated total energy savings is 44.8%, representing cost savings of $170,000/yr. The project will also use significantly less potable water than a similar conventional building by using groundwater and rainwater for toilet flushing and irrigation.

A series of other green building strategies will further reduce the environmental impacts of the building, including Forest Stewardship Council-certified wood for the structural gluelams.

Technology Fact Sheet

# CENTRAL HEAT PUMP AND AIR CONDITIONER INSTALLATION

## Buildings for the 21st Century

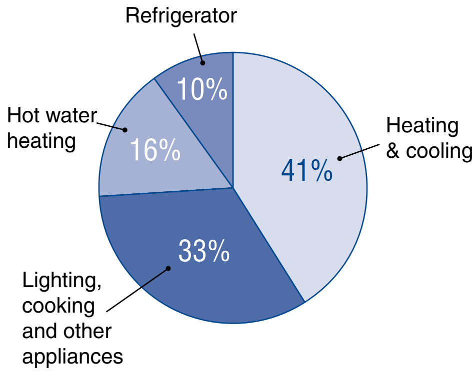
Buildings that are more energy-efficient, comfortable, and affordable…that's the goal of DOE's Office of Building Technologies Program.

To accelerate the development and wide application of energy efficiency measures, the Building Technologies Program:

- Conducts R&D on technologies and concepts for energy efficiency, working closely with the building industry and with manufacturers of materials, equipment, and appliances
- Promotes energy/money saving opportunities to both builders and buyers of homes and commercial buildings
- Works with State and local regulatory groups to improve building codes, appliance standards, and guidelines for efficient energy use

## INTRODUCTION

A typical family may spend 40 to 60 percent or more of its annual utility budget on heating and cooling. Careful installation of heating and cooling equipment can increase operating efficiency, increase occupant comfort, and reduce utility costs.


HOME ENERGY COSTS

## WHY IS INSTALLATION IMPORTANT?

Incorrect installation of central heat pumps and air conditioners leads to high electric bills, poor indoor comfort, and maintenance problems. Many studies have shown that heat pumps and air conditioners — even new units — are often improperly charged, which can reduce system capacity and efficiency by 20 percent or more.

Incorrect air flow across the indoor coil is another common problem in air conditioner and heat pump installations, with a subsequent impact on indoor comfort and operating costs. Low air flow affects the cooling and heating capacity and efficiency of the unit. Excess air flow is a less common problem, but it can cause poor dehumidification during cooling, duct noise, and drafts.

Reduced air flow across the outdoor coil or inadequate air circulation around the outside unit also lowers capacity and operating efficiency. This often occurs when bushes are planted too close to the unit, the unit is installed under a porch, or the outdoor coil becomes clogged with leaves, pollen, or lint from a dryer.

Improperly installed controls can cause poor humidity control during cooling operation and inefficient operation of a heat pump during the heating season. Other installation problems that lower capacity and operating efficiency and cause maintenance problems include refrigerant lines that are too long, incorrectly pitched, or crimped.

## DESIGN AND INSTALLATION ELEMENTS

Proper heat pump and air conditioner installation is just one of four elements needed to provide an economical, efficient, and comfortable heating and cooling system. The design and installation of central heat pump and air conditioner systems must also address the following elements before or during equipment installation:

- Equipment must be properly selected and sized to meet house heating and cooling loads and to be as efficient as possible.
- The duct system must be correctly designed to work with the air conditioning and heat pump equipment and to distribute conditioned air properly throughout the house.
- The duct system must be properly installed and sealed to ensure its design performance.

## INSTALLATION GUIDELINES

Heat pumps and air conditioners should be installed by knowledgeable technicians according to the manufacturer's installation instructions and all national and local code requirements. General installation guidelines are applicable to most units and should be followed insofar as they do not conflict with these other requirements.

Proper air conditioner and heat pump installation can be achieved by addressing four critical areas:

- indoor air handler, especially the air flow over the fan-coil unit and through the forced-air duct system
- refrigerant system, especially the refrigerant charge
- outdoor unit, especially its air supply
- control system, especially the thermostat that turns the equipment on and off.

## INDOOR AIR HANDLER

### ✓ Indoor Air Flow

For most heat pump and air conditioning equipment, air flow over the indoor coil should be 400 cubic feet per minute (cfm) per ton of air conditioning capacity (plus or minus 50 cfm/ton) when the air conditioner has been operating long enough to wet the indoor coil (usually about 15 minutes). If wet coil conditions cannot be obtained (e.g., installation during the winter), then air flow should be 425 to 450 cfm/ton (plus or minus 50 cfm/ton). In humid climates where removing humidity from the interior air is an important function, the best system efficiency may occur where the air flow is between 350 and 400 cfm/ton. In dry climates where little dehumidification is needed, the best system efficiency may occur when the air flow is between 400 and 450 cfm/ton.

Before indoor coil air flow measurements are performed, the duct system should be inspected and tested to ensure that leaks are minimized. Although no technique for air flow measurement currently has universal acceptance, the best flow measurement method available should be performed to verify and document that the air flow is within acceptable ranges.

There are several air flow measurement approaches:

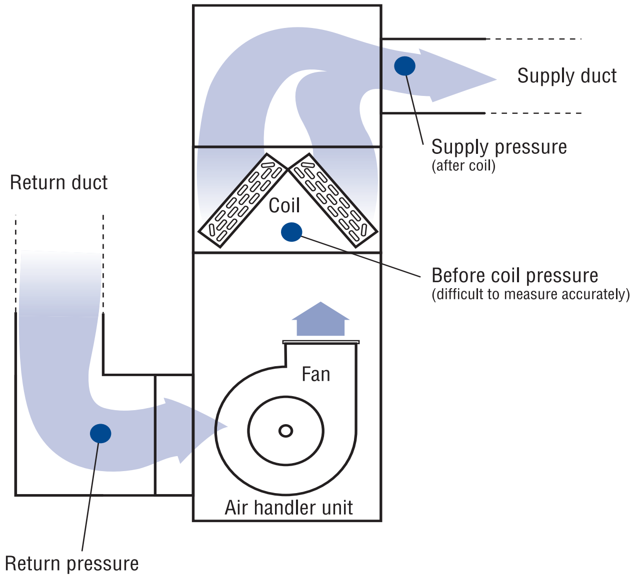
- The most common technique involves measuring the static pressure across the air handler unit and using the manufacturer's static pressure vs. flow rate curves for the air handler to estimate air flow. The manufacturer's curves will usually be based on the pressure between the return plenum and the area either before or after the indoor coil. Measuring the pressure before the coil is difficult, so it may be easier to calculate it by measuring the pressure after the coil and compensating for the pressure drop across the indoor coil.

  This method can give good results if accurate pressure measurements can be made and flow curves are available. However, pressure measurements are often not accurate because pressures fluctuate significantly around the air handler unit fan and coil as a result of flow turbulence induced by the fan, abrupt changes in flow direction near the air handler, etc. Flow curves are often not available to technicians in the field, and curves developed for new fans and coils are often not applicable to fans and coils that have become dirty while operating in the field.

  A variation of this method is to measure the static pressure across the indoor coil and use a flow curve supplied by the coil manufacturer to infer flow rate. Again, measuring the pressure before the coil is difficult and leads to errors.
- A second method is applicable just to heat pump systems equipped with supplementary strip heaters. The unit is operated with just the strip heaters on. The air flow rate can be calculated by measuring the temperature rise of air across the strip heaters and the energy consumption of the strip heaters

STATIC PRESSURES

To measure air flow



and indoor fan [air flow rate (cfm) = 3.16 x energy use (watts)/ΔT (°F)]. The accuracy of this method depends on the accuracy of the temperature and energy consumption measurements. In making the temperature measurements, it is important that the air be well mixed where the temperature is being measured and that the temperature sensor be out of the line of sight of the strip-heat elements to avoid an inaccurately high temperature reading due to radiative effects. The air flow measured using this technique must be corrected to wet coil conditions. Also, in some equipment, the fan speed during operation in the strip-heat mode is different from that during operation in the air-conditioning mode unless the thermostat and/or fan is properly configured by the technician for the test.

- Another method involves the use of flow hoods to measure air flow rates. In this approach, air flow rates are measured at the return registers or supply registers and added to obtain the total flow rate for the system. Researchers have found that many flow hoods used in residential applications in this manner are relatively inaccurate because of low air flow rates, non-uniform air flow through the flow hood, and other reasons. In addition, flow hoods underestimate the actual flow across the indoor coil when duct leaks are present.
- A new method that shows much promise for simplifying the measurement process while providing sufficiently accurate results is a specially designed orifice plate. The air filter in the system is removed and the orifice plate is inserted in its place. The pressure drop across the orifice plate is measured and used to estimate the system air flow rate using a flow curve for the orifice plate and a small correction factor for the different pressure drop induced by the orifice plate compared with the air filter. Non-uniform air flow entering the orifice plate (due to bends in the return duct before the orifice plate) reduces the accuracy of this method. As with flow hoods, duct leaks make this method underestimate the actual air flow across the indoor coil if the air filter is not located at the air handler.
- A final, more costly and complicated method involves use of a duct blower to measure air flow. A duct blower is a device used to measure duct leakage in an air distribution system. It comes equipped with its own fan and a flow metering system. First, the pressures in the supply and return ducts are measured under normal air-conditioning operation. The duct blower is then connected to the return register or the air handler directly (blocking off the existing return) so that all return air flows through the duct blower. The equipment is again operated in its normal air-conditioning mode, with the duct blower fan operated so that the same pressures are achieved in the supply and return ducts. The flow measured through the duct blower is the same as the flow rate through the equipment during normal operation.

### ✓ AIR FILTERS

Air filters should be located as close to the indoor fan and coil as possible and where they are easily accessible by the occupants. Forced-air heat pump and air conditioning systems use air filters to minimize the accumulation of dust on the indoor coil and fan because dust accumulation can reduce system efficiency. An air filter that is left in place too long will become plugged and will reduce air flow across the coil. Most manufacturers recommend replacing filters monthly, which requires frequent and ready access by the occupants.

## REFRIGERANT SYSTEM

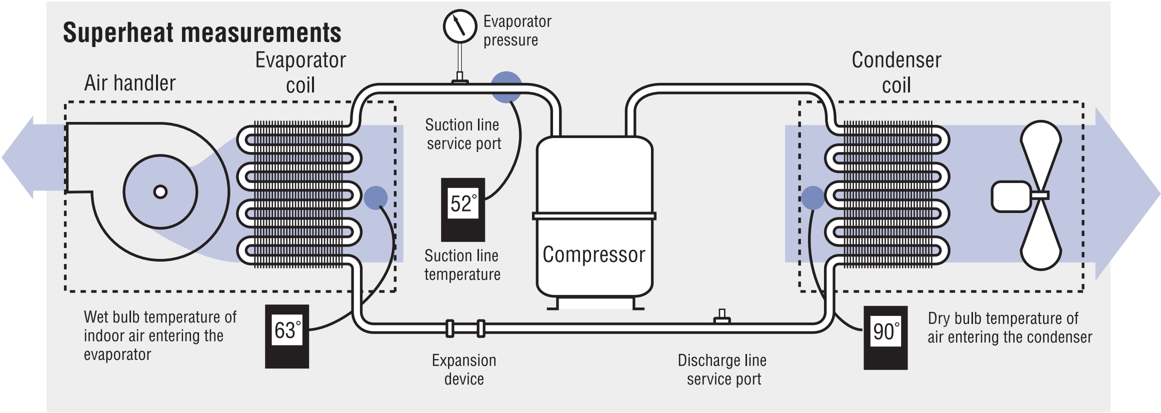
### ✓ CHARGE

Proper refrigerant charge is critical to efficient and reliable operation of air conditioners and heat pumps. Before new systems or lines that have been exposed to the atmosphere are charged, they should be evacuated by the *deep vacuum method*. This method of system evacuation requires use of a gauge that can accurately measure pressures at least as low as 500 microns of mercury and a pump that can achieve those levels of evacuation. The low pressures are needed to eliminate moisture from the refrigerant loop.

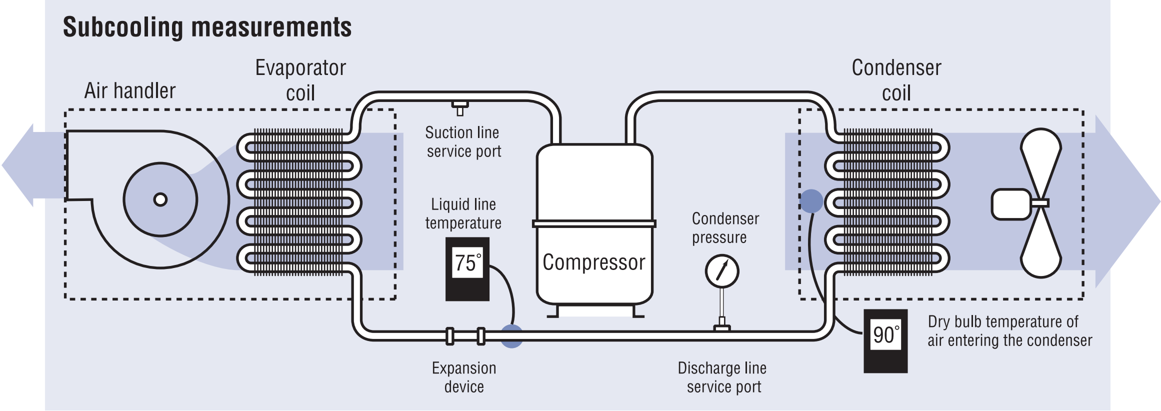
After the system is assembled and before refrigerant is added, the system should be evacuated to a pressure no higher than 500 microns. The pump should be valved off and the system pressure monitored and recorded once a minute for a minimum of five minutes. Subsequent action depends on the measurements obtained.

- In a tight, dry system, the pressure will quickly rise to about 1000 microns and then remain stable. Such a system is ready to receive an initial charge.
- In a tight system that contains too much moisture, the pressure will rise above 2000 microns before stabilizing. Continued pumping is needed to remove the moisture.
- A system that has a leak will show pressure that does not stabilize, slowly rising to atmospheric pressure. A leaky system must be sealed and re-evacuated.

## SUPERHEAT AND SUBCOOL METHODS



Superheat measurements



Subcooling measurements

Once the system has been properly evacuated, refrigerant can be weighed into the system per specifications or a pre-charge stored in the outdoor unit can be released (package systems are most often shipped fully charged). In both cases, account for any additional charge needed for refrigerant line lengths.

After the initial charge has been introduced and the correct air flow rate across the indoor coil had been verified, the charge should be checked after the system has operated for 15 minutes before the system can be considered accurately charged. There are three preferred methods of testing the refrigerant charge of heat pumps and air conditioners: superheat method, subcooling method, and approach method.

- The **superheat method** is suitable for systems that use fixed metering systems (e.g., a capillary tube or a fixed orifice). In general, the following measurements are made: the evaporator (indoor coil) pressure at the suction line service port, the suction line temperature within five feet of the compressor (e.g., at the suction line service port for split units, just before the accumulator of packaged units), the dry bulb temperature of the air entering the condenser (outdoor coil), and the wet bulb temperature of the indoor air entering the evaporator. The actual superheat is calculated by subtracting the saturation temperature based on the evaporator pressure from the suction line temperature. The desired superheat is determined from manufacturer specifications based on the entering evaporator and condenser air temperatures. The actual superheat is compared with the desired superheat, and the refrigerant charge is adjusted (refrigerant is added if the actual superheat is too high and removed if it is too low) until the actual superheat is within 2°F of the desired value. The system should operate for at least 10 minutes between adjustments.
- The **subcooling method** is used for systems with thermostatic expansion valves (TXVs). In general, the following measurements are made: the condenser pressure at the discharge line service port, the discharge (liquid) line temperature (e.g., entering the expansion valve, the condenser

outlet), and the dry bulb temperature of the air entering the condenser (outdoor coil). The actual subcooling is calculated by subtracting the discharge (liquid) line temperature from the saturation temperature based on the condenser pressure. The desired subcooling is determined from manufacturer specifications, possibly based on the entering condenser air temperature. The actual subcooling is compared with the desired subcooling, and the refrigerant charge is adjusted (refrigerant is added if the actual subcooling is too low and added if it is too high) until the actual subcooling is within 2°F of the desired value. The system should operate for at least 10 minutes between adjustments.

- The **approach method** is a less widely used method recommended by some manufacturers. Two measurements are made: the discharge (liquid) line temperature (between the condenser outlet and expansion device) and the dry bulb temperature of the air entering the condenser (outdoor coil). The difference between these two values is the approach temperature. The charge should be adjusted until the recommended approach temperature is achieved. The system should operate for at least 10 minutes between adjustments.

If ambient temperatures are below 80°F and the manufacturer does not provide superheat or subcooling data for outdoor temperatures below this value, then the tests must be modified to simulate higher outdoor temperatures, usually by partially blocking air flow to the outdoor coil.

The correct charge generally ensures that the evaporator and condenser operate at their design pressure and temperature. As a final check on system operation, the temperature difference across the indoor coil should be between 10 and 20°F (usually about 15°F).

### Refrigerant Lines

In split system designs:

- Refrigerant lines should be as short and straight as possible to minimize heat loss/gain and pressure drop. Normally, refrigerant lines should be less than 50 feet long, with a vertical length of less than 20 feet. Where longer runs are necessary, lines must comply with special manufacturer requirements.
- Refrigerant lines should be pitched and trapped according to manufacturer specifications. Bends and elbows should have a large radius (greater than twice the pipe diameter) to minimize pressure loss. Lines should be supported with hangers that avoid cutting the line or insulation.
- Suction lines should be insulated with a minimum 3/8-inch-thick closed-cell elastomeric foam pipe insulation to prevent condensation and heat gain. Refrigeration line insulation located outside should have a waterproof covering and should be protected from ultraviolet radiation (i.e., sunlight). Liquid lines normally do not need to be insulated.
- The hole in the outside wall through which the refrigerant lines go should be caulked. Similarly, the entry hole into the indoor unit should be sealed.
- Unless otherwise specified by the manufacturer, a liquid-line filter/dryer should be installed.

### OUTDOOR UNIT

The outdoor unit of heat pumps and air conditioners exchanges heat with outdoor air. To ensure effective heat dissipation, the outdoor unit should be located where air can circulate around it freely. Most outdoor units have a coil surrounding a centrally-located fan that pulls air through the coil. There should be no obstruction within 36 inches on the side with the service panel to allow for maintenance access, and there should be no obstructions within 12 inches on any of the remaining sides to allow for free air circulation. There should be no obstructions (e.g., porches) within 48 inches of the vertical air discharge from the unit that would force discharged air to recirculate directly back to the fan intakes. Landscaping should be kept at least 3 feet away from the outdoor unit so that leaves, seeds, and pollen do not plug the unit.

To prevent maintenance and other problems, the outdoor unit should be placed:

- on a level concrete (or equivalent) pad, elevated (if necessary) to prevent problems from snow or water accumulation, and leveled
- away from where collected rainwater, snow, or ice are likely to fall on it (e.g., under roof eaves)
- away from dryer vents (lint can plug the outdoor coil and chlorine in the dryer exhaust can cause corrosion)
- away from decks and windows to prevent the noise from disturbing occupants.

# CENTRAL HEAT PUMP AND AIR CONDITIONER INSTALLATION

*For more information, contact:*

***Energy Efficiency and Renewable Energy Clearinghouse (EREC)***
*1-800-DOE-3732*
*www.eere.doe.gov*

*Or visit the Building Technologies Program Web site at*
*www.buildings.gov*

*Or refer to the* Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems, *Consortium for Energy Efficiency*
*617-589-3949*
*www.cee1.org/resid/rs-ac/hvac.php3*

*Written and prepared for the U.S. Department of Energy by:*

***Southface Energy Institute***
*404-872-3549*
*www.southface.org*

***U.S. Department of Energy's Oak Ridge National Laboratory***
*Buildings Technology Center*
*865-574-5206*
*www.ornl.gov/btc*

## CONTROL SYSTEM

### ✓ THERMOSTAT

The heart of the control system is the thermostat. The thermostat should be placed on an inside wall, in a central area of the house, in a location protected from direct sunshine, and out of drafts induced by air supply registers. The interior wall cavity on which the thermostat is installed should be sealed at the top and bottom to prevent circulation of cool air in winter and warm air in summer, which would cause the thermostat to operate ineffectively. Make sure the control voltage of the thermostat is matched to the voltage specified by the thermostat manufacturer. Verify the correct operation of the thermostat by checking the anticipator setting and the cut-on and cut-off temperatures relative to the set point.

Programmable thermostats automatically allow different temperature settings during the day and week to save energy, although not all users are comfortable with their complexity. Setback can be performed manually using standard thermostat models, but a consistent pattern is usually not achieved in practice. If a programmable thermostat is installed, it should be one with an Energy Star® label. Energy Star® thermostats allow better control of heating and cooling equipment by ensuring essential programming features and accuracy.

### ✓ HEAT PUMP CONSIDERATIONS

For heat pump systems, a thermostat compatible with such systems must be installed. Changeover between heating and cooling should be performed manually rather than automatically. The thermostat should be equipped with an emergency heat switch that permits all resistance heaters to be energized when the refrigerant system is inoperative and activates an indoor indicator light. Programmable models for heat pumps that meet Energy Star® requirements ensure that costly back-up heat is not engaged under routine conditions or in using setback practices.

If the unit is not installed with an outdoor-lockout thermostat, such a device should be installed to prevent the supplemental heat from operating when the ambient temperature is above the heat pump balance point (that is, the temperature at which the heat pump has just enough capacity to keep the house warm, typically 25 to 40°F), especially when a non-intelligent or non-ramping thermostat is used. The outdoor-lockout should not prevent emergency heat operation or strip heat operation during defrost.

Check the operation of the resistance heaters to ensure that they are wired correctly to their control circuits (that they cycle correctly, are stagged properly, and are not on all the time).

The heat pump should preferably have a microprocessor defrost control to better defrost the system just when needed. Conventional defrost controls use temperature or pressure difference across the outdoor coil or time to initiate the defrost cycle; these should be set to provide the highest operating efficiency for the local weather conditions.

## DOCUMENTATION

Proper installation of heat pump and air conditioning equipment should be documented by providing the following information:

- results of the deep evacuation test that notes the initial evacuation pressure and time, and the system pressure each minute for at least five minutes after the initial pressure rise
- air flow rate across the indoor coil and the method used to measure this rate
- initial and final measurements and calculations relating to the charge check, as well as the manufacturer specifications
- temperature difference across the indoor coil.

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste.
February 2003 DOE/GO102002-0781

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HOME TURBO EFFECT PRODUCTS NEWS GEO ENERGY INFO SERVICE CONTACT US

Previous category
< Ground loops

Next category
Pre insulated pipes >

Manifold chambers and Manifolds

## Manifold with Ball Valve

Distributor for several probes

Manifold with Ball Valves 1" DN25 and air vents. Standard distance between terminals is 100mm CC. Manifolds are pressure tested to 10 bar before delivery. Tailored to requirements concerning appearance, dimensions and number of connections.

| Art.no. | Product | |
|---|---|---|
| 1066-2 | 2 port manifold Shutoff valves | |
| 1066-3 | 3 port manifold Shutoff valves | |
| 1066-4 | 4 port manifold Shutoff valves | |
| 1066-5 | 5 port manifold Shutoff valves | |
| 1066-6 | 6 port manifold Shutoff valves | |
| 1066-7 | 7 port manifold Shutoff valves | |
| 1066-8 | 8 port manifold Shutoff valves | |
| 1066-9 | 9 port manifold Shutoff valves | |
| 1066-AT -20+60 | Thermometer Plant -20/+60 Dim 32mm -75mm | |
| 1080-STAD | STAD Valve DN 25 Upgrade |  |

Print

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Manifold box

Up to 7 collectors.

Manifold chambers DN650

Access point up to 3 probes

Manifold chambers DN850

Access point up to 10 probes

Manifold chambers DN1200

Access point up to 20 probes

Manifold with Ball Valve

Distributor for several probes

Manifold with the adjustment valve

Manifold for balancing probe systems

Contact Us

**MuoviTech UK** 0303 031 0402 sales@muovitech.com

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Previous category
< Probes

Next category
Manifold chambers and Manifolds >

Ground loops

## Turbo ground loops

Improved heat transfer

A patented further development of traditional ground loops with flat inside. Turbo has a significantly improved heat transfer capacity compared to the same with flat inside.

| Art.no. | Product |
|---|---|
| T54063-6 | PE 40 PN10 PE100 SDR17 6m T Turbo® |
| T54063-50 | PE 40 PN10 PE100 SDR17 50M T Turbo® |
| T54063-100 | PE 40 PN10 PE100 SDR17 100M T Turbo® |
| T54063-150 | PE 40 PN10 PE100 SDR17 150M T Turbo® |
| T54063-200 | PE 40 PN10 PE100 SDR17 200M T Turbo® |
| T54063-250 | PE 40 PN10 PE100 SDR17 250M T Turbo® |
| T54063-300 | PE 40 PN10 PE100 SDR17 300M T Turbo® |
| T54063-350 | PE 40 PN10 PE100 SDR17 350M T Turbo® |
| T54063-400 | PE 40 PN10 PE100 SDR17 400M T Turbo® |
| T54063-450 | PE 40 PN10 PE100 SDR17450M T Turbo® |
| T54063-500 | PE 40 PN10 PE100 SDR17 500M T Turbo® |
| T54063-550 | PE 40 PN10 PE100 SDR17 550M T Turbo® |
| T54063-600 | PE 40 PN10 PE100 SDR17 600m T Turbo® |

Print

0

Turbo ground loops

Improved heat transfer

Traditional ground loops

Ground loops with a flat inside

Contact Us **MuoviTech UK** 0303 031 0402 sales@muovitech.com

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# Fan Coil

## Aquaris Silent

Ferdinand Schad KG
Steigstraße 25-27
D-78600 Kolbingen
Teléfono 0 74 63 - 980 - 0
Fax 0 74 63 - 980 - 200
info@schako.de
www.schako.de

# Fan Coil Aquaris Silent

## Contenido

# Fan Coil Aquaris Silent

## Descripción General

Las unidades de tratamiento de aire Aquaris Silent han sido diseñadas para cubrir la demanda de climatización en instalaciones con zonas individualizadas (oficinas, locales comerciales, hoteles, etc.).
Una instalación de fan coil se caracteriza por su gran ahorro de energía al ser una climatización personalizada y por su bajo coste, tanto de instalación como de mantenimiento.
Con la idea de adaptarse lo máximo posible a las necesidades arquitectónicas del local a climatizar, la línea de fan coils Aquaris Silent se fabrica en varias ejecuciones, desde equipos para instalaciones empotradas en falsos techos y suelos (ejecución horizontal), hasta equipos instalados a la vista con mueble decorativo (ejecución vertical y horizontal).

### Características

- Rango de caudales: 160 a 1850 $m^3/h$
- Potencias frigoríficas: 1 a 8,3 kW
- Potencias caloríficas: 1,25 a 11 kW
- Presión estática disponible: hasta 70 Pa

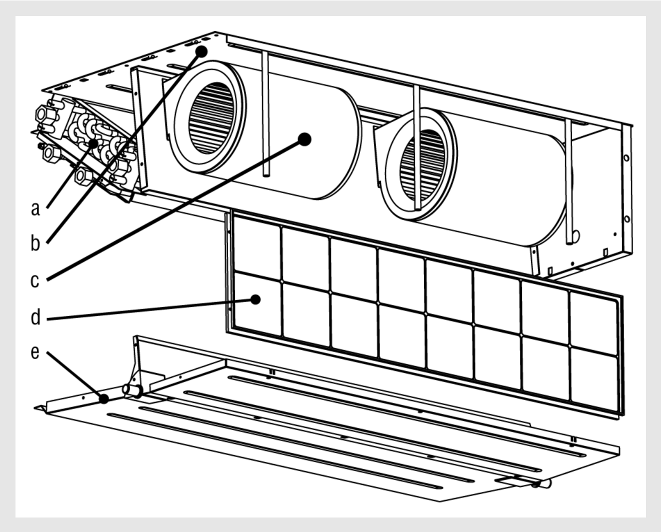
## Ventajas

- Sistema de control por zonas
- Altos rendimientos
- Estanqueidad
- Bajo nivel acústico
- Ahorro energético
- Equipo sólido y compacto
- Facilidad de montaje y mantenimiento
- Buena estética (unidad con mueble decorativo)

## Descripción de los equipos

### Unidad básica

La unidad básica consta de un grupo motoventilador una o dos baterías de intercambio térmico, un filtro y una bandeja de condensados. Todo el conjunto se encuentra alojado en una carcasa de chapa galvanizada aislada térmica y acústicamente.



**a** Batería(s) de intercambio térmico
**b** Carcasa
**c** Grupo motoventilador
**d** Filtro
**e** Bandeja de condensados

### Carcasa

La carcasa del equipo está formada por perfiles y paneles de chapa de acero galvanizado y aislante de 3 mm de espesor.

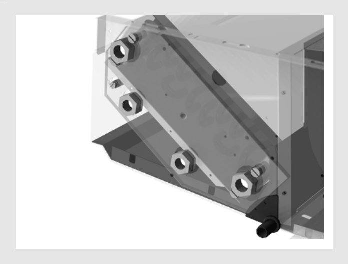
### Baterías de intercambio térmico

La sección de intercambio térmico puede estar formada por una única batería de 3 filas para refrigeración o calefacción (instalación a 2 tubos), o por dos baterías 3+1 filas (instalación a 4 tubos).

Las baterías, diseñadas para trabajar con o sin anticongelantes, están compuestas por tubos de cobre, aletas de aluminio, sistema manual de purga – drenaje y marco de acero galvanizado.
La longitud del paquete aleteado va en consonancia con las prestaciones requeridas por la instalación y las conexiones de agua pueden situarse indistintamente en el lado izquierdo o derecho de la batería.
De manera opcional, existe la posibilidad de incorporar una batería eléctrica de apoyo en régimen de calefacción.

# Fan Coil Aquaris Silent

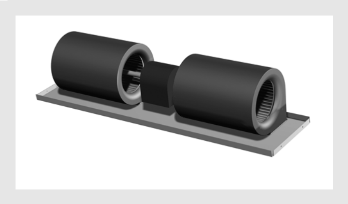
## Bandeja de condensados



La bandeja de condensados, diseñada tanto para instalación en horizontal como en vertical, se encarga de recoger el agua condensada por la batería de refrigeración. Se fabrica en chapa de acero galvanizado aislada mediante revestimiento térmico (polietileno de 3 mm de espesor) para evitar posibles condensaciones.

La bandeja incorpora un desagüe en el mismo lado de las conexiones hidráulicas para ser conectado al sistema de canalización y drenar los condensados evitando de esta manera la presencia de agua y suciedad retenida.

## Grupo motoventilador



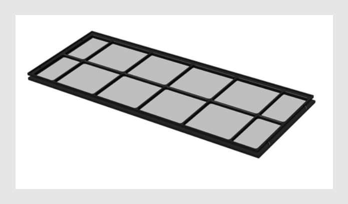
El grupo motoventilador está formado por ventiladores centrífugos de doble oído dinámicamente equilibrados de palas hacia delante con motor directo. El motor puede ser de tipo AC (serie SP) o de alta eficiencia EC (serie EC), con cojinetes libres de mantenimiento para garantizar una vida larga al producto.

La serie SP dispone de 6 velocidades gracias al transformador y la serie EC funciona con una señal de entrada 0-10V.

La carcasa y el motor están fabricados en material sintético.

El grupo de ventilación de cada unidad, se ha seleccionado de manera que se obtengan las presiones estáticas indicadas con unos niveles de potencia sonora reducidos.

## Filtro



Filtro de aire con eficacia G2 y G3 (bajo pedido) compuesto por una malla sintética en un marco de plástico. Los filtros se caracterizan por su fácil extracción (clips de apriete) y sencillo mantenimiento (lavado o soplado).

## Accesorios

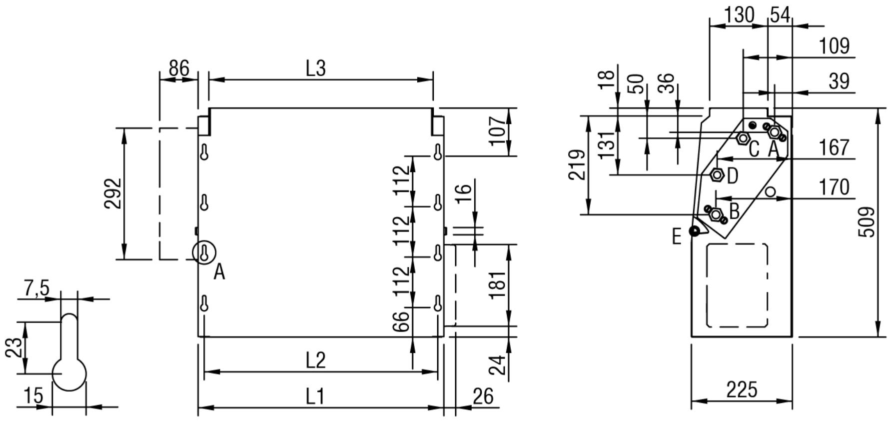
Opcionalmente, en función de las necesidades del cliente o de la instalación y con el objetivo de lograr unas mejores prestaciones y un óptimo funcionamiento, se pueden integrar otros componentes a la unidad tales como: plenum de impulsión y aspiración, batería eléctrica, manguito de unión flexible, marco de unión, mueble decorativo, bandeja auxiliar y bomba de condensados, kit de válvulas, rejilla modelo SCHAKO Ib 1 y difusor modelo SCHAKO DBB. Además se ofrece una amplia gama de elementos de control y regulación.

# Fan Coil Aquaris Silent

## Ejecuciones, medidas y pesos

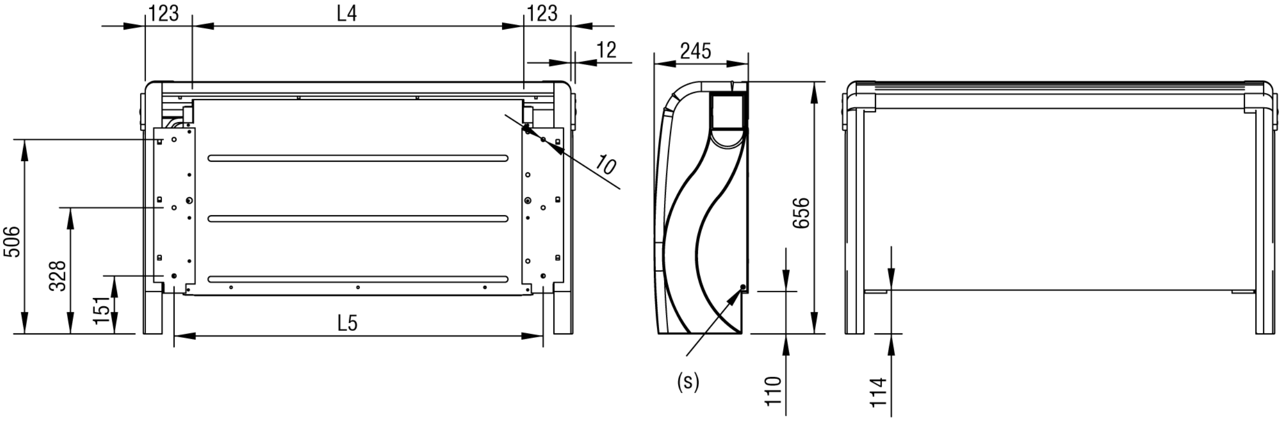
### Dimensiones y pesos

**Unidad básica**



- Vista lateral izquierda (dirección del aire)
- El modelo estándar lleva instalada la caja eléctrica en el lado opuesto a las conexiones hidráulicas del equipo

**Mueble decorativo (accesorio opcional)**



| Tamaño | Dimensiones (mm) | | | | | Pesos (Kg) | | Volumen de las baterías (l) | |
|---|---|---|---|---|---|---|---|---|---|
| | L1 | L2 | L3 | L4 | L5 | G1 | G2 | 3 filas | 1 fila |
| **10 / 11** | 697 | 670 | 645 | 649 | 755 | 14 | 20 | 1,2 | 0,3 |
| **20 / 21** | 912 | 885 | 860 | 864 | 970 | 20 | 28 | 1,6 | 0,4 |
| **30 / 31** | 1247 | 1220 | 1195 | 1199 | 1305 | 25 | 36 | 2,3 | 0,6 |
| **40 / 41** | 1352 | 1325 | 1300 | 1304 | 1410 | 32 | 46 | 2,5 | 0,7 |
| **50 / 51** | 1597 | 1570 | 1545 | 1549 | 1655 | 35 | 49 | 3,0 | 0,9 |

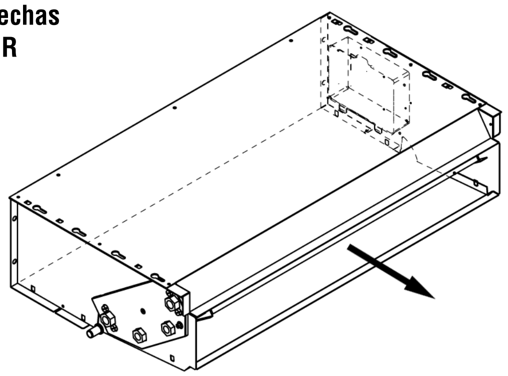
A= salida agua fría (rosca interior cilíndrica EN 10226-1 Rp 1/2)
B= entrada agua fría (rosca interior cilíndrica EN 10226-1 Rp 1/2)
C= entrada agua caliente (rosca interior cilíndrica EN 10226-1 Rp 1/2)
D= salida agua caliente (rosca interior cilíndrica EN 10226-1 Rp 1/2)
E= salida de condensados DN16 mm (exterior)
G1 = Peso unidad básica
G2 = Peso unidad básica + mueble decorativo

A fin de evitar incrustaciones o corrosión, la calidad del agua para el llenado de las baterías debe cumplir con lo requerido en las directivas VDI 2035 y DIN 50930.

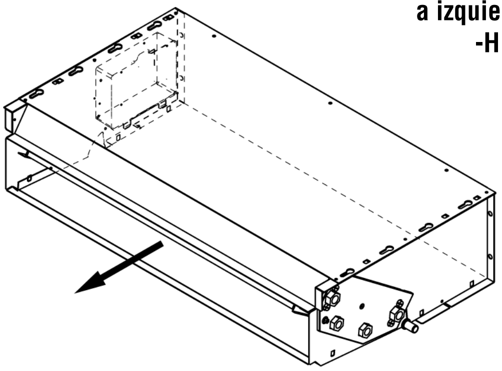
# Fan Coil Aquaris Silent

## Ejecuciones

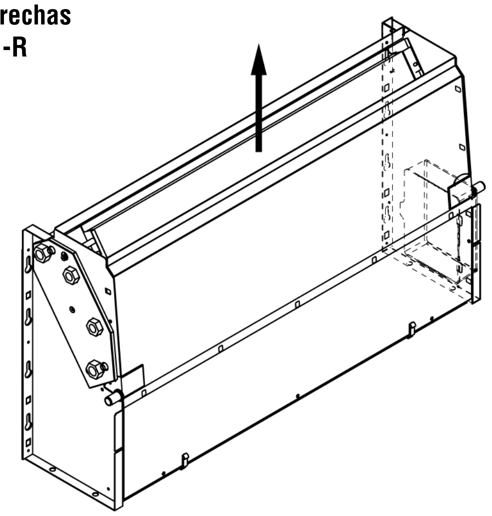
**Montaje horizontal con conexiones hidráulicas a derechas**
**-H...-R**



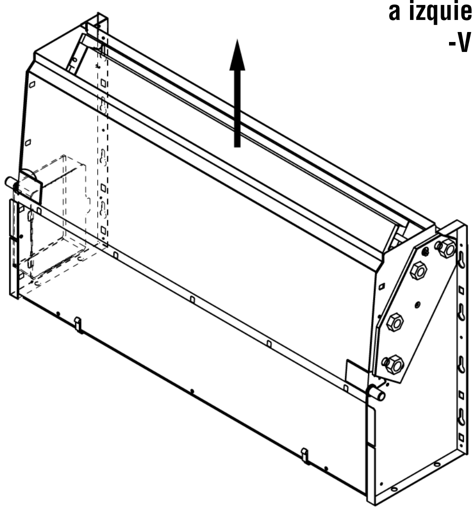
**Montaje horizontal con conexiones hidráulicas a izquierdas**
**-H...-L**



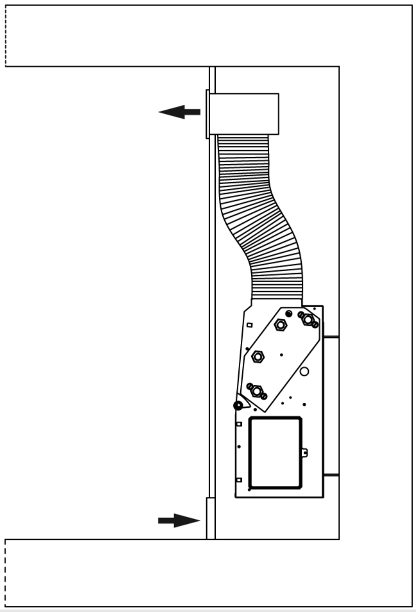
**Montaje vertical con conexiones hidráulicas a derechas**
**-V...-R**



**Montaje vertical con conexiones hidráulicas a izquierdas**
**-V...-L**

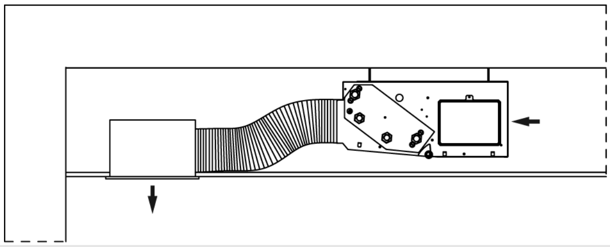


**Ejecución vertical**
Equipo especifico para montaje en muros perimetrales empotrados o a la vista.



**Ejecución horizontal**
El tamaño compacto y la altura reducida del fan coil Aquaris Silent, lo hacen idóneo para una instalación empotrada en falsos techos y suelos o a la vista suspendida del techo.

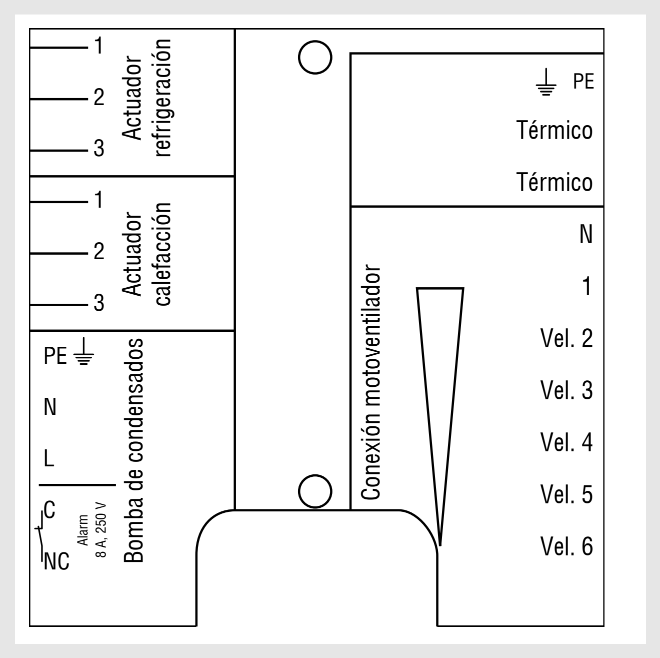
Equipo empotrado en falso techo:



# Fan Coil Aquaris Silent

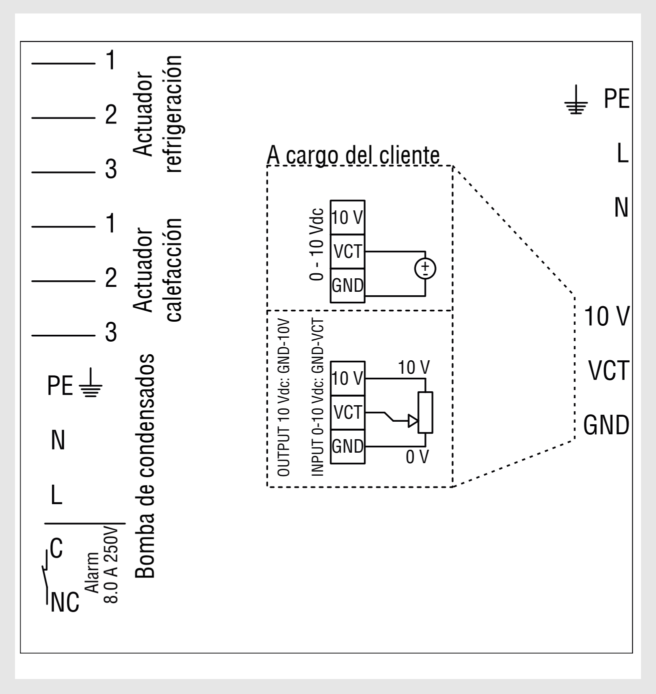
## Esquemas de conexión

### Esquema caja de conexiones eléctricas (serie SP)



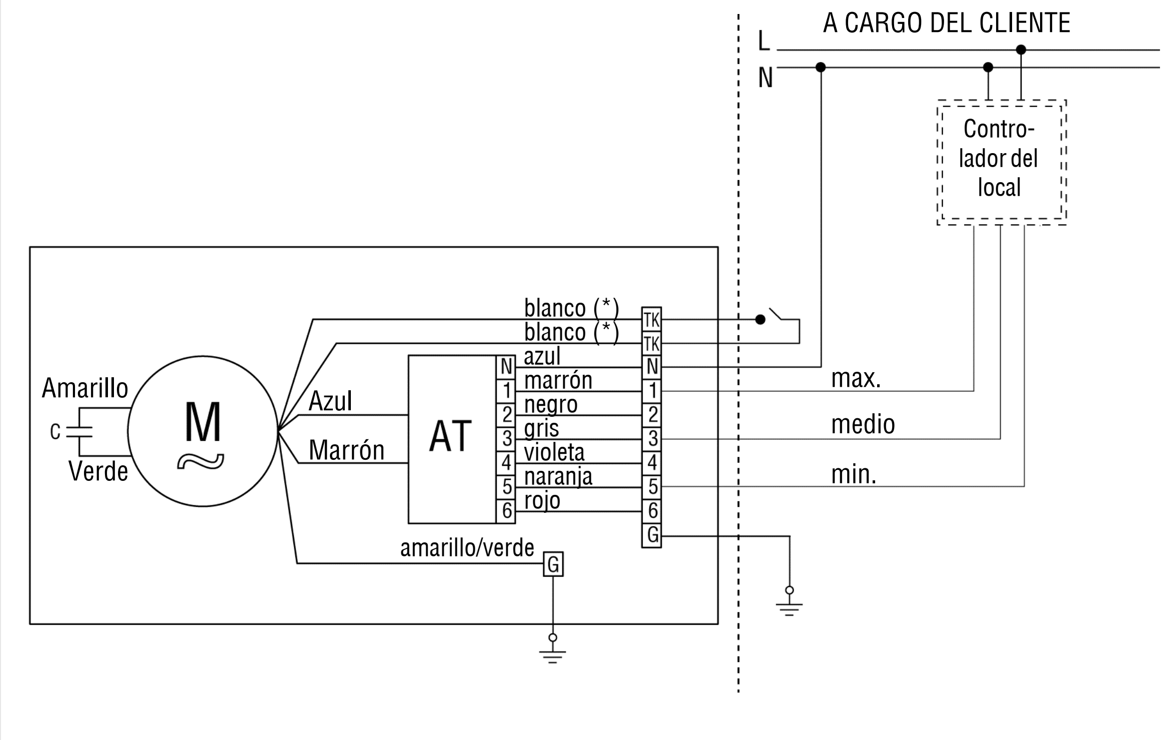
Conectar el fan coil con tomas de protección de tierra.
Desconectar la alimentación eléctrica antes de realizar las conexiones eléctricas.
SCHAKO declina toda la responsabilidad en caso de un mal conexionado eléctrico o por eventuales sustituciones del cable de alimentación por otro de diferentes características.

### Esquema caja de conexiones eléctricas (serie EC)

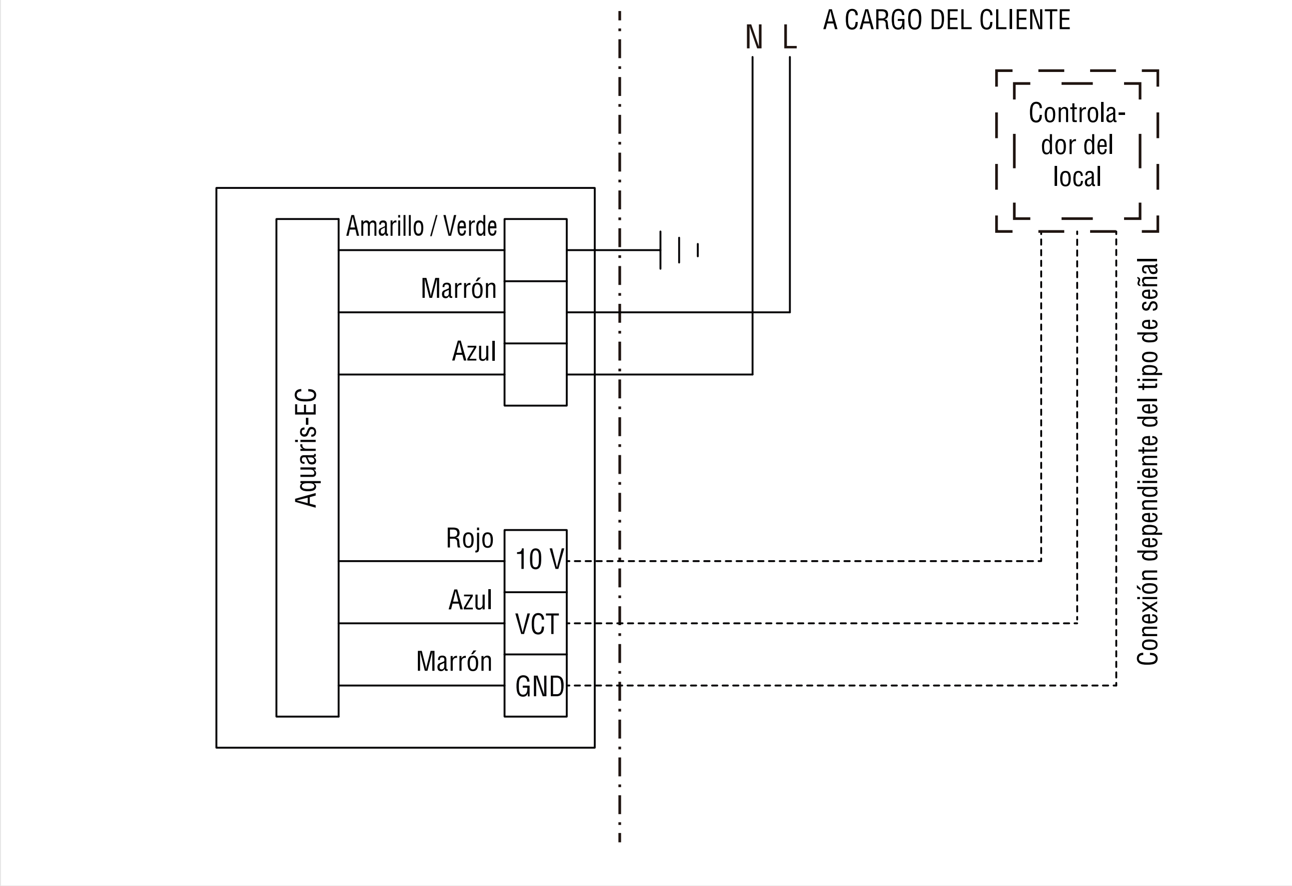


# Fan Coil Aquaris Silent

### Cableado del contacto térmico, protección de sobrecarga, aviso de servicio y avería (Serie SP)



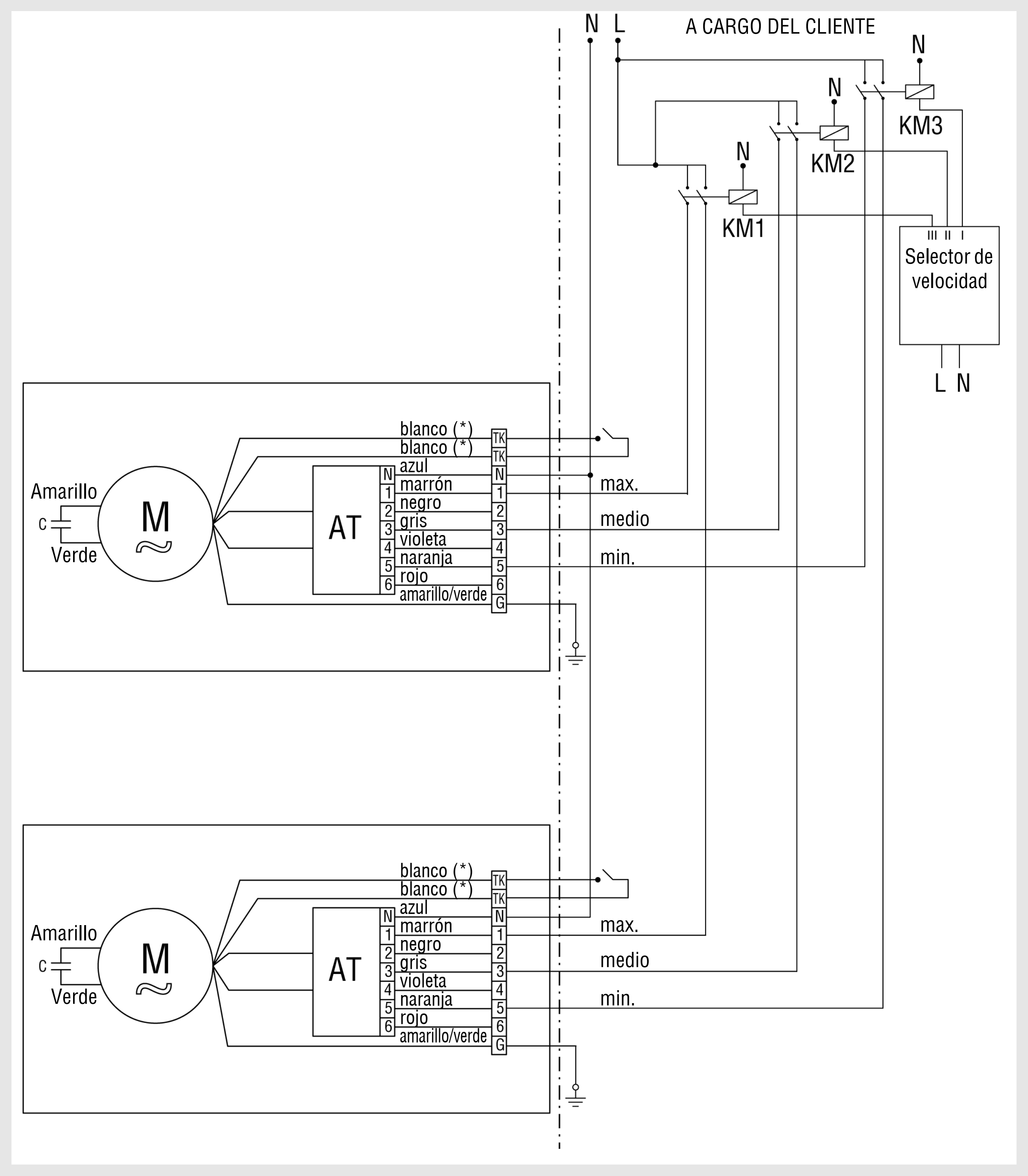
### Cableado del contacto térmico, protección de sobrecarga, aviso de servicio y avería (Serie EC)



blanco (*) = termocontacto sin tensión: protección contra sobrecarga del motor

# Fan Coil Aquaris Silent

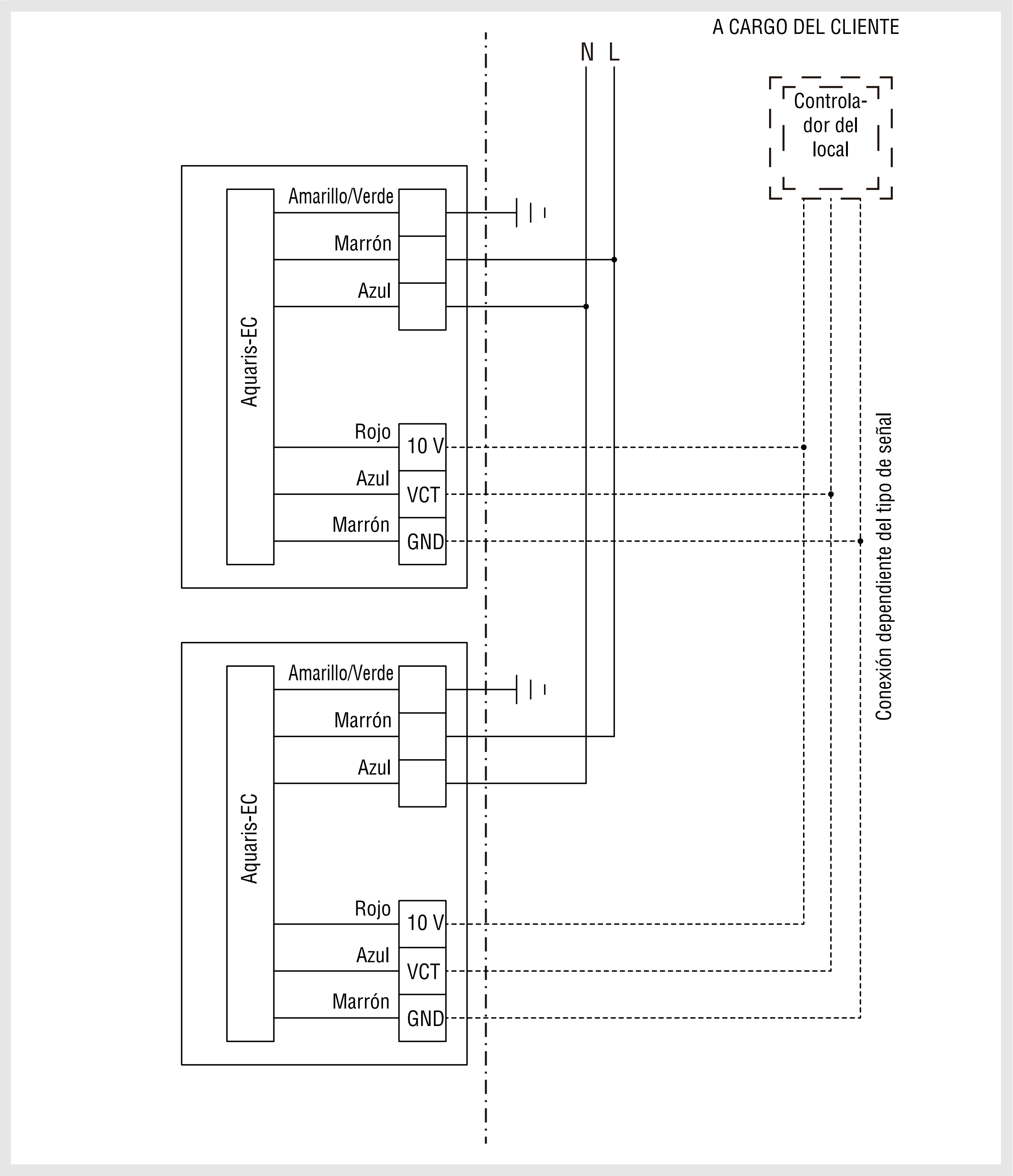
## Cableado en servicio paralelo (con protección térmica)
## 1 conmutador de velocidad + 2 o más fan coils (Serie SP)



blanco (*) = termocontacto sin tensión: protección contra sobrecarga del motor

# Fan Coil Aquaris Silent

## Cableado en servicio paralelo (con protección térmica)
## 1 conmutador de velocidad + 2 o más fan coils (Serie EC)

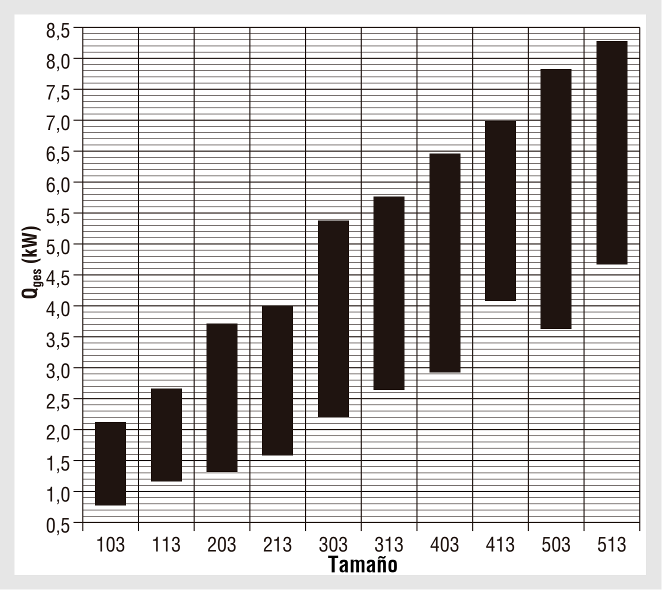


# Fan Coil Aquaris Silent

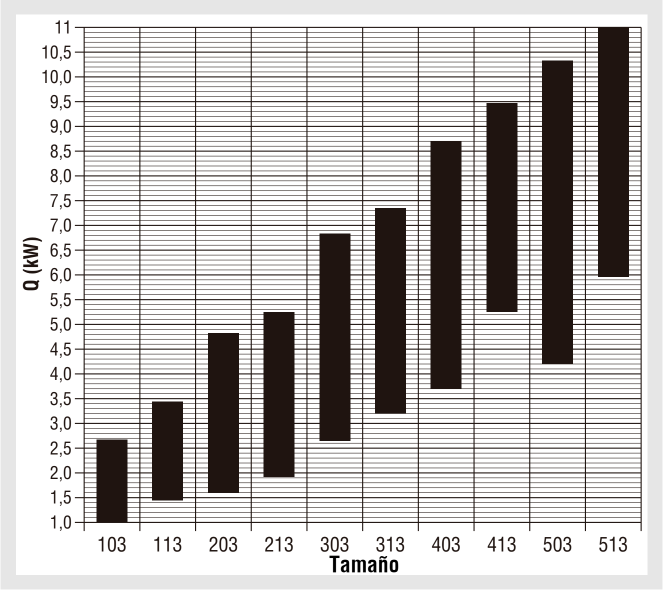
## Diagramas de selección rápida

### Serie SP

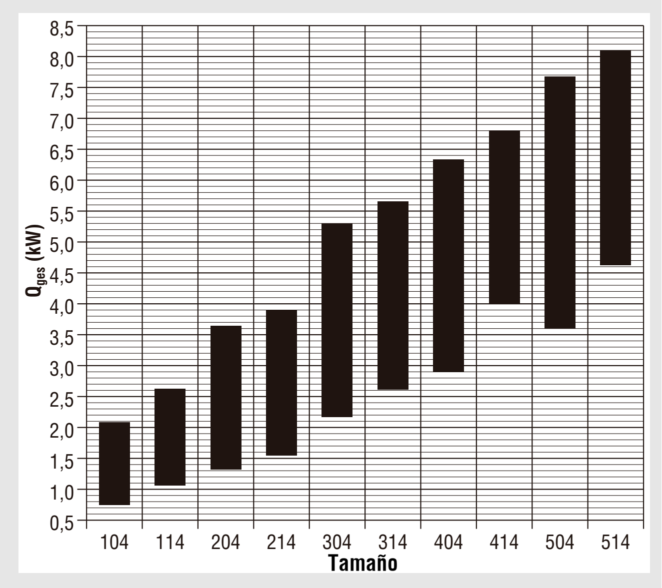
**Potencia frigorífica total en instalaciones a 2 tubos (1)**
(véase condiciones en página 13)



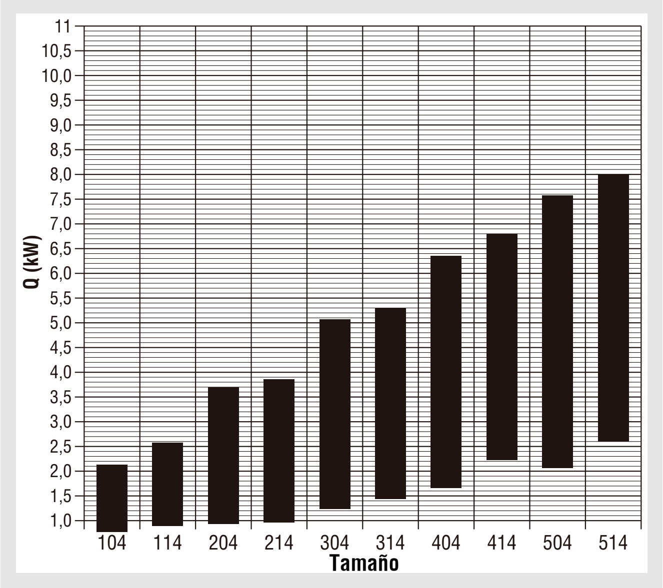
**Potencia calorífica total en instalaciones a 2 tubos(1)**
(véase condiciones en página 13)



**Potencia frigorífica total en instalaciones a 4 tubos (1)**
(véase condiciones en página 15)



**Potencia calorífica total en instalaciones a 4 tubos (1)**
(véase condiciones en página 15)

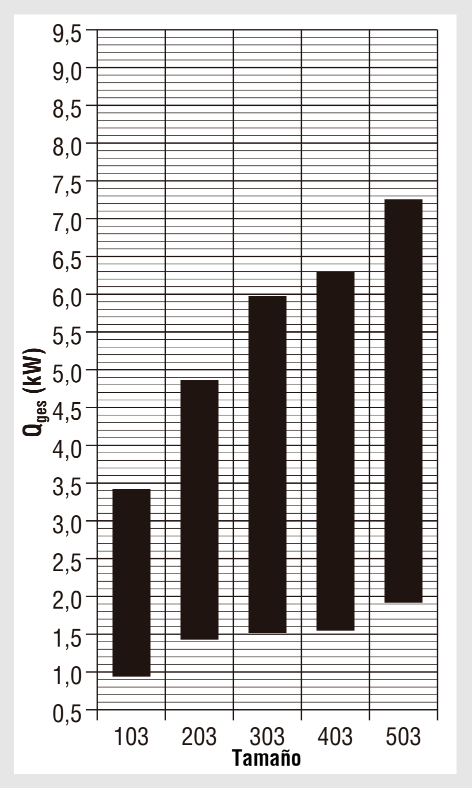


(1) Datos correspondientes a velocidades de la 1 a la 6

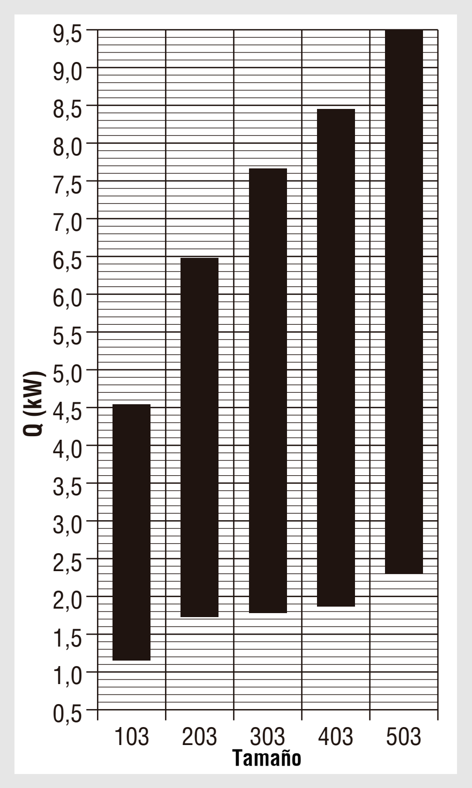
# Fan Coil Aquaris Silent

## Serie EC

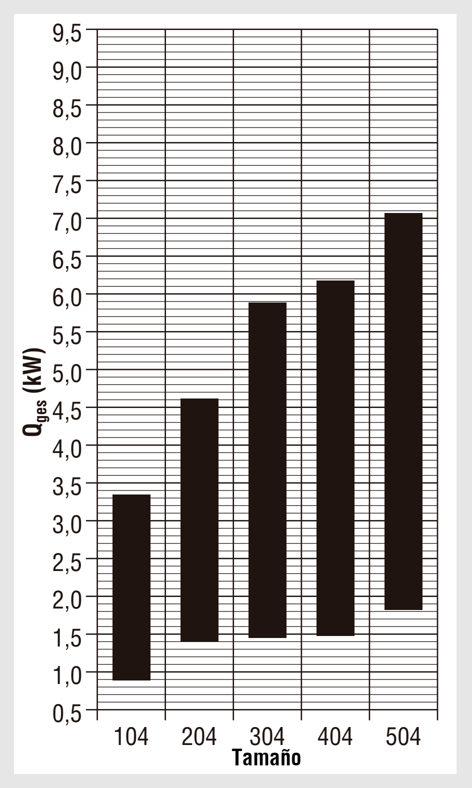
**Potencia frigorífica total en instalaciones a 2 tubos (2)**
(véase condiciones en página 14)



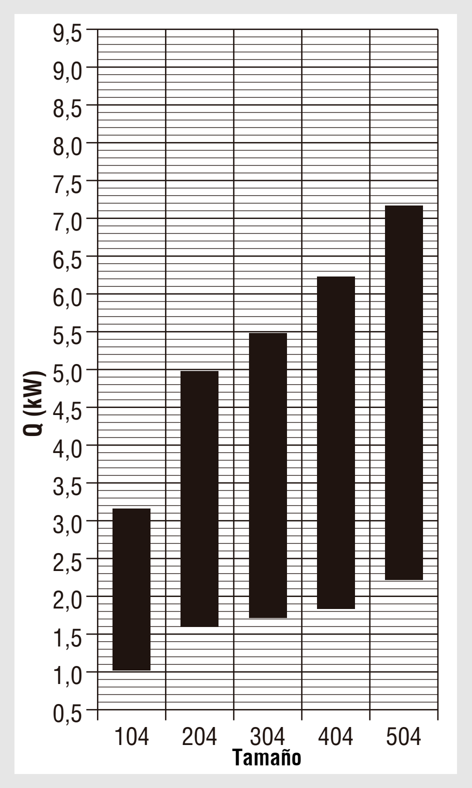
**Potencia calorífica total en instalaciones a 2 tubos (2)**
(véase condiciones en página 14)



**Potencia frigorífica total en instalaciones a 4 tubos (2)**
(véase condiciones en página 16)



**Potencia calorífica total en instalaciones a 4 tubos (2)**
(véase condiciones en página 16)



(2) Datos correspondientes a1-10V

# Fan Coil Aquaris Silent

## Datos técnicos

### Prestaciones nominales instalación a 2 tubos

**Modelo SP**

| | | n | Tamaños | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **10** | **11** | **20** | **21** | **30** | **31** | **40** | **41** | **50** | **51** |
| **$V$** ($m^3/h$) **(1)** | | 1-máx. | 385 | 530 | 750 | 835 | 1030 | 1135 | 1435 | 1620 | 1670 | 1825 |
| | | 3-med. | 270 | 385 | 485 | 570 | 850 | 970 | 1040 | 1275 | 1145 | 1350 |
| | | 5-mín. | 160 | 235 | 305 | 355 | 495 | 575 | 680 | 940 | 775 | 1020 |
| **$V$** (l/s) **(1)** | | 1-máx. | 107 | 147 | 208 | 232 | 286 | 315 | 399 | 450 | 464 | 507 |
| | | 3-med. | 75 | 107 | 135 | 158 | 236 | 269 | 289 | 354 | 318 | 375 |
| | | 5-mín. | 44 | 65 | 85 | 99 | 138 | 160 | 189 | 261 | 215 | 283 |
| **$Q_{ges}$** (kW) **(2)** | | 1-máx. | 2,11 | 2,65 | 3,70 | 3,98 | 5,37 | 5,75 | 6,45 | 6,97 | 7,81 | 8,27 |
| | | 3-med. | 1,61 | 2,11 | 2,71 | 3,05 | 4,68 | 5,15 | 5,19 | 5,96 | 6,02 | 6,76 |
| | | 5-mín. | 1,06 | 1,45 | 1,90 | 2,14 | 3,10 | 3,49 | 3,82 | 4,83 | 4,51 | 5,54 |
| **$Q_S$** (kW) **(2)** | | 1-máx. | 1,62 | 2,08 | 2,92 | 3,16 | 4,15 | 4,46 | 5,23 | 5,71 | 6,24 | 6,65 |
| | | 3-med. | 1,22 | 1,62 | 2,08 | 2,36 | 3,57 | 3,96 | 4,11 | 4,80 | 4,69 | 5,32 |
| | | 5-mín. | 0,78 | 1,09 | 1,42 | 1,62 | 2,31 | 2,61 | 2,95 | 3,80 | 3,44 | 4,28 |
| **$Q$** (kW) **(3)** | | 1-máx. | 2,68 | 3,44 | 4,83 | 5,24 | 6,83 | 7,35 | 8,69 | 9,47 | 10,32 | 11,01 |
| | | 3-med. | 2,03 | 2,68 | 3,45 | 3,92 | 5,89 | 6,52 | 6,84 | 7,97 | 7,77 | 8,81 |
| | | 5-mín. | 1,29 | 1,80 | 2,36 | 2,68 | 3,81 | 4,32 | 4,93 | 6,33 | 5,73 | 7,10 |
| **$V_W$** (l/h) **(2)** | | 1-máx. | 363 | 456 | 638 | 686 | 926 | 991 | 1110 | 1200 | 1345 | 1425 |
| | | 3-med. | 278 | 363 | 467 | 526 | 807 | 887 | 894 | 1027 | 1037 | 1164 |
| | | 5-mín. | 182 | 249 | 327 | 368 | 534 | 601 | 657 | 833 | 777 | 954 |
| **$Pa_{WK}$** (kPa) **(2)** | | 1-máx. | 18,09 | 26,99 | 19,93 | 22,65 | 50,96 | 57,40 | 10,93 | 12,53 | 17,93 | 19,87 |
| | | 3-med. | 11,29 | 18,09 | 11,51 | 14,18 | 39,99 | 47,30 | 7,46 | 9,53 | 11,35 | 13,92 |
| | | 5-mín. | 5,37 | 9,32 | 6,13 | 7,57 | 19,33 | 23,80 | 4,34 | 6,59 | 6,83 | 9,80 |
| **$Pa_{WH}$** (kPa) **(3)** | | 1-máx. | 14,74 | 22,0 | 16,24 | 18,46 | 41,52 | 46,77 | 8,91 | 10,22 | 14,62 | 16,20 |
| | | 3-med. | 9,20 | 14,74 | 9,38 | 11,55 | 32,58 | 38,53 | 6,10 | 7,77 | 9,25 | 11,34 |
| | | 5-mín. | 4,37 | 7,58 | 4,99 | 6,16 | 15,74 | 19,38 | 3,54 | 5,37 | 5,56 | 7,98 |
| **$T_{AK}$** (°C) **(2)** | | 1-máx. | 14,2 | 15,1 | 15,2 | 15,5 | 14,8 | 15,1 | 15,9 | 16,3 | 15,7 | 15,9 |
| | | 3-med. | 13,3 | 14,2 | 14,0 | 14,4 | 14,2 | 14,6 | 15,0 | 15,6 | 14,6 | 15,0 |
| | | 5-mín. | 12,1 | 13,0 | 12,8 | 13,2 | 12,9 | 13,2 | 13,8 | 14,7 | 13,5 | 14,3 |
| **$T_{AH}$** (°C) **(3)** | | 1-máx. | 40,7 | 39,2 | 39,1 | 38,6 | 39,7 | 39,2 | 38,0 | 37,4 | 38,3 | 37,9 |
| | | 3-med. | 42,3 | 40,7 | 41,1 | 40,4 | 40,5 | 39,9 | 39,5 | 38,5 | 40,1 | 39,4 |
| | | 5-mín. | 43,9 | 42,7 | 42,9 | 42,4 | 42,8 | 42,3 | 41,5 | 40,0 | 41,9 | 40,6 |
| **$rF_{AK}$** (%) | | 1-máx. | 88,0 | 85,2 | 85,1 | 84,1 | 85,6 | 84,7 | 83,3 | 82,2 | 83,7 | 82,8 |
| | | 3-med. | 90,9 | 88,0 | 89,0 | 87,5 | 87,4 | 85,2 | 86,3 | 84,4 | 87,1 | 85,6 |
| | | 5-mín. | 94,4 | 91,9 | 92,4 | 91,4 | 91,6 | 90,5 | 89,9 | 87,2 | 90,3 | 88,1 |
| **$rF_{AH}$** (%) | | 1-máx. | 15,3 | 16,5 | 16,6 | 17,1 | 16,1 | 16,5 | 17,7 | 18,3 | 17,3 | 17,7 |
| | | 3-med. | 14,1 | 15,3 | 15,0 | 15,5 | 15,4 | 15,9 | 16,3 | 17,1 | 15,7 | 16,4 |
| | | 5-mín. | 12,9 | 13,7 | 13,6 | 13,9 | 13,7 | 14,0 | 14,6 | 15,9 | 14,3 | 15,3 |
| **EK (230V 50 Hz)** | **W** (W) | 1-máx. | 59,1 | 80,2 | 86,3 | 83,7 | 128,9 | 141,5 | 190,9 | 191,7 | 221,1 | 233,3 |
| | | 3-med. | 40,3 | 51,2 | 55,1 | 61,4 | 106,1 | 114,7 | 140,5 | 141,9 | 152,7 | 157,4 |
| | | 5-mín. | 22,1 | 28,3 | 30,8 | 33,1 | 56,3 | 58,9 | 102,4 | 104,9 | 118 | 121,5 |
| | **I** (A) | 1-máx. | 0,24 | 0,32 | 0,35 | 0,33 | 0,52 | 0,57 | 0,76 | 0,77 | 0,88 | 0,93 |
| | | 3-med. | 0,16 | 0,20 | 0,22 | 0,25 | 0,42 | 0,46 | 0,56 | 0,57 | 0,61 | 0,63 |
| | | 5-mín. | 0,09 | 0,11 | 0,12 | 0,13 | 0,23 | 0,24 | 0,41 | 0,42 | 0,47 | 0,49 |

Mediciones con filtro G2
(1) Medición a 0 Pa de presión disponible
(2) Temperatura entrada de aire: 27 °C, temperatura entrada de agua: 7 °C, salto térmico del agua: 5 °C
(3) Temperatura entrada de aire: 20 °C, temperatura entrada de agua: 50 °C, mismo caudal de agua que en refrigeración (2)

# Fan Coil Aquaris Silent

## Modelo EC

| | **Voltios (V)** | **Tamaños** | | | | |
|---|---|---|---|---|---|---|
| | | **10** | **20** | **30** | **40** | **50** |
| **V**<br>($m^3$/h)<br>**(1)** | 10 | 775 | 1125 | 1200 | 1382 | 1495 |
| | 6 | 537 | 713 | 834 | 995 | 1140 |
| | 2 | 217 | 330 | 369 | 429 | 513 |
| **V**<br>(l/s)<br>**(1)** | 10 | 215,3 | 312,5 | 333,3 | 383,9 | 415,3 |
| | 6 | 149,2 | 198,1 | 231,7 | 276,4 | 316,7 |
| | 2 | 60,3 | 91,7 | 102,5 | 119,4 | 142,5 |
| $Q_{ges}$<br>(kW)<br>**(2)** | 10 | 3,4 | 4,83 | 5,97 | 6,29 | 7,25 |
| | 6 | 2,67 | 3,58 | 4,62 | 5,03 | 6,0 |
| | 2 | 1,36 | 2,02 | 2,44 | 2,67 | 3,26 |
| $Q_s$<br>(kW)<br>**(2)** | 10 | 2,74 | 3,92 | 4,65 | 5,09 | 5,74 |
| | 6 | 2,1 | 2,81 | 3,52 | 3,98 | 4,67 |
| | 2 | 1,02 | 1,52 | 1,8 | 2,01 | 2,44 |
| **Q**<br>(kW)<br>**(3)** | 10 | 4,53 | 6,49 | 7,66 | 8,45 | 9,51 |
| | 6 | 3,47 | 4,65 | 5,8 | 6,61 | 7,74 |
| | 2 | 1,68 | 2,52 | 2,95 | 3,34 | 4,03 |
| $V_W$<br>(l/h)<br>**(2)** | 10 | 584 | 830 | 1026 | 1081 | 1246 |
| | 6 | 459 | 615 | 794 | 864 | 1031 |
| | 2 | 234 | 347 | 419 | 459 | 560 |
| $Pa_{WK}$<br>(kPa)<br>**(2)** | 10 | 42 | 32 | 61 | 10 | 16 |
| | 6 | 27 | 19 | 39 | 7 | 11 |
| | 2 | 8 | 7 | 13 | 2 | 4 |
| $Pa_{WH}$<br>(kPa)<br>**(3)** | 10 | 34 | 26 | 50 | 9 | 13 |
| | 6 | 22 | 15 | 32 | 6 | 9 |
| | 2 | 7 | 6 | 10 | 2 | 3 |
| $T_{AK}$<br>(°C)<br>**(2)** | 10 | 16,2 | 16,4 | 15,2 | 15,8 | 15,3 |
| | 6 | 15,1 | 15 | 14,2 | 14,9 | 14,6 |
| | 2 | 12,8 | 13 | 12,2 | 12,8 | 12,6 |
| $T_{AH}$<br>(°C)<br>**(3)** | 10 | 37,3 | 37,1 | 38,9 | 38,1 | 38,9 |
| | 6 | 39,2 | 39,4 | 40,6 | 39,7 | 40,1 |
| | 2 | 43 | 42,7 | 43,7 | 43,1 | 43,3 |
| $rF_{AK}$<br>(%) | 10 | 82 | 81 | 84 | 84 | 85 |
| | 6 | 85 | 86 | 87 | 87 | 87 |
| | 2 | 92 | 92 | 94 | 93 | 93 |
| $rF_{AH}$<br>(%) | 10 | 18 | 19 | 17 | 17 | 17 |
| | 6 | 17 | 16 | 15 | 16 | 16 |
| | 2 | 14 | 14 | 13 | 13 | 13 |
| **W**<br>(W) | 10 | 52 | 59 | 74 | 77 | 84 |
| | 6 | 20 | 23 | 27 | 29 | 32 |
| | 2 | 6 | 6 | 7 | 8 | 8 |
| **SFP**<br>[W/ (l/s)] | 10 | 0,242 | 0,189 | 0,222 | 0,201 | 0,202 |
| | 6 | 0,134 | 0,116 | 0,117 | 0,105 | 0,101 |
| | 2 | 0,100 | 0,065 | 0,068 | 0,067 | 0,056 |

Mediciones con filtro G2
(1) Medición a 0 Pa de presión disponible
(2) Temperatura entrada de aire: 27 °C, temperatura entrada de agua: 7 °C, salto térmico del agua: 5 °C
(3) Temperatura entrada de aire: 20 °C, temperatura entrada de agua: 50 °C, mismo caudal de agua que en refrigeración (2)

# Fan Coil Aquaris Silent

## Prestaciones nominales instalación a 4 tubos

### Modelo SP

| | n | Tamaños | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 11 | 20 | 21 | 30 | 31 | 40 | 41 | 50 | 51 |
| **V** ($m^3/h$) **(1)** | 1-máx. | 380 | 520 | 730 | 810 | 1010 | 1110 | 1395 | 1560 | 1625 | 1770 |
| | 3-med. | 265 | 380 | 480 | 555 | 840 | 955 | 1020 | 1245 | 1125 | 1325 |
| | 5-mín. | 160 | 235 | 300 | 345 | 485 | 565 | 670 | 925 | 770 | 1005 |
| **V** (l/s) **(1)** | 1-máx. | 106 | 144 | 203 | 225 | 281 | 308 | 388 | 433 | 451 | 492 |
| | 3-med. | 74 | 106 | 133 | 154 | 233 | 265 | 283 | 346 | 313 | 368 |
| | 5-mín. | 44 | 65 | 83 | 96 | 135 | 157 | 186 | 257 | 214 | 279 |
| $Q_{ges}$ (kW) **(2)** | 1-máx. | 2,09 | 2,61 | 3,64 | 3,9 | 5,3 | 5,66 | 6,33 | 6,8 | 7,67 | 8,11 |
| | 3-med. | 1,59 | 2,09 | 2,69 | 2,99 | 4,64 | 5,09 | 5,12 | 5,87 | 5,94 | 6,67 |
| | 5-mín. | 1,06 | 1,45 | 1,87 | 2,09 | 3,05 | 3,44 | 3,77 | 4,78 | 4,49 | 5,48 |
| $Q_S$ (kW) **(2)** | 1-máx. | 1,61 | 2,05 | 2,86 | 3,09 | 4,08 | 4,38 | 5,13 | 5,56 | 6,11 | 6,51 |
| | 3-med. | 1,2 | 1,61 | 2,07 | 2,32 | 3,54 | 3,91 | 4,05 | 4,71 | 4,62 | 5,24 |
| | 5-mín. | 0,78 | 1,09 | 1,4 | 1,58 | 2,27 | 2,57 | 2,91 | 3,76 | 3,42 | 4,23 |
| **Q** (kW) **(3)** | 1-máx. | 2,12 | 2,58 | 3,69 | 3,86 | 5,11 | 5,31 | 6,36 | 6,79 | 7,58 | 7,98 |
| | 3-med. | 1,67 | 2,12 | 2,82 | 3,1 | 4,55 | 4,94 | 5,35 | 5,94 | 6,15 | 6,82 |
| | 5-mín. | 1,18 | 1,54 | 2,05 | 2,26 | 3,15 | 3,5 | 4,06 | 5,02 | 4,78 | 5,71 |
| $V_{WK}$ (l/h) **(2)** | 1-máx. | 360 | 450 | 626 | 672 | 913 | 976 | 1090 | 1171 | 1320 | 1397 |
| | 3-med. | 274 | 360 | 464 | 516 | 800 | 878 | 882 | 1011 | 1024 | 1149 |
| | 5-mín. | 182 | 249 | 322 | 360 | 525 | 593 | 650 | 823 | 773 | 943 |
| $V_{WH}$ (l/h) **(3)** | 1-máx. | 182 | 223 | 318 | 332 | 440 | 458 | 548 | 585 | 653 | 687 |
| | 3-med. | 143 | 182 | 243 | 267 | 392 | 425 | 461 | 511 | 530 | 588 |
| | 5-mín. | 102 | 132 | 177 | 194 | 272 | 301 | 350 | 433 | 412 | 492 |
| $Pa_{WK}$ (kPa) **(2)** | 1-máx. | 17,79 | 26,37 | 19,29 | 21,85 | 49,74 | 55,87 | 10,58 | 12,01 | 17,37 | 19,18 |
| | 3-med. | 11,01 | 17,79 | 11,36 | 13,71 | 39,39 | 46,38 | 7,29 | 9,27 | 11,10 | 13,60 |
| | 5-mín. | 5,37 | 9,32 | 5,99 | 7,28 | 18,79 | 23,23 | 4,26 | 6,46 | 6,77 | 9,61 |
| $Pa_{WH}$ (kPa) **(3)** | 1-máx. | 7,39 | 10,50 | 24,92 | 26,97 | 8,45 | 9,05 | 13,40 | 15,04 | 21,43 | 23,43 |
| | 3-med. | 4,84 | 7,39 | 15,49 | 18,35 | 6,88 | 7,95 | 9,89 | 11,88 | 14,82 | 17,80 |
| | 5-mín. | 2,64 | 4,20 | 8,87 | 10,48 | 3,61 | 4,33 | 6,08 | 8,86 | 9,51 | 13,01 |
| $T_{AK}$ (°C) **(2)** | 1-máx. | 14,2 | 15,1 | 15,1 | 15,4 | 14,7 | 15,0 | 15,8 | 16,2 | 15,6 | 15,8 |
| | 3-med. | 13,2 | 14,2 | 13,9 | 14,3 | 14,2 | 14,6 | 14,9 | 15,5 | 14,5 | 15,0 |
| | 5-mín. | 12,1 | 13,0 | 12,8 | 13,1 | 12,8 | 13,2 | 13,8 | 14,7 | 13,5 | 14,2 |
| $T_{AH}$ (°C) **(3)** | 1-máx. | 36,5 | 34,7 | 35,0 | 34,1 | 35,0 | 34,2 | 33,5 | 32,9 | 33,8 | 33,4 |
| | 3-med. | 38,6 | 36,5 | 37,4 | 36,6 | 36,1 | 35,3 | 35,6 | 34,2 | 36,2 | 35,3 |
| | 5-mín. | 41,9 | 39,4 | 40,3 | 39,4 | 39,3 | 38,4 | 38,0 | 36,1 | 38,4 | 36,9 |
| $rF_{AK}$ (%) | 1-máx. | 88,1 | 85,3 | 85,3 | 84,4 | 85,8 | 84,9 | 83,6 | 82,5 | 83,9 | 83,1 |
| | 3-med. | 91,0 | 88,1 | 89,1 | 87,8 | 87,4 | 86,3 | 86,5 | 84,6 | 87,3 | 85,8 |
| | 5-mín. | 94,4 | 91,9 | 92,6 | 91,6 | 91,8 | 90,7 | 90,0 | 87,3 | 90,5 | 88,3 |
| $rF_{AH}$ (%) | 1-máx. | 19,1 | 21,1 | 20,8 | 21,8 | 20,8 | 21,7 | 22,6 | 23,3 | 22,2 | 22,8 |
| | 3-med. | 17,0 | 19,1 | 18,2 | 19,1 | 19,6 | 20,4 | 20,1 | 21,8 | 19,4 | 20,5 |
| | 5-mín. | 14,3 | 16,4 | 15,6 | 16,4 | 16,5 | 17,3 | 17,7 | 19,5 | 17,2 | 18,8 |
| **EK (230V 50 Hz)** **W** (W) | 1-máx. | 58,8 | 79,8 | 85,6 | 83,9 | 127,6 | 140,4 | 185,9 | 186,6 | 215,9 | 228,9 |
| | 3-med. | 40,0 | 51,1 | 55,0 | 61,1 | 105,5 | 114,1 | 138,5 | 139,7 | 150,4 | 155,0 |
| | 5-mín. | 22,1 | 28,2 | 30,7 | 33,1 | 56,1 | 58,8 | 101,7 | 104,1 | 117,4 | 120,5 |
| **I** (A) | 1-máx. | 0,26 | 0,35 | 0,37 | 0,36 | 0,55 | 0,61 | 0,81 | 0,81 | 0,94 | 1,00 |
| | 3-med. | 0,17 | 0,22 | 0,24 | 0,27 | 0,46 | 0,50 | 0,60 | 0,61 | 0,65 | 0,67 |
| | 5-mín. | 0,10 | 0,12 | 0,13 | 0,14 | 0,24 | 0,26 | 0,44 | 0,45 | 0,51 | 0,52 |

Mediciones con filtro G2
(1) Medición a 0 Pa de presión disponible
(2) Temperatura entrada de aire: 27 °C, temperatura entrada de agua: 7 °C, salto térmico del agua: 5 °C
(3) Temperatura entrada de aire: 20 °C, temperatura entrada de agua: 70 °C, salto térmico del agua: 10 °C

# Fan Coil Aquaris Silent

## Modelo EC

| | Volt (V) | Tamaños | | | | |
|---|---|---|---|---|---|---|
| | | **10** | **20** | **30** | **40** | **50** |
| **V** ($m^3$/h) **(1)** | 10 | 753 | 1047 | 1171 | 1345 | 1440 |
| | 6 | 513 | 685 | 800 | 931 | 1070 |
| | 2 | 210 | 316 | 353 | 412 | 474 |
| **V** (l/s) **(1)** | 10 | 209,2 | 290,8 | 325,3 | 373,6 | 400 |
| | 6 | 142,5 | 190,3 | 222,2 | 258,6 | 297,2 |
| | 2 | 58,3 | 87,8 | 98,1 | 114,4 | 131,7 |
| **$Q_{ges}$** (kW) **(2)** | 10 | 3,34 | 4,62 | 5,88 | 6,18 | 7,07 |
| | 6 | 2,59 | 3,48 | 4,48 | 4,8 | 5,73 |
| | 2 | 1,32 | 1,95 | 2,35 | 2,58 | 3,05 |
| **$Q_s$** (kW) **(2)** | 10 | 2,69 | 3,73 | 4,57 | 4,99 | 5,58 |
| | 6 | 2,03 | 2,73 | 3,41 | 3,78 | 4,45 |
| | 2 | 0,99 | 1,47 | 1,73 | 1,94 | 2,28 |
| **Q** (kW) **(3)** | 10 | 3,16 | 4,49 | 5,49 | 6,22 | 7,17 |
| | 6 | 2,56 | 3,55 | 4,4 | 5,05 | 5,95 |
| | 2 | 1,42 | 2,12 | 2,54 | 2,92 | 3,43 |
| **$V_{WK}$** (l/h) **(2)** | 10 | 574 | 794 | 1011 | 1062 | 1215 |
| | 6 | 445 | 598 | 770 | 825 | 985 |
| | 2 | 227 | 335 | 404 | 443 | 524 |
| **$V_{WH}$** (l/h) **(3)** | 10 | 272 | 386 | 472 | 534 | 616 |
| | 6 | 220 | 305 | 378 | 434 | 511 |
| | 2 | 122 | 182 | 218 | 251 | 295 |
| **$Pa_{WK}$** (kPa) **(2)** | 10 | 41 | 29 | 60 | 10 | 15 |
| | 6 | 26 | 18 | 37 | 7 | 10 |
| | 2 | 8 | 6 | 12 | 2 | 3 |
| **$Pa_{WH}$** (kPa) **(3)** | 10 | 15 | 35 | 10 | 13 | 19 |
| | 6 | 10 | 23 | 7 | 9 | 14 |
| | 2 | 4 | 9 | 2 | 3 | 5 |
| **$T_{AK}$** (°C) **(2)** | 10 | 16,2 | 16,2 | 15,2 | 15,7 | 15,2 |
| | 6 | 15 | 14,9 | 14,1 | 14,7 | 14,4 |
| | 2 | 12,7 | 12,9 | 12,1 | 12,7 | 12,4 |
| **$T_{AH}$** (°C) **(3)** | 10 | 32,5 | 32,7 | 33,9 | 33,7 | 34,8 |
| | 6 | 34,8 | 35,4 | 36,3 | 36,1 | 36,5 |
| | 2 | 40,1 | 40 | 41,3 | 41 | 41,5 |
| **$rF_{AK}$** (%) | 10 | 82 | 82 | 84 | 84 | 85 |
| | 6 | 85 | 86 | 88 | 87 | 88 |
| | 2 | 93 | 92 | 94 | 93 | 94 |
| **$rF_{AH}$** (%) | 10 | 24 | 24 | 22 | 22 | 21 |
| | 6 | 21 | 20 | 19 | 20 | 19 |
| | 2 | 16 | 16 | 15 | 15 | 15 |
| **W** (W) | 10 | 51 | 56 | 72 | 76 | 82 |
| | 6 | 19 | 22 | 26 | 29 | 31 |
| | 2 | 6 | 6 | 7 | 8 | 8 |
| **SFP** [W/ (l/s)] | 10 | 0,244 | 0,193 | 0,221 | 0,203 | 0,205 |
| | 6 | 0,133 | 0,116 | 0,117 | 0,112 | 0,104 |
| | 2 | 0,103 | 0,068 | 0,071 | 0,070 | 0,061 |

Mediciones con filtro G2
(1) Medición a 0 Pa de presión disponible
(2) Temperatura entrada de aire: 27 °C, temperatura entrada de agua: 7 °C, salto térmico del agua: 5 °C
(3) Temperatura entrada de aire: 20 °C, temperatura entrada de agua: 70 °C, salto térmico del agua: 10 °C

# Fan Coil Aquaris Silent

## Niveles de potencia sonora

### Instalación a 2 y 4 tubos (motor SP)

| Tamaño | n | $L_W$ [dB/ Okt] |  |  |  |  |  |  | $L_{WA}$ [dB(A)] |
|---|---|---|---|---|---|---|---|---|---|
|  |  | fm (Hz) |  |  |  |  |  |  |  |
|  |  | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |  |
| **10** | máx | 55,8 | 50,0 | 50,2 | 46,1 | 43,1 | 35,9 | 30,4 | 51,7 |
|  | med | 43,9 | 42,0 | 41,5 | 35,4 | 30,6 | 23,6 | 28,7 | 41,9 |
|  | mín | 50,4 | 34,4 | 28,3 | 20,1 | 18,9 | 20,8 | 28,7 | 36,4 |
| **11** | máx | 52,5 | 57,6 | 54,8 | 52,8 | 50,8 | 45,3 | 37,8 | 57,9 |
|  | med | 42,9 | 47,7 | 47,3 | 44,3 | 41,3 | 33,5 | 29,5 | 49,1 |
|  | mín | 41,1 | 38,7 | 37,7 | 31,4 | 26,6 | 21,9 | 28,5 | 38,4 |
| **20** | máx | 45,9 | 49,4 | 50,6 | 45,9 | 43,1 | 34,1 | 29,6 | 51,4 |
|  | med | 40,7 | 39,6 | 40,0 | 33,8 | 27,9 | 21,9 | 28,7 | 40,2 |
|  | mín | 40,4 | 28,2 | 24,7 | 17,0 | 18,0 | 21,0 | 28,8 | 31,5 |
| **21** | máx | 48,1 | 52,3 | 53,3 | 48,9 | 46,5 | 38,6 | 31,2 | 54,4 |
|  | med | 42,9 | 43,1 | 43,5 | 37,9 | 32,9 | 24,1 | 28,6 | 43,8 |
|  | mín | 42,0 | 31,1 | 29,1 | 21,9 | 19,4 | 20,5 | 28,9 | 33,0 |
| **30** | máx | 50,5 | 55,3 | 56,3 | 53,8 | 51,5 | 44,2 | 36,8 | 58,5 |
|  | med | 46,7 | 50,5 | 51,2 | 48,3 | 45,4 | 36,1 | 30,8 | 53,0 |
|  | mín | 42,7 | 41,8 | 39,1 | 34,9 | 28,4 | 22,2 | 28,7 | 40,5 |
| **31** | máx | 51,9 | 57,8 | 58,4 | 56,4 | 54,2 | 47,8 | 40,8 | 61,1 |
|  | med | 49,3 | 53,5 | 54,4 | 52,1 | 49,6 | 41,7 | 34,5 | 56,7 |
|  | mín | 43,2 | 43,0 | 43,0 | 38,6 | 33,1 | 24,1 | 28,8 | 43,8 |
| **40** | máx | 52,3 | 57,1 | 57,8 | 54,6 | 50,9 | 43,7 | 35,7 | 59,3 |
|  | med | 45,1 | 49,9 | 51,5 | 48,3 | 43,0 | 34,6 | 30,2 | 52,6 |
|  | mín | 37,5 | 42,0 | 42,4 | 40,7 | 36,4 | 29,6 | 29,6 | 44,8 |
| **41** | máx | 54,5 | 59,9 | 60,7 | 57,1 | 54,6 | 49,0 | 40,8 | 62,3 |
|  | med | 49,3 | 54,3 | 55,5 | 51,4 | 48,6 | 41,6 | 34,0 | 56,6 |
|  | mín | 42,2 | 47,4 | 48,4 | 44,6 | 41,4 | 34,2 | 30,6 | 49,7 |
| **50** | máx | 56,0 | 59,2 | 60,3 | 58,6 | 56,0 | 50,2 | 41,9 | 63,1 |
|  | med | 46,9 | 49,2 | 51,4 | 48,8 | 45,3 | 35,5 | 26,5 | 53,1 |
|  | mín | 38,8 | 41,8 | 42,8 | 39,7 | 34,6 | 25,3 | 22,3 | 44,0 |
| **51** | máx | 57,1 | 60,9 | 62,1 | 60,5 | 57,9 | 52,8 | 44,7 | 65,0 |
|  | med | 50,1 | 53,1 | 55,0 | 52,6 | 50,2 | 42,0 | 32,6 | 57,2 |
|  | mín | 43,4 | 46,8 | 49,1 | 45,8 | 42,3 | 32,0 | 24,3 | 50,4 |

Nivel de potencia sonora obtenido de acuerdo a la norma ISO 3741

### Instalación a 2 y 4 tubos (motor EC)

| Tamaño | Volt (V) | $L_W$ [dB/ Okt] |  |  |  |  |  |  | $L_{WA}$ [dB(A)] |
|---|---|---|---|---|---|---|---|---|---|
|  |  | fm (Hz) |  |  |  |  |  |  |  |
|  |  | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |  |
| **10** | 10 | 57 | 59 | 61 | 56 | 52 | 48 | 41 | 62 |
|  | 6 | 49 | 51 | 53 | 46 | 42 | 34 | 32 | 52 |
|  | 2 | 45 | 32 | 30 | 20 | 22 | 21 | 28 | 34 |
| **20** | 10 | 53 | 57 | 58 | 54 | 52 | 47 | 39 | 59 |
|  | 6 | 49 | 47 | 49 | 44 | 41 | 32 | 32 | 50 |
|  | 2 | 45 | 26 | 25 | 16 | 20 | 22 | 28 | 33 |
| **30** | 10 | 56 | 60 | 58 | 56 | 54 | 50 | 42 | 61 |
|  | 6 | 47 | 51 | 50 | 46 | 46 | 35 | 29 | 52 |
|  | 2 | 36 | 35 | 29 | 20 | 20 | 19 | 27 | 32 |
| **40** | 10 | 57 | 58 | 58 | 53 | 50 | 44 | 37 | 59 |
|  | 6 | 47 | 49 | 49 | 44 | 39 | 31 | 32 | 50 |
|  | 2 | 45 | 28 | 26 | 22 | 24 | 23 | 29 | 33 |
| **50** | 10 | 54 | 59 | 58 | 54 | 52 | 46 | 39 | 60 |
|  | 6 | 49 | 50 | 49 | 45 | 42 | 33 | 32 | 51 |
|  | 2 | 46 | 30 | 27 | 27 | 29 | 24 | 30 | 36 |

Nivel de potencia sonora obtenido de acuerdo a la norma ISO 3741

# Fan Coil Aquaris Silent

## Prestaciones con difusor DBB y rejilla Ib 1

### instalación a 2 tubos

| | n | Tamaños | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **10** | **11** | **20** | **21** | **30** | **31** | **40** | **41** | **50** | **51** |
| **V** (m$^3$/h) | máximo | 360 | 470 | 630 | 725 | 910 | 985 | 1155 | 1360 | 1295 | 1490 |
| | medio | 255 | 355 | 435 | 515 | 775 | 865 | 905 | 1130 | 990 | 1180 |
| | mínimo | 155 | 225 | 275 | 325 | 460 | 530 | 625 | 865 | 715 | 935 |
| **$Q_{ges}$** (kW) **(2)** | máximo | 2,01 | 2,43 | 3,28 | 3,62 | 4,92 | 5,21 | 5,58 | 6,22 | 6,57 | 7,23 |
| | medio | 1,54 | 1,99 | 2,50 | 2,84 | 4,38 | 4,74 | 4,70 | 5,50 | 5,42 | 6,15 |
| | mínimo | 1,03 | 1,40 | 1,74 | 1,99 | 2,92 | 3,27 | 3,58 | 4,55 | 4,24 | 5,19 |
| **$Q_s$** (kW) **(2)** | máximo | 1,54 | 1,90 | 2,56 | 2,85 | 3,77 | 4,01 | 4,45 | 5,03 | 5,15 | 5,73 |
| | medio | 1,16 | 1,52 | 1,91 | 2,18 | 3,32 | 3,62 | 3,70 | 4,38 | 4,18 | 4,80 |
| | mínimo | 0,76 | 1,05 | 1,30 | 1,50 | 2,17 | 2,44 | 2,75 | 3,57 | 3,22 | 4,00 |

### instalación a 4 tubos

| | n | Tamaños | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **10** | **11** | **20** | **21** | **30** | **31** | **40** | **41** | **50** | **51** |
| **V** (m$^3$/h) | máximo | 355 | 460 | 620 | 710 | 890 | 965 | 1130 | 1330 | 1280 | 1465 |
| | medio | 255 | 350 | 430 | 505 | 765 | 845 | 890 | 1110 | 980 | 1165 |
| | mínimo | 155 | 220 | 270 | 320 | 455 | 525 | 615 | 855 | 715 | 925 |
| **$Q_{ges}$** (kW) **(2)** | máximo | 1,99 | 2,40 | 3,24 | 3,57 | 4,84 | 5,13 | 5,50 | 6,13 | 6,51 | 7,15 |
| | medio | 1,54 | 1,97 | 2,48 | 2,79 | 4,33 | 4,66 | 4,65 | 5,43 | 5,38 | 6,09 |
| | mínimo | 1,03 | 1,37 | 1,72 | 1,97 | 2,90 | 3,25 | 3,54 | 4,52 | 4,24 | 5,15 |
| **$Q_s$** (kW) **(2)** | máximo | 1,52 | 1,86 | 2,52 | 2,80 | 3,70 | 3,94 | 4,38 | 4,95 | 5,11 | 5,66 |
| | medio | 1,16 | 1,50 | 1,89 | 2,15 | 3,29 | 3,56 | 3,65 | 4,32 | 4,15 | 4,75 |
| | mínimo | 0,76 | 1,03 | 1,28 | 1,48 | 2,15 | 2,42 | 2,72 | 3,54 | 3,22 | 3,96 |
| **Q** (kW) **(3)** | máximo | 2,02 | 2,40 | 3,33 | 3,63 | 4,72 | 4,97 | 5,70 | 6,18 | 6,68 | 7,12 |
| | medio | 1,62 | 2,01 | 2,62 | 2,91 | 4,28 | 4,56 | 4,90 | 5,64 | 5,61 | 6,29 |
| | mínimo | 1,15 | 1,47 | 1,91 | 2,14 | 3,02 | 3,33 | 3,83 | 4,77 | 4,55 | 5,40 |

Mediciones con filtro G2

(2) Temperatura bulbo seco entrada de aire: 27°C, temperatura bulbo húmedo entrada de aire: 19°C, temperatura entrada de agua: 7°C, salto térmico del agua: 5°C

(3) Temperatura entrada de aire: 20°C, temperatura entrada de agua: 70°C, salto térmico del agua: 10°C

### Factor de corrección para un equipo con rejilla Ib 1

| **Instalación** | **Factor de corrección** |
|---|---|
| **2 tubos** | 0,96 |
| **4 tubos** | 0,97 |

### Factor de corrección para potencia en refrigeración

| **Temperatura entrada / salida del agua de refrigeración** (°C) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Temperatura entrada del aire: 27°C** | | | | | **Temperatura entrada del aire: 26°C** | | | | |
| 6/12 | 7/12 | 7/13 | 8/14 | 10/15 | 6/12 | 7/12 | 7/13 | 8/14 | 10/15 |
| 1,02 | 1 | 0,93 | 0,84 | 0,74 | 0,91 | 0,93 | 0,84 | 0,76 | 0,70 |

### Factor de corrección para potencia en calefacción

| **Temperatura entrada / salida del agua de calefacción** (°C) | | | | |
|---|---|---|---|---|
| 90/70 | 70/60 | 70/50 | 60/40 | 40/30 |
| 1,32 | 1 | 0,84 | 0,60 | 0,30 |

# Fan Coil Aquaris Silent

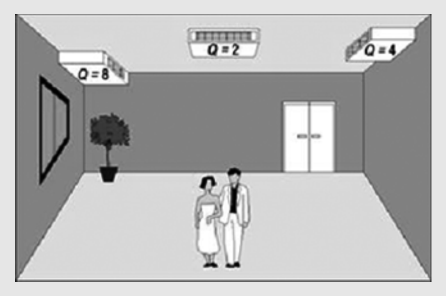
## Nivel de presión sonora ($L_P$)

$$R = \frac{S \times \alpha}{1 - \alpha}$$

$$L_P = L_W + 10 \times \left[\log_{10}\left(\frac{Q}{4 \times \pi \times r^2} + \frac{4}{R}\right) + \log_{10}(N)\right] + 0,5$$

Q = Directividad de la fuente de ruido
r = Distancia a la fuente de ruido (m)
R = Constante del local
S = Suma de las áreas de las superficies de la sala ($m^2$)
$\alpha$ = Valor medio del coeficiente de absorción de la sala
N = Número de equipos instalados en el local

Valor de Q



| $\alpha$ | **Tipo de edificio:** |
|---|---|
| 0,03 | Valor mínimo |
| 0,05 | Fábricas, piscinas cubiertas, iglesias grandes, aulas de escuelas |
| 0,10 | Habitaciones en hospitales, iglesias pequeñas |
| 0,15 | Viviendas, oficinas, habitaciones de hoteles, salas de conferencias, teatros |
| 0,25 | Salas de lectura, estudios de televisión, centros comerciales |
| 0,40 | Estudios de radio, salas de música |

### Ejemplo cálculo de $L_P$ en dB(A)

Valores conocidos:

$L_W$ = 48,1 [dB(A)]
Q = 2
r = 1,5 m
S = 140 $m^2$
$\alpha$ = 0,15 (habitación de un hotel)
N = 1 (1 equipo instalado)

$$R = \frac{140 \times 0,15}{1 - (0,15)} = 24,71$$

$$L_P = 48,1 + 10 \times \left[\log_{10}\left(\frac{2}{4 \times \pi \times 1,5^2} + \frac{4}{24,71}\right) + \log_{10}(1)\right] + 0,5 = 42,2 \mathrm{dB(A)}$$

### Niveles de presión sonora (instalación a 2 y 4 tubos)

| | n | Tamaños | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **10** | **11** | **20** | **21** | **30** | **31** | **40** | **41** | **50** | **51** |
| $L_p$ [dB(A)] **(4)** | máximo | 51,7 | 57,9 | 51,4 | 54,4 | 58,5 | 61,1 | 59,3 | 62,3 | 63,1 | 65 |
| | medio | 41,9 | 49,1 | 40,2 | 43,8 | 53 | 56,7 | 52,6 | 56,6 | 53,1 | 57,2 |
| | mínimo | 36,4 | 38,4 | 31,5 | 33,0 | 40,5 | 43,8 | 44,8 | 49,7 | 44,0 | 50,4 |
| $L_p$ [dB(A)] **(5)** | máximo | 45,9 | 52,1 | 45,6 | 48,5 | 52,7 | 55,2 | 53,4 | 56,5 | 57,2 | 59,1 |
| | medio | 36,0 | 43,3 | 34,3 | 37,9 | 47,2 | 50,8 | 46,8 | 50,8 | 47,3 | 51,3 |
| | mínimo | 30,6 | 32,6 | 25,6 | 27,2 | 34,7 | 37,9 | 38,9 | 43,8 | 38,2 | 44,5 |
| $L_p$ [dB(A)] **(6)** | máximo | 40,3 | 46,5 | 40,0 | 43,0 | 47,2 | 49,7 | 47,9 | 51,0 | 51,7 | 53,6 |
| | medio | 30,5 | 37,8 | 28,8 | 32,4 | 41,6 | 45,3 | 41,2 | 45,3 | 41,7 | 45,8 |
| | mínimo | 25,1 | 27,0 | 20,1 | 21,6 | 29,1 | 32,4 | 33,4 | 38,3 | 32,6 | 39,0 |

(4) Nivel de potencia sonora obtenido de acuerdo a la norma ISO 3741
(5) Nivel aproximado de presión sonora (Lp) para un local con una superficie de 140 $m^2$ y un volumen de 100 $m^3$ (Q= 2; r=1,5 m; $\alpha$=0,15)
(6) Nivel aproximado de presión sonora (Lp) para un local con una superficie de 478 $m^2$ y un volumen de 400 $m^3$ (Q= 2; r=3,0 m; $\alpha$=0,15)

# Fan Coil Aquaris Silent

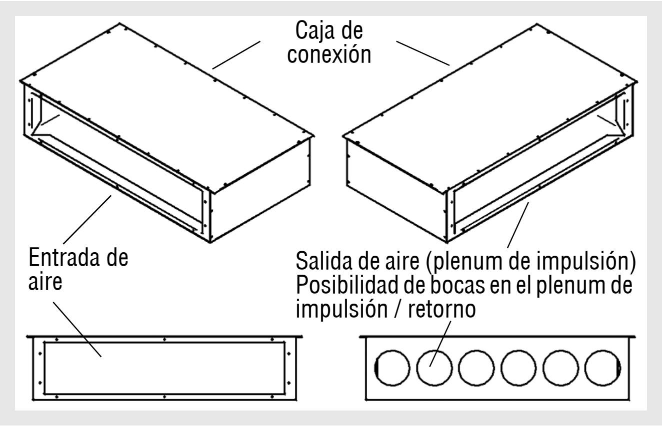
## Accesorios

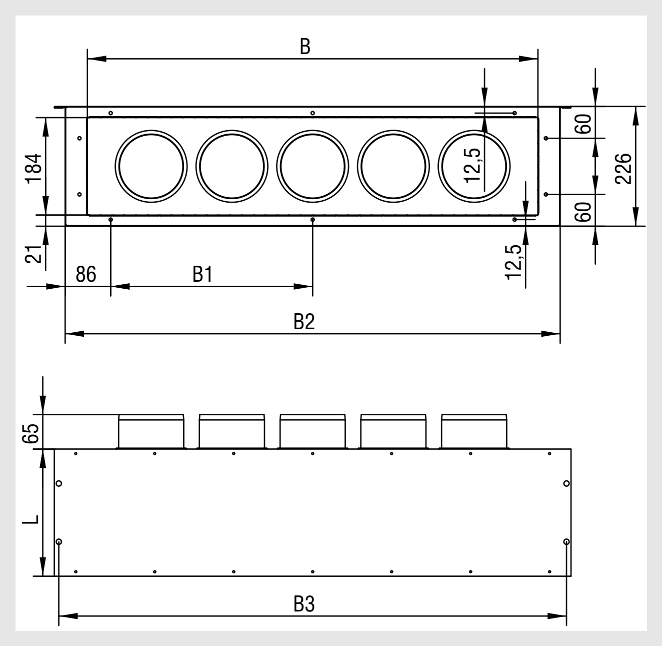
### Plenums para impulsión (-PZ) y retorno (-PA)

Los plenums se fabrican en chapa de acero galvanizado con aislante térmico y acústico. Los diferentes tipos de aislamiento son:

- Aislante 1: Revestimiento térmico de espuma de polietileno de 10 mm de espesor, especialmente indicado para evitar la formación de condensados en el plenum de impulsión cuando se trabaja en régimen de refrigeración.
- Aislante 2: Revestimiento térmico y acústico de lana mineral de 20 mm de espesor, indicado para atenuar el nivel sonoro además de evitar eficazmente la formación de condensados.
- Aislante 3: Revestimiento térmico y acústico de lana mineral de 40 mm de espesor. Además de evitar la formación de condensados, el aislante esta especialmente indicado para atenuar, con una mayor eficacia, el nivel sonoro para frecuencias menores de 100 Hz.

Los plenums de impulsión disponen de tres tipos de conexiones diferentes con el conducto de impulsión: conexión rectangular (opcional), conexión abierta (estándar) y conexión mediante bocas circulares (opcional).





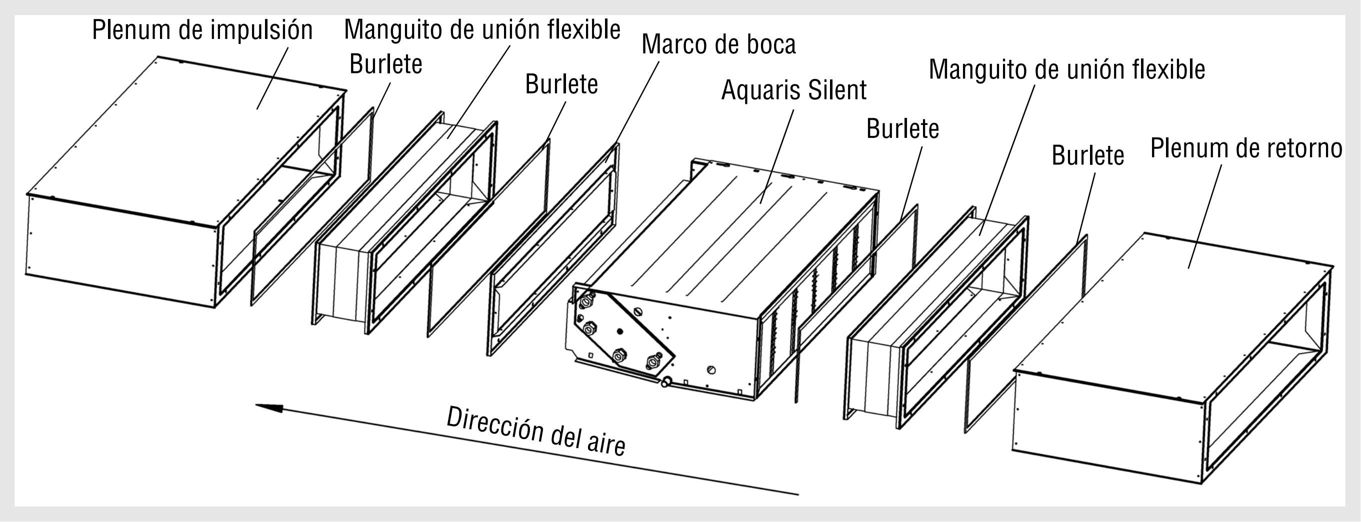
| Modelo | B (mm) | B1 (mm) | B2 (mm) | B3 (mm) | número de sujeciones | número máximo de conexiones |  | L (mm) | tipo de aislante |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | Ø 125 | Ø 160 (*) |  |  |
| **10-11** | 720 | 548 | 636 | 744 | 8 | 4 | 3 | de<br>200<br>a<br>1100 | 0 = ninguno<br>1= 10 mm<br>2= 20 mm<br>3= 40 mm |
| **20-21** | 935 | 382 | 851 | 959 | 10 | 5 | 4 |  |  |
| **30-31** | 1270 | 549 | 1186 | 1294 | 10 | 7 | 6 |  |  |
| **40-41** | 1375 | 401 | 1291 | 1399 | 12 | 8 | 7 |  |  |
| **50-51** | 1620 | 483 | 1536 | 1644 | 12 | 9 | 8 |  |  |

(*) No se puede aplicar para un aislante 3

| Modelo | **Peso del plenum** (kg) |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | L-200 | L-300 | L-400 | L-500 | L-600 | L-700 | L-800 | L-900 | L-1000 | L-1100 |
| **10-11** | 5,23 | 6,79 | 8,35 | 9,91 | 11,47 | 13,03 | 14,59 | 16,15 | 17,17 | 19,27 |
| **20-21** | 6,43 | 8,33 | 10,23 | 12,13 | 14,03 | 15,93 | 17,83 | 19,73 | 21,63 | 23,53 |
| **30-31** | 8,30 | 10,73 | 13,16 | 15,59 | 18,02 | 20,45 | 22,88 | 25,31 | 27,74 | 30,17 |
| **40-41** | 8,89 | 11,48 | 14,07 | 16,66 | 19,25 | 21,84 | 24,43 | 27,02 | 29,61 | 32,20 |
| **50-51** | 10,26 | 13,23 | 16,20 | 19,17 | 22,14 | 25,11 | 28,08 | 31,05 | 34,02 | 36,99 |

# Fan Coil Aquaris Silent

## Ejemplo de montaje



## Insonorización de inserción

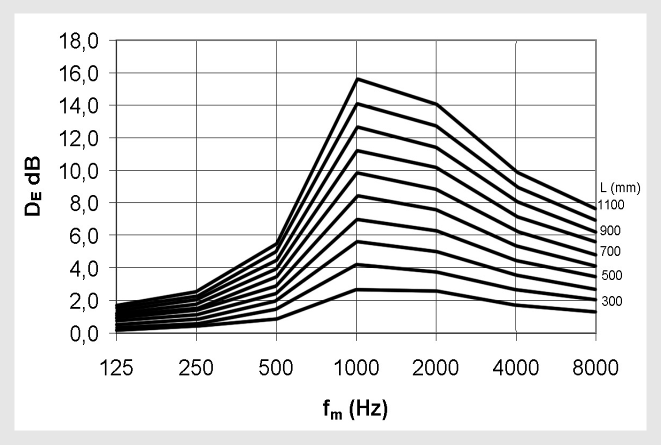
Los datos de atenuación sonora se encuentran en el programa de diseño del Aquaris Silent. A continuación se representan únicamente los datos correspondientes al tamaño1.

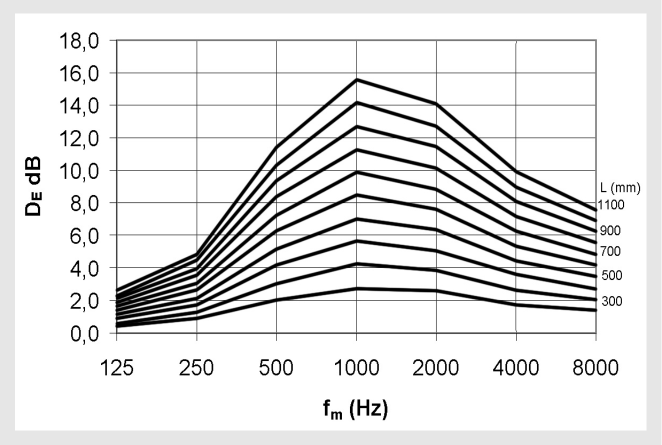
### P1 con aislante 2 y conexión abierta

| L | $f_m$ (Hz) | | | | | | |
|---|---|---|---|---|---|---|---|
| (mm) | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 200 | 0,3 | 0,5 | 1 | 2,8 | 2,6 | 1,8 | 1,4 |
| 300 | 0,5 | 0,7 | 1,5 | 4,3 | 3,8 | 2,7 | 2,1 |
| 400 | 0,6 | 0,9 | 2 | 5,7 | 5,1 | 3,6 | 2,8 |
| 500 | 0,8 | 1,2 | 2,5 | 7,1 | 6,4 | 4,5 | 3,5 |
| 600 | 0,9 | 1,4 | 3 | 8,5 | 7,7 | 5,4 | 4,2 |
| 700 | 1,1 | 1,6 | 3,5 | 9,9 | 8,9 | 6,3 | 4,9 |
| 800 | 1,3 | 1,9 | 4 | 11,3 | 10,2 | 7,2 | 5,6 |
| 900 | 1,4 | 2,1 | 4,5 | 12,8 | 11,5 | 8,1 | 6,3 |
| 1000 | 1,6 | 2,3 | 5 | 14,2 | 12,8 | 9 | 7 |
| 1100 | 1,7 | 2,6 | 5,5 | 15,6 | 14,1 | 9,9 | 7,7 |
| | $D_e$ (dB/Okt) | | | | | | |

### P1 con aislante 3 y conexión abierta

| L | $f_m$ (Hz) | | | | | | |
|---|---|---|---|---|---|---|---|
| (mm) | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 200 | 0,5 | 0,9 | 2,1 | 2,8 | 2,6 | 1,8 | 1,4 |
| 300 | 0,7 | 1,3 | 3,1 | 4,3 | 3,8 | 2,7 | 2,1 |
| 400 | 1 | 1,8 | 4,2 | 5,7 | 5,1 | 3,6 | 2,8 |
| 500 | 1,2 | 2,2 | 5,2 | 7,1 | 6,4 | 4,5 | 3,5 |
| 600 | 1,4 | 2,7 | 6,3 | 8,5 | 7,7 | 5,4 | 4,2 |
| 700 | 1,7 | 3,1 | 7,3 | 9,9 | 8,9 | 6,3 | 4,9 |
| 800 | 1,9 | 3,6 | 8,4 | 11,3 | 10,2 | 7,2 | 5,6 |
| 900 | 2,2 | 4 | 9,4 | 12,8 | 11,5 | 8,1 | 6,3 |
| 1000 | 2,4 | 4,5 | 10,4 | 14,2 | 12,8 | 9 | 7 |
| 1100 | 2,6 | 4,9 | 11,5 | 15,6 | 14,1 | 9,9 | 7,7 |
| | $D_e$ (dB/Okt) | | | | | | |



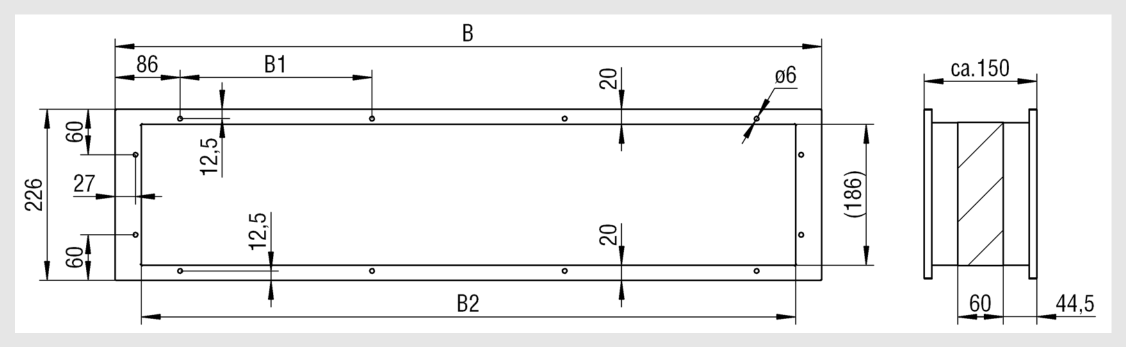


# Fan Coil Aquaris Silent

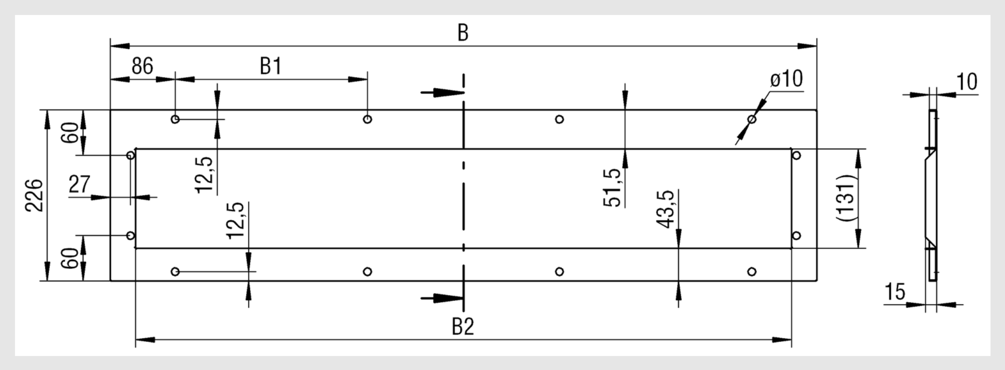
## Unión a los conductos de aire

El equipo se une a los conductos de aire mediante un manguito de unión flexible **(-FS-F)**, que impide la transmisión de vibraciones al conjunto, o mediante un marco de boca **(-FL)**.

### Manguito de unión flexible (-FS-F)



### Marco de boca (-FL)

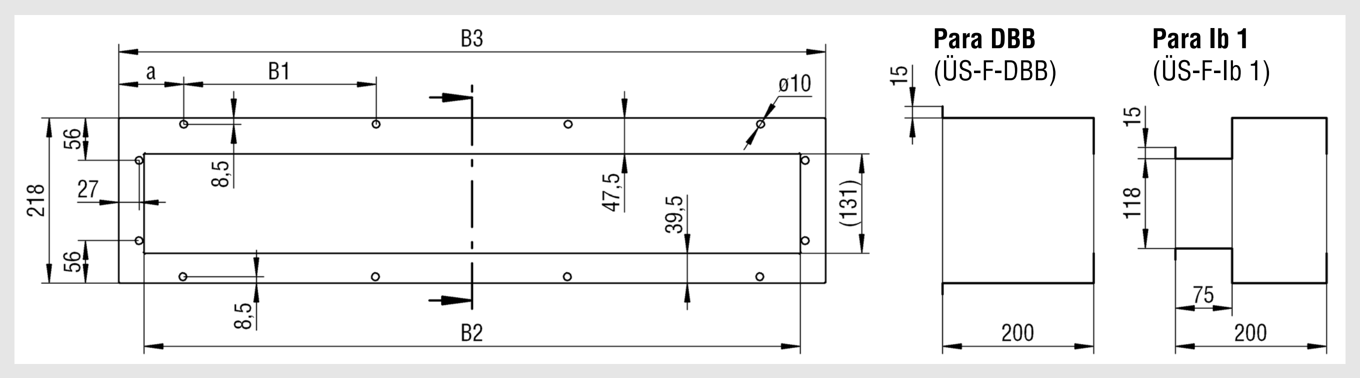


| Tamaño | **B** (mm) | **B1** (mm) | **B2** (mm) | **Pesos** (kg) | |
|---|---|---|---|---|---|
| | | | | **-FS-F** | **-FL** |
| **10/11** | 720 | 548 | 651 | 1,90 | 0,88 |
| **20/21** | 935 | 381,5 | 866 | 2,38 | 1,11 |
| **30/31** | 1270 | 549 | 1201 | 3,13 | 1,48 |
| **40/41** | 1375 | 401 | 1306 | 3,36 | 1,59 |
| **50/51** | 1620 | 482,5 | 1551 | 3,91 | 1,86 |

# Fan Coil Aquaris Silent

## Embocadura (-ÜS-F)

Para equipos que lleven incorporados una rejilla Ib 1 **(-ÜS-F-Ib 1)** o un difusor DBB **(-ÜS-F-DBB)**.

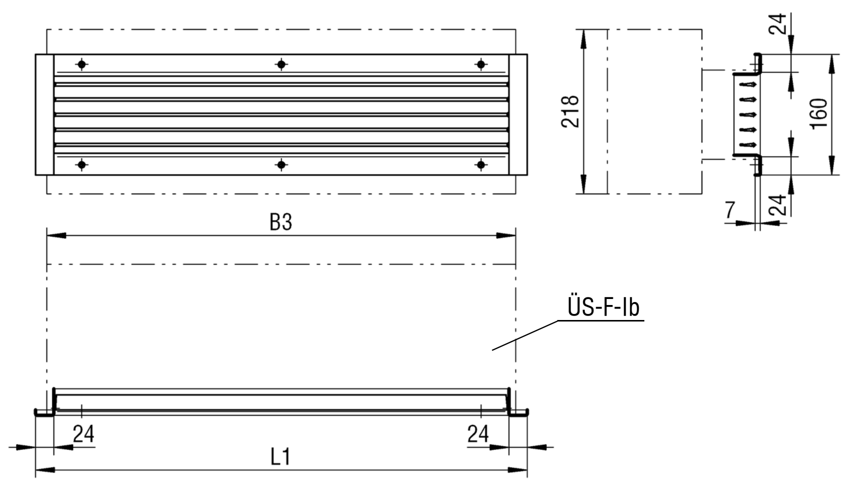


| Tamaño | DBB | Ib 1 | B1 (mm) | B2 (mm) | B3 (mm) | número de conexiones | a (mm) | Pesos -ÜS-F (kg) |
|---|---|---|---|---|---|---|---|---|
| **10** | 825/215 | 825/215 | 548 | 651 | 820 | 8 | 136 | 5,1 |
| **11** | 825/215 | 825/215 | 548 | 651 | 820 | 8 | 136 | |
| **20** | 1025/215 | 1025/215 | 381,5 | 866 | 1020 | 10 | 128 | 6,1 |
| **21** | 1225/215 | 1225/215 | 381,5 | 866 | 1220 | 10 | 228 | 7,3 |
| **30** | 1525/215 | 1525/215 | 549 | 1201 | 1520 | 10 | 211 | 8,79 |
| **31** | 1525/215 | 1525/215 | 549 | 1201 | 1520 | 10 | 211 | |
| **40** | 1525/215 | 1525/215 | 401 | 1306 | 1520 | 12 | 159 | 8,68 |
| **41** | 2025/215 | 2025/215 | 401 | 1306 | 2020 | 12 | 409 | 11,74 |
| **50** | 2025/215 | 2025/215 | 482,5 | 1551 | 2020 | 12 | 286 | 9,04 |
| **51** | 2025/215 | 2025/215 | 482,5 | 1551 | 2020 | 12 | 286 | 11,48 |

# Fan Coil Aquaris Silent

## Rejilla de ventilación Ib 1

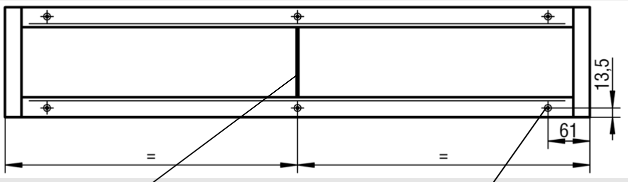
Reja de impulsión con lamas aerodinámicas orientables y regulables individualmente (posición horizontal y vertical). Fabricada en chapa de acero galvanizada o lacada en RAL 9010 (blanco).



**Tamaños**

| L1 (mm) | B3 (mm) |
|---|---|
| 650 | 620 |
| 850 | 820 |
| 1050 | 1020 |
| 1250 | 1220 |
| 1550 | 1520 |
| 1650 | 1620 |
| 2050 | 2020 |

### Montaje atornillado (SM)

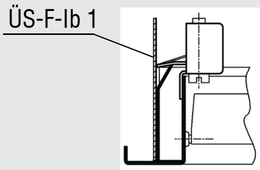


**Brida intermedia**

Tornillo de cabeza avellanada
DIN ISO 6051 ST3,9 (en obra)

| | |
|---|---|
| 650 mm | - |
| 850-1250 mm | 1 |
| 1550-2050 mm | 2 |

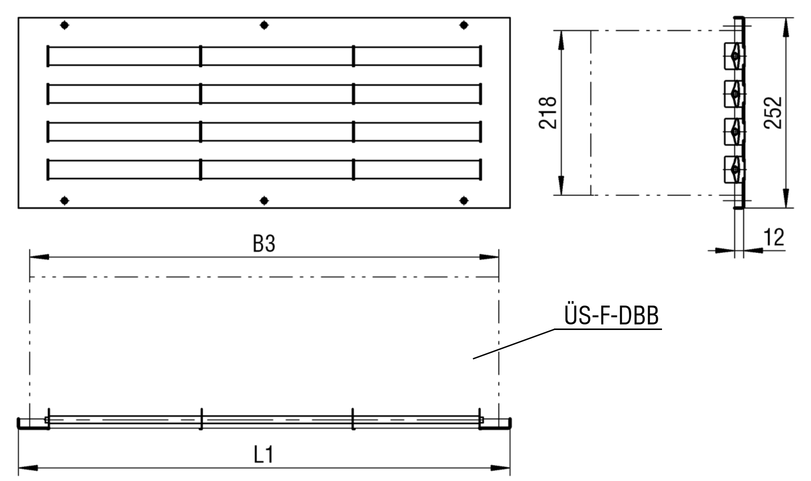
### Montaje oculto (para rejillas con una longitud menor de 1250 mm)



# Fan Coil Aquaris Silent

## Difusor de techo DBB

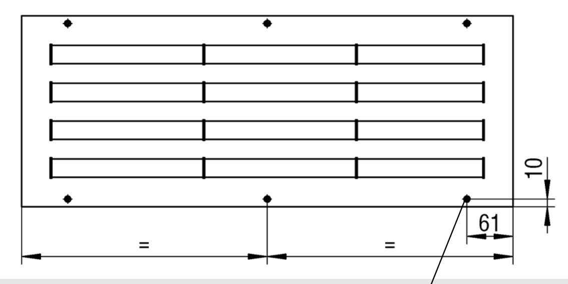
Compuesto por placa frontal fabricada en chapa de acero lacado RAL 9010 (blanco), y lamas deflectoras regulables individualmente fabricadas en plástico de color similar RAL 9005 (negro), RAL 9010 o aluminio lacado en el color RAL de la placa frontal.



**Dimensiones**

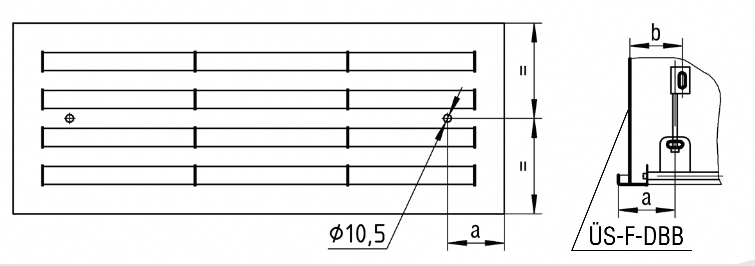
| L1 (mm) | B3 (mm) | a (mm) | b (mm) |
|---|---|---|---|
| 650 | 620 | 75 | 68 |
| 850 | 820 | 125 | 118 |
| 1050 | 1020 | | |
| 1250 | 1220 | | |
| 1550 | 1520 | | |

### Montaje atornillado (SM)

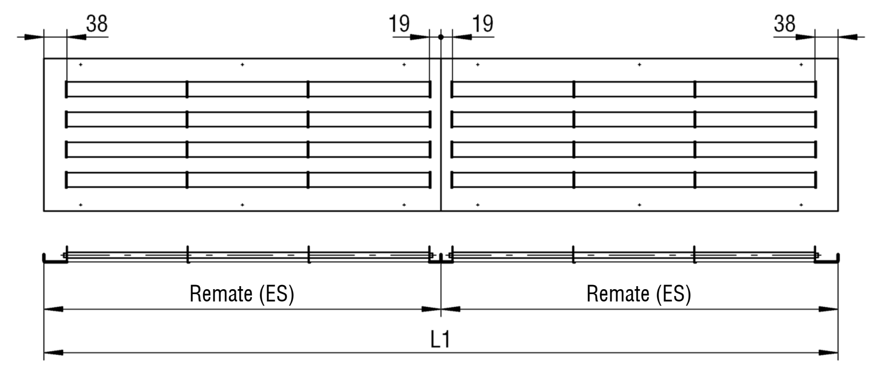


Tornillo de cabeza avellanada DIN ISO 6051 ST3,9
(en obra)

### Montaje oculto (para difusores con una longitud menor de 1525 mm)



### Ejecución en línea continua en 2 tramos



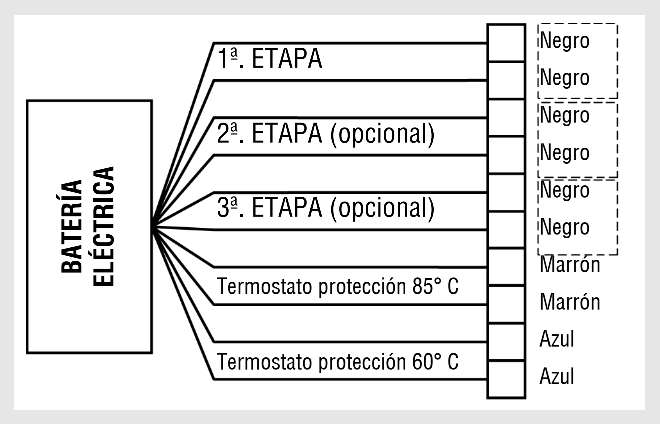
| L1 (mm) |
|---|
| 1650 |
| 1850 |
| 2050 |

# Fan Coil Aquaris Silent

## Batería eléctrica (-BE)

Batería de calefacción eléctrica formada por bastidor de chapa de acero galvanizado, serpentín de acero inoxidable y doble sistema de seguridad de corte por exceso de temperatura. Posibilidad de ejecución con lamas y sin lamas.

### Esquema de conexión



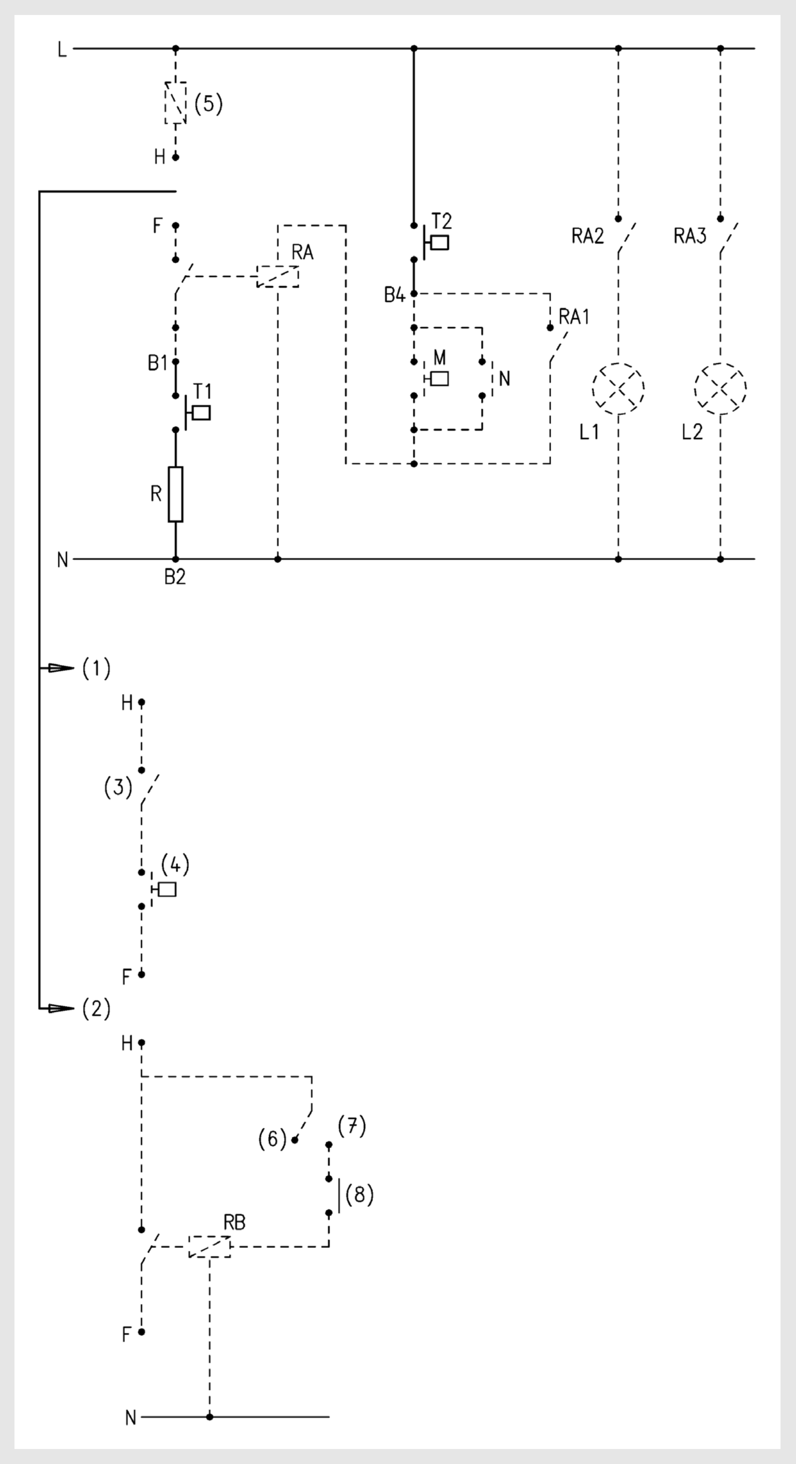
### Con lamas

### Sin lamas

| Batería | P (kW) | Modelo | n= máximo V (m$^3$/h) | ΔT (K) | n= medio V (m$^3$/h) | ΔT (K) | n= mínimo V (m$^3$/h) | ΔT (K) |
|---|---|---|---|---|---|---|---|---|
| **BE1** | 1,25 | 103 | 385 | 9,7 | 270 | 13,8 | 160 | 23,3 |
| | | 113 | 530 | 7,0 | 385 | 9,7 | 235 | 15,9 |
| **BE2** | 2,0 | 203 | 750 | 8,0 | 485 | 12,3 | 305 | 19,6 |
| | | 213 | 835 | 7,2 | 570 | 10,5 | 355 | 16,8 |
| **BE3** | 2,5 | 303 | 1030 | 7,2 | 850 | 8,8 | 495 | 15,1 |
| | | 313 | 1135 | 6,6 | 970 | 7,7 | 575 | 13,0 |
| **BE4** | 2,75 | 403 | 1435 | 5,7 | 1040 | 7,9 | 680 | 12,1 |
| | | 413 | 1620 | 5,1 | 1275 | 6,4 | 940 | 8,7 |
| **BE5** | 3,0 | 503 | 1670 | 5,4 | 1145 | 7,8 | 775 | 11,6 |
| | | 513 | 1825 | 4,9 | 1350 | 6,6 | 1020 | 8,8 |

# Fan Coil Aquaris Silent

## Ejemplo de esquema de conexión



**Suministrado por SCHAKO:**

| | |
|---|---|
| **B1/B2/B3/B4** | Bornes de conexión (en la caja de bornes del equipo) |
| **T1** | Termostato con rearme automático |
| **T2** | Termostato de seguridad, recomendado para rearme manual |
| **R** | Batería eléctrica |

**No suministrado por SCHAKO**:

| | |
|---|---|
| **M** | Pulsador para rearme manual |
| **N** | Rearme desde control central |
| **RA/RB/RA1** | Emisor eléctrico de control/guarda/ |
| **RA2** | Contacto auxiliar “servicio” L1 |
| **RA3** | Contacto auxiliar “avería” L2 |
| **L1** | Piloto de servicio |
| **L2** | Piloto de avería |

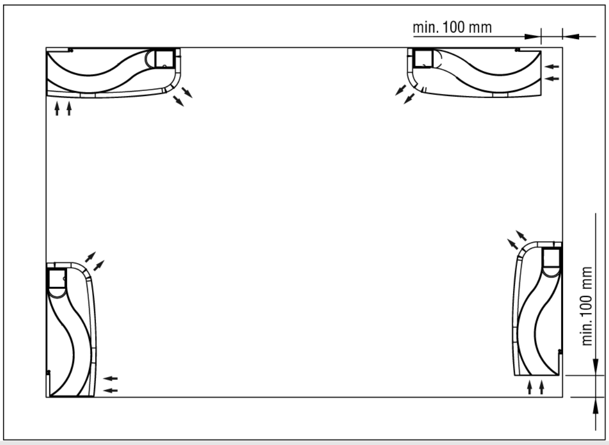
| | |
|---|---|
| (1) | Posibilidad de conexión 1 |
| (2) | Posibilidad de conexión 2 |
| (3) | Interruptor |
| (4) | Dispositivo de control del local |
| (5) | Fusible |
| (6) | Desconectado |
| (7) | Servicio automático |
| (8) | Conectado / Desconectado |

# Fan Coil Aquaris Silent

## Mueble decorativo

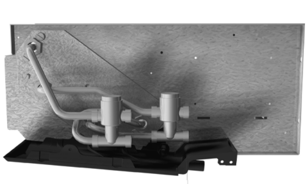
Para equipos instalados a la vista, SCHAKO ha diseñado una envolvente especial fabricada en material sintético (similar RAL 9010), chapa galvanizada (RAL 9010) y aluminio (RAL 9010). El mueble mantiene un diseño decorativo que se integra a la perfección con el mobiliario del local.

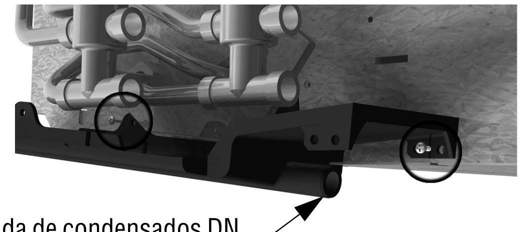
### Ejemplos de montaje para equipo con mueble decorativo



## Bandeja auxiliar de condensados (-KW)

La bandeja auxiliar de condensados diseñada tanto para una ejecución en horizontal como en vertical, está fabricada en plástico y se encarga de recoger los posibles condensados formados en el kit de válvulas así como de drenar el agua condensada por la batería de refrigeración.

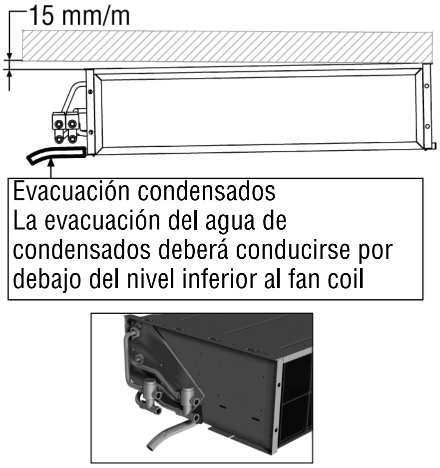




Salida de condensados DN exterior 17 mm

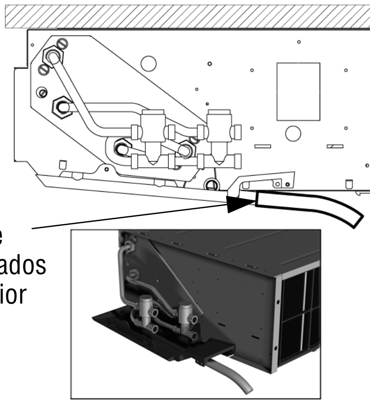
## Kit de válvulas

**FAN-COIL**



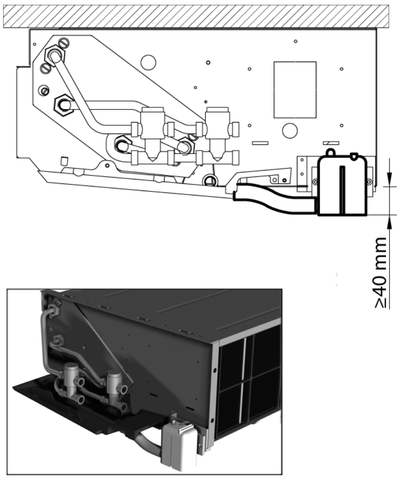
Evacuación condensados
La evacuación del agua de condensados deberá conducirse por debajo del nivel inferior al fan coil

**FAN-COIL + BANDEJA**



Salida de condensados DN exterior 17 mm

**FAN-COIL + BANDEJA + BOMBA CONDENSADOS**



Fecha: 05.04.2013

# Fan Coil Aquaris Silent

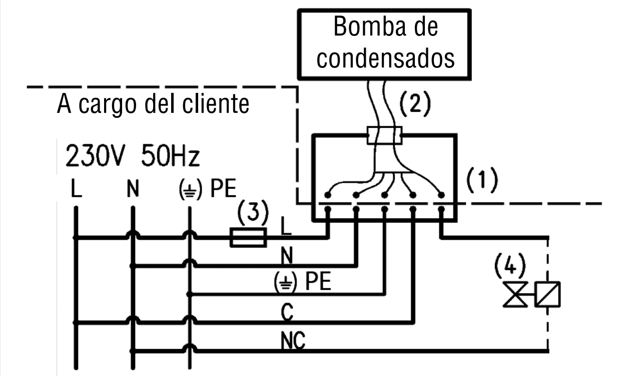
## Bomba de condensados (-KP)

Bomba de condensados para desalojar el agua condensada de la batería de refrigeración hasta un desagüe situado por encima del nivel de salida de dichos condensados.
La bomba de condensados suministrada de fábrica, si se solicita, dispone de un dispositivo de seguridad que detiene el funcionamiento del Aquaris Silent en el caso de que los condensados no pudiesen evacuarse correctamente (atasco, exceso de condensados, fallo de la bomba, etc.)

### Datos técnicos

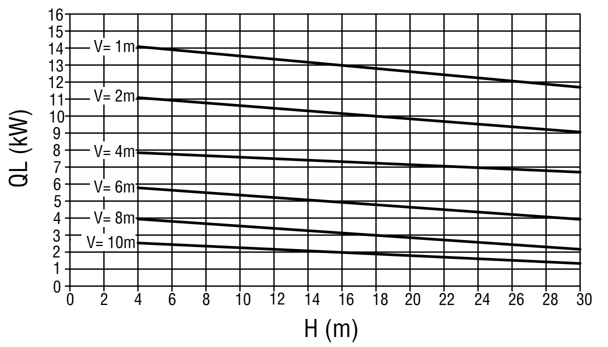
| | |
|---|---|
| Caudal máximo: | 20 l/h |
| Altura máx. de descarga: | 10 m (caudal 4 l/h) |
| Presión máxima: | 14 m (caudal 0 l/h) |
| Nivel acústico: | < 28 dB (A) |
| Potencia eléctrica: | 230 V - 50/60 Hz - 14 W |
| Niveles de detección: | On (18 mm) Off (12 mm) Alarma (21 mm) |
| Contacto de seguridad: | NC 8 A resistivo-250V |
| Protección térmica: | 90°C (rearme automático) |
| Tipo de bomba: | Bomba de pistón |
| Protección: | IP54 |
| Dimensiones del codo: | 165 x 165 x 60 mm |
| Dimensiones de la tapa: | 750 x 80 x 60 mm |

### Esquema de conexión del contacto de seguridad:



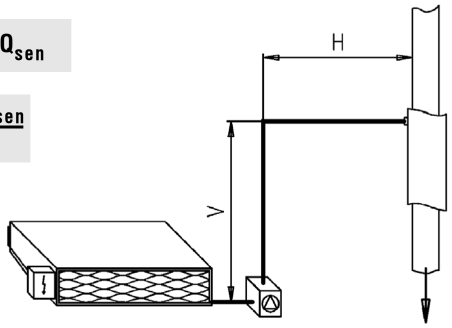
| | | | |
|---|---|---|---|
| (1) Caja de conexiones | L | = rojo |
| (2) Cable de la bomba | N | = azul |
| (3) Fusible 630 mA | PE (Tierra) | = amarillo/verde |
| (4) Aquaris Silent | C | = negro |
| | NC | = negro |

El diagrama muestra la potencia de la bomba de condensados (expresada en potencia frigorífica latente) en función de la altura de descarga (V) y de la distancia horizontal (H).



$$Q_L = Q_{ges} - Q_{sen}$$

$$Q_V = \frac{Q_{ges} - Q_{sen}}{0.68}$$



$Q_L$ (kW) = Potencia latente
$Q_{ges}$ (kW) = Potencia total
$Q_{sen}$ (kW) = Potencia sensible
$Q_V$ (l/h) = Caudal de condensados
H (m) = Distancia horizontal
V (m) = Altura de descarga

# Fan Coil Aquaris Silent

## Sistemas de control y regulación

- Control Basic
- Control Economic (regulación integrada)
- Control Comfort

### Control Basic

### Termostato de ambiente en instalación a 2 tubos

**Modelo RAB21** (solo serie SP)

- Control para calefacción o refrigeración
- Salida de control On/Off sobre válvula
- Interruptor manual de ventilador 3 velocidades/paro
- Tensión de alimentación 24...250 V AC

**Modelo RCC10** (solo serie SP)

- Control para calefacción y refrigeración
- Salida para servomotores de válvula Off/On
- Salidas para ventilador de 3 velocidades
- Control en función de la temperatura del aire ambiente o retorno
- Conmutación automática entre régimen de frío y calor mediante sonda QAH11.1
- Entrada contacto de conmutación Confort/Eco/Stand-by
- Tensión de alimentación 230 V AC

### Termostato en instalación a 2 tubos con batería eléctrica

**Modelo RCC20** (solo serie SP)

- Salida para servomotores de válvula On/Off
- Salida ventilador de 3 velocidades
- Control en función de la temperatura del aire de ambiente o de retorno
- Interruptor manual de ventilador 3 velocidades/paro
- Modos de operación: Normal, Económico y Protección antihielo o Paro mediante contacto externo (ventanas, habitación de hotel...)
- Tensión alimentación 230 V AC

### Termostato de ambiente en instalación a 4 tubos

**Modelo RCC30** (solo serie SP)

- Salida para servomotores válvula On/Off
- Ventilador de 3 velocidades
- Control en función de la temperatura del aire ambiente o de retorno
- Modos de operación: Normal, Económico y Protección antihielo o Paro mediante contacto externo (ventanas, habitación de hotel...)
- Tensión alimentación 230 V AC

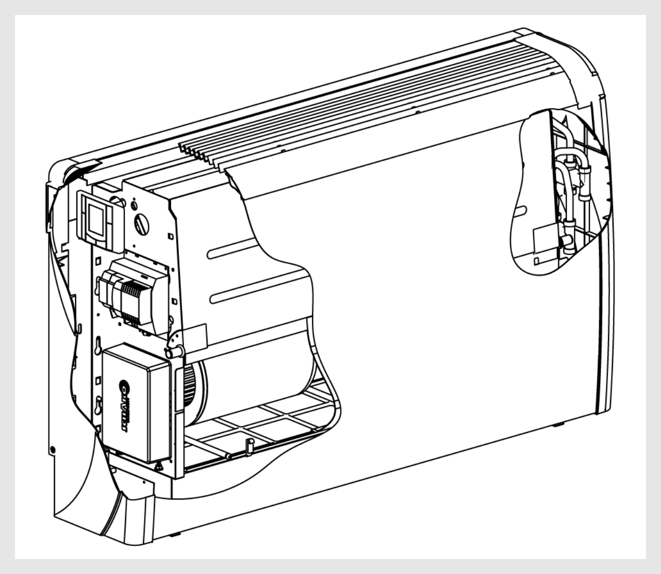
### Termostato de ambiente en instalación a 2 tubos con o sin batería eléctrica y a 4 tubos

**Modelo RDG**

- Gran display digital retroiluminado
- 3 velocidades de ventilación automática en función de la demanda o regulación 0-10 V para serie EC (RDG 160)
- Conmutación automática entre régimen de frío y calor mediante sonda QAH11.1
- Opción conexión sonda retorno
- Contacto externo modo funcionamiento Confort/Eco/Off
- Opción control proporcional PWM
- Versión con reloj programador

# Fan Coil Aquaris Silent

## Control Economic (regulación integrada)



Ventajas de la regulación integrada (montada y cableada):

- Máxima sencillez al menor precio (PLUG & PLAY)
- Sin necesidad de cuadro eléctrico en instalación
- Reducción del cableado y coste de la instalación eléctrica
- Óptima adaptación de la válvula de control al fan coil mediante un kit de válvula

## Unidades de ambiente con interfaz bifilar QAA07.3/ QAA07.5

- Interfaz bifilar para el controlador
- Medición de la temperatura ambiente
- LCD para visualización de la temperatura ambiente, el modo de operación y la potencia del ventilador
- Opción reloj programador (QAA07.5)
- Diseño extraplano para montaje ambiente o integrado en el fan coil

## Controlador de fan coil ACC071 (modular)

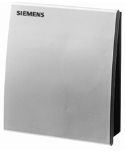
Dos posibilidades de control; control de 3 velocidades de ventilador (ACC071.2) o control de motores EC (ACC071.4).
Para instalaciones a 2 tubos o 2 tubos+ batería eléctrica (con submódulo ACE071.4 salida hasta 1,8 kW control PWM) o 4 tubos (con submódulo ACE071.3)

- 14 aplicaciones de fancoil, seleccionables mediante conmutadores DIL
- Control de la velocidad el ventilador en función de la demanda
- Control de los actuadores térmicos de las válvulas a 230 V AC
- Dos posibilidades de comunicación:
  Comunicación KNX LTE-Mode (con submódulo ACE072.1) o comunicación Modbus (con submódulo ACE072.2)
- Conexión de hasta 8 controladores a la misma unidad ambiente por el bus de comunicación KNX

# Fan Coil Aquaris Silent

## Control Comfort
## Controlador individual de zona con comunicación de bus (LonMark)
## Modelo RXC21.5 (2 o 4 tubos)
## Modelo RXC22.5 (2 tubos y batería eléctrica)

- Control integrado (montado y cableado) para fan coil con bus de comunicaciones compatible con LonMark

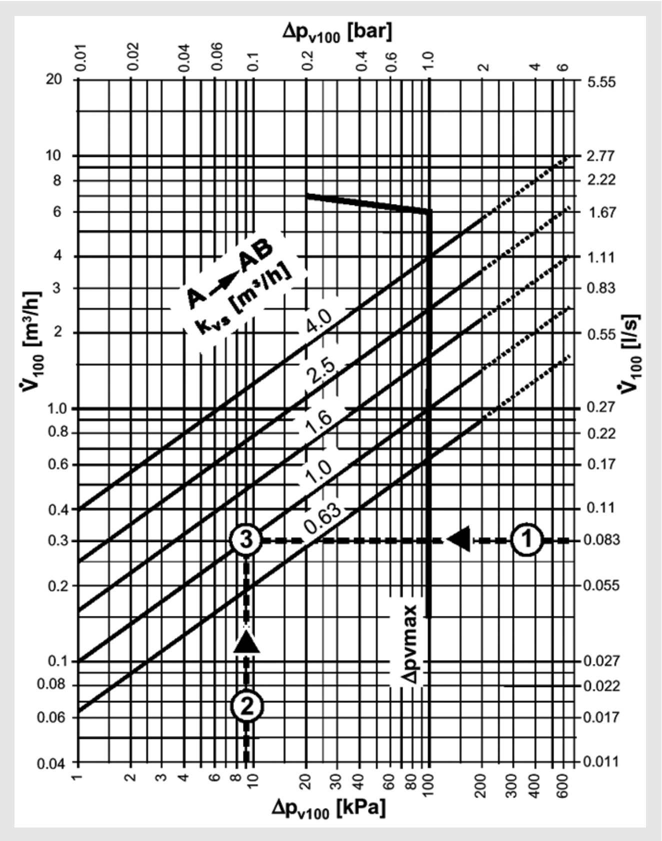
| **Unidades de control local** | **QAX 30.1** | **QAX 31.1** | **QAX 32.1** | **QAX 33.1** | **QAX 34.1** |
|---|---|---|---|---|---|
| |  |  |  |  |  |
| Sensor de temperatura ambiente integrado | x | x | x | x | x |
| Ajuste de la consigna de la temperatura ambiente | | x | x | x | x |
| Selección del modo de operación (Comfort / Stand-by o Economic) | | | x | x | x |
| Selección del modo de operación (Comfort / Stand-by o Economic) y control de la velocidad del ventilador. | | | | x | x |
| Display LCD para temperatura ambiente y velocidad del ventilador | | | | | x |

Fecha: 05.04.2013

# Fan Coil Aquaris Silent

## Válvulas y actuadores

| Modelo | | DN (mm) | Conexión | $K_{vs}$ ($m^3/h$) | $\Delta p_s$ (kPa) | $K_{vs}$ By pass ($m^3/h$) | $\Delta p_{max}$ (kPa) | Actuador | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | **100 N** | **105 N** |
| **V V P 46**<br>(2 vías)<br> | VVP469.10-0.63 | **10** | $G^{1/2}$ B | 0,63 | 150 | 0,44 | 100 | SSA | STA |
| | VVP469.10-1.0 | | | 1 | | 0,7 | | | |
| | VVP469.10-1.6 | | | 1,6 | | 1,12 | | | |
| | VVP469.15-2.5 | **15** | $G^{3/4}$ B | 2,5 | 150 | 1,75 | 100 | SSA | STA |
| | VVP469.20-4.0 | **20** | G1B | 4 | 150 | 2,8 | 100 | SSA | STA |
| **V X P 46**<br>(3 vías)<br> | VXP469.10-0.63 | **10** | $G^{1/2}$ B | 0,63 | 150 | 0,44 | 100 | SSA | STA |
| | VXP469.10-1.0 | | | 1 | | 0,7 | | | |
| | VXP469.10-1.6 | | | 1,6 | | 1,12 | | | |
| | VXP469.15-2.5 | **15** | $G^{3/4}$ B | 2,5 | 150 | 1,75 | 100 | SSA | STA |
| | VXP469.20-4.0 | **20** | G1B | 4 | 150 | 2,8 | 100 | SSA | STA |
| **V M P 46**<br>(4 vías)<br> | VMP469.10-0.63 | **10** | $G^{1/2}$ B | 0,63 | 150 | 0,44 | 100 | SSA | STA |
| | VMP469.10-1.0 | | | 1 | | 0,7 | | | |
| | VMP469.10-1.6 | | | 1,6 | | 1,12 | | | |
| | VMP469.15-2.5 | **15** | $G^{3/4}$ B | 2,5 | 150 | 1,75 | 100 | SSA | STA |
| | VMP469.20-4.0 | **20** | G1B | 4 | 150 | 2,8 | 100 | SSA | STA |



**Modelo STA**

- Fuerza nominal de 105 N
- Montaje directo
- Versión estándar con cable de conexión 1,2 ó 5 m
- Indicación de posición
- Conexión a 2 hilos

STA21: voltaje 230 V AC, control de 2 posiciones
STA71: voltaje 24 V AC/DC, control de 2 posiciones o MID

**Modelo SSA**

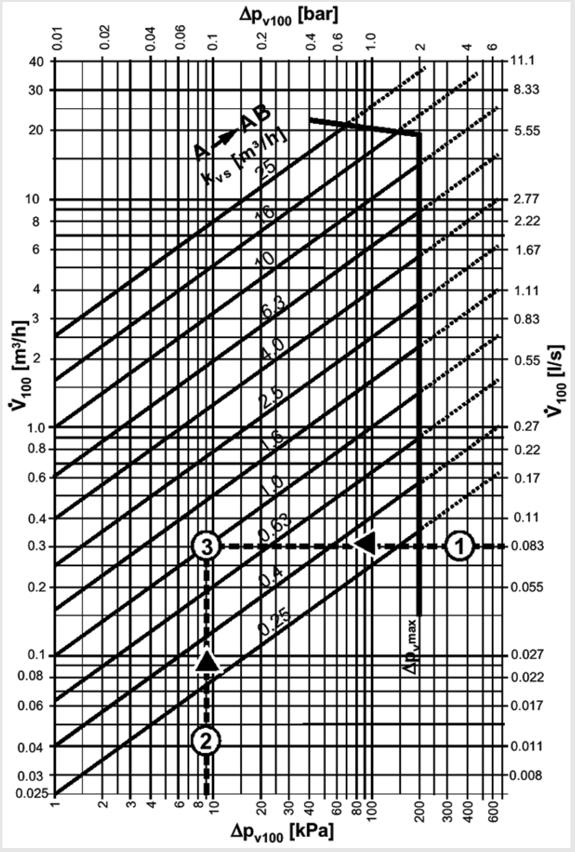
- Fuerza nominal de 100 N
- Identificación automática del recorrido de la válvula
- Montaje directo
- Control manual con indicación de posición y dirección del recorrido
- Cable de conexión 1,5, 2,5 ó 4,5 m

SSA31: voltaje 230 V AC, control de 3 posiciones
SSA61: voltaje 24 V AC/DC, control 0...10 V DC
SSA81: voltaje 24 V AC, control de 3 posiciones

# Fan Coil Aquaris Silent

| Modelo | | DN (mm) | Conexión | $K_{vs}$ ($m^3/h$) | $\Delta p_s$ (kPa) | $K_{vs}$ By pass ($m^3/h$) | $\Delta p_{max}$ (kPa) | Actuador | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | **100 N** | **105 N** |
| **V V P 45**<br>(2 vías)<br> | VVP45.10-0.4 | **10** | $G^{1/2}$ B | 0,4 | 600 | 0,28 | 200 | SSB (200 N) | |
| | VVP45.10-0.63 | | | 0,63 | | 0,44 | | | |
| | VVP45.10-1 | | | 1,0 | | 0,70 | | | |
| | VVP45.10-1.6 | | | 1,6 | | 1,12 | | | |
| | VVP45.25-6.3 | **25** | $G1^{1/4}$ B | 6,3 | 300 | 4,4 | 300 | SSB (300 N) | |
| | VVP45.25-10 | | $G1^{1/2}$ B | 10 | | 10 | | SSC (300 N) | |
| **V X P 45**<br>(3 vías)<br> | VXP45.10-0.4 | **10** | $G^{1/2}$ B | 0,4 | 600 | 0,28 | 200 | SSB (200 N) | |
| | VXP45.10-0.63 | | | 0,63 | | 0,44 | | | |
| | VXP45.10-1 | | | 1,0 | | 0,70 | | | |
| | VXP45.10-1.6 | | | 1,6 | | 1,12 | | | |
| | VXP45.25-6.3 | **25** | $G1^{1/4}$ B | 6,3 | 300 | 4,4 | 300 | SSB (300 N) | |
| | VXP45.25-10 | | $G1^{1/2}$ B | 10 | | 10 | | SSC (300 N) | |
| **V M P 45**<br>(4 vías)<br> | VMP45.10-0.4 | **10** | $G^{1/2}$ B | 0,4 | 600 | 0,28 | 200 | SSB (200 N) | |
| | VMP45.10-0.63 | | | 0,63 | | 0,44 | | | |
| | VMP45.10-1 | | | 1,0 | | 0,70 | | | |
| | VMP45.10-1.6 | | | 1,6 | | 1,12 | | | |

**Selección valor Kvs**



**Modelo SSB**

- Fuerza nominal de 200 N
- Identificación automática del recorrido de la válvula
- Montaje directo
- Anulación manual e indicación de posición
- Cable conexión 1,5 m

SSB31: voltaje 230 V AC, control de 3 posiciones
SSB61: voltaje 24 V AC/DC, control 0…10 V DC
SSB81: voltaje 24 V AC, control de 3 posiciones

**Modelo SSC**

- Fuerza nominal de 300 N
- Identificación automática del recorrido de la válvula
- Montaje directo
- Control manual con indicación de posición y dirección del recorrido

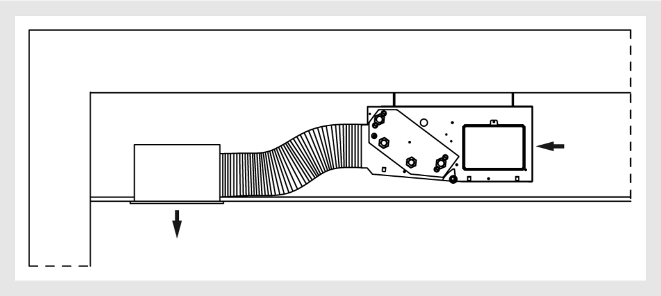
SSC31: voltaje 230 V AC, control de 3 posiciones
SSC61: voltaje 24 V AC/DC, control 0…10 V DC
SSC81: voltaje 24 V AC, control de 3 posiciones

# Fan Coil Aquaris Silent

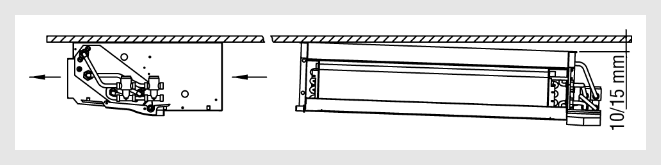
## Instalación

### Instalación en horizontal

Para una instalación en el falso techo, el equipo se suspende mediante elementos de anclaje (por ejemplo varillas roscadas) sujetas mediante tuercas a los soportes de anclaje existentes en la carcasa del equipo.

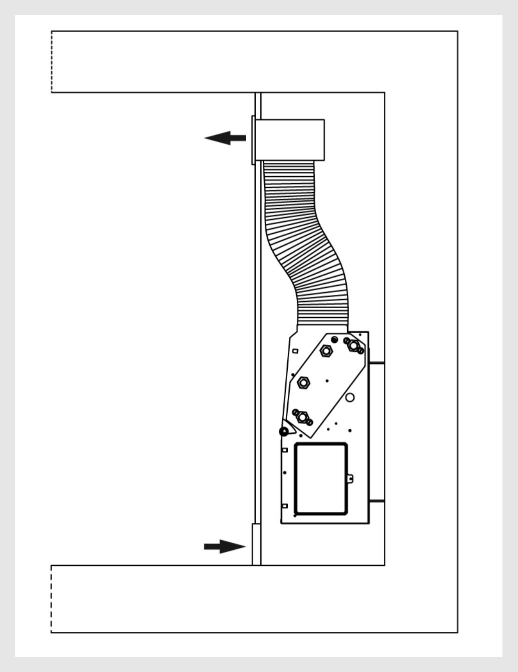


Para todo tipo de instalación en horizontal y a fin de facilitar el desagüe de condensados, el equipo se instala con una inclinación de 10-15 mm por cada metro de anchura del equipo.



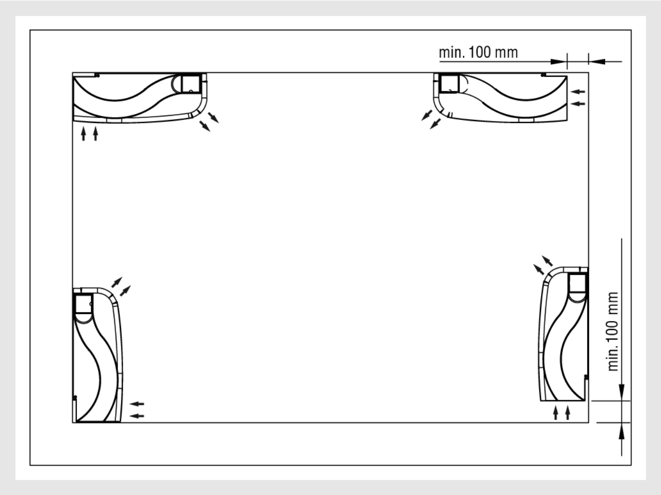
### Instalación en vertical

El fan coil se fija a la pared mediante el marco de chapa de sujeción instalado en los laterales del mismo. Si la unidad incorpora mueble, este se acopla por medio de las pestañas situadas en el marco de chapa del fan coil.



### Instalación con mueble

Todos los equipos que incorporen mueble y no dispongan de rejilla de retorno, se deberán instalar a una distancia mínima de 100 mm entre la pared (instalación horizontal) o suelo (instalación vertical) para un correcto paso del aire.



## Mantenimiento

La línea Aquaris Silent se caracteriza por tener un mantenimiento sencillo ya que únicamente es necesario limpiar o sustituir periódicamente el filtro y realizar una limpieza anual del desagüe de condensados. El grupo motoventilador carece de mantenimiento al poseer motores autolubricados.

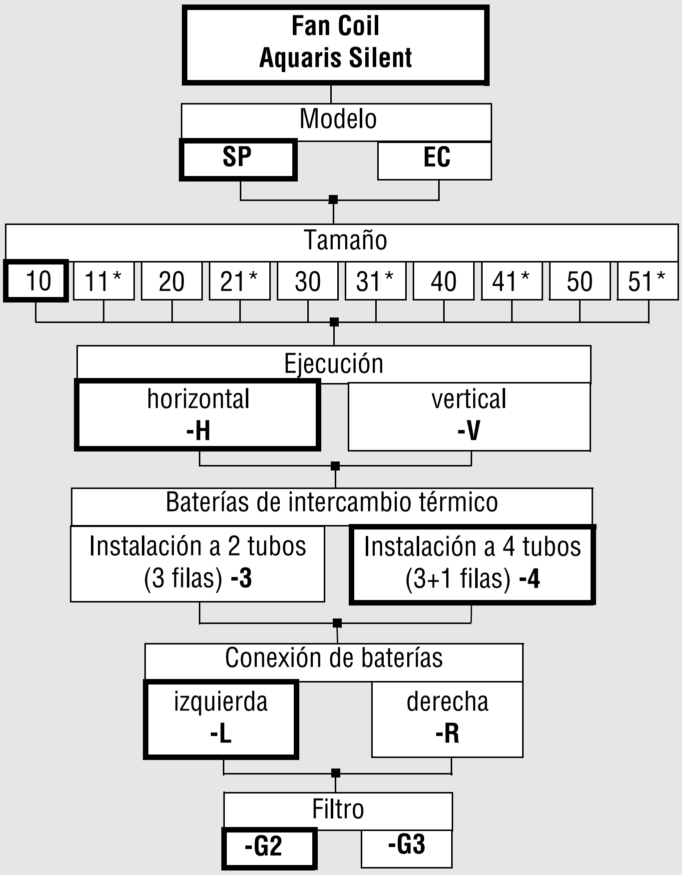
# Fan Coil Aquaris Silent

## Leyenda

n = Velocidad del ventilador
$G_1$ (kg) = Peso unidad básica
$G_2$ (kg) = Peso unidad básica con mueble
V (m$^3$/h) [l/s] = Caudal de aire
$Q_{ges}$ (kW) = Potencia total en refrigeración
$Q_s$ (kW) = Potencia sensible en refrigeración
Q (kW) = Potencia en calefacción
$V_W$ (l/h) = Caudal de agua
$V_{WK}$ (l/h) = Caudal de agua en refrigeración
$V_{WH}$ (l/h) = Caudal de agua en calefacción
$Pa_{WK}$ (kPa) = Pérdida de carga en el circuito de agua, régimen refrigeración
$Pa_{WH}$ (kPa) = Pérdida de carga en el circuito de agua, régimen calefacción
$T_{AK}$ (°C) = Temperatura del aire de salida en refrigeración
$T_{AH}$ (°C) = Temperatura del aire de salida en calefacción
$rF_{AK}$ (%) = Humedad relativa del aire de salida en refrigeración
$rF_{AH}$ (%) = Humedad relativa del aire de salida en calefacción
EK (W/A) = Características eléctricas (vatios / amperios)
$L_W$ (dB) = Nivel de potencia sonora
$L_{WA}$ [dB(A)] = Nivel de potencia sonora, ponderado A
$f_m$ (Hz) = Frecuencia por banda de octava
De (dB/Okt) = Atenuación
$L_P$ [dB(A)] = Nivel de presión sonora
W (W) = Consumo eléctrico
I (A) = Intensidad
SFP [W/ (l/s)] = Potencia específica del ventilador
DN (mm) = Diámetro nominal
$K_{vs}$ (m$^3$/h) = Caudal de agua que pasa a través de la válvula 100% abierta para una caída de presión de 1 bar
$\Delta p_t$ (kPa) = Presión diferencial máxima admitida por la válvula
$\Delta p_{tmax}$ (kPa) = Presión diferencial máxima admitida por el actuador de la válvula
$\Delta t$ (K) = Diferencia de temperatura entrada y salida aire
P (kW) = Potencia batería eléctrica

# Fan Coil Aquaris Silent

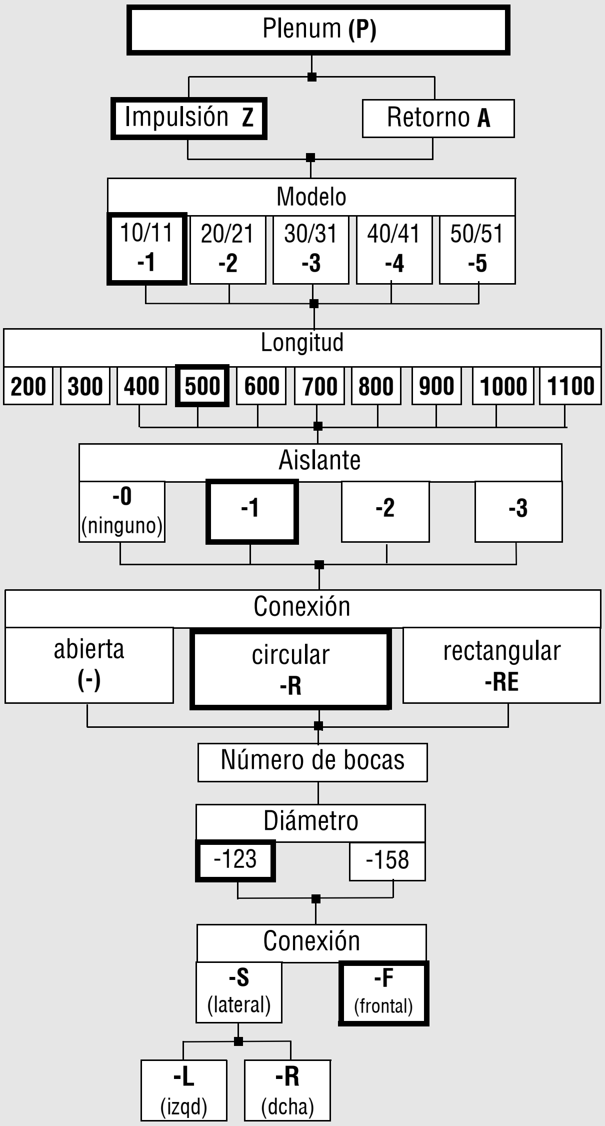
## Datos del pedido



* solo para modelo SP

**Ejemplo de pedido:** Aquaris Silent SP/10/H/4/L/G2

**Datos de pedido de plenums:**

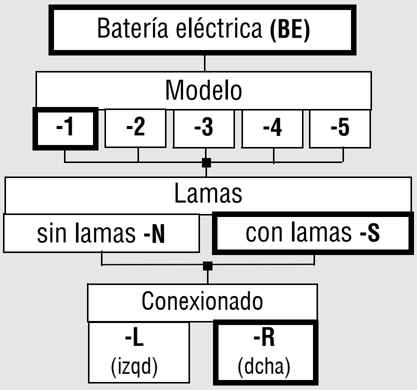


**Ejemplo de pedido:** P-Z-1/500/1/R/1/123/F

**Accesorios:**

- Mueble decorativo
- Embocadura **(-ÜS-F)**
- Marco de boca **(-FL)**
- Manguito flexible **(-FS-F)**
- Batería eléctrica **(-BE)**
- Rejilla de ventilación Ib 1
- Difusor de techo DBB
- Plenum impulsión y retorno con atenuación **(-PZ) (-PA)**
- Bandeja auxiliar **(-KW)**
- Bomba condensados **(-KP)**
- Kit de válvulas
- Control y regulación
- Válvulas y actuadores

**Datos de pedido de la batería eléctrica:**



**Ejemplo de pedido:** BE1SR

# Fan Coil Aquaris Silent

## Texto de especificación

Fan coil Aquaris Silent para montaje horizontal o vertical, empotrado en falsos techos y suelos o la vista con mueble decorativo. Carcasa formada por perfiles y paneles de chapa de acero galvanizado y aislante térmico y acústico de polietileno de 3 mm de espesor. Grupo motoventilador formado por ventiladores centrífugos de doble oído con motor directo. Baterías de intercambio térmico con bastidor de acero galvanizado, aletas de aluminio y tubos de cobre. Bandeja de condensados fabricada en acero galvanizado. Filtro de eficacia G2 y G3 (EN 779) formado por malla sintética y marco de plástico.
Producto: SCHAKO **Modelo Fan coil, Serie Aquaris Silent**

**Modelo:**
- SP (Motor AC)
- EC (Motor EC)

**Tamaño**
- 10 / 11* / 20 / 21* / 30 / 31* / 40 / 41* / 50 / 51*
  (*solo para Modelo SP)

**Ejecución:**
- H (horizontal)
- V (vertical)

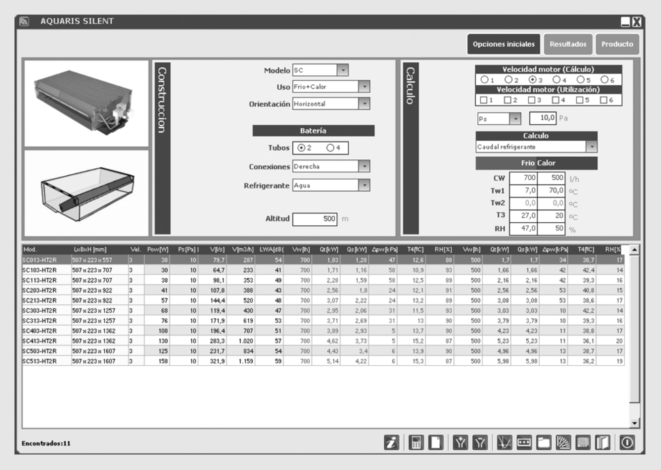
**Baterías de intercambio térmico:**
- Instalación a 2 tubos
- Instalación a 4 tubos
- Conexiones hidráulicas derecha
- Conexiones hidráulicas izquierda

**Filtro:**
- Eficacia G2
- Eficacia G3 (opcional)

**Accesorios:**
- Plenum de impulsión con atenuación **(-PZ)**
- Plenum de retorno con atenuación **(-PA)**
- Manguito de unión flexible **(-FS-F)**
- Marco de boca **(-FL)**
- Rejilla Ib 1
- Difusor DBB
- Embocadura **(-ÜS-F)**
- Mueble decorativo
- Batería eléctrica **(-BE)**
- Bandeja auxiliar de condensados **(-KW)**
- Bomba de condensados **(-KP)**
- Kit de válvulas
- Sistemas de control y regulación
- Válvulas y actuadores

## Programa de selección

La selección técnica del fan coil y los plenums está optimizada gracias a nuestro programa de cálculo y dimensionado.



Modelo: SC
Uso: Frio+Calor
Orientación: Horizontal

Batería
Tubos: ● 2 ○ 4
Conexiones: Derecha
Refrigerante: Agua

Altitud: 500 m

Velocidad motor (Cálculo): ○ 1 ○ 2 ● 3 ○ 4 ○ 5 ○ 6
Velocidad motor (Utilización): ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

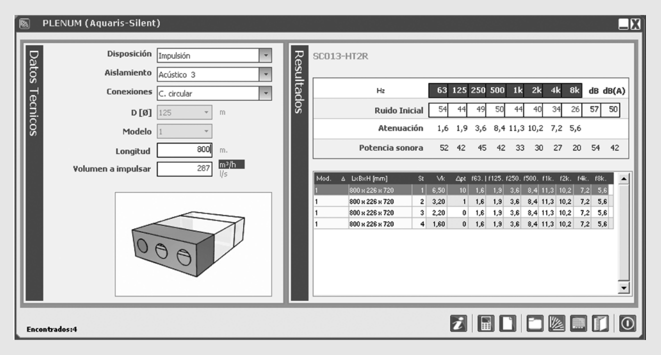
Ps: 10,0 Pa

Calculo: Caudal refrigerante

| | Frio | Calor | |
|---|---|---|---|
| CW | 700 | 500 | l/h |
| Tw1 | 7,0 | 70,0 | ºC |
| Tw2 | 0,0 | 0,0 | ºC |
| T3 | 27,0 | 20 | ºC |
| RH | 47,0 | 50 | % |

| Mod. | LxBxH [mm] | Vel. | Pow[W] | Ps[Pa] I | V[l/s] | V[m3/h] | LWA[dB( | Vw[lh] | Qt[kW] | Qs[kW] | Δpw[kPa] | T4[ºC] | RH[%] | Vw[lh] | Qt[kW] | Qs[kW] | Δpw[kPa] | T4[ºC] | RH[% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SC013-HT2R | 507 x 223 x 557 | 3 | 38 | 10 | 79,7 | 287 | 54 | 700 | 1,83 | 1,28 | 47 | 12,6 | 88 | 500 | 1,7 | 1,7 | 34 | 38,7 | 17 |
| SC103-HT2R | 507 x 223 x 707 | 3 | 30 | 10 | 64,7 | 233 | 41 | 700 | 1,71 | 1,16 | 58 | 10,9 | 93 | 500 | 1,66 | 1,66 | 42 | 42,4 | 14 |
| SC113-HT2R | 507 x 223 x 707 | 3 | 38 | 10 | 98,1 | 353 | 49 | 700 | 2,28 | 1,59 | 58 | 12,5 | 89 | 500 | 2,16 | 2,16 | 42 | 39,3 | 16 |
| SC203-HT2R | 507 x 223 x 922 | 3 | 41 | 10 | 107,8 | 388 | 43 | 700 | 2,56 | 1,8 | 24 | 12,1 | 91 | 500 | 2,56 | 2,56 | 53 | 40,8 | 15 |
| SC213-HT2R | 507 x 223 x 922 | 3 | 57 | 10 | 144,4 | 520 | 48 | 700 | 3,07 | 2,22 | 24 | 13,2 | 89 | 500 | 3,08 | 3,08 | 53 | 38,6 | 17 |
| SC303-HT2R | 507 x 223 x 1257 | 3 | 68 | 10 | 119,4 | 430 | 47 | 700 | 2,95 | 2,06 | 31 | 11,5 | 93 | 500 | 3,03 | 3,03 | 10 | 42,2 | 14 |
| SC313-HT2R | 507 x 223 x 1257 | 3 | 76 | 10 | 171,9 | 619 | 53 | 700 | 3,71 | 2,69 | 31 | 13 | 90 | 500 | 3,79 | 3,79 | 10 | 39,3 | 16 |
| SC403-HT2R | 507 x 223 x 1362 | 3 | 108 | 10 | 196,4 | 707 | 51 | 700 | 3,89 | 2,93 | 5 | 13,7 | 90 | 500 | 4,23 | 4,23 | 11 | 38,8 | 17 |
| SC413-HT2R | 507 x 223 x 1362 | 3 | 130 | 10 | 283,3 | 1.020 | 57 | 700 | 4,62 | 3,73 | 5 | 15,2 | 87 | 500 | 5,23 | 5,23 | 11 | 36,1 | 20 |
| SC503-HT2R | 507 x 223 x 1607 | 3 | 125 | 10 | 231,7 | 834 | 54 | 700 | 4,43 | 3,4 | 6 | 13,9 | 90 | 500 | 4,96 | 4,96 | 13 | 38,7 | 17 |
| SC513-HT2R | 507 x 223 x 1607 | 3 | 158 | 10 | 321,9 | 1.159 | 59 | 700 | 5,14 | 4,22 | 6 | 15,3 | 87 | 500 | 5,98 | 5,98 | 13 | 36,2 | 19 |

Encontrados:11



Disposición: Impulsión
Aislamiento: Acústico 3
Conexiones: C. circular
D [Ø]: 125 m
Modelo: 1
Longitud: 800 m.
Volumen a impulsar: 287 m³/h l/s

SC013-HT2R

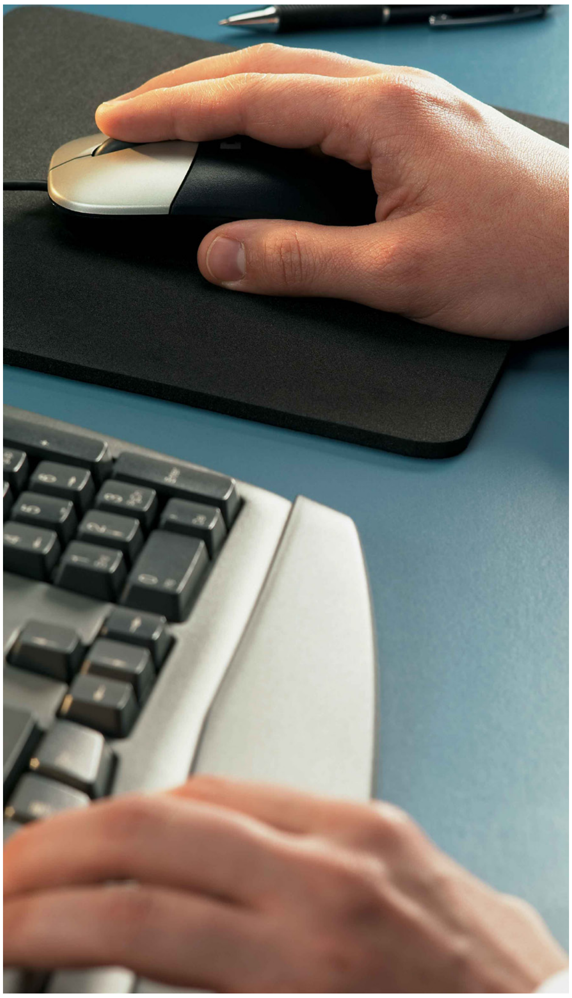
| Hz | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | dB | dB(A) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ruido Inicial | 54 | 44 | 49 | 50 | 44 | 40 | 34 | 26 | 57 | 50 |
| Atenuación | 1,6 | 1,9 | 3,6 | 8,4 | 11,3 | 10,2 | 7,2 | 5,6 | | |
| Potencia sonora | 52 | 42 | 45 | 42 | 33 | 30 | 27 | 20 | 54 | 42 |

| Mod. | Δ | LxBxH [mm] | St | Vk | Δpt | f63. | f125. | f250. | f500. | f1k. | f2k. | f4k. | f8k. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 800 x 226 x 720 | 1 | 6,50 | 10 | 1,6 | 1,9 | 3,6 | 8,4 | 11,3 | 10,2 | 7,2 | 5,6 |
| 1 | | 800 x 226 x 720 | 2 | 3,20 | 1 | 1,6 | 1,9 | 3,6 | 8,4 | 11,3 | 10,2 | 7,2 | 5,6 |
| 1 | | 800 x 226 x 720 | 3 | 2,20 | 0 | 1,6 | 1,9 | 3,6 | 8,4 | 11,3 | 10,2 | 7,2 | 5,6 |
| 1 | | 800 x 226 x 720 | 4 | 1,60 | 0 | 1,6 | 1,9 | 3,6 | 8,4 | 11,3 | 10,2 | 7,2 | 5,6 |

Encontrados:4

# User manual

# HPC



VUBQB102

## Table of contents

# 1. Purpose

HPC is a program for dimensioning heat pumps. The program provides support, based on the geographical and climate data for the relevant area, to enable the selection of the right model and size of heat pump for the customer's needs. It also dimensions the depth of the borehole for rock heating as well as providing support for a financial calculation showing how much energy and money the customer saves thanks to the investment. The program is also used to create quotes based on this information.

# 2. Background

HPC contains a calculation engine, which has been developed over a long time, based on many years of experience, measurements in the laboratory and monitoring of installations in the field. All the climate data used by the program comes from an official database for these, Meteonorm. Meteonorm holds meteorological data from 8055 weather stations from the years 1961-90 and 1996-2005. For those locations that lack a weather station, the climate data is interpolated with the help of the program. In order to obtain as correct a calculation as possible it is important that the climate data used correspond to the location's climate.

# 3. System requirements

Currently, the system supports Win2000, XP and Windows Vista. This will change as Microsoft stops supporting various operating systems. You also need to have Acrobat Reader installed.

On some computers, the firewall/antivirus protection has deleted a component, Filesystemobject, which is required to run the application. This must be allowed or, alternatively, reinstalled.

# 4. Downloading HPC

You can find the program for downloading on Thermia's website. Go to http://www.thermia.se and click on the link "Partner login", in the top right corner of the page. Log in using your user name and password. Click on "Market Support" in the top menu. In the list on the right of the page that then appears, you choose "Dimensioning & Quote Support". You then come to the link "Installation Packet HPC", which you click on. Save the file to the desktop and then open it, the installation starts automatically.

# 5. Description of the interface

When you start to use HPC, you should make a number of settings. These are described in the section "Tools", in the chapter "Main Menu" below.

In HPC, there are a number of tabs for different steps:

- Customer
- Energy prices
- Heat pump dimensioning
- Financial calculation
- Pre inspected quote

In the following sections, there are descriptions of the main menu and each tab.

## 5.1 Main Menu

When you open HPC, you see a main menu at the top. You have the following options in the menu:

- Archive
- Show
- Tools
- Help

### 5.1.1 Archive

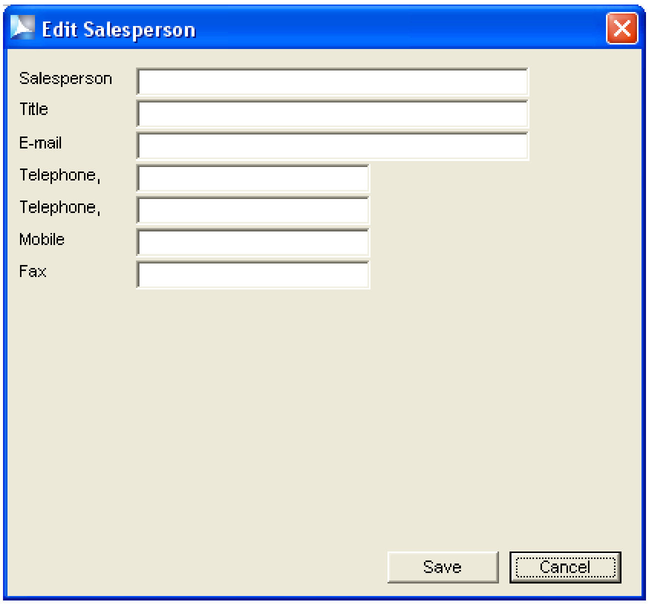
From "Archive", you can choose to import information from an existing file, save information to file, save information as a new quote or save the current calculation for another customer.

### 5.1.2 Show

From "Show", you choose whether you want to see the next or the previous tab on the screen.

### 5.1.3 Tools

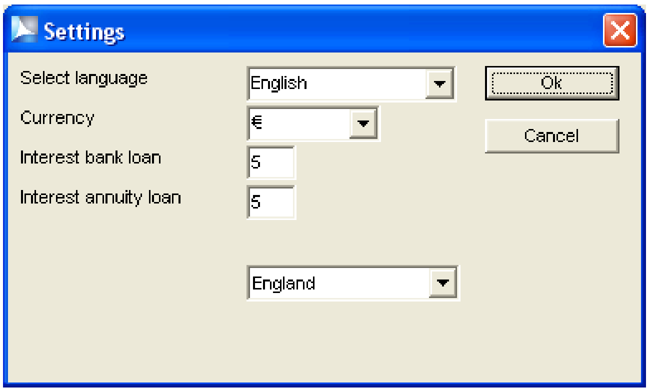
If you choose "Tools" -> "Edit Salesperson", you come to the following page:



Here you can add salespeople in your company, so each quote is linked to a specific salesperson. You then come to a form where you can enter details about the salesperson.

From "Remove own logotype", you can delete an image you have entered previously. From "Copy in own logotype", you enter your own image. The file type has to be jpeg and the format 214 x 94 pixels.

If you choose "Program settings", you come to the following window:



Select language: English
Currency: €
Interest bank loan: 5
Interest annuity loan: 5
England

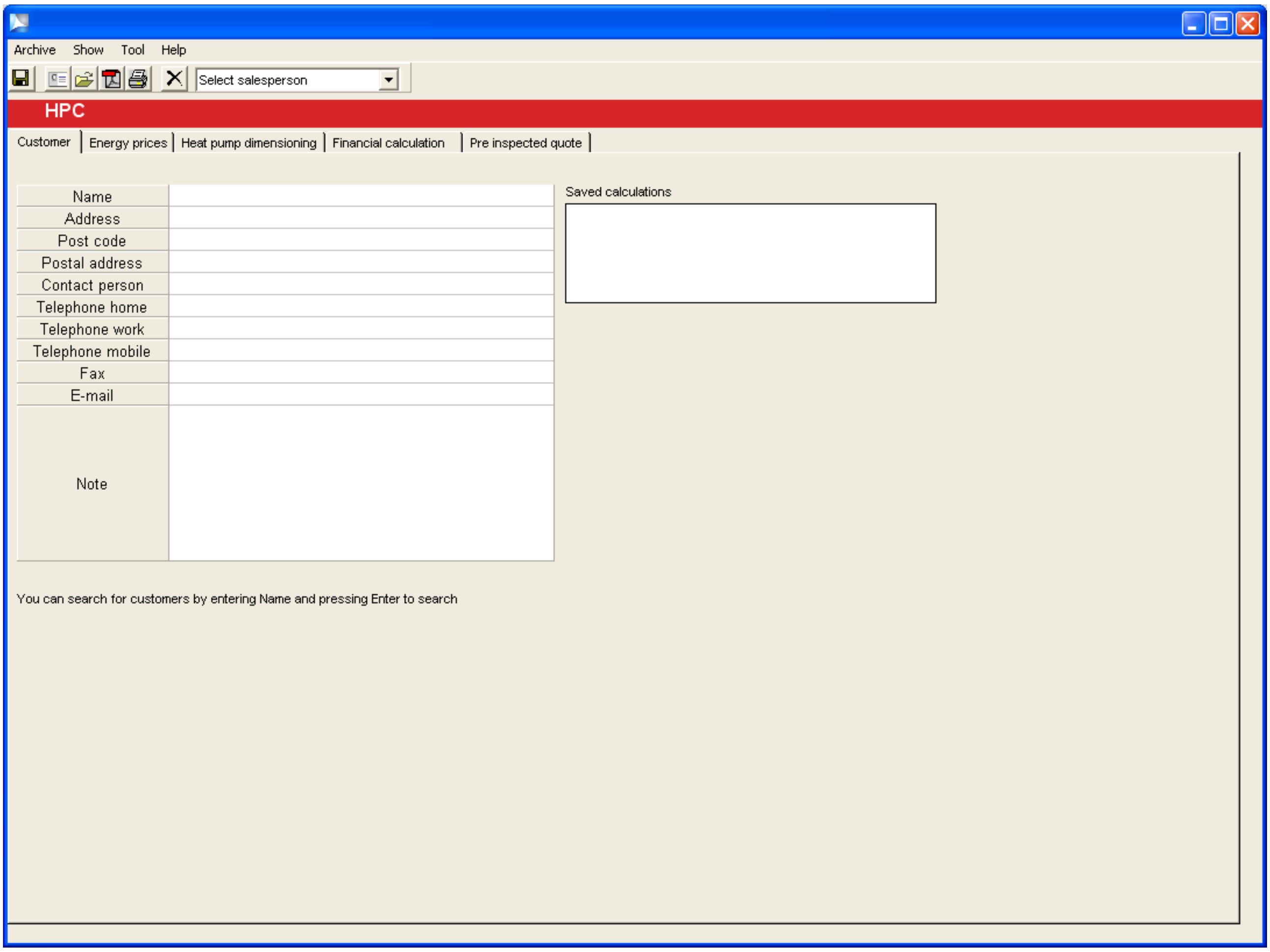
Here you choose the language you want for the program and quotes from the scroll list "Select language". The next option is the currency you want to use for the quote. You can also enter the terms for the loan from the bank here.

From "Updating", you choose to update the information in the databases used by the program. You must be connected to the Internet when you choose "Updating". For the updates to take effect, it is also necessary to restart the program.

The menu option "Extended log" is used for troubleshooting.

## 5.2 Customer

When you start HPC, the following window is shown, this is the first tab, "Customer".

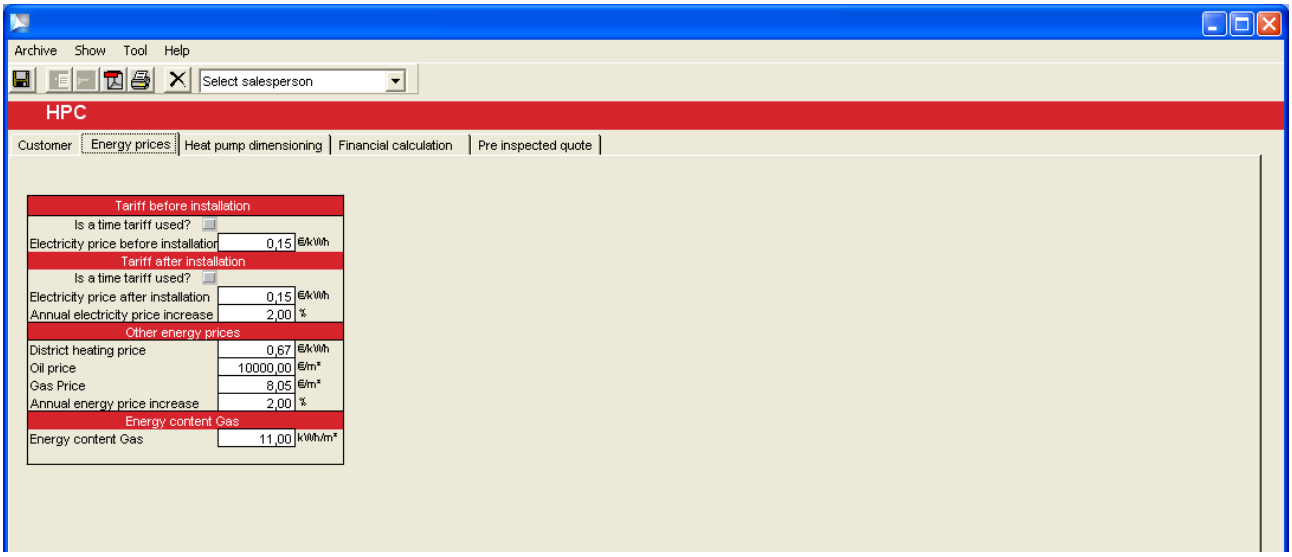


You can search for customers by entering Name and pressing Enter to search

Here you enter the customer details for the quote. You can also search for existing customers by entering the customer's name and pressing enter. You then obtain the information saved previously and any calculations for the customer. If your want to clear previous information in order to add a new customer, click on the second button from the left (next to the Save button) in the button menu, "New customer".

## 5.3 Energy prices

Here you enter the electricity price before and after the investment. If a time tariff is used in the country, you click on the box for this. Then further fields appear in the form, where you can enter the low and high tariff. You also enter here the energy prices for alternative/auxiliary energy sources, as well as the energy content of any gas that may be available.



| | | |
|---|---|---|
| **Tariff before installation** | | |
| Is a time tariff used? | ☐ | |
| Electricity price before installation | 0,15 | €/kWh |
| **Tariff after installation** | | |
| Is a time tariff used? | ☐ | |
| Electricity price after installation | 0,15 | €/kWh |
| Annual electricity price increase | 2,00 | % |
| **Other energy prices** | | |
| District heating price | 0,67 | €/kWh |
| Oil price | 10000,00 | €/m$^3$ |
| Gas Price | 8,05 | €/m$^3$ |
| Annual energy price increase | 2,00 | % |
| **Energy content Gas** | | |
| Energy content Gas | 11,00 | kWh/m$^3$ |

## 5.4 Heat pump dimensioning

Under this tab, you enter all the information that is needed to obtain the correct dimensions for your heat pump. The form contains some logical functions and calculates the values of certain parameters based on the values you have given for other parameters.

If you place the cursor over a red point in the form, a pop-up box appears with help instructions.

### 5.4.1 Data automatically provided from customer details

Enter the postcode and the system fetches the town automatically. Based on this information, the system fetches the annual average temperature and DOT (dimensioned outdoor temperature) for the location in question from the Meteonorm database. The dimensioned outdoor temperature is calculated based on the most extreme cold period with a given duration, which occurs once every ten years considered statistically. This means that for shorter periods the outdoor temperatures can be colder than DOT.

### 5.4.2 Input data – Building information (obligatory)

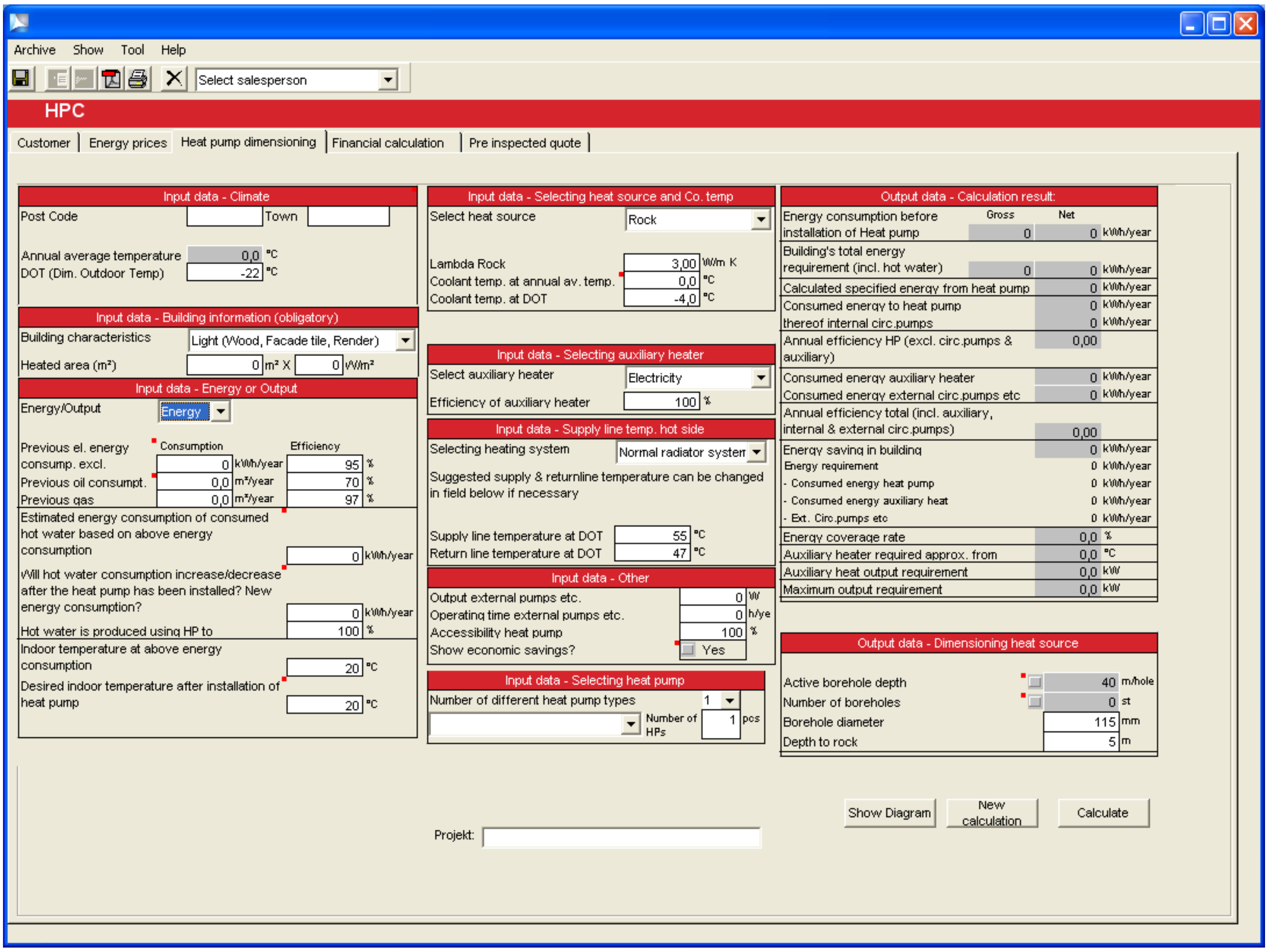
Here you enter the building characteristics, that is to say whether it is a heavy house, built from concrete or stone, or a light house, built from timber with a tile facade or rendering. A heavy house warms up slowly, but holds the warmth longer, while a light house is heated quickly, but also cools quickly. Therefore, information about the type of building concerned is important when choosing a heat pump.

Heated area refers to the area in the house (m$^2$) that is to be heated. The amount of energy needed to heat one m$^2$ in the house (W/m$^2$) is then calculated automatically. You also tick if the house has additional insulation. This also affects the figure for the amount of energy needed to heat one m$^2$.

### 5.4.3 Input data – Energy or Output

You start by choosing in the dropdown menu whether the calculation is to be done with respect to energy or output. If there is an existing heating system in the building, you normally choose to calculate with energy, based on the previous energy consumption. On the other hand, if the calculation concerns a newly built building you calculate the output. In which case, the building firm provides figures for the required output. This choice will also have some affect on the fields that appear under the heading "Output data - Calculation result".

**Energy**



Select salesperson

**Input data - Climate**

| | | |
|---|---|---|
| Post Code | | Town |
| Annual average temperature | 0,0 | °C |
| DOT (Dim. Outdoor Temp) | -22 | °C |

**Input data - Building information (obligatory)**

| | | |
|---|---|---|
| Building characteristics | Light (Wood, Facade tile, Render) | |
| Heated area (m²) | 0 m² X | 0 W/m² |

**Input data - Energy or Output**

Energy/Output: Energy

| | Consumption | | Efficiency | |
|---|---|---|---|---|
| Previous el. energy consump. excl. | 0 | kWh/year | 95 | % |
| Previous oil consumpt. | 0,0 | m³/year | 70 | % |
| Previous gas | 0,0 | m³/year | 97 | % |

| | | |
|---|---|---|
| Estimated energy consumption of consumed hot water based on above energy consumption | 0 | kWh/year |
| Will hot water consumption increase/decrease after the heat pump has been installed? New energy consumption? | 0 | kWh/year |
| Hot water is produced using HP to | 100 | % |
| Indoor temperature at above energy consumption | 20 | °C |
| Desired indoor temperature after installation of heat pump | 20 | °C |

**Input data - Selecting heat source and Co. temp**

| | | |
|---|---|---|
| Select heat source | Rock | |
| Lambda Rock | 3,00 | W/m K |
| Coolant temp. at annual av. temp. | 0,0 | °C |
| Coolant temp. at DOT | -4,0 | °C |

**Input data - Selecting auxiliary heater**

| | | |
|---|---|---|
| Select auxiliary heater | Electricity | |
| Efficiency of auxiliary heater | 100 | % |

**Input data - Supply line temp. hot side**

Selecting heating system: Normal radiator systen

Suggested supply & returnline temperature can be changed in field below if necessary

| | | |
|---|---|---|
| Supply line temperature at DOT | 55 | °C |
| Return line temperature at DOT | 47 | °C |

**Input data - Other**

| | | |
|---|---|---|
| Output external pumps etc. | 0 | W |
| Operating time external pumps etc. | 0 | h/ye |
| Accessibility heat pump | 100 | % |
| Show economic savings? | ☐ Yes | |

**Input data - Selecting heat pump**

Number of different heat pump types: 1

Number of HPs: 1 pcs

Projekt:

**Output data - Calculation result:**

| | Gross | Net | |
|---|---|---|---|
| Energy consumption before installation of Heat pump | 0 | 0 | kWh/year |
| Building's total energy requirement (incl. hot water) | 0 | 0 | kWh/year |
| Calculated specified energy from heat pump | | 0 | kWh/year |
| Consumed energy to heat pump | | 0 | kWh/year |
| thereof internal circ.pumps | | 0 | kWh/year |
| Annual efficiency HP (excl. circ.pumps & auxiliary) | | 0,00 | |
| Consumed energy auxiliary heater | | 0 | kWh/year |
| Consumed energy external circ.pumps etc | | 0 | kWh/year |
| Annual efficiency total (incl. auxiliary, internal & external circ.pumps) | | 0,00 | |
| Energy saving in building | | 0 | kWh/year |
| Energy requirement | | 0 | kWh/year |
| - Consumed energy heat pump | | 0 | kWh/year |
| - Consumed energy auxiliary heat | | 0 | kWh/year |
| - Ext. Circ.pumps etc | | 0 | kWh/year |
| Energy coverage rate | | 0,0 | % |
| Auxiliary heater required approx. from | | 0,0 | °C |
| Auxiliary heat output requirement | | 0,0 | kW |
| Maximum output requirement | | 0,0 | kW |

**Output data - Dimensioning heat source**

| | | |
|---|---|---|
| Active borehole depth | ☐ 40 | m/hole |
| Number of boreholes | ☐ 0 | st |
| Borehole diameter | 115 | mm |
| Depth to rock | 5 | m |

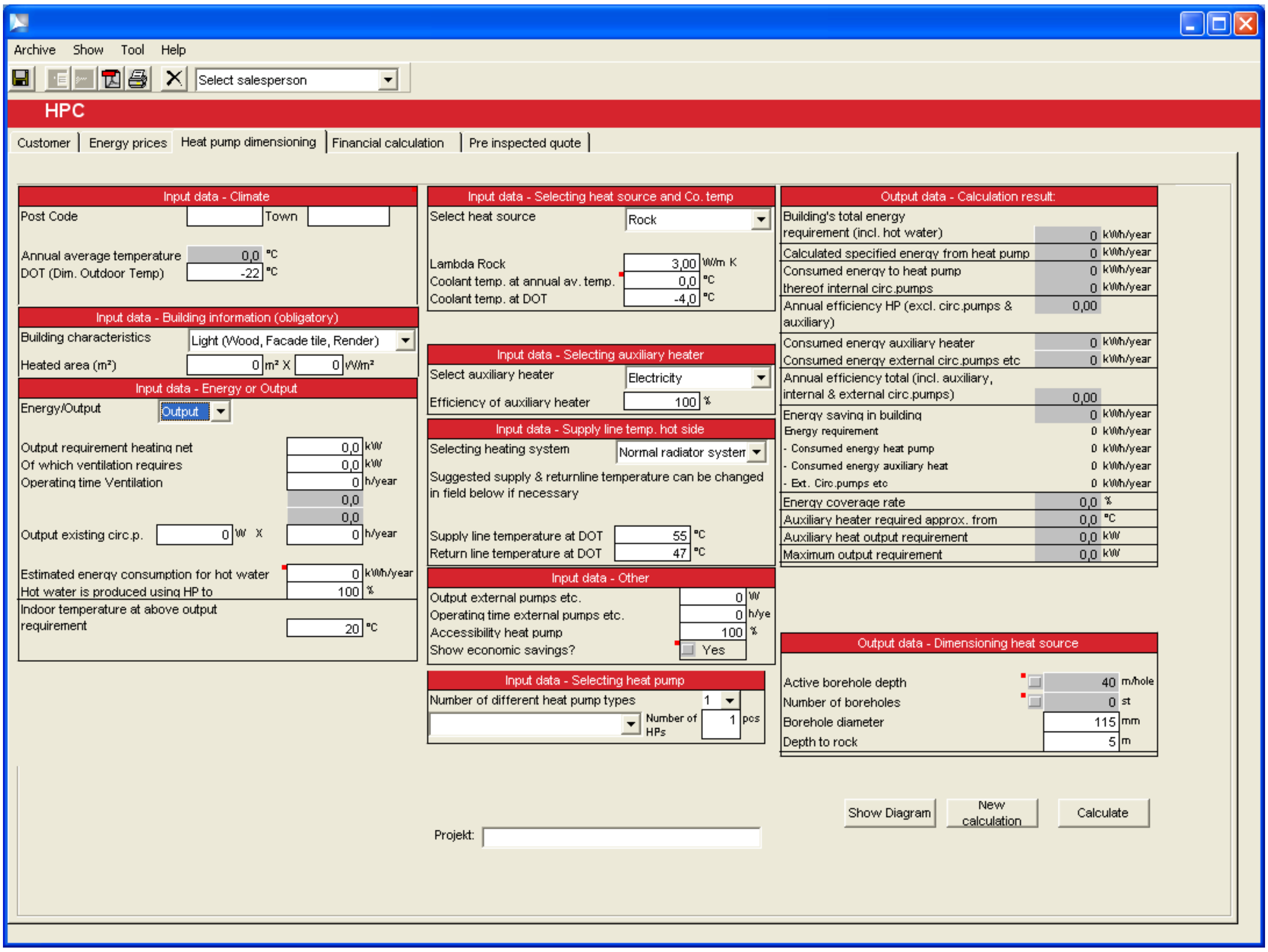
When you choose to perform a calculation based on the energy consumption, you enter the customer's previous annual energy consumption, excluding household electricity, as well as the efficiency for the energy source used. It can be electricity, oil or gas. You should consider the efficiency that should be used. A burner with low efficiency gives rise to larger heat losses from the house through the chimney, which means compensation should be made for the efficiency.

In the next field, you enter the estimated energy consumption for the hot water consumed. If the customer, after the installation of the heat pump, intends to increase or decrease their hot water consumption, this value can be changed. In which case, the net energy requirement used in the calculation will be increased or decreased accordingly. A few guideline values are; a normal family house consumes 4000-5000 kWh/year, while 1-10 flats in an apartment block consume 3500 kWh/year per flat. More than 10 flats in the same building consume 3000 kWh/year per flat.

Under this heading you also enter the current indoor temperature with the given energy consumption as well as the indoor temperature you want after the installation of the heating pump.

## Output

If you choose to perform the calculations based on output, the tab looks like this:



**Input data - Climate**

| | | |
|---|---|---|
| Post Code | | |
| Town | | |
| Annual average temperature | 0,0 | °C |
| DOT (Dim. Outdoor Temp) | -22 | °C |

**Input data - Building information (obligatory)**

Building characteristics: Light (Wood, Facade tile, Render)

Heated area (m²): 0 m² X 0 W/m²

**Input data - Energy or Output**

Energy/Output: Output

| | | |
|---|---|---|
| Output requirement heating net | 0,0 | kW |
| Of which ventilation requires | 0,0 | kW |
| Operating time Ventilation | 0 | h/year |
| | 0,0 | |
| | 0,0 | |
| Output existing circ.p. | 0 W X 0 | h/year |
| Estimated energy consumption for hot water | 0 | kWh/year |
| Hot water is produced using HP to | 100 | % |
| Indoor temperature at above output requirement | 20 | °C |

**Input data - Selecting heat source and Co. temp**

| | | |
|---|---|---|
| Select heat source | Rock | |
| Lambda Rock | 3,00 | W/m K |
| Coolant temp. at annual av. temp. | 0,0 | °C |
| Coolant temp. at DOT | -4,0 | °C |

**Input data - Selecting auxiliary heater**

| | | |
|---|---|---|
| Select auxiliary heater | Electricity | |
| Efficiency of auxiliary heater | 100 | % |

**Input data - Supply line temp. hot side**

Selecting heating system: Normal radiator systen

Suggested supply & returnline temperature can be changed in field below if necessary

| | | |
|---|---|---|
| Supply line temperature at DOT | 55 | °C |
| Return line temperature at DOT | 47 | °C |

**Input data - Other**

| | | |
|---|---|---|
| Output external pumps etc. | 0 | W |
| Operating time external pumps etc. | 0 | h/ye |
| Accessibility heat pump | 100 | % |
| Show economic savings? | ☐ Yes | |

**Input data - Selecting heat pump**

Number of different heat pump types: 1

Number of HPs: 1 pcs

Projekt:

**Output data - Calculation result:**

| | | |
|---|---|---|
| Building's total energy requirement (incl. hot water) | 0 | kWh/year |
| Calculated specified energy from heat pump | 0 | kWh/year |
| Consumed energy to heat pump | 0 | kWh/year |
| thereof internal circ.pumps | 0 | kWh/year |
| Annual efficiency HP (excl. circ.pumps & auxiliary) | 0,00 | |
| Consumed energy auxiliary heater | 0 | kWh/year |
| Consumed energy external circ.pumps etc | 0 | kWh/year |
| Annual efficiency total (incl. auxiliary, internal & external circ.pumps) | 0,00 | |
| Energy saving in building | 0 | kWh/year |
| Energy requirement | 0 | kWh/year |
| - Consumed energy heat pump | 0 | kWh/year |
| - Consumed energy auxiliary heat | 0 | kWh/year |
| - Ext. Circ.pumps etc | 0 | kWh/year |
| Energy coverage rate | 0,0 | % |
| Auxiliary heater required approx. from | 0,0 | °C |
| Auxiliary heat output requirement | 0,0 | kW |
| Maximum output requirement | 0,0 | kW |

**Output data - Dimensioning heat source**

| | | |
|---|---|---|
| Active borehole depth | ☐ 40 | m/hole |
| Number of boreholes | ☐ 0 | st |
| Borehole diameter | 115 | mm |
| Depth to rock | 5 | m |

You first enter the net output need to heat one m$^2$ of your building.

Also enter here how much of the output is required by the ventilation, as well as the operating time per year for the ventilation. It is important to take into consideration the output required by the ventilation when dimensioning the heat pump, otherwise there is a risk you will choose too small a pump. The normal operating time for extract ventilation in a single-family house is 8760 h/year.

A rule of thumb for calculating the output requirement for the ventilation is:

$$P = 1.2 \times q_L \times \Delta T$$

Where 1.2 is a constant for the specific thermal capacity of air, units W/(l/s x K).

$q_L$ = airflow, units l/s

ΔT = the difference between the indoor temperature and the supply air temperature

In the next field, "Output existing circ. p.", you enter the operating output for the existing circulation pump and the number of hours per year (Example: 100W x 8760 h/year).

You also enter the estimated energy consumption for the hot water. A normal family house consumes ca 4000-5000 kWh/year, while 1-10 flats in an apartment block consume ca 3500 kWh/year per flat. If there are more than 10 flats in the building, the consumption is ca 3000 kWh/year per flat. Enter the share of the hot water that will be produced by the heat pump (100% if no other heat source is used for this purpose). Also enter the indoor temperature the customer has at the given output requirement.

### 5.4.4 Input data – Selecting heat source and Co. temp

Under this heading you choose the heat source you want to use as well as the coolant temperature. The coolant temperature appears automatically, based on the heat source you choose, and refers to the temperature in the coolant circuit from the heat source at DOT. The coolant temperature can be changed manually in those cases where you know that the value at the location differs somewhat from the value specified for the region in question. Other parameters under this heading vary, depending on the heat source you choose. In those cases where exhaust air is used, the system asks for the output this provides. If the Vent system is used, you can find this information in the energy transfer diagram in the Installation and Maintenance Instructions for the Vent system. In other cases, you can obtain this information from the HVAC consultant who was responsible for the new construction. Note that the output requirement for ventilation losses has to be included in this figure.

You can choose between the following heat sources:

- **Rock**

  If you choose this alternative, a default value of Lambda for the rock is shown, that is to say the rock's capacity to transport energy (heat transfer coefficient). This value can be changed. Other parameters here are the coolant temperature at annual average temperature and at DOT. These appear automatically, but they can be changed.

- **Rock + exhaust air**

  Apart from the parameters for rock, you also enter the output you obtain from the exhaust air here as well as the number of hours per year the ventilation is in use. To carry out the dimensioning correctly, in a case where exhaust air is used as an auxiliary heat source, do as follows:

  1. First, perform a dimensioning with only "Rock" as the heat source. This is to calculate the borehole depth required. Make a note of these figures.
  2. Now change the heat source to "Rock + Exhaust Air".
  3. Add the values for "Output from exhaust air" and "Operating time ventilation".
  4. Tick the box to the left of the parameter "Active borehole depth" to make this field editable
  5. Enter the borehole depth you calculated in step 1.

- **Ground**

  Coolant temperature at annual average temperature and at DOT. These appear automatically, but they can be changed.

- **Ground + exhaust air**

  Apart from the parameters for ground, you also enter the output you obtain from the exhaust air as well as the number of hours per year the ventilation is in use. To carry out the dimensioning correctly, in a case where exhaust air is used as an auxiliary heat source, do as follows:

  1. First, perform a dimensioning with only "Ground" as the heat source. This is to calculate the collector length required. Make a note of these figures.
  2. Now change the heat source to "Ground + Exhaust Air".
  3. Add the values for "Output from exhaust air" and "Operating time ventilation".
  4. Tick the box to the left of the parameter "Hose length" to make this field editable
  5. Enter the collector length you calculated in step 1.

- **Water**

  Coolant temperature at annual average temperature and at DOT. These appear automatically, but they can be changed.

- **Ground water**

  Coolant temperature at annual average temperature and at DOT. These appear automatically, but they can be changed.

- **Exhaust air**

  Coolant temperature at annual average temperature and at DOT. These appear automatically, but they can be changed.
  Output from exhaust air.

- **Outdoor air**

  No other parameters.

- **Outdoor air + exhaust air**

  The output from the exhaust air as well as the number of hours per year the ventilation is in use.

### 5.4.5 Input data – selecting auxiliary heater

For auxiliary energy, you choose from the following

- Electricity
- District heating
- Oil
- Gas

You also enter here the efficiency for this energy source.

### 5.4.6 Input data – Supply line temp. hot side

For type of heating system, you choose from the following:

- Under floor heating in concrete
- Under floor heating in wood
- Normal radiator system

Depending on the heating system chosen, the values for the supply/return line temperature at DOT are changed. Can be changed manually.

### 5.4.7 Input data - Other

Here you enter output and operating time for energy-intensive components that are located outside the heat pump. These may be, for example, all types of external circulation pumps or exhaust air units. If you tick for the economic savings to be shown, this info is added at the end of the calculation result under the heading Output data. If you select this alternative, remember to enter the correct prices from the tab "Financial calculation".

### 5.4.8 Input data – Selecting heat pump

Here you choose whether you want one or two different types of heat pump as well as how many pumps of each type. Here you can experiment with various models, in order to compare the calculation results. It is important when you are assessing which model is suitable that the degree of energy coverage is in the right interval. For household pumps, the degree of energy coverage should lie between 95-99%, while the value for a pump in larger properties should be circa 90%.

### 5.4.9 Output data - calculation result

Here are presented the results of the calculation, based on the input data you entered. Depending on the choice of heat source, in some cases output data for dimensioning the heat source are appended after the calculation result. For the heat sources below, the following is added to the output data:

- **Rock and Rock + exhaust air**

  *Active borehole depth*. Depending on the input data, the active borehole depth required to satisfy the energy requirement is calculated. In those cases where an existing borehole is to be used, you can click in the box next to this parameter and enter the active borehole depth. The program now calculates the brine temperatures in the hole based on the selected heat pump. If the brine temperature is too low, you have to change to a smaller heat pump.

  *Number of boreholes*. Click in the box to edit the field. Where there is to be more than one borehole, two further fields are displayed, in which you enter the borehole separation and the borehole layout.

  *Borehole diameter*. Here you enter the diameter the borehole will have.

  *Depth to rock*. Here you enter the estimated value for the depth down to the rock, in metres below the ground.

- **Ground and ground + exhaust air**

  *Is there information about accessible area?* If this information is available, deselect the "No" box. When you do this the field "Ground area" further down becomes editable.

  *Centre distance*. Here you enter the minimum distance allowed between each coil. The coils must not lie closer than 1 m from each other, otherwise there is a risk for them freezing and breaking.

*Ground type*. Here you can choose from other natural soil (not fill), marshy ground of fen and moss type, and gravel or sand.

*Ground area*. This field is filled in automatically during calculation, but it is editable if you deselect the No box for information on the available area, see above.

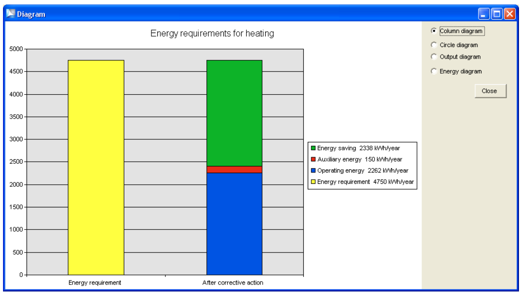
*Minimum laying depth*. The minimum depth for laying the coil in the ground is entered here.

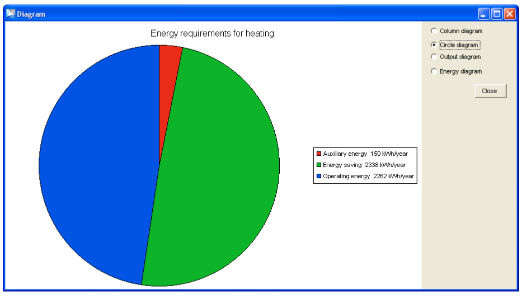
*Hose length*. Here the length of hose required is entered automatically. It can be edited, if you click in the box. The length of the hose is linked to the coolant temperature required, therefore only one of these fields is editable while the other is calculated depending on the value of the first. However, both fields can be edited alternately, if you want to experiment with the figures.

- **Water**

  *Collector length*. Here the length of hose that collects the heat from the lake water is entered. The longer the hose the more heat is collected. This length is filled in automatically, but it can be edited if you click of the box to the side. The length of the hose is linked to the coolant temperature required, therefore only one of these fields is editable while the other is calculated depending on the value of the first. However, both fields can be edited alternately, if you want to experiment with the figures.

When you have entered all the data, you can click on the button "Show Diagram", under the output field on the left. You then see an overview of the calculated result as a diagram. You can choose whether you want to see the overview as a column diagram or a circle diagram as well as whether you want to see an output diagram or an energy diagram.





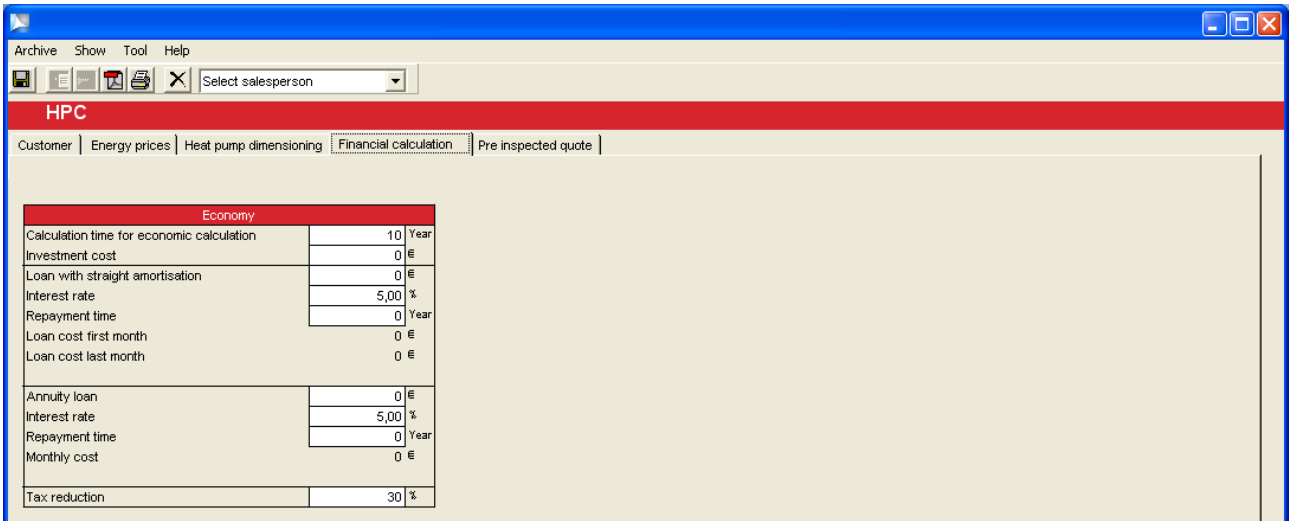
If you click on the button "New calculation", all the data is zeroed and you return to the customer tab.

To keep together several heat pump dimensionings, a project name can be entered. This is shown on the quotes.

The calculations are performed as the data is entered and updated when you change from one field to another or click on the "Calculate" button.

## 5.5 Financial calculation

From this tab, you perform a calculation for how the customer can finance his or her investment. When you enter the customer's values, the system calculates how high the borrowing cost will be for a loan with straight amortisation, for the number of repayments you have chosen, for the first and last month. If the customer chooses an annuity loan, you can see the monthly cost he/she will have here. It is possible to combine straight loan and annuity loan, if so desired. Note, you cannot show calculations for straight amortisation and annuity loan in the same calculation.

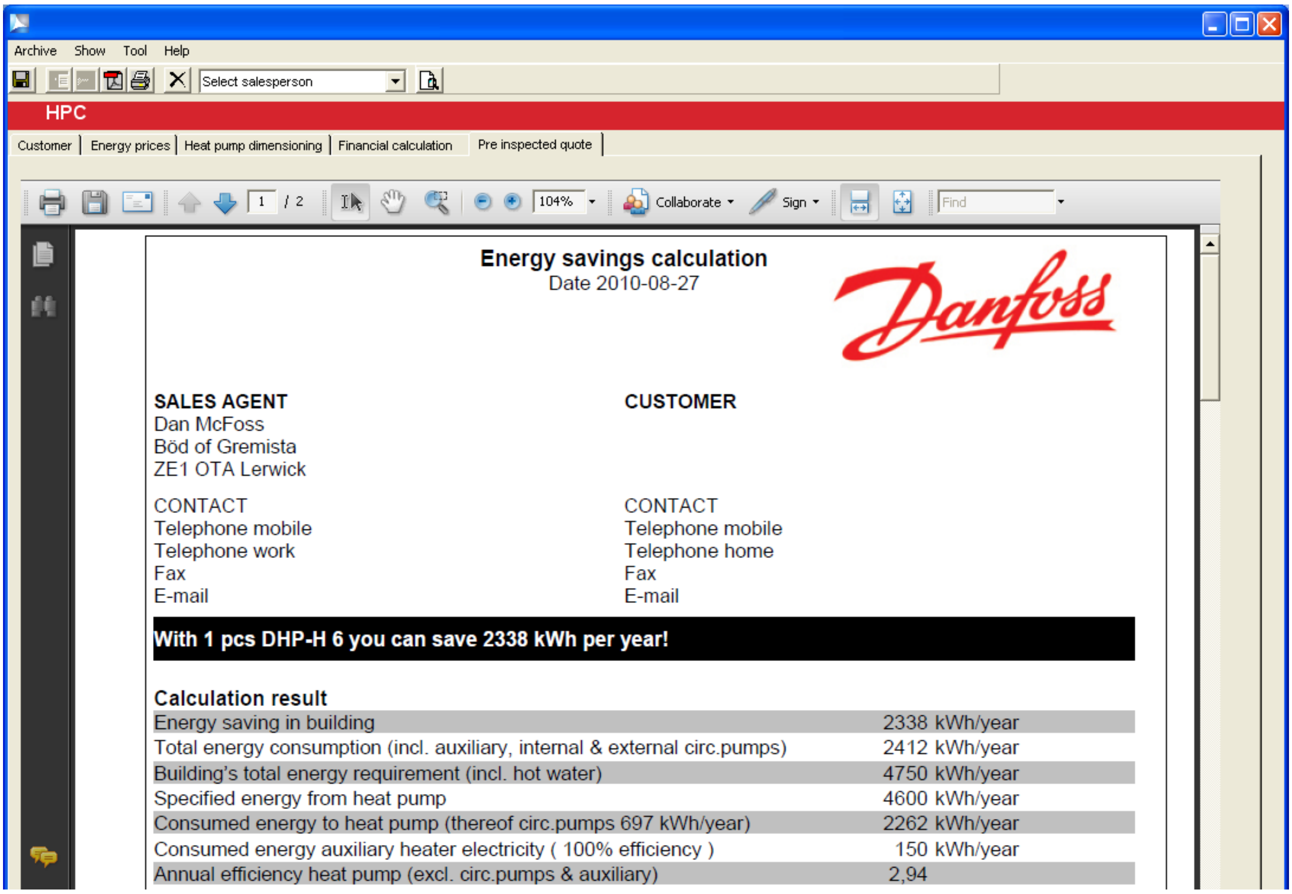


| Economy | | |
|---|---|---|
| Calculation time for economic calculation | 10 | Year |
| Investment cost | 0 | € |
| Loan with straight amortisation | 0 | € |
| Interest rate | 5,00 | % |
| Repayment time | 0 | Year |
| Loan cost first month | 0 | € |
| Loan cost last month | 0 | € |
| Annuity loan | 0 | € |
| Interest rate | 5,00 | % |
| Repayment time | 0 | Year |
| Monthly cost | 0 | € |
| Tax reduction | 30 | % |

## 5.6 Pre inspected quote

### 5.6.1 See the quote

When you click on this tab you can see how your quote will look. The calculation is in the PDF format and has the same functionality as Adobe Reader. You can print, save the file or send it via e-mail.



**Energy savings calculation**
Date 2010-08-27

**SALES AGENT**
Dan McFoss
Böd of Gremista
ZE1 OTA Lerwick

CONTACT
Telephone mobile
Telephone work
Fax
E-mail

**CUSTOMER**

CONTACT
Telephone mobile
Telephone home
Fax
E-mail

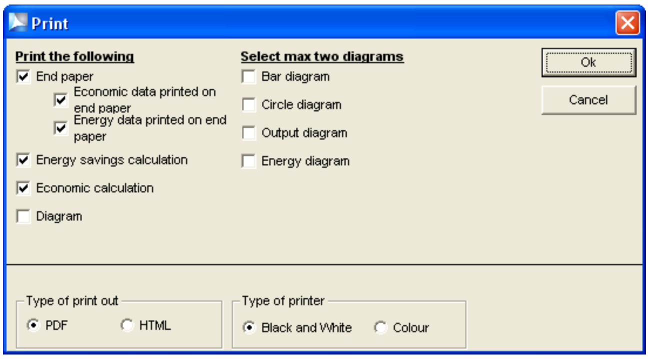
**With 1 pcs DHP-H 6 you can save 2338 kWh per year!**

**Calculation result**

| | |
|---|---|
| Energy saving in building | 2338 kWh/year |
| Total energy consumption (incl. auxiliary, internal & external circ.pumps) | 2412 kWh/year |
| Building's total energy requirement (incl. hot water) | 4750 kWh/year |
| Specified energy from heat pump | 4600 kWh/year |
| Consumed energy to heat pump (thereof circ.pumps 697 kWh/year) | 2262 kWh/year |
| Consumed energy auxiliary heater electricity ( 100% efficiency ) | 150 kWh/year |
| Annual efficiency heat pump (excl. circ.pumps & auxiliary) | 2,94 |

### 5.6.2 Print the quote

To print the quote click on the printer icon. The following box then appears:



**Print the following**
- ☑ End paper
  - ☑ Economic data printed on end paper
  - ☑ Energy data printed on end paper
- ☑ Energy savings calculation
- ☑ Economic calculation
- ☐ Diagram

**Select max two diagrams**
- ☐ Bar diagram
- ☐ Circle diagram
- ☐ Output diagram
- ☐ Energy diagram

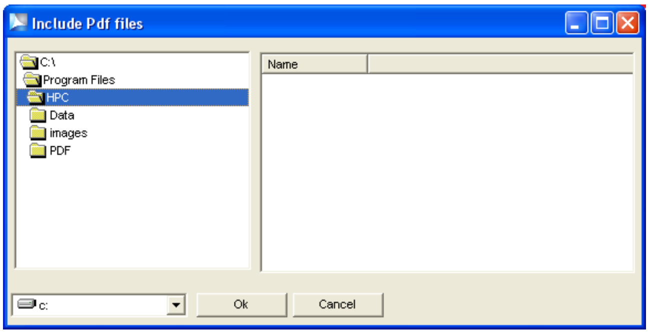
Type of print out: ● PDF ○ HTML

Type of printer: ● Black and White ○ Colour

You can choose what you want to include on your printout. You can choose to print in PDF format or HTML, black and white or colour.

### 5.6.3 Include Pdf files

You can easily include, for example, product sheets in PDF format by using the import function. You do this by clicking on the icon "Add Pdf files to the print". The following box then appears:



Here you choose the file or files you want to include in the quote and the click on OK.

# 6. Example of dimensioning

## 6.1 Assumptions

A new customer wants to install geothermal heating in his/her existing house. The customer wants, with the lowest possible installation costs, to use the rock as the energy source. The plan is to install a Jacuzzi in the house.

Customer

Carry Grant

Albert Building

ZE1 A11 Lerwick

Building data:

Timber house with cellar 150 m$^2$

Built 1948

Existing waterborne radiator system

Electric boiler with inbuilt hot water heater

Current electricity consumption 35,000 kWh/year, whereof 5000 kWh for the hot water

Historic indoor temperature: 20 °C

Desired indoor temperature: 20 °C

Financing plan:

Investment cost to be financed by a bank loan

2/3 of the investment cost to be paid by straight amortisation

1/3 as an annuity loan

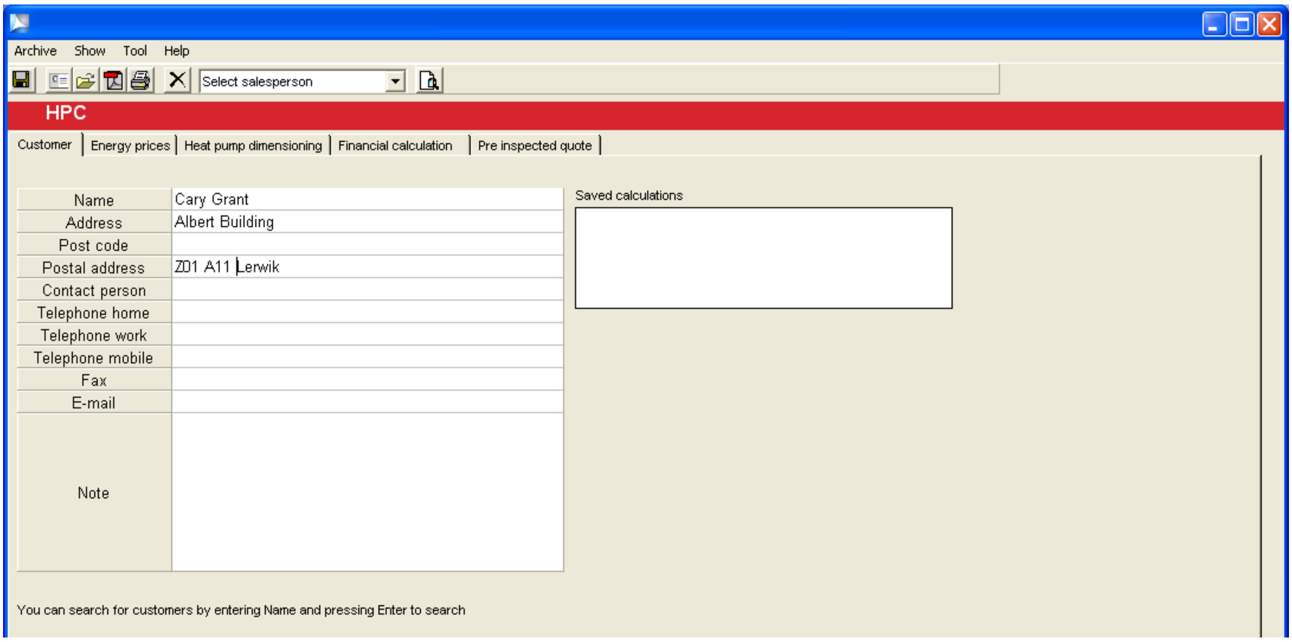
Both loans to be repaid after 20 years

5% bank interest rate

Calculation time 10 years

## 6.2 Customer

Login to HPC and go to the "Customer" tab. Enter the customer information.



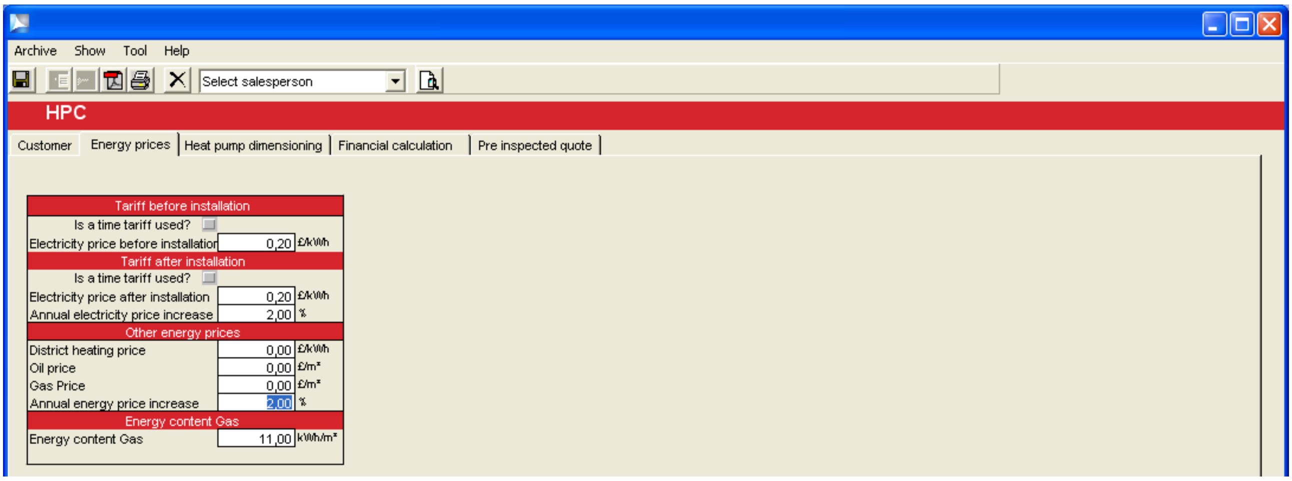
| | |
|---|---|
| Name | Cary Grant |
| Address | Albert Building |
| Post code | |
| Postal address | Z01 A11 Lerwik |
| Contact person | |
| Telephone home | |
| Telephone work | |
| Telephone mobile | |
| Fax | |
| E-mail | |
| Note | |

Saved calculations

You can search for customers by entering Name and pressing Enter to search

## 6.3 Energy prices

Go to the "Energy prices" tab. The customer has an agreement with his/her electricity supplier that results in an electricity price of 0.20 £/kWh. The supplier in question reckons on an annual energy price rise of 2%. Enter these details as in the image below.



| | | |
|---|---|---|
| **Tariff before installation** | | |
| Is a time tariff used? ☐ | | |
| Electricity price before installation | 0,20 | £/kWh |
| **Tariff after installation** | | |
| Is a time tariff used? ☐ | | |
| Electricity price after installation | 0,20 | £/kWh |
| Annual electricity price increase | 2,00 | % |
| **Other energy prices** | | |
| District heating price | 0,00 | £/kWh |
| Oil price | 0,00 | £/m$^3$ |
| Gas Price | 0,00 | £/m$^3$ |
| Annual energy price increase | 2,00 | % |
| **Energy content Gas** | | |
| Energy content Gas | 11,00 | kWh/m$^3$ |

## 6.4 Heat pump dimensioning

Go to the "Heat pump dimensioning" tab.

### 6.4.1 Address details

Enter the location and the annual average temperature and DOT is automatically fetched from the Meteonorm database.

### 6.4.2 Input data – Building information (obligatory)

Enter that it a timber house with cellar, built 1948, of 150 m$^2$..

### 6.4.3 Input data – Energy or Output

Since it is an older house with an existing heating system, you choose to perform the calculation in this case based on energy.

1. Previous electrical energy consumption excl. household electricity: 30000 kWh/year The efficiency is filled in automatically with a standard value (95%) and assumes a certain energy loss. Change this to 100%.
   The house does not use oil or gas, so hop over these fields.
2. Estimated energy consumption for the hot water consumed based on the above energy consumption: 5000 kWh/year

3. Will the hot water consumption increase/decrease after the heat pump has been installed? New energy consumption: 6000 kWh/year. Since a Jacuzzi is to be installed, the hot water consumption is estimated to increase by 20%.
4. Hot water is produced using HP to: 100% (default value, do not change it in this case).
5. Indoor temperature at above energy consumption: 20 °C.
6. Desired indoor temperature after installation of heat pump: 20 °C.

### 6.4.4 Input data – Selecting heat source and Co. temp

As heat source, you choose rock. Check the local conditions and enter "Lambda for rock", "Coolant temperature at annual average temperature" and "DOT".

### 6.4.5 Input data – selecting auxiliary heater

As auxiliary energy, you choose electricity, since the heat pump has an inbuilt immersion heater that is used as an auxiliary heater. Efficiency is thus 100 & and it is filled in by the system.

### 6.4.6 Input data – Supply line temp. hot side

Type of heating system is "Normal radiator system". The supply and return temperature at DOT have the default values and they are filled in by the system.

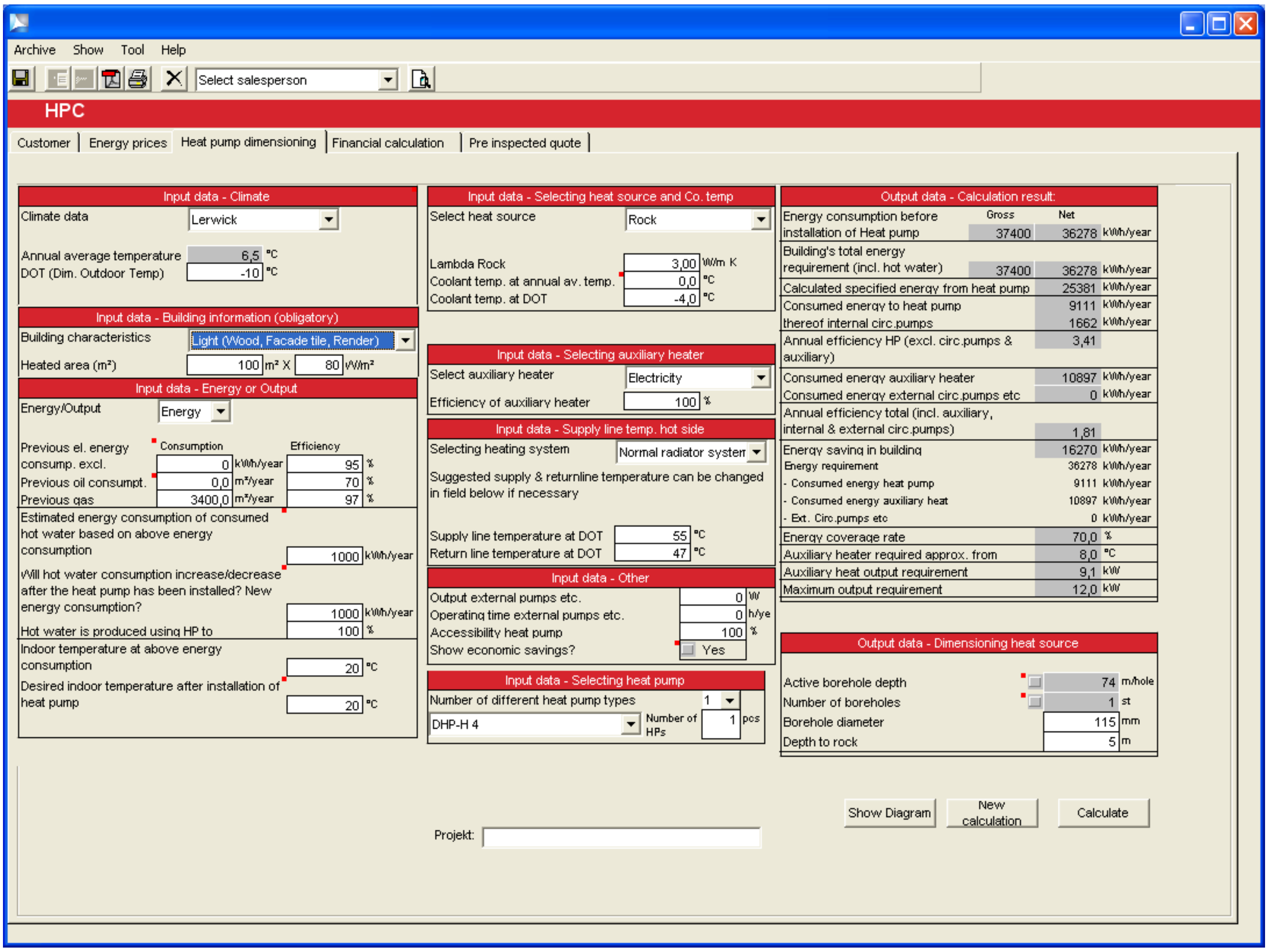
### 6.4.7 Input data - Other

The availability of the heat pump is 100%. Also, select for the economic savings to be shown, we will then see this in this example.

### 6.4.8 Input data – Selecting heat pump

Under the number of different heat pump types, you enter 1. The alternative with several different ones is mainly used for larger properties, for example apartment buildings and industrial properties.

In the dropdown menu, you choose the model of rock heat pump. With a DHP-H 4, the degree of energy coverage will be 70%, which falls in the interval suitable for houses. Number of heat pumps for this house is 1.



**Input data - Climate**

| | | |
|---|---|---|
| Climate data | Lerwick | |
| Annual average temperature | 6,5 | °C |
| DOT (Dim. Outdoor Temp) | -10 | °C |

**Input data - Building information (obligatory)**

| | | | | |
|---|---|---|---|---|
| Building characteristics | Light (Wood, Facade tile, Render) | | | |
| Heated area (m²) | 100 | m² X | 80 | W/m² |

**Input data - Energy or Output**

Energy/Output: Energy

| | Consumption | | Efficiency | |
|---|---|---|---|---|
| Previous el. energy consump. excl. | 0 | kWh/year | 95 | % |
| Previous oil consumpt. | 0,0 | m³/year | 70 | % |
| Previous gas | 3400,0 | m³/year | 97 | % |

| | | |
|---|---|---|
| Estimated energy consumption of consumed hot water based on above energy consumption | 1000 | kWh/year |
| Will hot water consumption increase/decrease after the heat pump has been installed? New energy consumption? | 1000 | kWh/year |
| Hot water is produced using HP to | 100 | % |
| Indoor temperature at above energy consumption | 20 | °C |
| Desired indoor temperature after installation of heat pump | 20 | °C |

**Input data - Selecting heat source and Co. temp**

| | | |
|---|---|---|
| Select heat source | Rock | |
| Lambda Rock | 3,00 | W/m K |
| Coolant temp. at annual av. temp. | 0,0 | °C |
| Coolant temp. at DOT | -4,0 | °C |

**Input data - Selecting auxiliary heater**

| | | |
|---|---|---|
| Select auxiliary heater | Electricity | |
| Efficiency of auxiliary heater | 100 | % |

**Input data - Supply line temp. hot side**

Selecting heating system: Normal radiator systen

Suggested supply & returnline temperature can be changed in field below if necessary

| | | |
|---|---|---|
| Supply line temperature at DOT | 55 | °C |
| Return line temperature at DOT | 47 | °C |

**Input data - Other**

| | | |
|---|---|---|
| Output external pumps etc. | 0 | W |
| Operating time external pumps etc. | 0 | h/ye |
| Accessibility heat pump | 100 | % |
| Show economic savings? | ☐ Yes | |

**Input data - Selecting heat pump**

Number of different heat pump types: 1

DHP-H 4 Number of HPs: 1 pcs

**Output data - Calculation result:**

| | Gross | Net | |
|---|---|---|---|
| Energy consumption before installation of Heat pump | 37400 | 36278 | kWh/year |
| Building's total energy requirement (incl. hot water) | 37400 | 36278 | kWh/year |
| Calculated specified energy from heat pump | | 25381 | kWh/year |
| Consumed energy to heat pump | | 9111 | kWh/year |
| thereof internal circ.pumps | | 1662 | kWh/year |
| Annual efficiency HP (excl. circ.pumps & auxiliary) | | 3,41 | |
| Consumed energy auxiliary heater | | 10897 | kWh/year |
| Consumed energy external circ.pumps etc | | 0 | kWh/year |
| Annual efficiency total (incl. auxiliary, internal & external circ.pumps) | | 1,81 | |
| Energy saving in building | | 16270 | kWh/year |
| Energy requirement | | 36278 | kWh/year |
| - Consumed energy heat pump | | 9111 | kWh/year |
| - Consumed energy auxiliary heat | | 10897 | kWh/year |
| - Ext. Circ.pumps etc | | 0 | kWh/year |
| Energy coverage rate | | 70,0 | % |
| Auxiliary heater required approx. from | | 8,0 | °C |
| Auxiliary heat output requirement | | 9,1 | kW |
| Maximum output requirement | | 12,0 | kW |

**Output data - Dimensioning heat source**

| | | |
|---|---|---|
| Active borehole depth | ☐ 74 | m/hole |
| Number of boreholes | ☐ 1 | st |
| Borehole diameter | 115 | mm |
| Depth to rock | 5 | m |

Projekt:

### 6.4.9 Output data - Calculation result

The calculation result is now displayed, under this heading, for the data you have entered, see the image below. With the figures we have used in the example, the economic savings are xxx £/year. If you scroll down the image, you can see that the energy cost before the heat pump is installed was xxx £/year and the corresponding cost after installing the heat pump will be xxx £/year.

Choose "Archive ->, "Save" to save your dimensioning for the customer in question. A box then appears in which you enter a name for your dimensioning.

# 7. Example of financial calculation

## 7.1 Assumptions

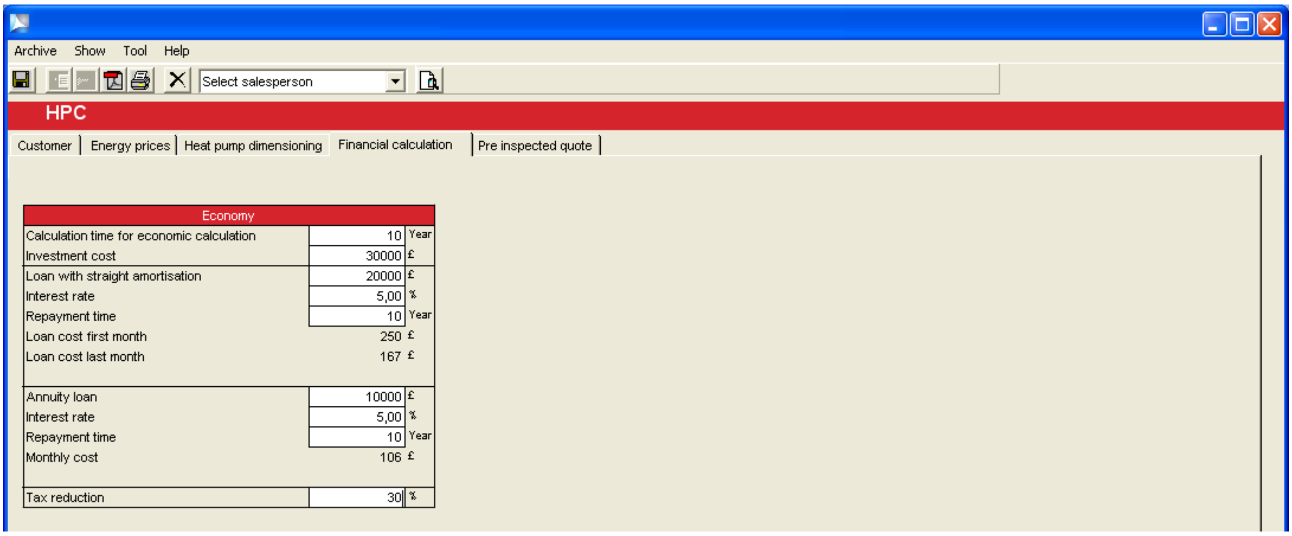
We will perform a financing calculation based on the previous example.

## 7.2 Customer

Go to the "Customer" tab. Enter the customer's name and press Enter. Double-click on the calculation you saved.

## 7.3 Financial calculation

Go to the "Financial calculation" tab. Here you can choose to divide the financing up into different types of loan, for example as follows:



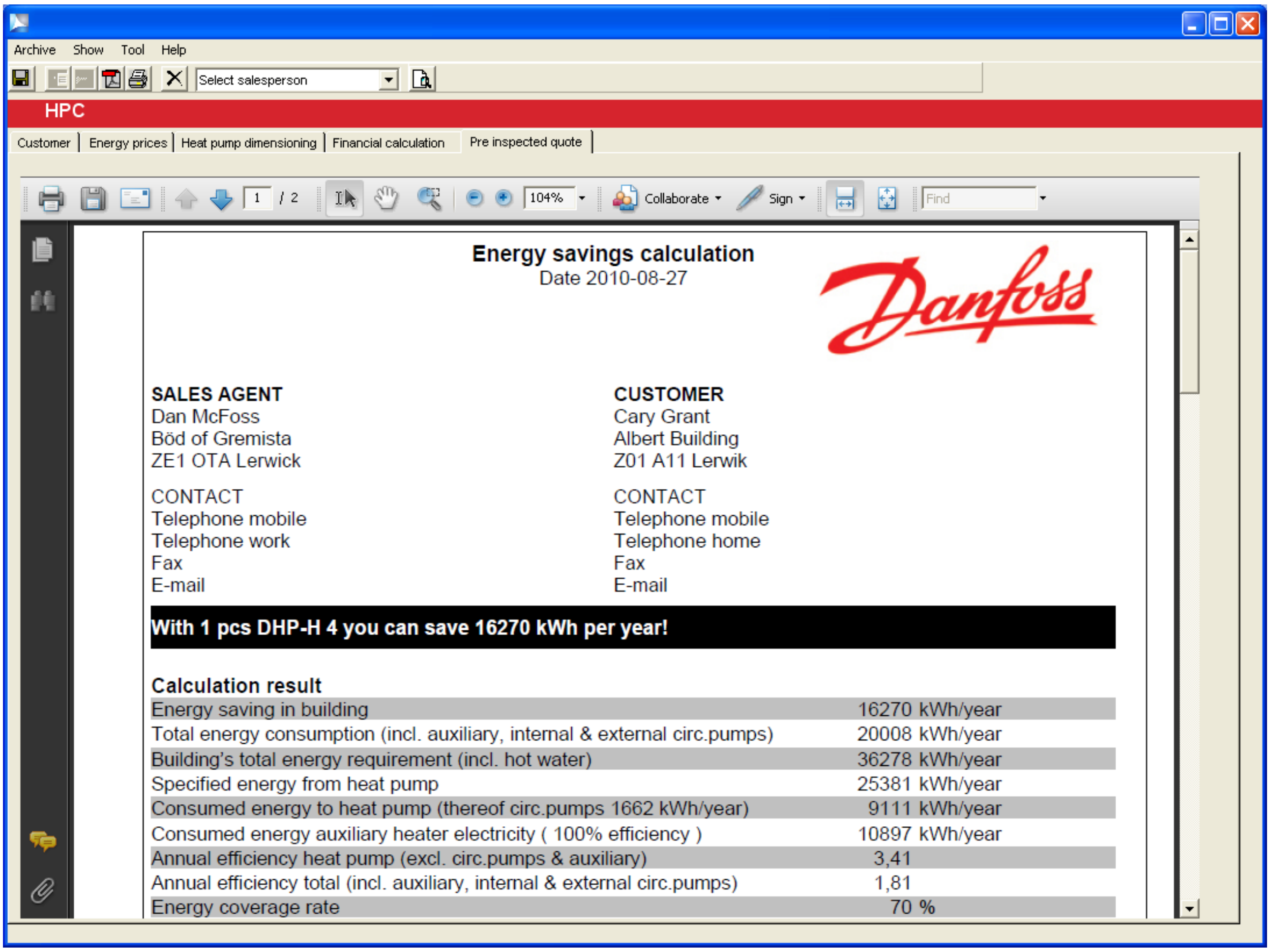
| Economy | | |
|---|---|---|
| Calculation time for economic calculation | 10 | Year |
| Investment cost | 30000 | £ |
| Loan with straight amortisation | 20000 | £ |
| Interest rate | 5,00 | % |
| Repayment time | 10 | Year |
| Loan cost first month | 250 | £ |
| Loan cost last month | 167 | £ |
| Annuity loan | 10000 | £ |
| Interest rate | 5,00 | % |
| Repayment time | 10 | Year |
| Monthly cost | 106 | £ |
| Tax reduction | 30 | % |

# 8. Pre inspected quote

## 8.1 Assumptions

Go to the "Customer" tab. Enter the customer's name and press Enter. Double-click on the saved calculation in the box on the right.

Go to the next tab, "Pre inspected quote". Here you can see how your quote will look:



**Energy savings calculation**
Date 2010-08-27

**SALES AGENT**
Dan McFoss
Böd of Gremista
ZE1 OTA Lerwick

CONTACT
Telephone mobile
Telephone work
Fax
E-mail

**CUSTOMER**
Cary Grant
Albert Building
Z01 A11 Lerwik

CONTACT
Telephone mobile
Telephone home
Fax
E-mail

**With 1 pcs DHP-H 4 you can save 16270 kWh per year!**

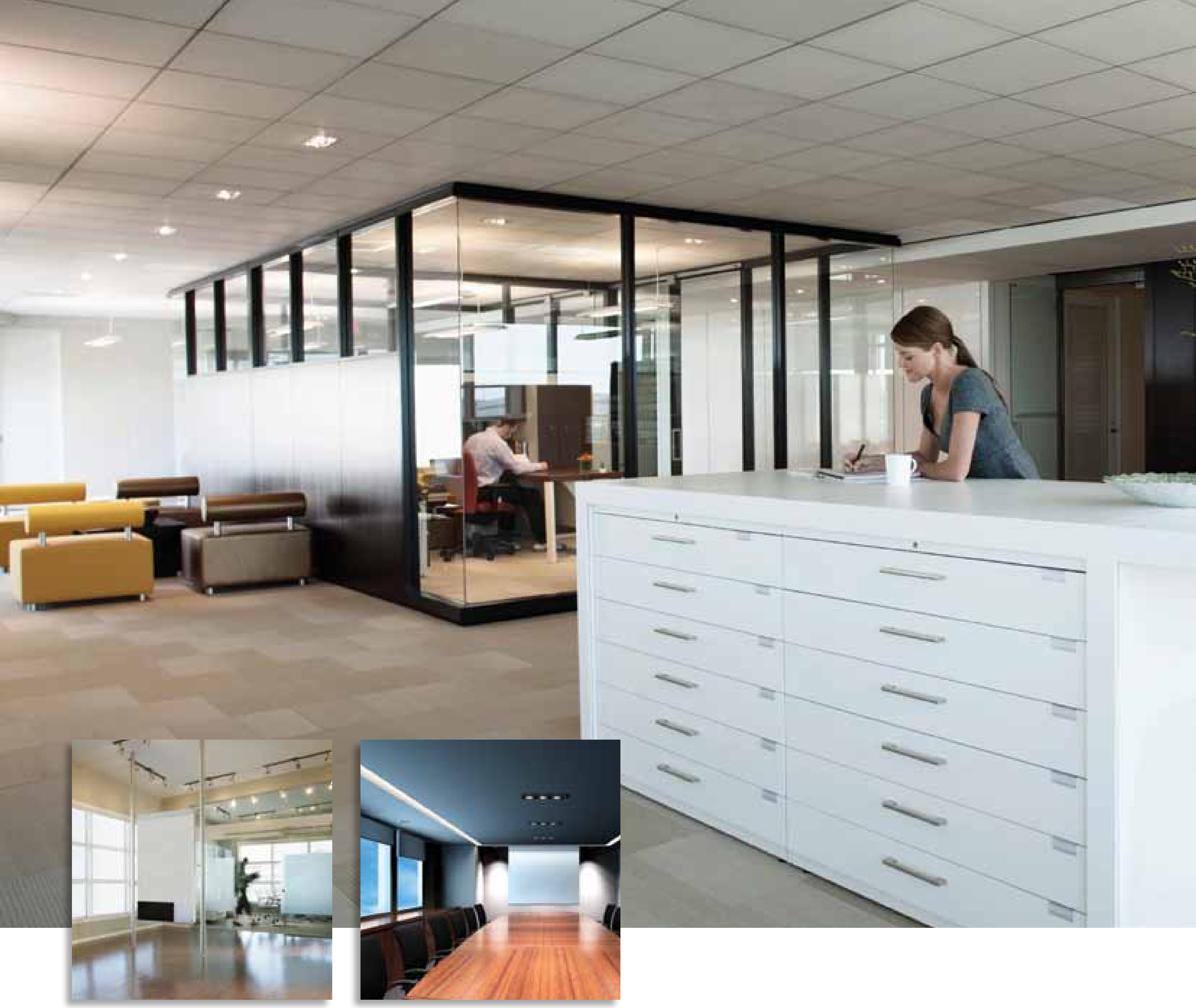
**Calculation result**

| | |
|---|---|
| Energy saving in building | 16270 kWh/year |
| Total energy consumption (incl. auxiliary, internal & external circ.pumps) | 20008 kWh/year |
| Building's total energy requirement (incl. hot water) | 36278 kWh/year |
| Specified energy from heat pump | 25381 kWh/year |
| Consumed energy to heat pump (thereof circ.pumps 1662 kWh/year) | 9111 kWh/year |
| Consumed energy auxiliary heater electricity ( 100% efficiency ) | 10897 kWh/year |
| Annual efficiency heat pump (excl. circ.pumps & auxiliary) | 3,41 |
| Annual efficiency total (incl. auxiliary, internal & external circ.pumps) | 1,81 |
| Energy coverage rate | 70 % |

## 9. Troubleshooting

If any operating problems should occur, please take the following steps when reporting errors, so we can provide you with faster support:

1. Take a screen dump (Print Screen) showing the relevant error message
2. Paste the screen dump into an E-mail message
3. Include the following information in the E-mail message:
   a) Name of the user and telephone number and E-mail address
   b) Information about the local computer:
      - Internal in the Danfoss network or external?
      - Type of Windows: XP? Vista? Other?
   c) Short description of the problem
4. Send the E-mail message to: support@thermia.se



# DALI lighting control solutions

Creating a new benchmark for energy savings, occupancy comfort and flexibility.

sense and simplicity

# The DALI system – helping you to create an

Where once the 'green office' was something of a buzz word, the passing of new government legislation now demands that all building owners and landlords demonstrate the energy efficiency rating of their building.

The revolutionary DALI lighting control system delivers unparalleled performance, easy installation and maintenance, maximum control and flexibility and increased energy savings, making it one of the easiest ways for building managers and owners to achieve higher energy efficiency ratings.

DALI provides simplified communication and installation, yet maximum control and flexibility. Wiring is simpler. Installation costs are lower.

What's more, it allows architects and designers to create high-performance lighting that is perfectly matched to the needs of the building's occupants.

> “DALI provides simplified installation and communication, yet maximum control and flexibility. Wiring is simpler. Installation costs are lower.”

# intelligent office

## Optimizing energy savings

Simple to install and commission, a DALI lighting control system can monitor and control lighting within a commercial office environment, which significantly reduces the use of energy. Energy costs are lowered through daylight harvesting and standard controls such as dimming and occupancy sensors.

Rather than depend on staff to turn off the lighting, the intuitive DALI system does it for you.

The system also allows facility managers and building owners to receive status reports so they can monitor energy savings and adjust lighting where necessary.

An intuitive DALI system also delivers lower maintenance costs.

## A comfortable work environment

Savings in energy bills aside, the more effective the lighting control in an office, the more comfortable it is for the occupants. The DALI lighting control system allows lighting to be customized to each work environment and gives occupants control of their own lighting. The continuous automatic adjustment of lighting in response to changing ambient light levels provides occupants with a constant light level. More comfortable lighting helps to enhance workplace productivity and efficiency.

## Compatibility and interchangeability

DALI was designed by leading lighting manufacturers to offer a standard to the lighting market that complies with all requirements and solves complex lighting tasks in a simple and cost-effective manner.

DALI allows interchangeability of different manufacturers' devices and controls to create a lighting system. This includes ballasts, control systems, sensors, controllers, switches and emergency and exit signs.

## Lighting flexibility

With DALI, design and user flexibility is dramatically improved over conventional, proprietary systems.

A DALI control lighting system can be scaled from a single room to a complete commercial office building. Each ballast can be individually controlled as well as belong to any or all of 16 different groups.

When building occupancy needs change, the DALI system can easily be reconfigured without the need for complex and costly rewiring.

## A green office for the future

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DALI is an industry standard protocol that allows DALI-compliant components from different manufacturers to be mixed and matched together seamlessly into complete systems.

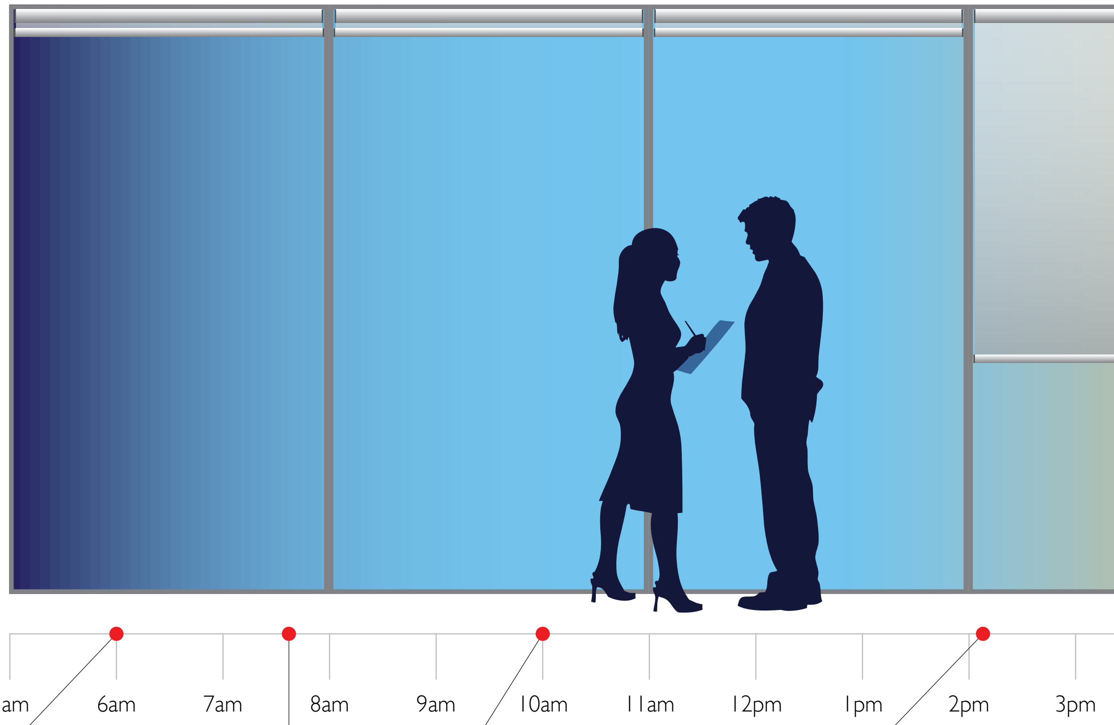
The DALI standard, specified in IEC standard 60929, is one of the world's preferred standards.

DALI

# The daily cycle of lighting within a typical office

The energy requirements throughout a 24-hour cycle in an office environment vary.

Coordinating the different services within a Philips lighting control system allows an automated event-based strategy, which maximizes energy efficiency and creates a comfortable and productive work environment.



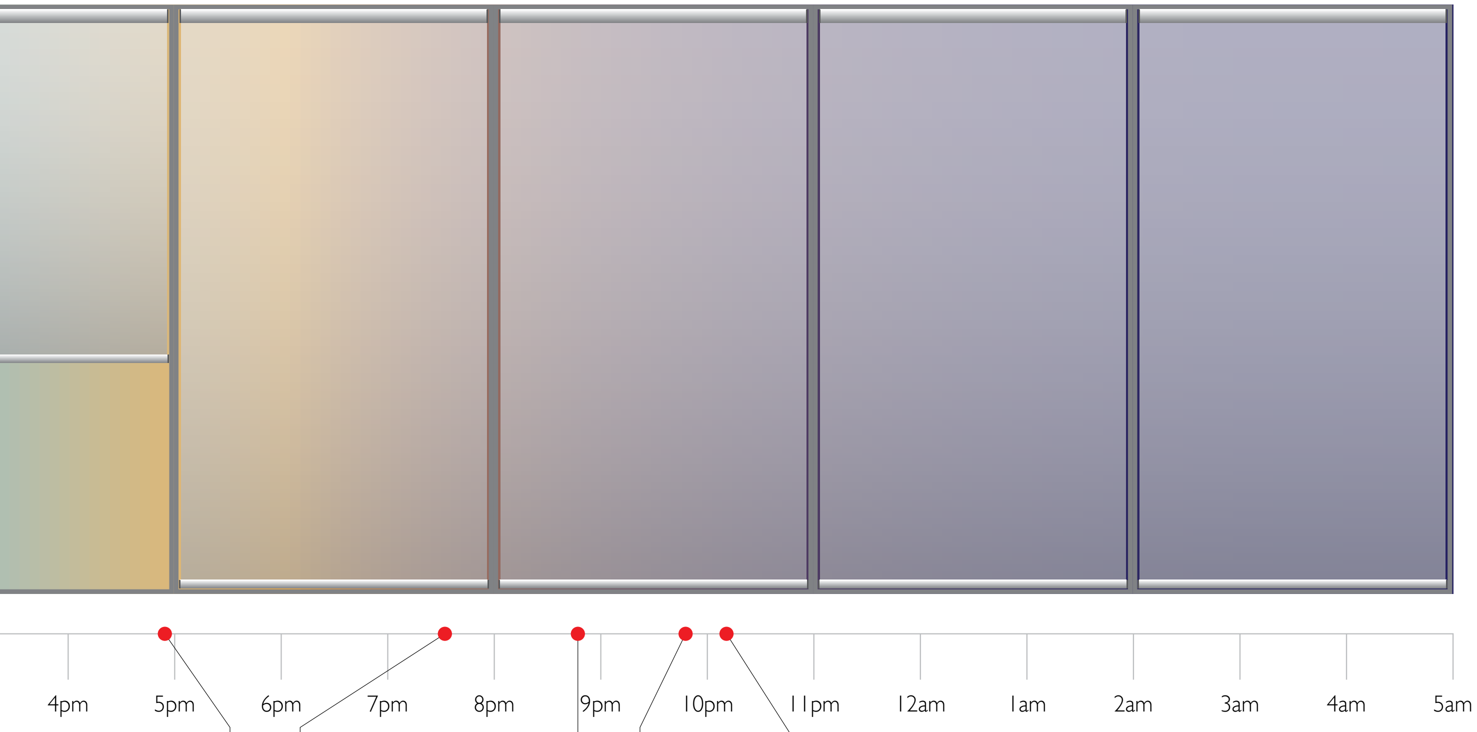
**Site warm up**
- Open blinds 100%
- Turn on lighting to 90% in lobby and main hall ways
- Enable air conditioning

**Turn off unused areas**
- Turn off lighting in any areas with no tray pan activity

**Open office start**
- Enable perimeter areas for daylight harvesting
- Adjust presence sensors to 30 minute time-out for trading mode
- Turn core lighting to 70%
- Turn on up lighting to 40%

**Afternoon adjustment**
- Drop west blinds 60% to reduce sun glare
- Turn core lighting to 90%
- Turn up lighting to 70%

> “An automated event-based strategy maximizes energy efficiency and occupancy comfort throughout the daily cycle.”



**Begin shut down**

- Close all blinds for thermal insulation
- Adjust presence sensors to 15 minute time-out for more aggressive energy management strategy

**Afterhours mode**

- Turn off all area lighting that have not had an extended lighting request
- Disable air conditioning
- Adjust all presence sensors to 5 minute time-out for most aggressive energy management
- Re-test all areas that have extended lighting every half hour until all areas have been shut down.

**Sunset**

- Close west blinds
- Turn core lighting to 90%
- Turn up lighting to 90%
- Disable perimeter daylight harvesting

**Testing for after hours mode**

- Flash lighting to indicate area is about to be shut down
- Register staff requests for extended lighting through user interfaces.

**Background lighting**

- Switch off all corridor lighting after associated area lighting has been switched off
- Dim reception lighting to 15% for after hours re-entry

# Understanding the importance of lighting control

One of the biggest challenges facing commercial building owners is reducing the day-to-day operating costs of a building while maintaining occupant comfort.

Too much or too little lighting can impact on occupant comfort levels and productivity.

Intelligent lighting control systems allow building owners to create inviting and functional office environments that improve light quality, enhance efficiency and productivity and optimize energy use.

Lighting control systems empower individuals to have direct control over their work environment and also allow users to plan for future layout and occupancy changes.

Think of it as a system that allows a building to make intelligent decisions about the optimum delivery of light. Lighting controls can switch lights off when no one is around, automatically adjust lighting levels based on the amount of natural daylight in the space and turn off or dim lights, based on the daily cycle of the office.

The perfect control of lighting means that the least possible amount of light is supplied when needed.

It's easy to see how automatic lighting control can deliver significant bottom-line savings in energy costs as well as ensuring optimum comfort for occupants.

## What is DALI?

DALI stands for Digital Addressable Lighting Interface. In other words, it is a worldwide standardized digital lighting interface.

The DALI standard, specified in IEC standard 60929, ensures interchange ability and compatibility of lighting products from different manufacturers.

The DALI system was created by leading lighting manufacturers who recognized the need for a common interface. DALI was engineered to meet the new challenges of lighting control – more flexibility, greater scalability of control and faster installation.

## What can DALI MultiMaster do for lighting?

Good lighting design has to include good control design and there's no better control solution than DALI MultiMaster.

Put simply, DALI MultiMaster is a two-way communication system that brings digital technology to lighting. Every aspect of lighting can be incorporated into a DALI MultiMaster control solution.

DALI can control a single light fitting or a defined group of light fittings within a network. It brings remarkable flexibility to lighting systems. Previous generations of lighting control techniques depended on two or more data networks to be wired throughout the project for the different lamps and user interfaces within the system.

DALI MultiMaster allows for light fittings and user interfaces to use the same data network effectively reducing cabling by half.

> “A DALI system helps reduce day-to-day running costs of a building while increasing occupancy comfort.”

Daylight harvesting & motion detection

Blind control via integrator

Sensor control in toilets

Integration to security system via integrator

Daylight harvesting

Logical control of corridor lighting

Local lighting control

Scene control of multiple lighting groups

Energy management and reports via integrator

Projector screen control via integrator

AV integration via integrator

**Above:** A typical office includes many different controls that need to be connected in the simplest way possible.

## Typical Floor Plan

This diagram illustrates how an office floor with controls can achieve efficiency and effectiveness.

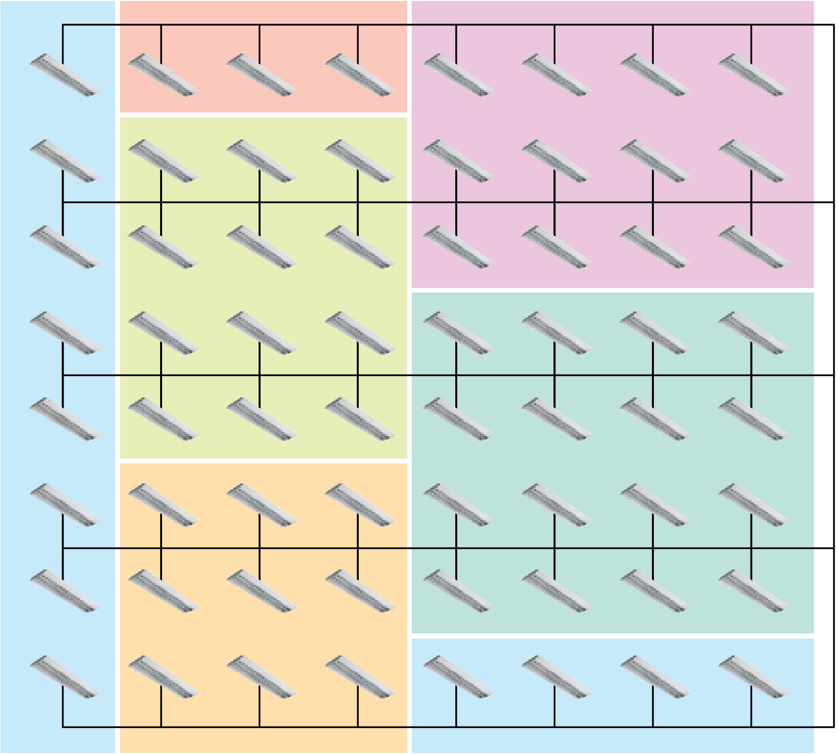
| | |
|---|---|
| ▬ | Fluorescent lights |
| ● | Downlights |
| ◎ | Pendant lights |
| ⊙ | Sensor |

# The advantages of a DALI office lighting control system

## The DALI system at work

Traditional DALI allows for individual light fittings to be controlled and grouped together into logical areas. The DALI protocol allows for a maximum of 64 fittings on a single network and the network can be broken up into 16 different possible areas.

Shown on the right is an example of 64 DALI light fittings connected in a single network, which is divided into seven different areas.



**Above:** A single DALI network consisting of up to 64 fittings can be divided into multiple control zones.

## Standby Power Management

The DALI network only controls the output level of the lamps. Once a lamp has been instructed by the control system to 0%, it's still consuming a standby current consumption.

Individual lamp standby power consumption may not seem significant, but multiply the number of lamps within one project and it is considerable. Without a power management strategy, this standby power consumption does not stop, 24 hours a day, 365 days a year.

The Philips Controls Dynalite portfolio solution eliminates the need for standby power consumption when the lamps are in the 'Off' state, thus allowing greater savings and true energy management.

## Unlimited scalability with multiple DALI networks

The DALI specification details how to operate a single network. However, most projects require multiple DALI networks operating together to create a single seamless lighting system solution.

The Dynalite portfolio allows unlimited scalability by combining multiple DALI networks into one system. Any single area can be supported by multiple DALI networks that are coordinated via a single user interface.

## Controlling more than DALI

Sometimes a project does require more than DALI. For instance, lighting groups that require phase cut dimming, switching control or blind integration, will need more than a DALI system.

All Philips devices in the Dynalite portfolio support Dynet communication, which allows a unit to communicate directly to any other unit on the Dynet network without additional network gateways or central micro controllers.

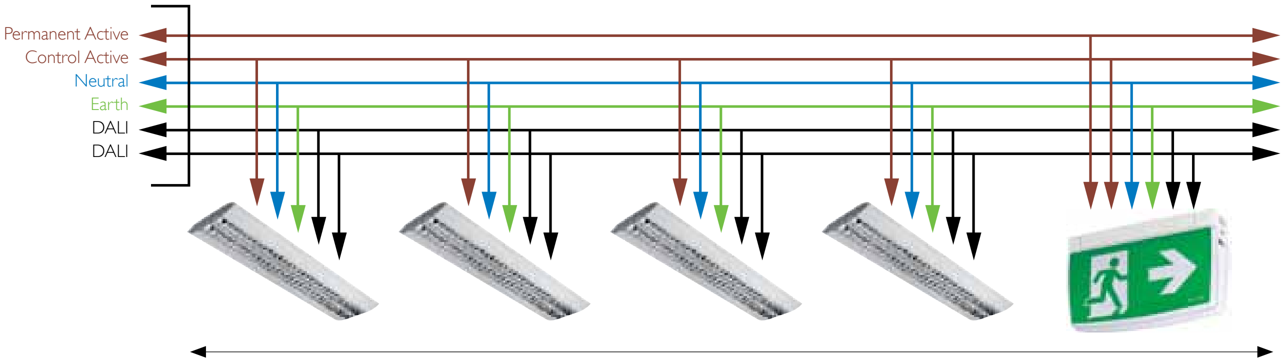
This network topology supports the full range of Dynalite integration gateways, user interfaces, sensors and other types of load controllers.

> “Easily control an entire building or multiple small tenancies.”

# Grouped lighting and emergency light monitoring

The DALI specification allows for a maximum of 64 lamps per network, which can be broken up into 16 different groups, each with its own lighting scene. The diagram below shows all the fittings directly connected to each other.

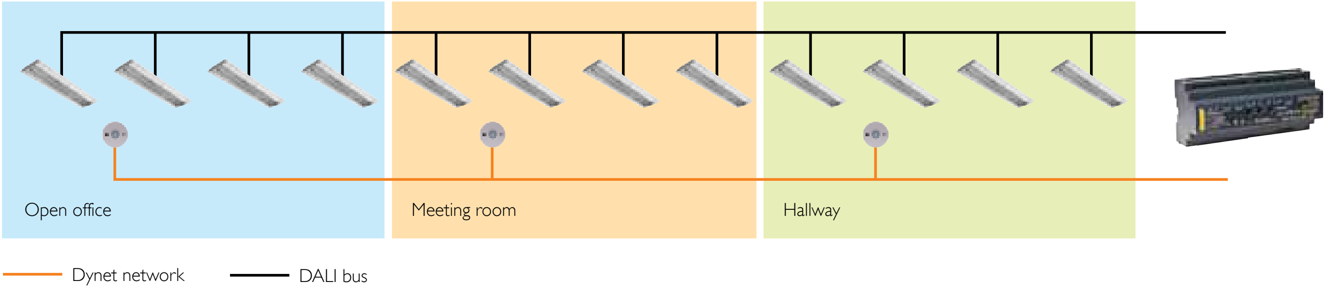
DALI emergency exit fittings are also compatible, allowing for scheduled testing of the lamp and battery with the Philips Dynalite Mapview head-end software. This makes the monitoring of emergency exit fittings easy.



64 x DALI lamps per network, 16 x groups within each network, 16 scenes per group

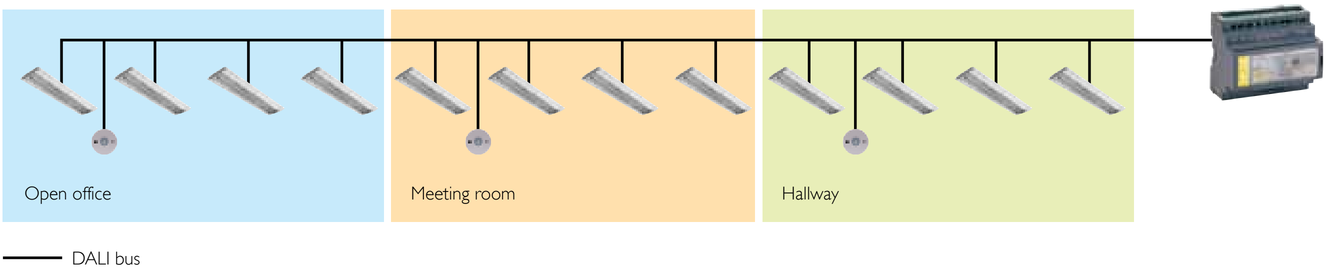
## Understanding DALI hardware and wiring

A DALI system normally consists of DALI compatible light fittings and a DALI controller. In the example below, the DALI system has all fittings connected in one network and the sensors within each of the areas are connected back on a separate control systems network.



## Reduce network cabling by up to 50%

Using the existing DALI bus for lighting control system user interface communication, effectively reduces the required network cabling by half. As the user interfaces are still networked devices, they can issue commands to change any lighting group on its own DALI network or any other lighting group within the Philips Dynalite portfolio network.



# Introducing the innovative DALI MultiMaster range

## Maximizing the DALI network advantages

Philips has developed a dedicated range of products in it's Dynalite portfolio that provide the scalability and feature-set of our system. Below is an outline of the product features that combine to produce a new benchmark in office lighting control.

### Gateway Controller

DDBC120-DALI

- Supports full DALI network of 64 fittings.
- Allows for 10 Dynalite user interfaces on the DALI bus.
- Device is fully self contained requiring no external devices for power or to be part of the DALI network.
- Built-in DALI power supply and DALI transmitter. No external devices required.
- Built-in 20A lighting power relay for removing standby power consumption when lighting is not needed.
- Directly integrated into the Philips Dynalite network Dynet.

### Dry Contact Interface

DPMI940-DALI

- 4 x Dry contact inputs.
- Fully DALI network compatible with no need for extra power supply.
- All settings are software configurable allowing for remote programming.
- Able to control multiple DALI groups, fitting and other Philips Dynalite load controllers.
- Supports a wide range of selectable functions lighting scene select, ramping, area join or start event.
- Fully powered from the DALI network.

### Multifunction Sensor

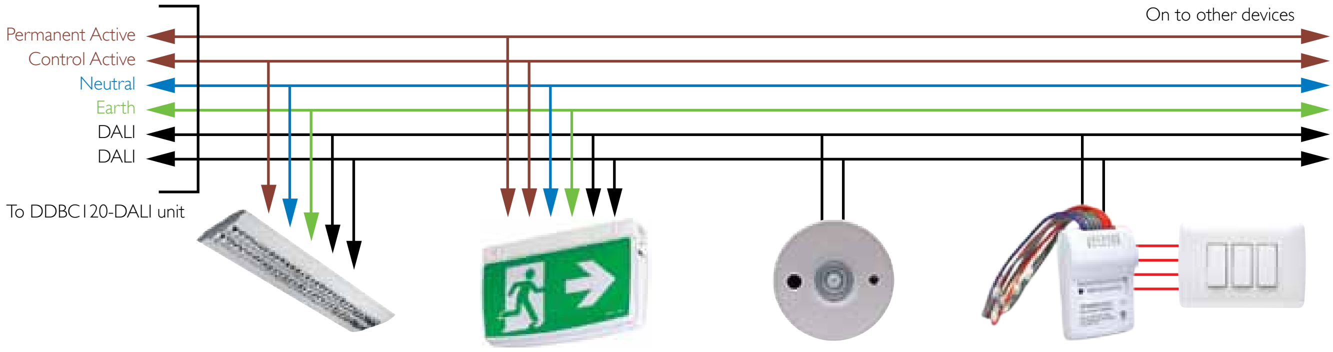
DUS804C-DALI

- Multifunction sensor supporting PIR and measured light level detection.
- Fully DALI network compatible with no need for extra power supply.
- All settings are software configurable allowing sensors to have different responses throughout a 24-hour work cycle.
- Able to control multiple DALI groups, multiple DALI networks and other Philips Dynalite portfolio load controllers.
- Supporting multiple functions such as performing daylight harvesting once motion has been detected.
- Fully powered from the DALI network.

# Simple network cabling means lower installation costs

The Philips Dynalite portfolio of user interfaces connect directly to the same network bus as other DALI devices. There is no need for additional network or power wiring, which removes the need to run multiple networks across the office space for the lighting control system.

On any single DALI network, a total of 10 Dynalite user interfaces can be mounted. These devices do not use the fittings of the DALI addressing system, allowing for the full use of 64 DALI fittings. Using the existing DALI bus means up to 50% less network cabling.



### DALI fittings

- All fittings must be DALI compatible.
- A total of 64 fittings can be controlled on a single DALI universe. If control over more fittings is required, an additional DALI controller will be needed.
- Power to the fitting is supplied by the DDBC120-DALI.
- The DALI group addressing can be changed by the DDBC120-DALI unit with Envision software.
- Full DALI reporting on current lamp status is available. Reports on tests can be generated with Envision software.

### DALI emergency

- All emergency and exit fittings must be DALI compatible.
- Including emergency and exit lighting, a total of 64 fittings can be controlled on a single DALI universe. If control over more fittings is required, an additional DALI controller will be needed.
- Some emergency and exit fittings use two DALI addresses per fitting. See manufacturers data sheet for details.
- Power to the fitting is supplied by the DDBC120-DALI.
- The DALI group addressing can be changed by the DDBC120-DALI unit.
- Full DALI emergency reporting on current lamp status is available.
- Reports of testing can be generated with Envision software.

### DUS804C-DALI

- Sensor transmits messages directly onto the DALI network.
- The sensor is powered directly from the DALI network requiring no additional cabling.
- Capable of motion detection and light level measurement at the same time.
- Able to control fittings located on different DALI universes or any other part of the Dynet network.
- All device settings are configured remotely through the DALI network by Envision software. No manual adjustment is required.
- Capable of variable time-out setting between trading and after hours modes.

### DPMI940-DALI

- 4 x Dry Contact input interface for DALI network.
- Able to transmit messages directly onto the DALI network.
- The DPMI940-DALI is powered from the DALI network requiring no additional cabling.
- Able to control fittings located on different DALI universes.
- All device settings are configured remotely through the DALI network by Envision software. No manual adjustment is required.

> “Up to 50% less network cabling that you'll never touch again.”

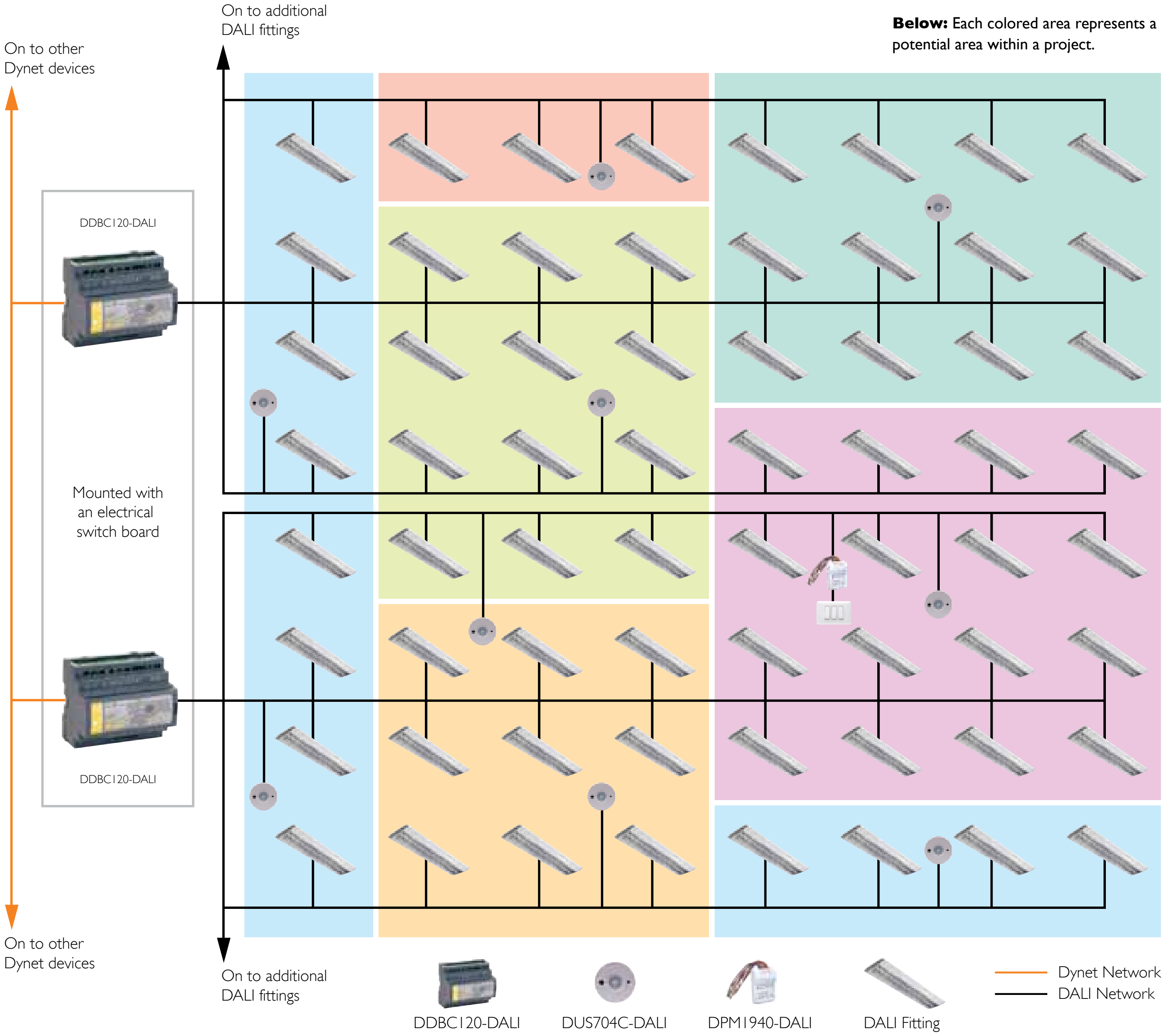
# DALI MultiMaster brings functionality to every project

Often a project floor layout is not known until the late stages of construction, which means electrical installers need to change the DALI bus to match the desired floor plan, ensuring that each area does not cross the physical boundary from one DALI network into another.

The DALI MultiMaster system overcomes these restrictions by directly connecting each of the load controllers in the electrical switchboard via Dynet.

This allows the Dynalite system to coordinate multiple DALI networks into one seamless system. So, a sensor physically connected in one DALI network can control a fitting in another, reducing the number of user interfaces and allowing for unlimited area shapes and sizes.

In the example below, each colored area represents a potential area within a project. Two of the required control areas have crossed from one physical DALI network into another. The Dynalite system can automatically manage the logical areas so that the DALI network physical boundaries are no longer a restriction. Intuitive head-end software allows users the freedom to change lighting zones easily.



**Below:** Each colored area represents a potential area within a project.

# Tray Pan – the freedom to control individual work environments

In a typical office environment, DALI's ability to control individual light fittings empowers occupants to automatically control task lighting. Tray Pan is a program that resides in the task bar of an individual's computer and communicates to the Dynalite server to carry out requests. Tray Pan can be set to dim the lighting when the computer screen saver activates or turn the lighting off when the computer has been turned off. With task lighting connected back to the lighting control system, there's no risk of lights being left on all weekend.

**Left:** Tray Pan acts as an onscreen remote control empowering individuals.

# Sophisticated head-end software

Every device on the Philips portfolio Dynalite lighting control system can be managed from one central location. Dlight III software allows users to have a floor plan overview of the site showing all areas of control. The software allows users to edit scheduled events, override current lighting, rezone areas and run lamp tests.

**Left:** Users can view a building's floorplan and control lighting functions with a click of a button.

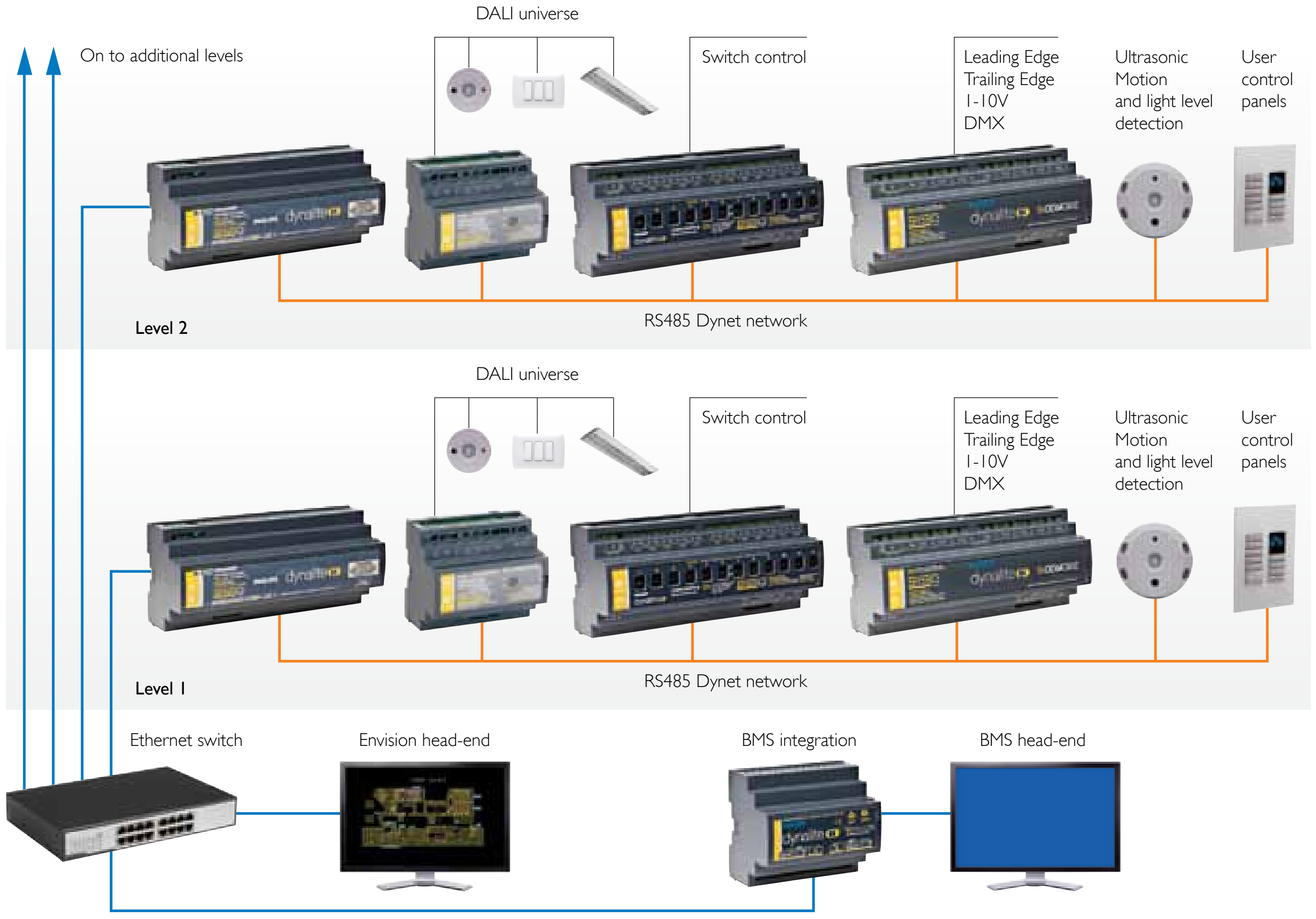
# Integrate DALI MultiMaster into an entire system solution

The DALI MultiMaster system complements the many features and product options available within the Dynalite portfolio of Philips lighting controls solution offers.

The DALI MultiMaster can be used in conjunction with other devices to control non-DALI light fittings and integrate with other elements of a project including blinds and AV systems.

This diagram shows how the DALI MultiMaster can become part of the whole system solution. A direct connection with any other device in the Dynalite system gives the complete flexibility of DALI and the full features of Dynet.

With a direct connection to the Dynet network, the DALI MultiMaster controllers can be in direct communication with any other device, requiring no additional gateways or commissioning tools.



**Above:** DALI MultiMaster becomes another solution to the Philips Dynalite lighting control system.

# Superior control brought to you by Philips

Philips through it's Dynalite portfolio of controls solutions already supports a wide range of load controllers, user interfaces and integration gateways, which offer seamless compatibility and configuration by the one commissioning tool – EnvisionProject software.

## Load controllers for every job

A complete range of load controllers for dimming of all lamp types and heavy-duty relay devices for any switching requirements. Control types supported are:

- Leading Edge dimming
- Trailing Edge dimming
- 1-10V, DSI, DALI broadcast
- LED Pulse Width Modulation
- Switching control

## Smart user interfaces

Bring the power of the Dynalite system with a touch of a single button. One multifunction sensor reduces ceiling clutter.

- Pushbutton panel
- Touchscreens
- Timer clocks
- Multifunction Sensors (Ultrasonic, PIR, IR and Lux)

## High performance Integration Gateways

Coordinating multiple systems to perform together ensures the system is easy to use and easily configured. High level of integration into many different BMS protocols.

- BACnet
- LON
- RS232 / RS485
- Ethernet
- Somfy
- Low level volt-free
- KNX

www.philips.com/dynalite

For more information, please contact

# DALI lighting control systems

Delivering maximum control and flexibility by bridging the gap between KNX and DALI.

DALI KNX

PHILIPS

sense and simplicity

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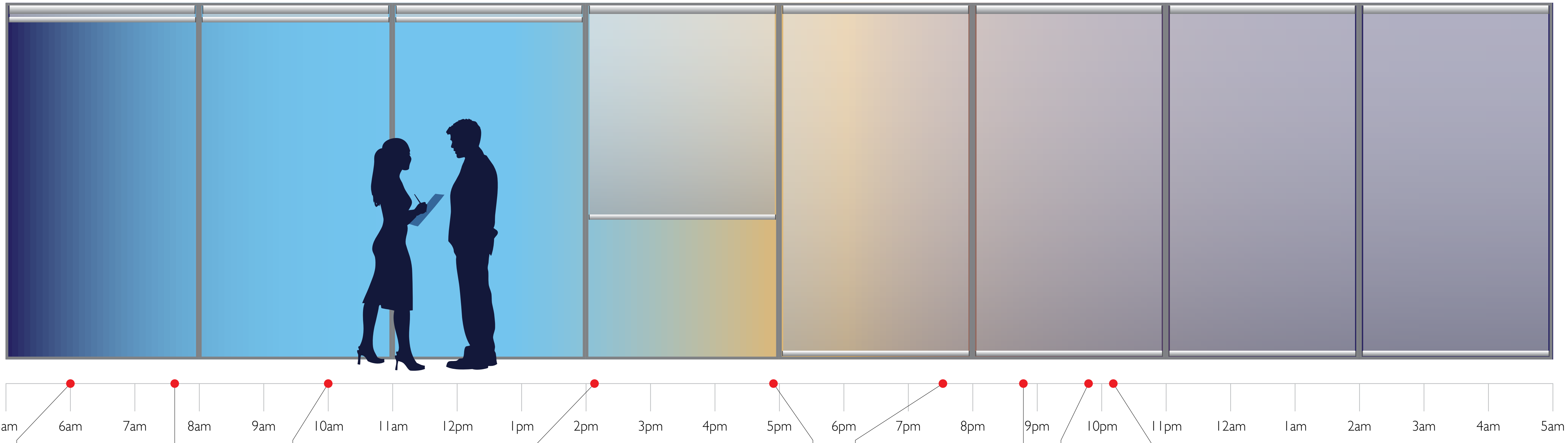
The energy requirements throughout a 24-hour cycle in an office environment vary.

Coordinating the different services within a Philips lighting control system allows an automated event-based strategy, which maximizes energy efficiency and creates a comfortable and productive work environment.



**Site warm up**
- Open blinds 100%
- Turn on lighting to 90% in lobby and main hall ways
- Enable air conditioning

**Open office start**
- Enable perimeter areas for daylight harvesting
- Adjust presence sensors to 30 minute time-out for trading mode
- Turn core lighting to 70%
- Turn on up lighting to 40%

**Turn off unused areas**
- Turn off lighting in any areas with no activity

**Afternoon adjustment**
- Drop west blinds 60% to reduce sun glare
- Turn core lighting to 90%
- Turn up lighting to 70%

**Sunset**
- Close west blinds
- Turn core lighting to 90%
- Turn up lighting to 90%
- Disable perimeter daylight harvesting

**Begin shut down**
- Close all blinds for thermal insulation
- Adjust presence sensors to 15 minute time-out for more aggressive energy management strategy

**Testing for after hours mode**
- Flash lighting to indicate area is about to be shut down
- Register staff requests for extended lighting through user interfaces.

**Afterhours mode**
- Turn off all area lighting that have not had an extended lighting request
- Disable air conditioning
- Adjust all presence sensors to 5 minute time-out for most aggressive energy management
- Re-test all areas that have extended lighting every half hour until all areas have been shut down.

**Background lighting**
- Switch off all corridor lighting after associated area lighting has been switched off
- Dim reception lighting to 15% for after hours re-entry

> “An automated event-based strategy maximizes energy efficiency and occupancy comfort throughout the daily cycle.”

# Understanding the importance of lighting control

One of the biggest challenges facing commercial building owners is reducing the day-to-day operating costs of a building while maintaining occupant comfort.

Too much or too little lighting can impact on occupant comfort levels and productivity.

Intelligent lighting control systems allow building owners to create inviting and functional office environments that improve light quality, enhance efficiency and productivity and optimize energy use.

Lighting control systems empower individuals to have direct control over their work environment and also allow users to plan for future layout and occupancy changes.

Think of it as a system that allows a building to make intelligent decisions about the optimum delivery of light. Lighting controls can switch lights off when no one is around, automatically adjust lighting levels based on the amount of natural daylight in the space and turn off or dim lights, based on the daily cycle of the office.

The perfect control of lighting means that the least possible amount of light is supplied when needed.

It's easy to see how automatic lighting control can deliver significant bottom-line savings in energy costs as well as ensuring optimum comfort for occupants.

## What is KNX?

KNX is a standardized (EN 50090, ISO/IEC 14543), OSI-based network communications protocol for intelligent buildings. Products available in the market cater for many diverse applications, for example, the integration of:

- Lighting control
- Heating/ventilation & Air Conditioning control
- Shutter/Blind & shading control
- Alarm monitoring
- Energy management & Electricity/Gas/Water metering
- Audio & video distribution

## What is DALI?

DALI stands for Digital Addressable Lighting Interface. In other words, it is a worldwide standardized digital lighting interface.

The DALI standard, specified in IEC standard 60929, ensures interchange ability and compatibility of lighting products from different manufacturers.

The DALI system was created by leading lighting manufacturers who recognized the need for a common interface. DALI was engineered to meet the new challenges of lighting control – more flexibility, greater scalability of control and faster installation.

## What can DALI MultiMaster do for lighting?

Good lighting design has to include good control design and there's no better control solution than DALI MultiMaster.

Put simply, DALI MultiMaster is a two-way communication system that brings digital technology to lighting. Every aspect of lighting can be incorporated into a DALI MultiMaster control solution.

DALI can control a single light fitting or a defined group of light fittings within a network. It brings remarkable flexibility to lighting systems. Previous generations of lighting control techniques depended on two or more data networks to be wired throughout the project for the different lamps and user interfaces within the system.

DALI MultiMaster allows for light fittings and user interfaces to use the same data network effectively reducing cabling by half.

> “A DALI system helps reduce day-to-day running costs of a building while increasing occupancy comfort.”

Daylight harvesting & motion detection

Blind control via integrator

Sensor control in toilets

Integration to security system via integrator

Daylight harvesting

Logical control of corridor lighting

Local lighting control

Energy management and reports via integrator

Scene control of multiple lighting groups

Projector screen control via integrator

AV integration via integrator

**Above:** A typical office includes many different controls that need to be connected in the simplest way possible.

### Typical Floor Plan

This diagram illustrates how an office floor with controls can achieve efficiency and effectiveness.

▬ Fluorescent lights
● Downlights
◉ Pendant lights
⊙ Sensor

# The advantages of a DALI office lighting control system

## The DALI system at work

Traditional DALI allows for individual light fittings to be controlled and grouped together into logical areas. The DALI protocol allows for a maximum of 64 fittings on a single network and the network can be broken up into 16 different possible areas.

Shown on the right is an example of 64 DALI light fittings connected in a single network, which is divided into seven different areas.

## Standby Power Management

The DALI network only controls the output level of the lamps. Once a lamp has been instructed by the control system to 0%, it's still consuming a standby current consumption.

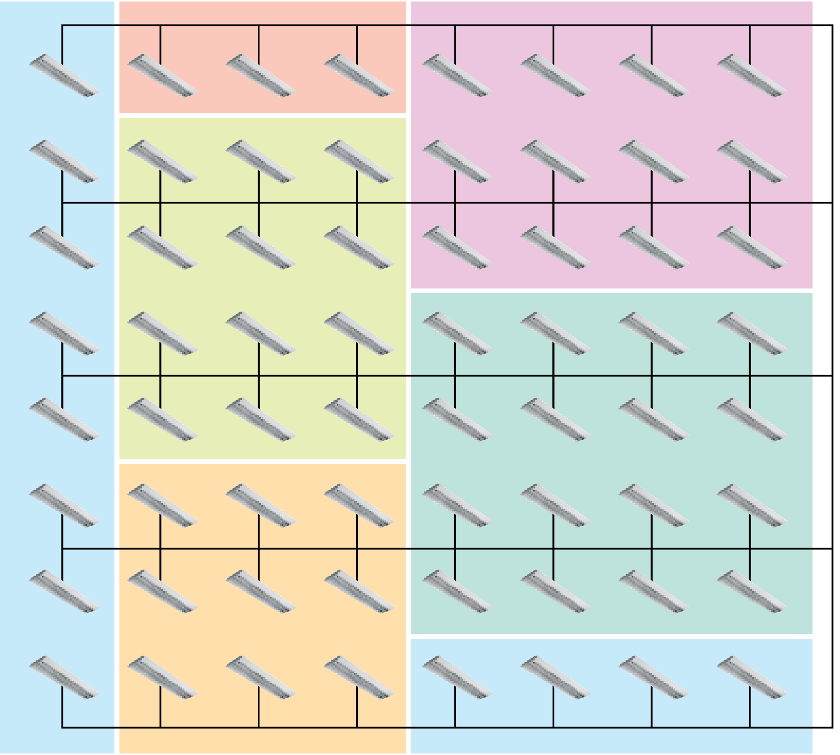
Individual lamp standby power consumption may not seem significant, but multiply the number of lamps within one project and it is considerable. Without a power management strategy, this standby power consumption does not stop, 24 hours a day, 365 days a year.

The Philips Controls LightMaster portfolio solution eliminates the need for standby power consumption when the lamps are in the 'Off' state, thus allowing greater savings and true energy management.

## Unlimited scalability with multiple DALI networks

The DALI specification details how to operate a single network. However, most projects require multiple DALI networks operating together to create a single seamless lighting system solution.

The LightMaster portfolio allows unlimited scalability by combining multiple DALI networks into one system. Any single area can be supported by multiple DALI networks that are coordinated via a single user interface.



**Above:** A single DALI network consisting of up to 64 fittings can be divided into multiple control zones.

## Controlling more than DALI

Sometimes a project does require more than DALI. For instance, lighting groups that require phase cut dimming, switching control or blind integration, will need more than a DALI system.

All Philips devices in the LightMaster portfolio support KNX communication, which allows a unit to communicate directly to any other unit on the KNX network without additional network gateways or central micro controllers.

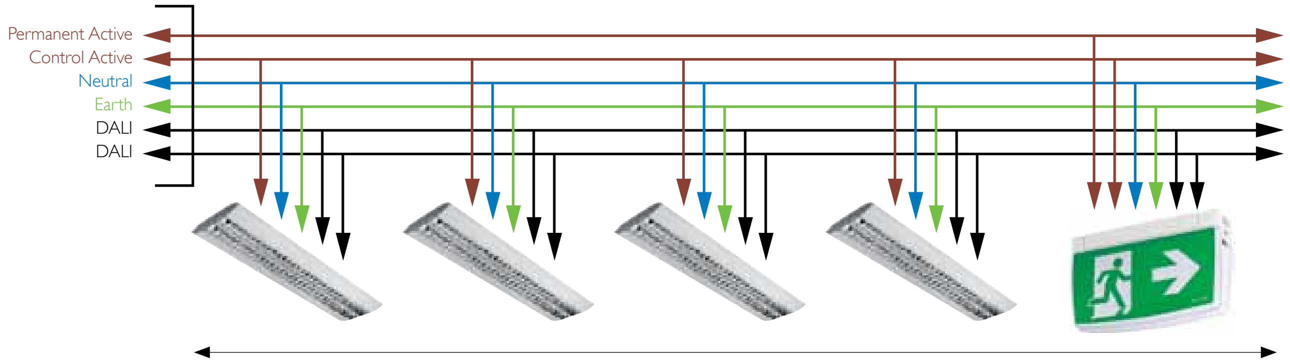
This network topology supports the full range of LightMaster user interfaces, sensors and other types of load controllers.

> “Easily control an entire building or multiple small tenancies.”

# Grouped lighting and emergency light monitoring

The DALI specification allows for a maximum of 64 lamps per network, which can be broken up into 16 different groups, each with its own lighting scene. The diagram below shows all the fittings directly connected to each other.

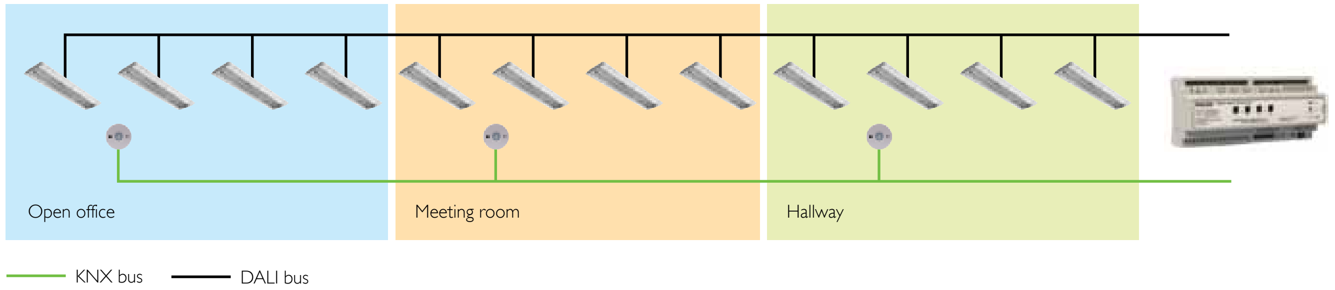
DALI emergency exit fittings are also compatible, allowing for scheduled testing of the lamp and battery.



64 x DALI lamps per network, 16 x groups within each network, 16 scenes per group

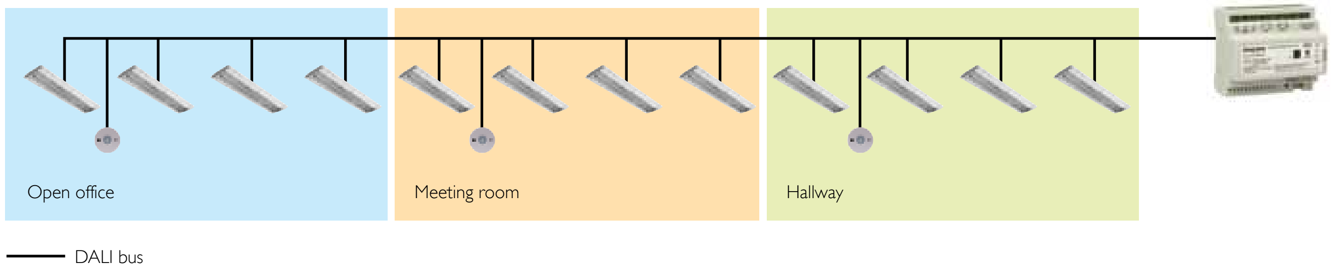
## Understanding DALI hardware and wiring

A DALI system normally consists of DALI compatible light fittings and a DALI controller. In the example below, the DALI system has all fittings connected in one network and the sensors within each of the areas are connected back on a separate control systems network.



## Reduce network cabling by up to 50%

Using the existing DALI bus for lighting control system user interface communication, effectively reduces the required network cabling by half. As the user interfaces are still networked devices, they can issue commands to change any lighting group on its own DALI network or any other lighting group within the Philips LightMaster portfolio network.



# Introducing the innovative DALI MultiMaster range

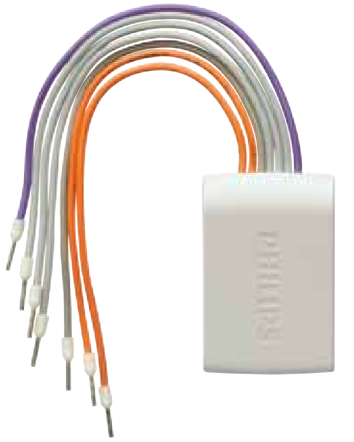
## Maximizing the DALI network advantages

Philips has developed a dedicated range of products in it's LightMaster KNX portfolio that provide the scalability and feature-set of our system. Below is an outline of the product features that combine to produce a new benchmark in office lighting control.

### DALI MultiMaster Controller

PDBC120-DALI-KNX

- Supports full DALI network of 64 fittings.
- Allows for 10 LightMaster DALI user interfaces on the DALI bus.
- Device is fully self contained requiring no external devices for power or to be part of the DALI network.
- Built-in DALI power supply and DALI transmitter. No external devices required.
- Built-in 20A lighting power relay for removing standby power consumption when lighting is not needed.
- Directly integrated into the Philips LightMaster KNX network.



### Dry Contact Interface

PPMI4-DALI

- 4 x Dry contact inputs.
- Fully DALI network compatible with no need for extra power supply.
- All settings are software configurable allowing for remote programming.
- Able to control multiple DALI groups, fitting and other Philips LightMaster KNX load controllers.
- Supports a wide range of selectable functions lighting scene select or ramping.
- Fully powered from the DALI network.

### Multifunction Sensor

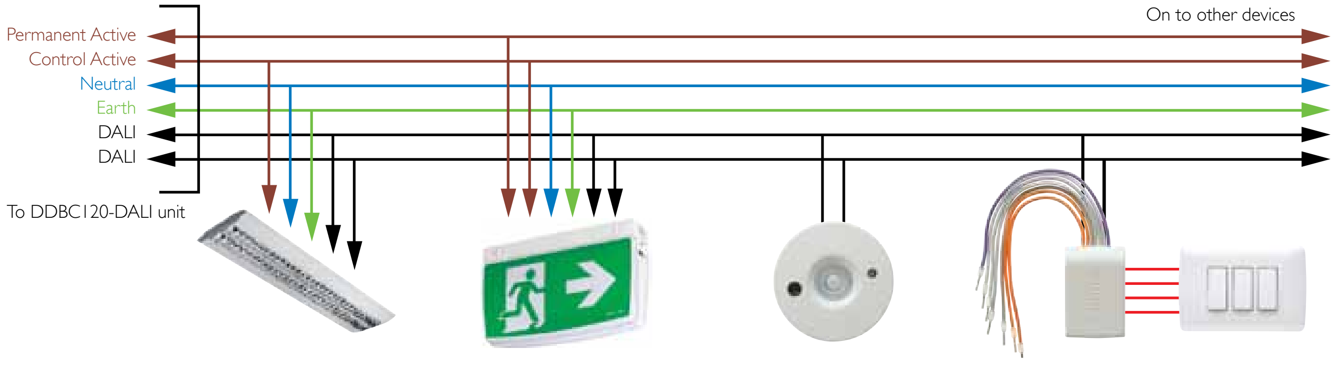
PLOS-CM-DALI

- Multifunction sensor supporting PIR and measured light level detection.
- Fully DALI network compatible with no need for extra power supply.
- All settings are software configurable allowing sensors to have different responses throughout a 24-hour work cycle.
- Able to control multiple DALI groups, multiple DALI networks and other Philips LightMaster KNX portfolio load controllers.
- Supporting multiple functions such as performing daylight harvesting once motion has been detected.
- Fully powered from the DALI network.

## Simple network cabling means lower installation costs

The Philips LightMaster KNX portfolio of user interfaces connect directly to the same network bus as other DALI devices. There is no need for additional network or power wiring, which removes the need to run multiple networks across the office space for the lighting control system.

On any single DALI network, a total of 10 LightMaster DALI user interfaces can be mounted. These devices do not use the fittings of the DALI addressing system, allowing for the full use of 64 DALI fittings. Using the existing DALI bus means up to 50% less network cabling.



### DALI fittings

- All fittings must be DALI compatible.
- A total of 64 fittings can be controlled on a single DALI universe. If control over more fittings is required, an additional DALI controller will be needed.
- Power to the fitting is supplied by the PDBC120-DALI-KNX.
- The DALI group addressing can be changed by the unit with ETS software.
- Full DALI reporting on current lamp status is available. Reports on tests can be generated with ETS software.

### DALI emergency

- All emergency and exit fittings must be DALI compatible.
- Including emergency and exit lighting, a total of 64 fittings can be controlled on a single DALI universe. If control over more fittings is required, an additional DALI controller will be needed.
- Some emergency and exit fittings use two DALI addresses per fitting. See manufacturers data sheet for details.
- Power to the fitting is supplied by the unit.
- The DALI group addressing can be changed by the unit.
- Full DALI emergency reporting on current lamp status is available.

### PLOS-CM-DALI

- Sensor transmits messages directly onto the DALI network.
- The sensor is powered directly from the DALI network requiring no additional cabling.
- Capable of motion detection and light level measurement at the same time.
- Able to control fittings located on different DALI universes or any other part of the KNX network.
- All device settings are configured remotely through the DALI network by ETS software. No manual adjustment is required.
- Capable of variable time-out setting between trading and after hours modes.

### PPMI4-DALI

- 4 x Dry Contact input interface for DALI network.
- Able to transmit messages directly onto the DALI network.
- The PPMI40-DALI is powered from the DALI network requiring no additional cabling.
- Able to control fittings located on different DALI universes.
- All device settings are configured remotely through the DALI network by KNX ETS software. No manual adjustment is required.

> “Up to 50% less network cabling that you'll never touch again.”

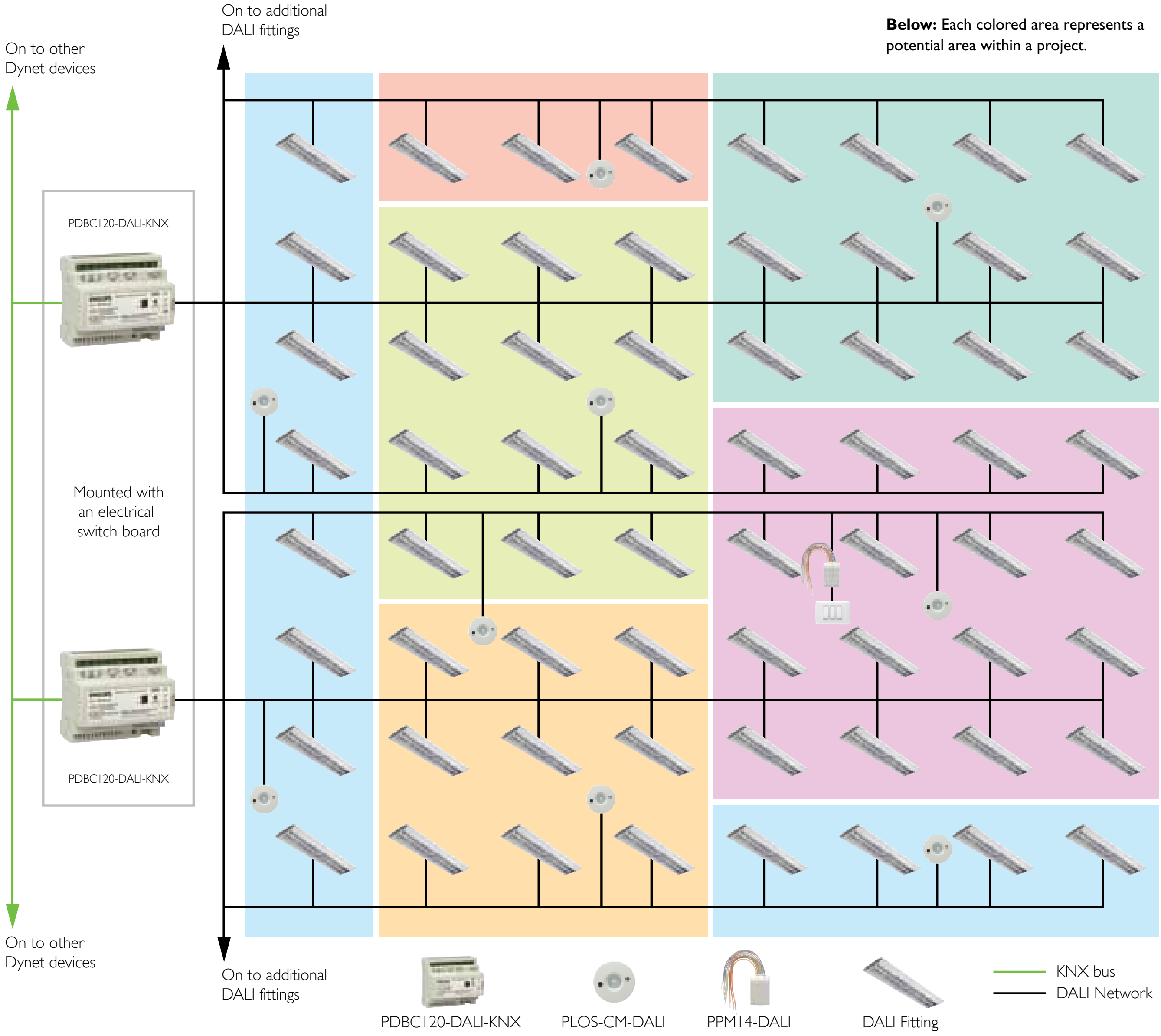
# LightMaster KNX DALI MultiMaster brings functionality to every project

Often a project floor layout is not known until the late stages of construction, which means electrical installers need to change the DALI bus to match the desired floor plan, ensuring that each area does not cross the physical boundary from one DALI network into another.

The LightMaster KNX DALI MultiMaster system overcomes these restrictions by directly connecting each of the load controllers in the electrical switchboard via the KNX bus.

This allows the LightMaster KNX system to coordinate multiple DALI networks into one seamless system. So, a sensor physically connected in one DALI network can control a fitting in another, reducing the number of user interfaces and allowing for unlimited area shapes and sizes.

In the example below, each colored area represents a potential area within a project. Two of the required control areas have crossed from one physical DALI network into another. The LightMaster KNX system can automatically manage the logical areas so that the DALI network physical boundaries are no longer a restriction. Intuitive head-end software allows users the freedom to change lighting zones easily.


**Below:** Each colored area represents a potential area within a project.

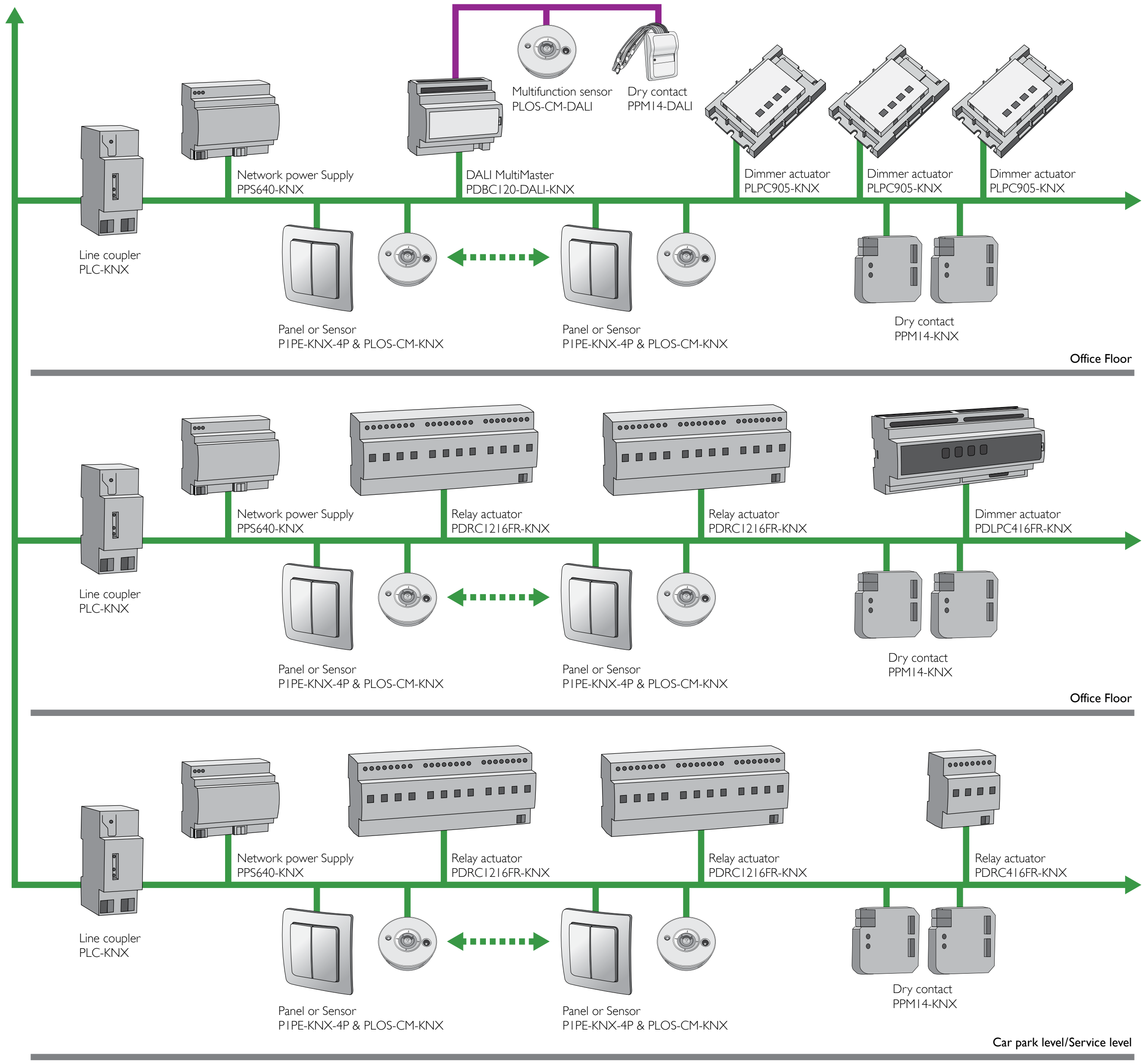
# Integrate LightMaster KNX DALI MultiMaster into an entire system solution

The LightMaster KNX DALI MultiMaster system complements the many features and product options available within the LightMaster KNX portfolio of Philips lighting controls solution offers.

The LightMaster KNX DALI MultiMaster can be used in conjunction with other devices to control non-DALI light fittings and integrate with other elements of a project including blinds and AV systems.

This diagram shows how the LightMaster KNX DALI MultiMaster can become part of the whole system solution. A direct connection with any other device in the Dynalite system gives the complete flexibility of DALI and the full features of LightMaster KNX.

With a direct connection to the KNX bus, the LightMaster KNX DALI MultiMaster controllers can be in direct communication with any other device, requiring no additional gateways or commissioning tools.



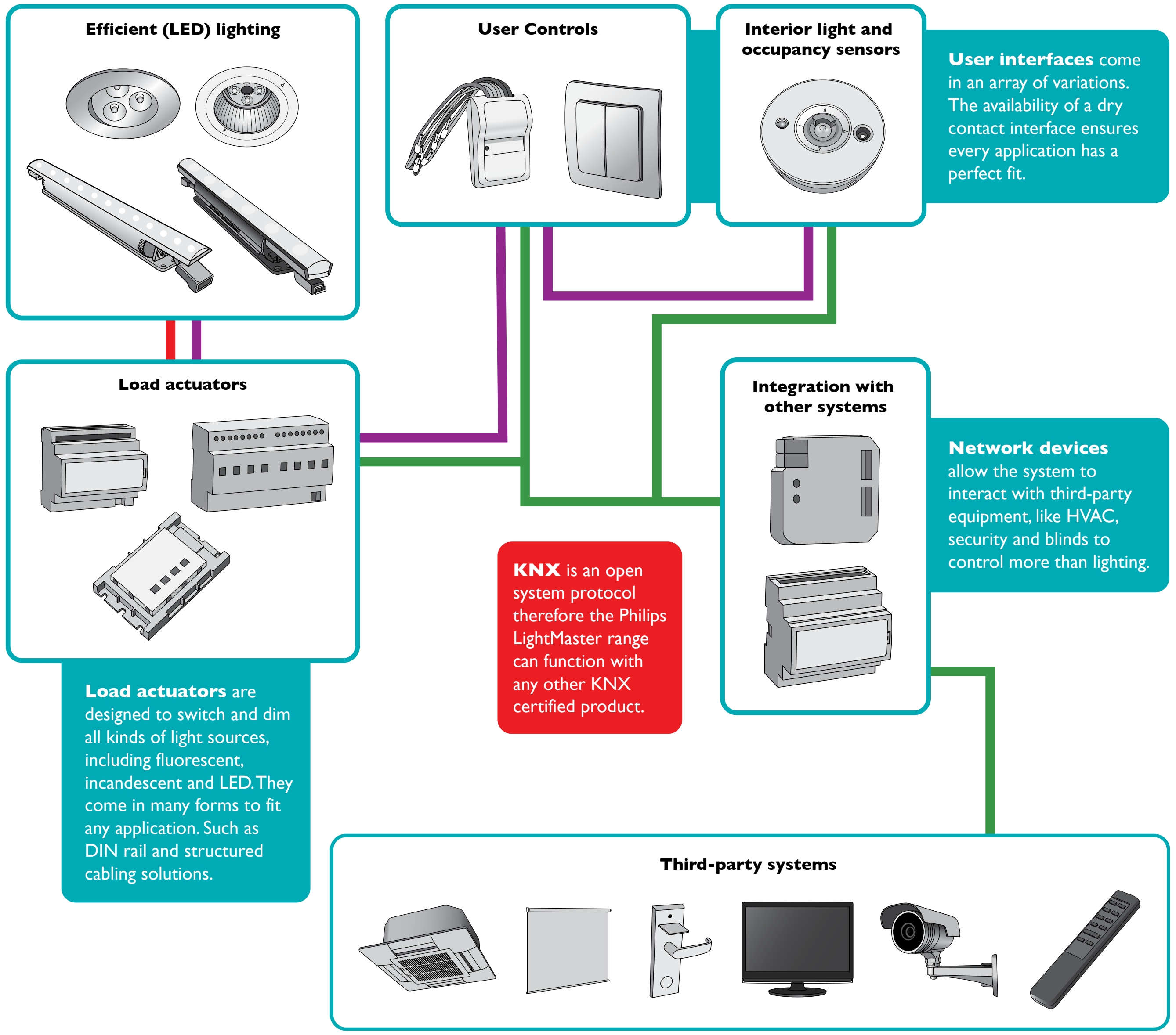
# The Philips LightMaster Solution

The Philips LightMaster range has been developed to ensure easy integration into today's modern office environment, for either retrofit or new installations by maximizing the effectiveness of KNX and DALI.

The Philips LightMaster range now brings additional solutions to the KNX world including:

- dimming actuator solutions that allow the user to decide which lighting protocol output they want to work with, including DALI addressed, DALI broadcast, DSI and 1-10v.
- a true structured cabling solution to bring the benefits of faster installation, commissioning and reduced costs.
- the benefits of being able to add sensors and dry contact user interfaces to the DALI line, reducing installation costs in field wiring.
- low profile aesthetics to the sensor range, reducing ceiling clutter without compromising performance.

The Philips LightMaster office based controls system is fully scalable and suited to both large and small installations.



**User interfaces** come in an array of variations. The availability of a dry contact interface ensures every application has a perfect fit.

**Load actuators** are designed to switch and dim all kinds of light sources, including fluorescent, incandescent and LED. They come in many forms to fit any application. Such as DIN rail and structured cabling solutions.

**KNX** is an open system protocol therefore the Philips LightMaster range can function with any other KNX certified product.

**Network devices** allow the system to interact with third-party equipment, like HVAC, security and blinds to control more than lighting.

🟥 Mains Power Cable
🟩 KNX
🟪 DALI

www.philips.com/knx

For more information, please contact

Grammar school Süderelbe, Germany

# Let’s save energy - now!

With a simple switch to energy efficient lighting in your school, you can make a difference

asimpleswitch.com

PHILIPS

sense and simplicity

**“I helped my school save costs and the environment”**

Mr. Hans Verbraak (Director of primary school De Sponder, The Netherlands)

# Save money and the environment – make the switch now!

Lighting consumes around 19% of all electricity worldwide. In Europe, 75% of all office lighting is still based on outdated, energy-inefficient lighting. A typical high-school building with 26 classrooms using older, less energy-efficient lighting technology could save 15,000 kg of $CO_2$ and € 6,500 in running costs per year by upgrading its lighting to the latest technology. Over the average lifetime of a school lighting system (15 years), this means a saving of € 115,000.

**So how can your make the switch for your school?**
It's simple: Philips offers a complete range of energy-saving lighting solutions. You can recognise these products by our Green Logo. Products with this logo are not only energy-efficient and reduce running costs, they also provide better quality light. It's a simple switch!

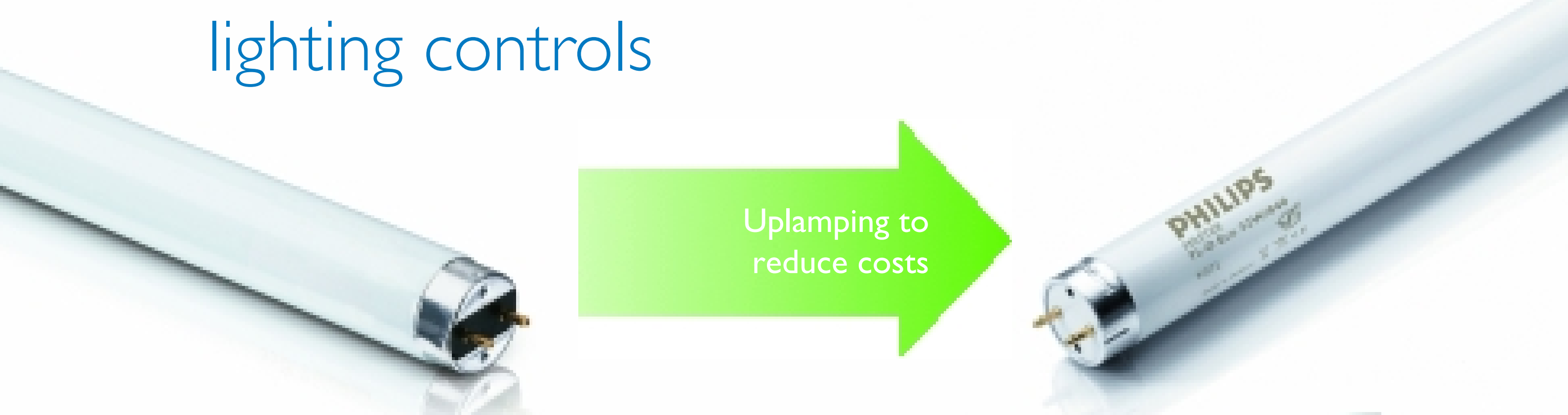
For more information on our green products and their impact on the environment, please contact your local Philips representative or visit **www.asimpleswitch.com** .

Under the European Energy Performance of Buildings Directive, building owners with a useful floor space of more than 1000 m² must comply with minimum energy consumption levels when refurbishing. For lighting, the norm EN15193 sets standards for the maximum annual energy consumption per square metre using the Lighting Energy Numeric Indicator (LENI).

**When switching over to energy-efficient lighting for your school, you have two options:**

**Additional savings can be achieved by applying Lighting controls.**

# Simply upgrade your lamps and apply lighting controls



Standard T8 → **MASTER TL-D Eco**
Energy savings: **>10%**
Payback time: **< 1.5 years**

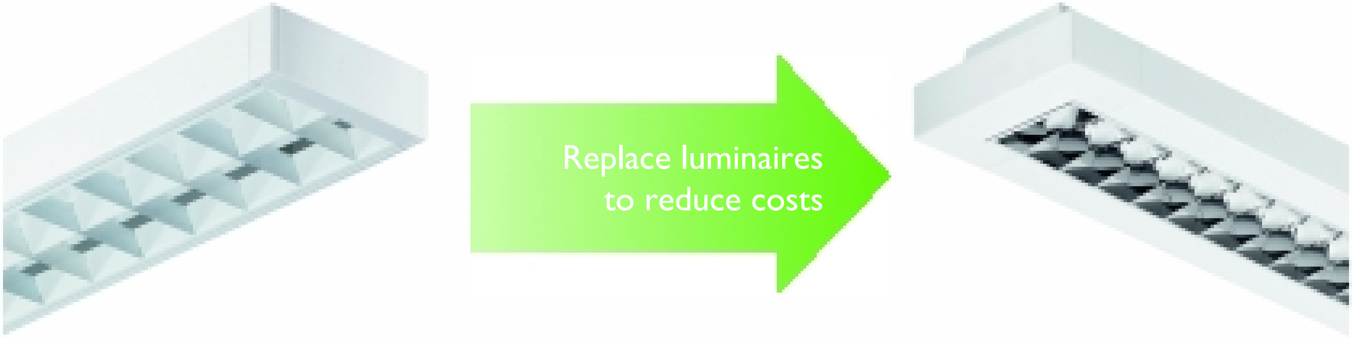
### MASTER TL-D Eco – saves over 10% energy

Fluorescent lighting is the most widely used technology in the market and therefore offers major opportunities for energy saving. For example, by simply replacing your current T8 fluorescent lamps with Philips MASTER TL-D Eco, you can instantly reduce your energy consumption by over 10%.

### Lighting controls for even greater savings

Additional savings can be achieved by installing lighting controls for presence detection or daylight-dependent dimming. Applying the Philips Occuswitch stand-alone movement detector, for example, allows energy savings of up to 30%. Occuswitch switches the lights off when a classroom is vacated and optionally when there is enough incident daylight as well.

# Simply replace your luminaires and apply lighting controls



Standard T8 → **MASTER TL5** system + controls
Energy savings: **up to 75%**
Payback time: **< 5 years**

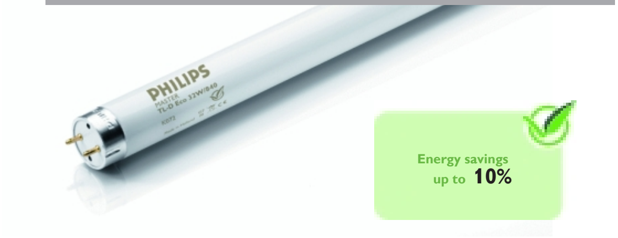
**High energy-saving potential**
Replacing your luminaires will increase your energy-saving potential. The primary savings can be made by upgrading from fittings with electromagnetic ballasts and standard TL fluorescent lamps to fittings with high-frequency (electronic) gear and TL5 fluorescent lamps. Energy savings of 30% are easily achievable, and these start immediately after installation.

**EFix TL5 luminaire range – an affordable, innovative solution**
The Philips EFix TL5 luminaire range is an affordable, innovative solution that offers significant energy savings when replacing conventional electromagnetic installations as well as versatility in application and ease of installation. The recessed EFix TL5 luminaires are available in square and rectangular versions to suit every application. The EFix range is also available in surface-mounted and suspended versions, making it an ideal choice for schools. All EFix families are available with a wide choice of optics – for high efficiency and maximum comfort, as well as asymmetric beams for black and whiteboards.

**Lighting controls – energy savings of up to 75%**
As well as incorporating energy-efficient MASTER TL5 lamps and an electronic gear, the EFix TL5 luminaire range can also be equipped with the ActiLume control for presence detection and daylight-dependent dimming. ActiLume can save up to 75% of the energy compared to older fluorescent lighting systems. Since ActiLume is part of the fitting, installation is straightforward – one simple touch of a button suffices.

# Simply upgrade your lamps and apply lighting controls

## MASTER TL-D Eco



- More than 10% energy savings compared with other T8 fluorescent lamps
- Lower maintenance costs because of longer lifetime compared to standard T8 fluorescent lamps (12,000 hours service lifetime on conventional gear; 17,000 hours on electronic gear)
- Good colour rendering (Ra>80) improves lighting quality
- Optimised for indoor applications (room temperature ≥ 20 °C)

## Occuswitch

- Energy savings of up to 30%
- Presence detection
- Versatile stand-alone movement detector for use in any renovation project

## MASTER LED

- Up to 80% energy savings compared with halogen / incandescent lamps
- Lower maintenance costs because of 45-times-longer lifetime compared with incandescent lamps (45,000 hours)
- Good colour rendering (Ra>80) ensures good lighting quality

## MASTERLine ES

- Up to 40% energy savings compared with standard halogen lamps
- Lower maintenance costs because of 66% longer lifetime compared with standard halogen lamps (5,000 hours)
- Bright, sparkling white light with excellent colour rendering (Ra=100) ensures a comfortable ambience

# Simply replace your luminaires and apply lighting controls

## EFix TPS/TCS260

Energy savings up to **35%**

- Features MASTER TL5 lamps and HF gear for energy savings of up to 35%
- Affordable, cost-effective solution
- Ease of installation ensures quick and simple replacement of luminaires

## EFix TBS260

Energy savings up to **35%**

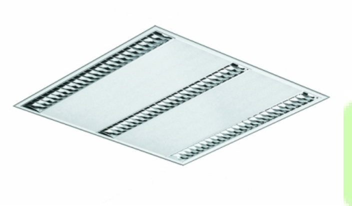
- Features MASTER TL5 lamps and HF gear for energy savings of up to 35%
- Affordable, cost-effective solution
- Ease of installation ensures quick and simple replacement of luminaires

## ActiLume

Energy savings up to **75%**

- Energy savings of up to 75%
- Combines daylight dependent dimming with presence detection
- Integrated into the luminaire

## SmartForm TBS460



Energy savings up to **50%**

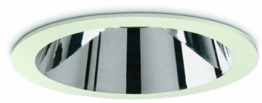
- Features MASTER TL5 lamps and HF gear for up to 50% reduction in energy consumption and $CO_2$ production
- Highly versatile luminaire, designed to fit in a wide range of modular ceiling types and plaster ceilings
- Luminaire can be adapted with various design elements for seamless integration into the ceiling

## Luxsense

Energy savings up to **30%**

- Energy savings up to 30%
- Daylight-dependent dimming
- Integrated into the luminaires

## Fugato downlight



Energy savings up to **50%**

- Features innovative MASTER PL-R Eco lamp and gear for energy savings (compared with PL-C lamps) of up to 50% on conventional gear and 25% on electronic gear
- Lower maintenance costs because of longer lifetime compared to standard PL-C
- Good colour rendering (Ra>80) improves lighting quality

# Realized project: Lamps upgrade

Photo: Primary school De Sponder, The Netherlands

| | before | after |
|---|---|---|
| Lamp type | T8 lamps (58 W) | MASTER TL-D Eco (51 W) |
| Quantity (pcs) | 650 | 650 |

**Savings**

**Cost savings on energy: 10% (approx. 1,000 Euro per year)**

**$CO_2$ savings: approx. 8,000 kg per year**

# Realized project: Luminaires with lighting controls

Photo: Grammar school Süderelbe, Germany

| | before | after |
|---|---|---|
| Luminaire type | T8 luminaires with prismatic optic | EFix luminaires with TL5 lamps and ActiLume control |
| Quantity (pcs) | 10 | 12 (including blackboard lighting) |

**Savings**

**Cost savings on energy: 54% (approx. 65 Euro per classroom per year)**

**$CO_2$ savings: approx. 324 kg per classroom per year**

For more information: **www.asimpleswitch.com**

Data subject to change
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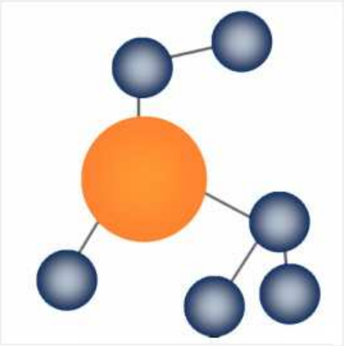
# DALI Professional Controller-4

## Software Manual



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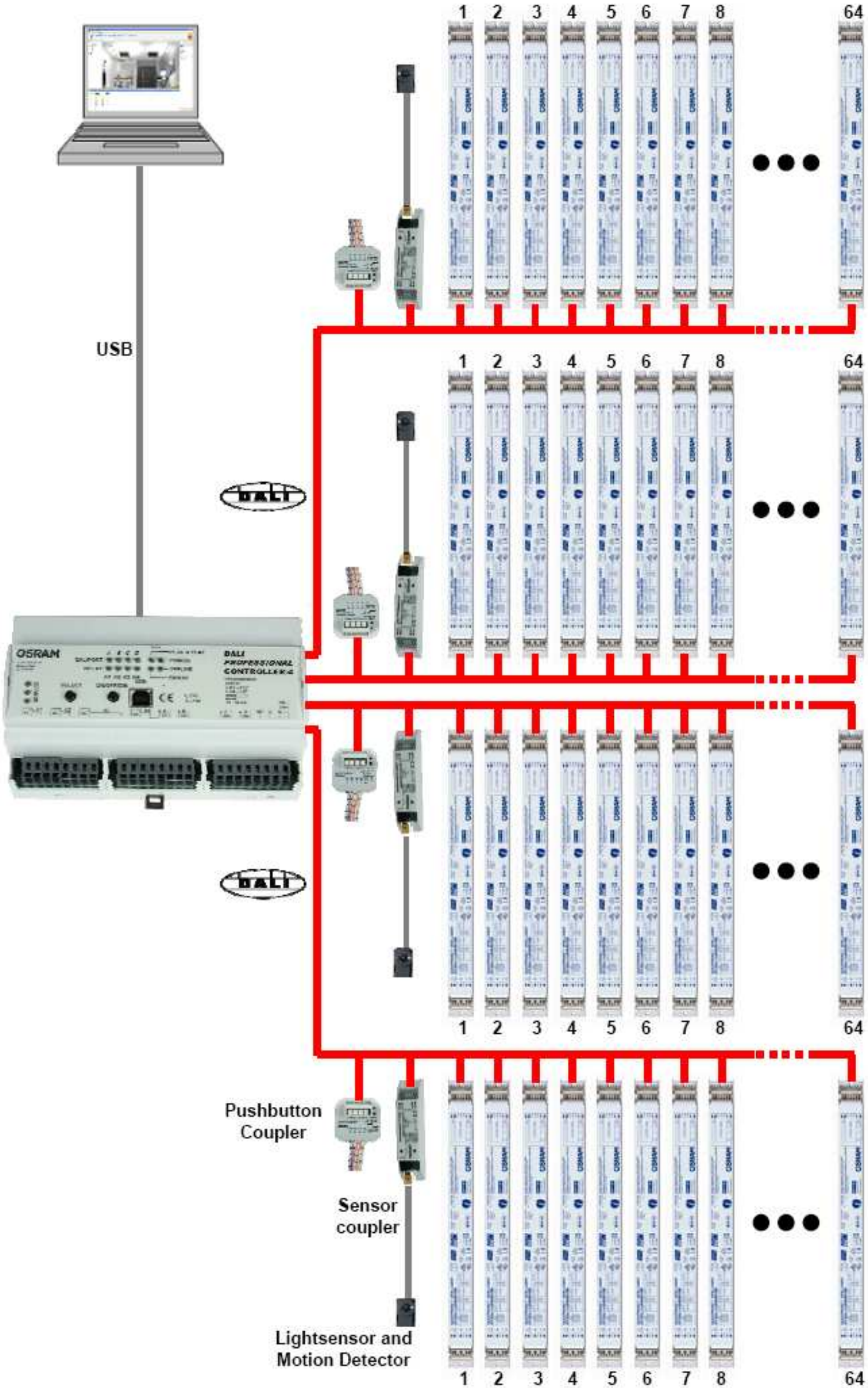
# Introduction

The OSRAM DALI PROFESSIONAL System is a lighting control based on standartized DALI Bus according to IEC 62386 -> *see :* [http://www.dali-ag.org/](http://www.dali-ag.org/)
With this a flexible addressable digital lighting control can be built-up. The central component is the DALI PROFESSIONAL CONTROLLER with 4 DALI lines. These DALI lines can be equipped with DALI suitable ECG for lamp operation and DALI operation units / sensors.



Detailed product descriptions are available for :

- DALI Controller
- DALI Pushbutton Coupler
- DALI Sensorcoupler + Sensors LS/PD
- DALI HIGHBAY Adapter
  + Sensor HIGHBAY or VISION
- DALI LS/PD LI
- DALI e:bus Gateway
- e:bus Glasstouch 6T, 12T, 6TR
- e:bus Touchpanel

# Use with PC, first steps

## Software Installation

Load software from [www.osram.com/software](http://www.osram.com/software)
Extract the .zip file

Install DALI Professional system software by starting
'Setup OSRAM DALI Professional vx.x.x.x.exe'
Default directory for the software : C:\Program Files\OSRAM\DALI Professional\

Establish USB connection Controller - PC

Start program with desktop icon or by
Start / Programs / OSRAM / DALI Professional / OSRAM DALI Professional

Start firmware update to controller if requested by the software
(latest firmware is already automatically stored on PC with software installation)

Supported Windows Versions :
successfully tested with Windows XP, Windows Vista, Win7, Win8

## Operation, Commissioning

Connect controller to PC via USB
Read out devices / assign names
Define groups and functions
Define scenes
Store settings
Upload configuration / settings to controller
Perform tests
Disconnect USB

---

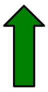
## Caption for Screenshots

Menue line

Message line

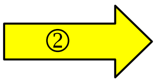
Connected to DALI Professional

click for action



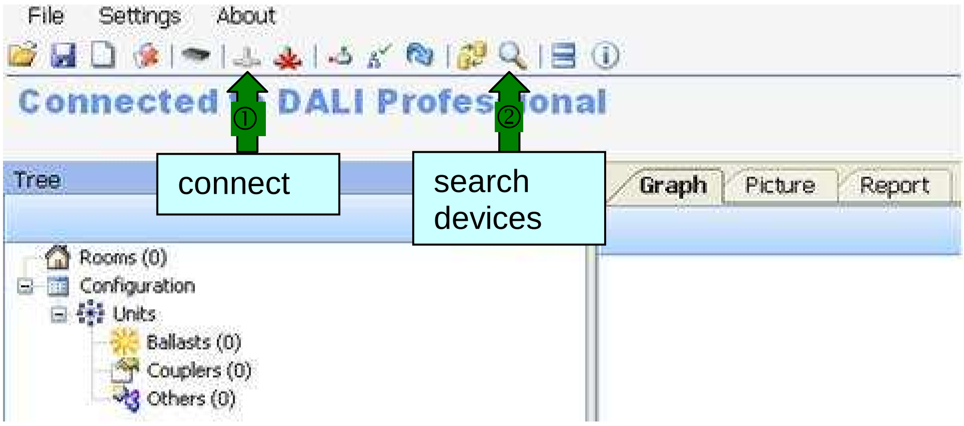
look here

pull for drawing connection
(use numerical order)

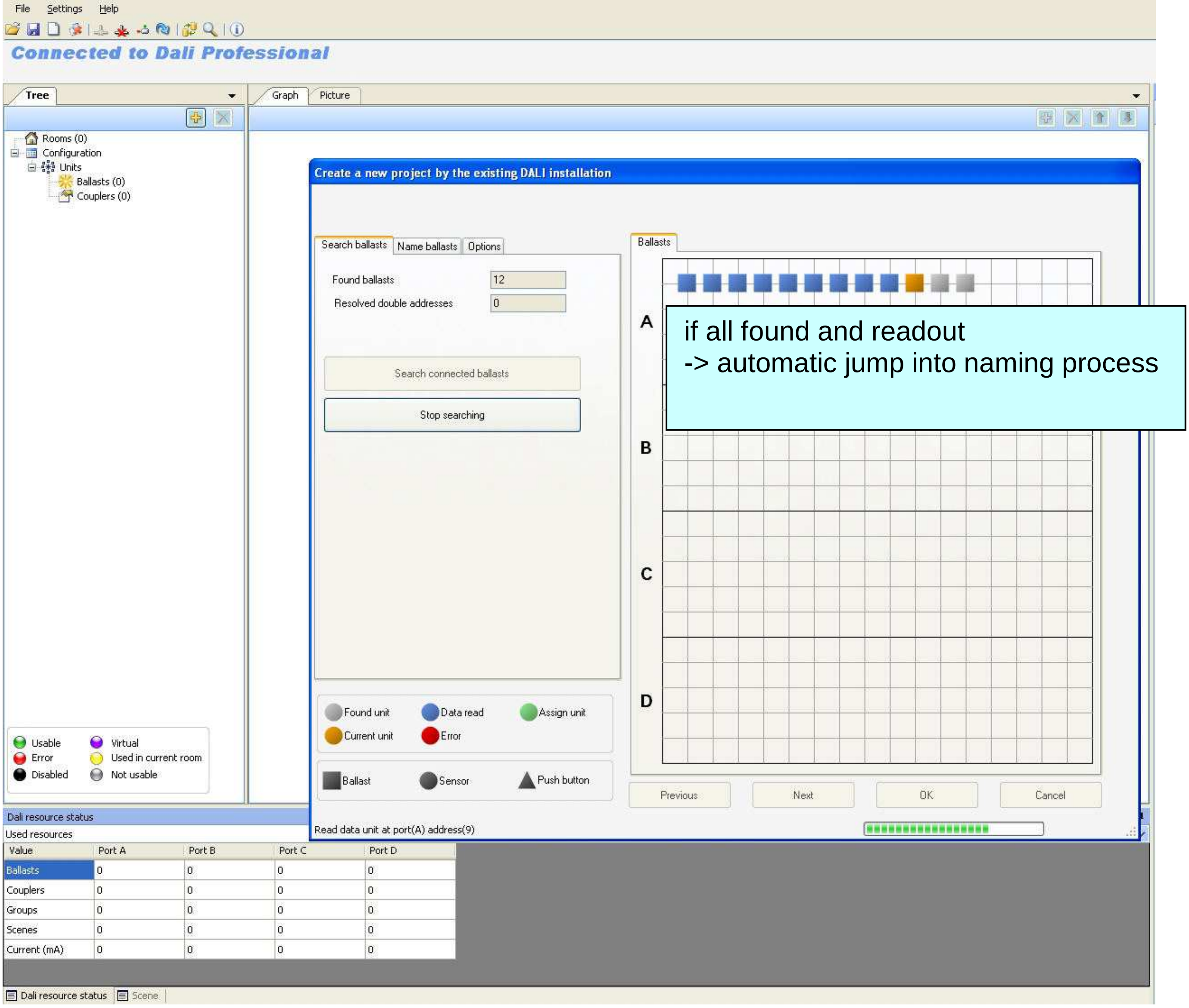


| | |
|---|---|
| **Example application** | Office |
| **Components** | Controller, Luminaires (ECG), Pushbutton- / Sensorcoupler |

## Startscreen, connection with Controller, start search devices



## Search devices, search process



Found ballasts 12

Resolved double addresses 0

if all found and readout
-> automatic jump into naming process

Read data unit at port(A) address(9)

Dali resource status

Used resources

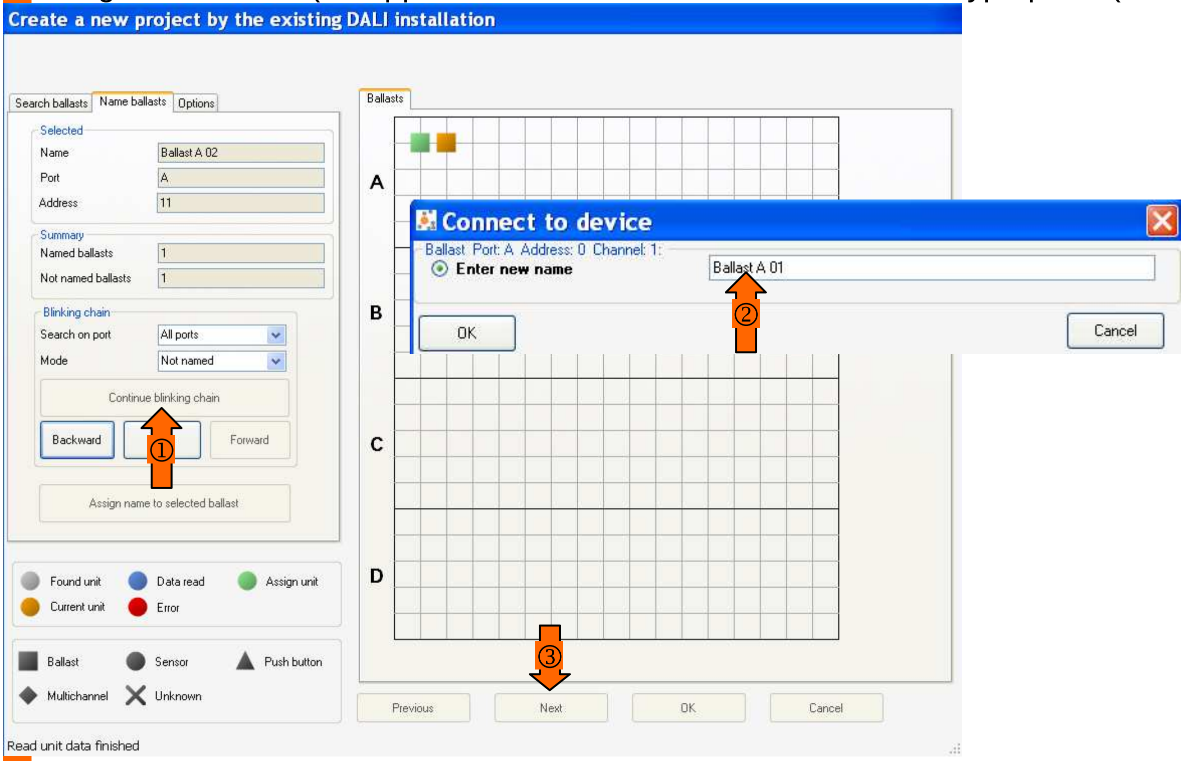
| Value | Port A | Port B | Port C | Port D |
|---|---|---|---|---|
| Ballasts | 0 | 0 | 0 | 0 |
| Couplers | 0 | 0 | 0 | 0 |
| Groups | 0 | 0 | 0 | 0 |
| Scenes | 0 | 0 | 0 | 0 |
| Current (mA) | 0 | 0 | 0 | 0 |

# Find devices and assign names to them / Blink Chain

① start search process

In the blink chain different parameters can be changed in 'Options' :
e.g. chain velocity, blinkfrequency, lightlevel before, after ....

② assign ECG name (if skipped automatic name definition = devicetype port# (device#)



Selected
Name: Ballast A 02
Port: A
Address: 11

Summary
Named ballasts: 1
Not named ballasts: 1

Blinking chain
Search on port: All ports
Mode: Not named

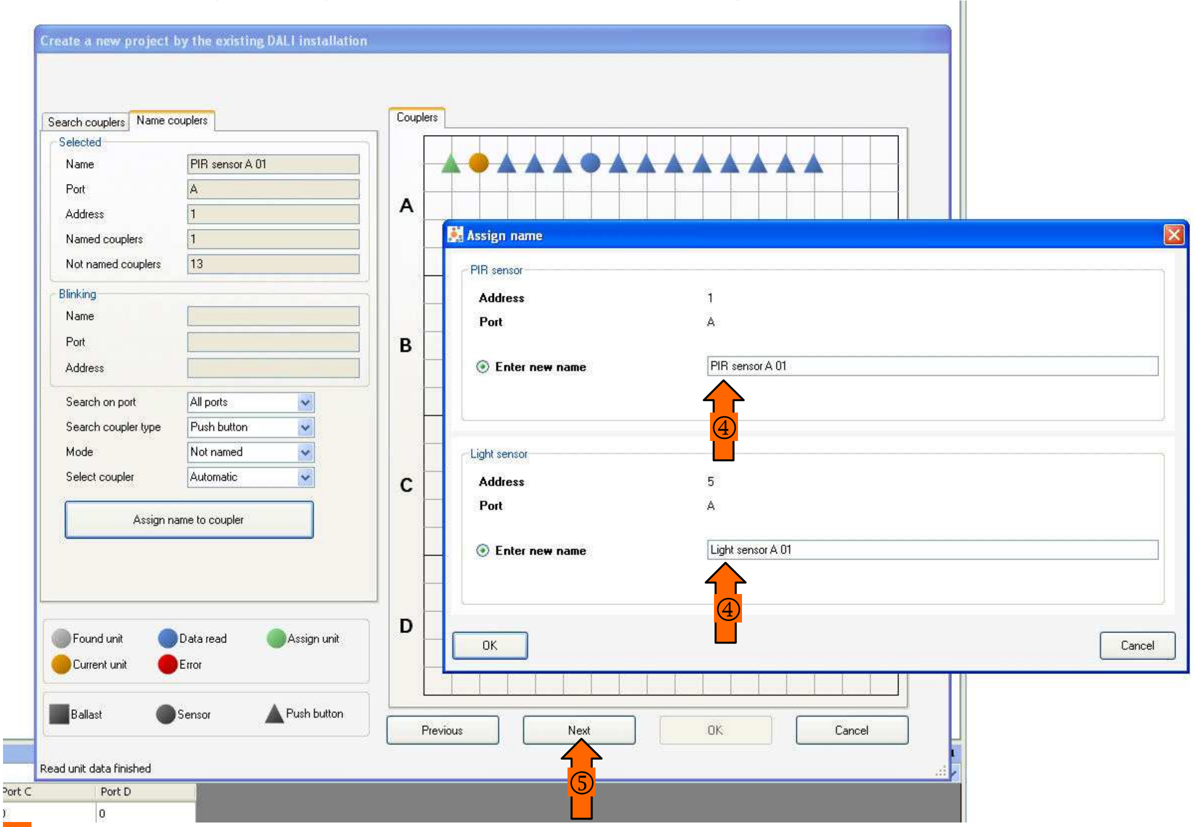
Ballast Port: A Address: 0 Channel: 1:
● Enter new name: Ballast A 01

Read unit data finished

③ If all ECGs identified -> continue with Next

Then proceed analog for coupler devices :

④ Select in 'Search coupler type' between Pushbutton or PIR- and Lightsensor.
Due to the fix mechanical connection between PIR- and Lightsensor,
these devices get assigned names in same workstep.



Selected
Name: PIR sensor A 01
Port: A
Address: 1
Named couplers: 1
Not named couplers: 13

Blinking
Name:
Port:
Address:

Search on port: All ports
Search coupler type: Push button
Mode: Not named
Select coupler: Automatic

PIR sensor
Address: 1
Port: A
● Enter new name: PIR sensor A 01

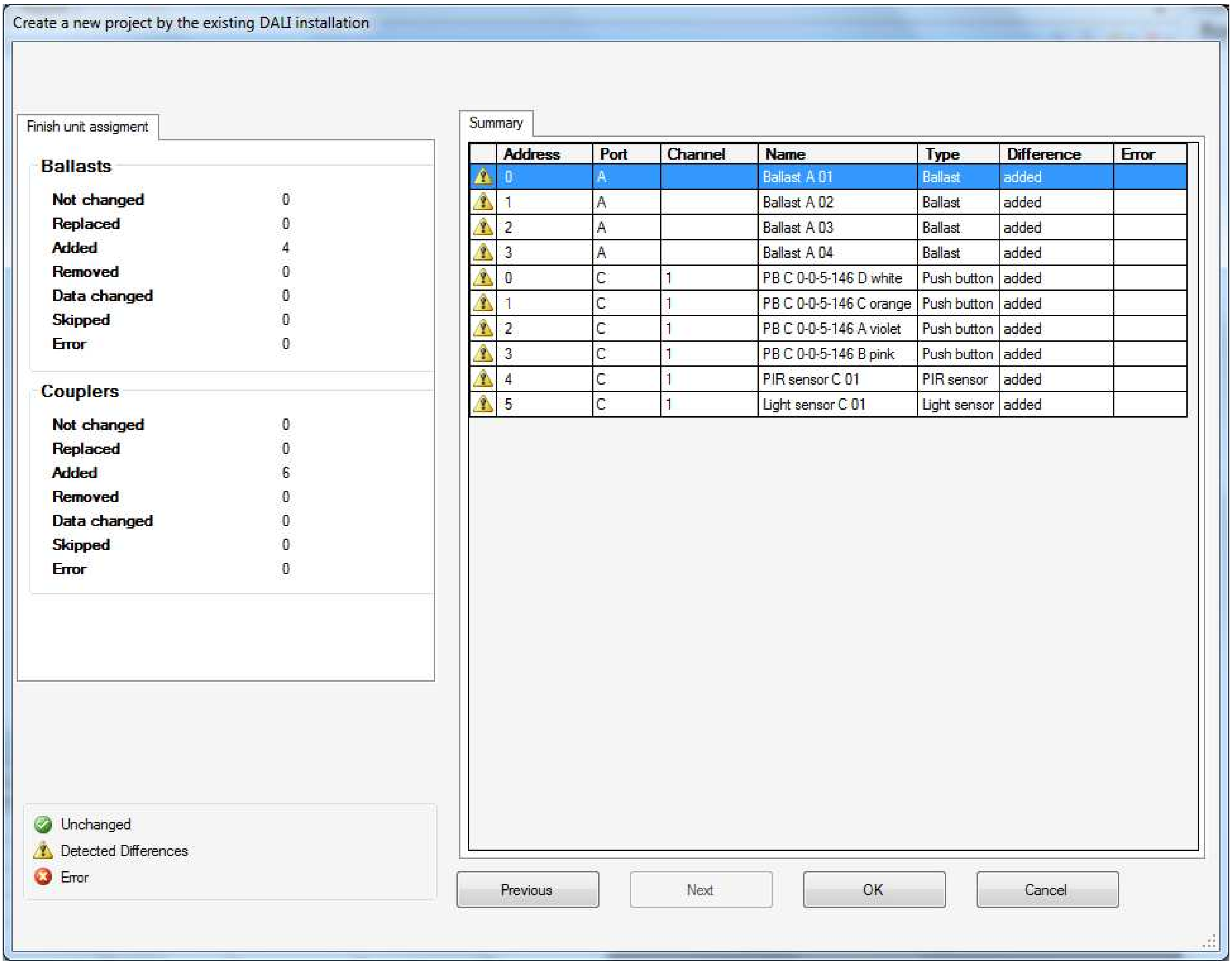
Light sensor
Address: 5
Port: A
● Enter new name: Light sensor A 01

Read unit data finished

Port C: 0
Port D: 0

⑤ continue with Next and complete

# Identification Result - Identification of Devices



Create a new project by the existing DALI installation

Finish unit assigment

**Ballasts**

| | |
|---|---|
| Not changed | 0 |
| Replaced | 0 |
| Added | 4 |
| Removed | 0 |
| Data changed | 0 |
| Skipped | 0 |
| Error | 0 |

**Couplers**

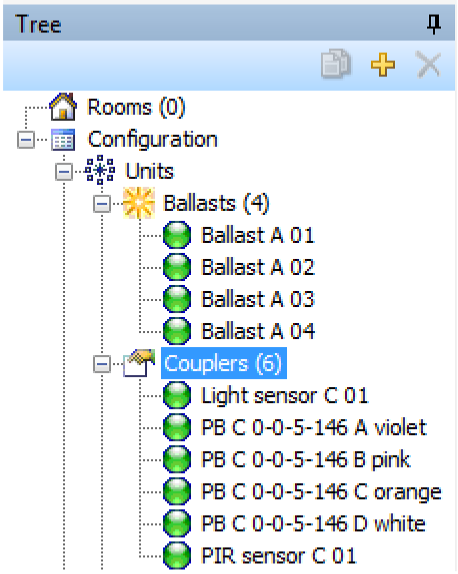
| | |
|---|---|
| Not changed | 0 |
| Replaced | 0 |
| Added | 6 |
| Removed | 0 |
| Data changed | 0 |
| Skipped | 0 |
| Error | 0 |

✓ Unchanged
⚠ Detected Differences
✖ Error

Summary

| | Address | Port | Channel | Name | Type | Difference | Error |
|---|---|---|---|---|---|---|---|
| ⚠ | 0 | A | | Ballast A 01 | Ballast | added | |
| ⚠ | 1 | A | | Ballast A 02 | Ballast | added | |
| ⚠ | 2 | A | | Ballast A 03 | Ballast | added | |
| ⚠ | 3 | A | | Ballast A 04 | Ballast | added | |
| ⚠ | 0 | C | 1 | PB C 0-0-5-146 D white | Push button | added | |
| ⚠ | 1 | C | 1 | PB C 0-0-5-146 C orange | Push button | added | |
| ⚠ | 2 | C | 1 | PB C 0-0-5-146 A violet | Push button | added | |
| ⚠ | 3 | C | 1 | PB C 0-0-5-146 B pink | Push button | added | |
| ⚠ | 4 | C | 1 | PIR sensor C 01 | PIR sensor | added | |
| ⚠ | 5 | C | 1 | Light sensor C 01 | Light sensor | added | |

after OK all identified devices will show up in device tree



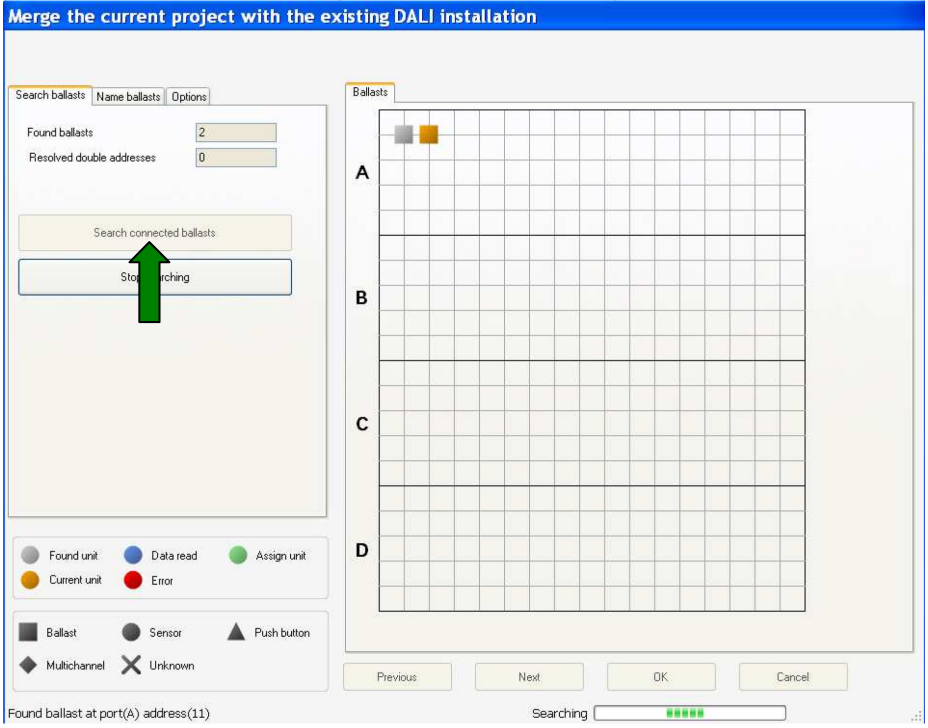
Tree

- Rooms (0)
- Configuration
  - Units
    - Ballasts (4)
      - Ballast A 01
      - Ballast A 02
      - Ballast A 03
      - Ballast A 04
    - Couplers (6)
      - Light sensor C 01
      - PB C 0-0-5-146 A violet
      - PB C 0-0-5-146 B pink
      - PB C 0-0-5-146 C orange
      - PB C 0-0-5-146 D white
      - PIR sensor C 01

# Merge of configuration with existing system / new devices

Combine project with existing DALI installation

Runs similar as search process in first setup, but additional choice of already exisiting names.

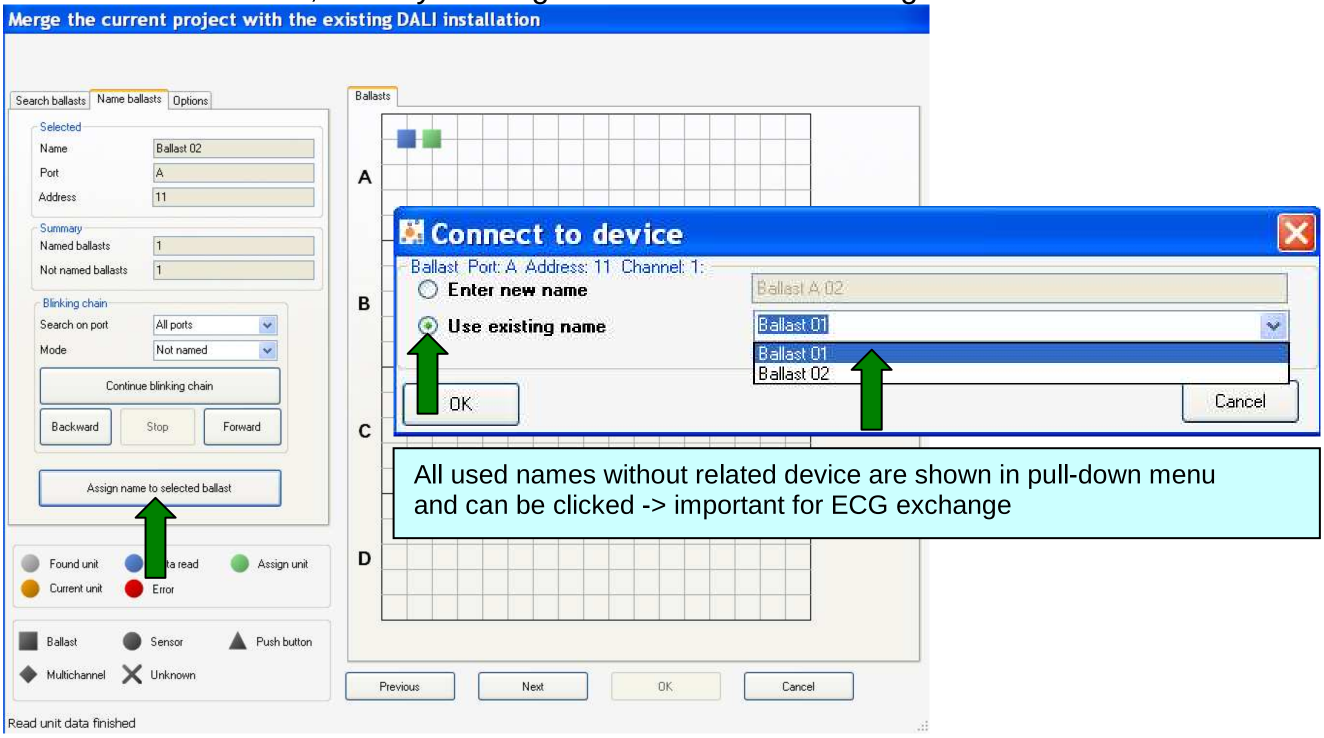


Found ballasts: 2
Resolved double addresses: 0

Found ballast at port(A) address(11)

Searching

Goto Blinkchain und find the related ECGs / coupler
New devices are blue, already existing and named devices are green.



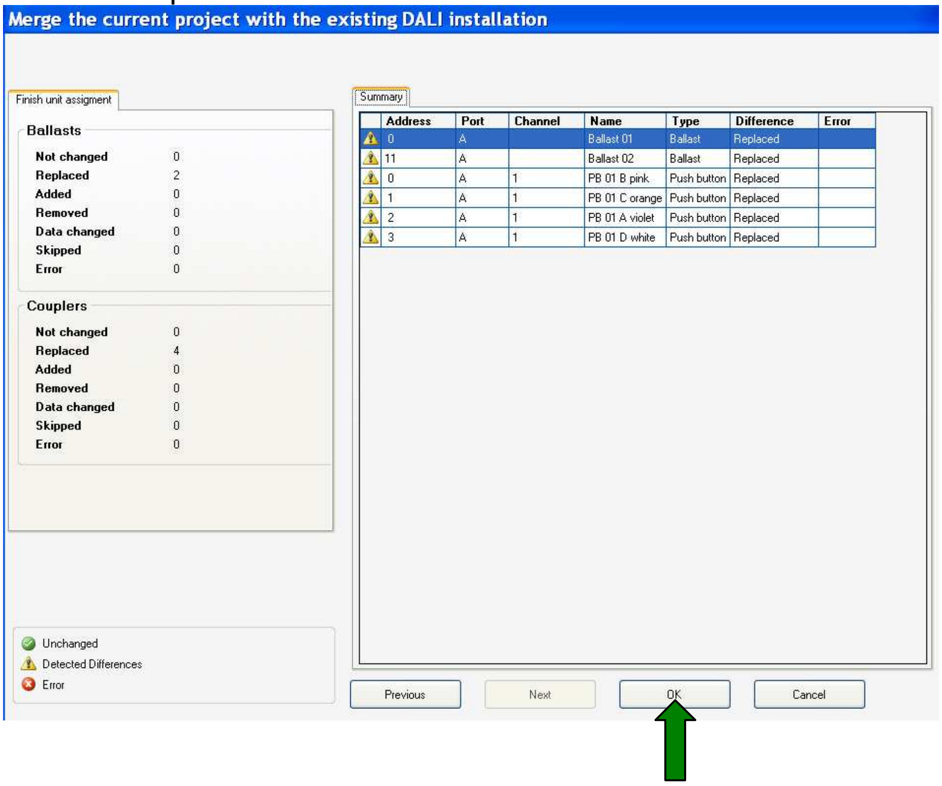
Name: Ballast 02
Port: A
Address: 11
Named ballasts: 1
Not named ballasts: 1
Search on port: All ports
Mode: Not named

Ballast Port: A Address: 11 Channel: 1:
○ Enter new name: Ballast A 02
● Use existing name: Ballast 01
Ballast 01
Ballast 02

All used names without related device are shown in pull-down menu and can be clicked -> important for ECG exchange

Read unit data finished

## Result -> replaced units shown in difference row


**Merge the current project with the existing DALI installation**

**Ballasts**

| | |
|---|---|
| Not changed | 0 |
| Replaced | 2 |
| Added | 0 |
| Removed | 0 |
| Data changed | 0 |
| Skipped | 0 |
| Error | 0 |

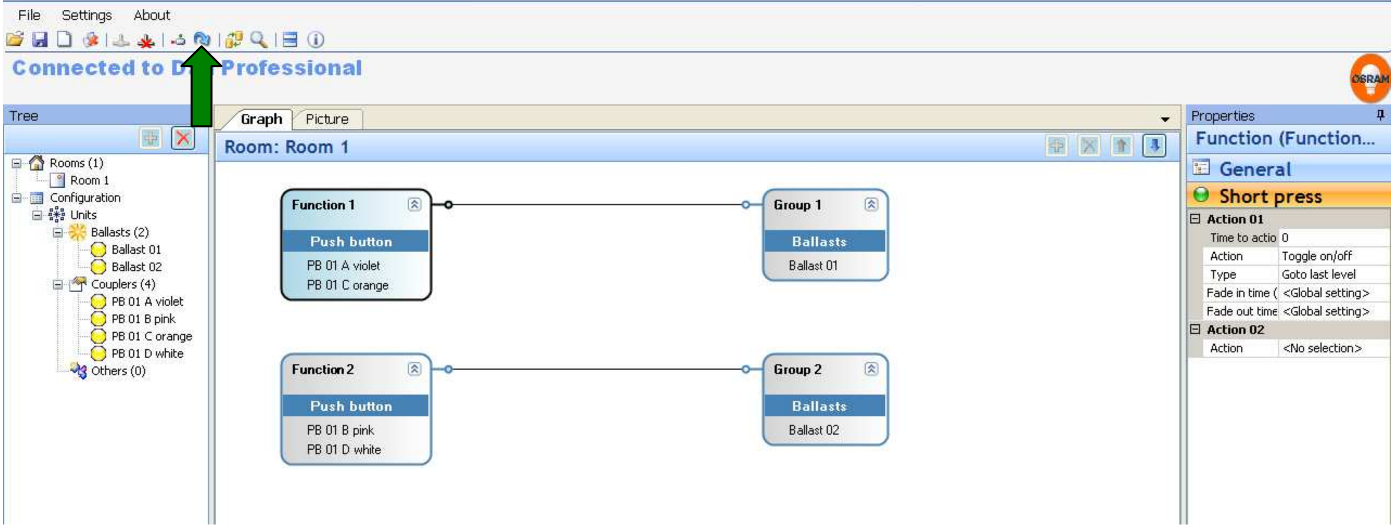
**Couplers**

| | |
|---|---|
| Not changed | 0 |
| Replaced | 4 |
| Added | 0 |
| Removed | 0 |
| Data changed | 0 |
| Skipped | 0 |
| Error | 0 |

| | Address | Port | Channel | Name | Type | Difference | Error |
|---|---|---|---|---|---|---|---|
| ⚠ | 0 | A | | Ballast 01 | Ballast | Replaced | |
| ⚠ | 11 | A | | Ballast 02 | Ballast | Replaced | |
| ⚠ | 0 | A | 1 | PB 01 B pink | Push button | Replaced | |
| ⚠ | 1 | A | 1 | PB 01 C orange | Push button | Replaced | |
| ⚠ | 2 | A | 1 | PB 01 A violet | Push button | Replaced | |
| ⚠ | 3 | A | 1 | PB 01 D white | Push button | Replaced | |

✓ Unchanged
⚠ Detected Differences
✕ Error

## View of merged project



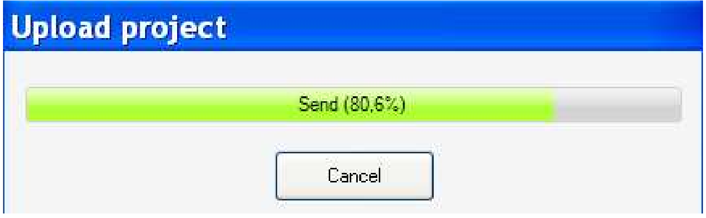
**Action 01**

| | |
|---|---|
| Time to actio | 0 |
| Action | Toggle on/off |
| Type | Goto last level |
| Fade in time ( | <Global setting> |
| Fade out time | <Global setting> |

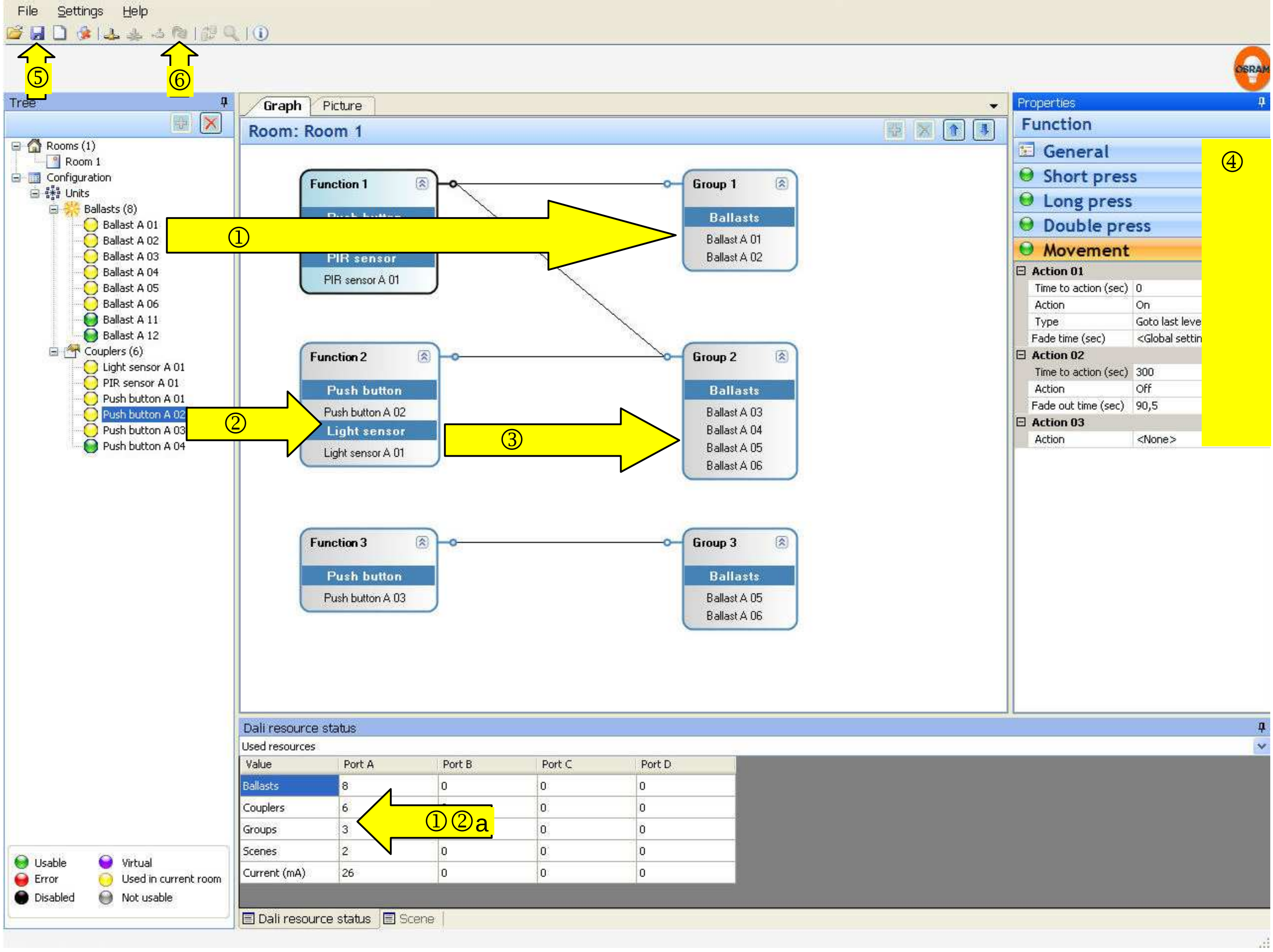
**Action 02**

| | |
|---|---|
| Action | <No selection> |

## Final upload merged project to controller



# Graph View - Define Functions and Parameters



**Action 01**
Time to action (sec): 0
Action: On
Type: Goto last leve
Fade time (sec): <Global settin

**Action 02**
Time to action (sec): 300
Action: Off
Fade out time (sec): 90,5

**Action 03**
Action: <None>

| Value | Port A | Port B | Port C | Port D |
|---|---|---|---|---|
| Ballasts | 8 | 0 | 0 | 0 |
| Couplers | 6 | 0 | 0 | 0 |
| Groups | 3 | 0 | 0 | 0 |
| Scenes | 2 | 0 | 0 | 0 |
| Current (mA) | 26 | 0 | 0 | 0 |

① pull Ballast with into Graph window
into empty area -> new group will be opened
into group -> added to group

② pull Sensor into Graph window
into empty area -> new function will be opened
into function -> added to function

①②a observe ressource status

③ click into function field and draw a line to according group field -> connected

④ define parameters of function (optional, only neccessary if presets shall be changed)
define actions, default for finish sequence is with Action ..= <none>

## Finish Setup

⑤ Store configuration

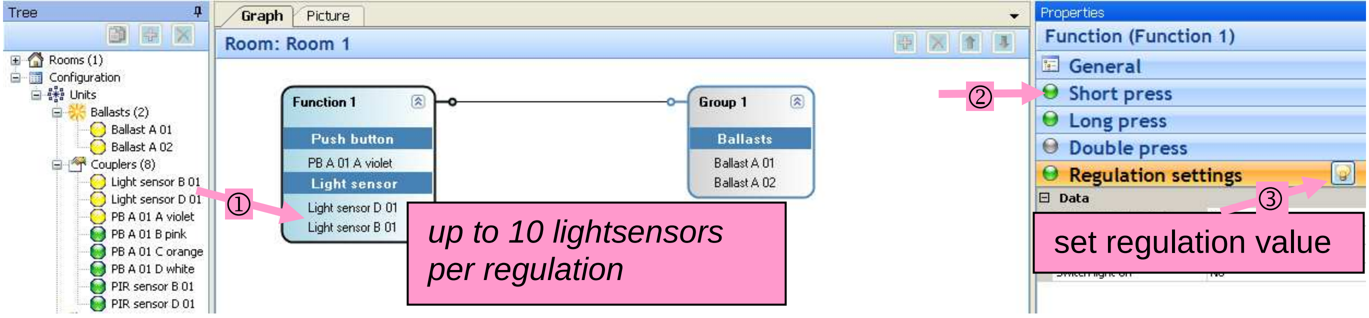
⑥ Upload configuration to controller

Close software program and disconnect USB

-> installation ready for use

## Light Regulation - include lightsensor and set value

① Pull lightsensor into a function, add activation device (pushbutton and/or PIR sensor).
② Configure a shortpress / movement to action = regulation.

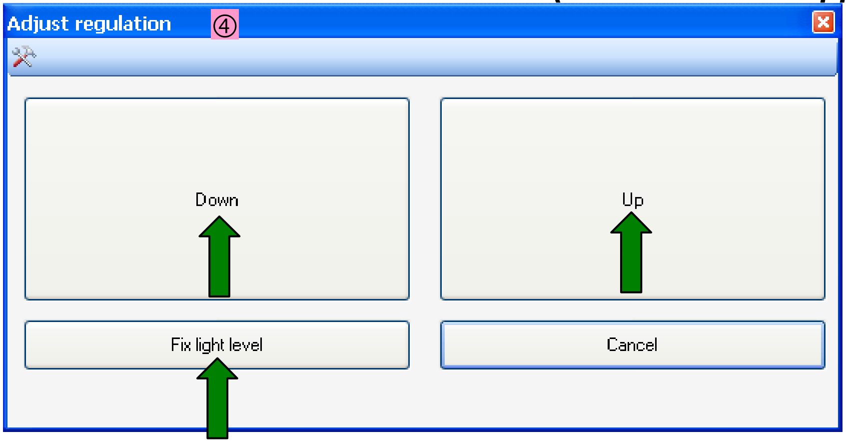


up to 10 lightsensors per regulation

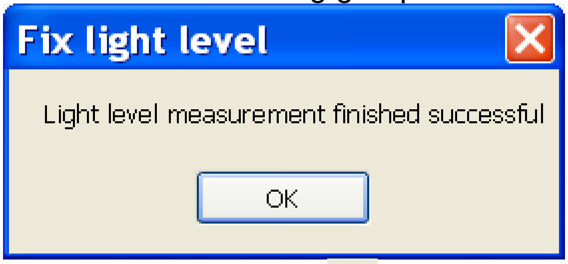
set regulation value

③ Press button for 'regulation setting'
④Adjustment window shows up

### *Procedure without room calibration (standard for all applications)*



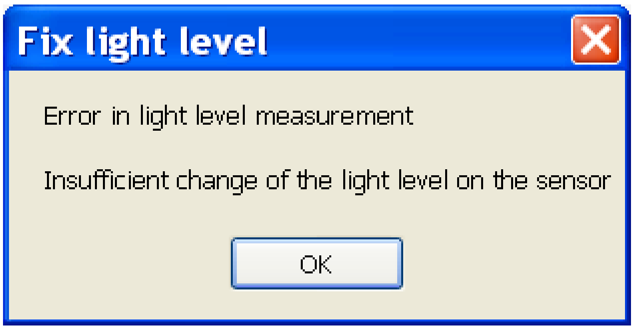
set requested illumination level by pressing Down / Up
store value - according group flashes -> value saved



Light level measurement finished successful

-> Upload to controller , then start regulation via related pushbutton or PIR

We recommend to set the lightregulation levels at a time of the day when the lightinfluence from outside is low to avoid sensor overflow. If not there could happen a error message :



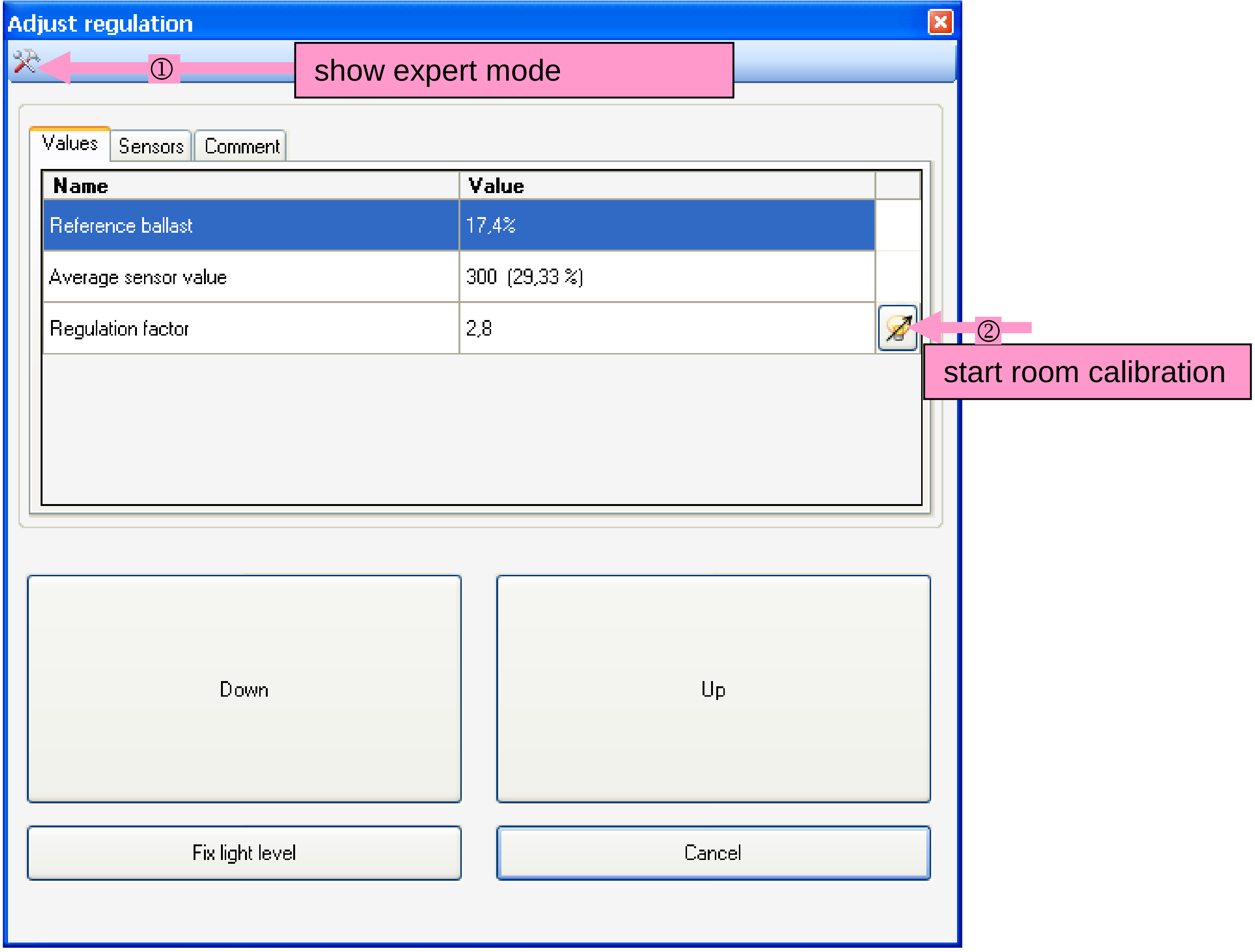
Error in light level measurement

Insufficient change of the light level on the sensor

# (OPTIONAL) Extended functions for light regulation

***Procedure with room calibration***

Recommended in case of critical light environments where the standard method provides unsufficient accuracy e.g. caused by direct sunlight influence. Checks the geometric paramenters of the room and positioning of the lightsensor, but needs a light measurement device (Luxmeter).

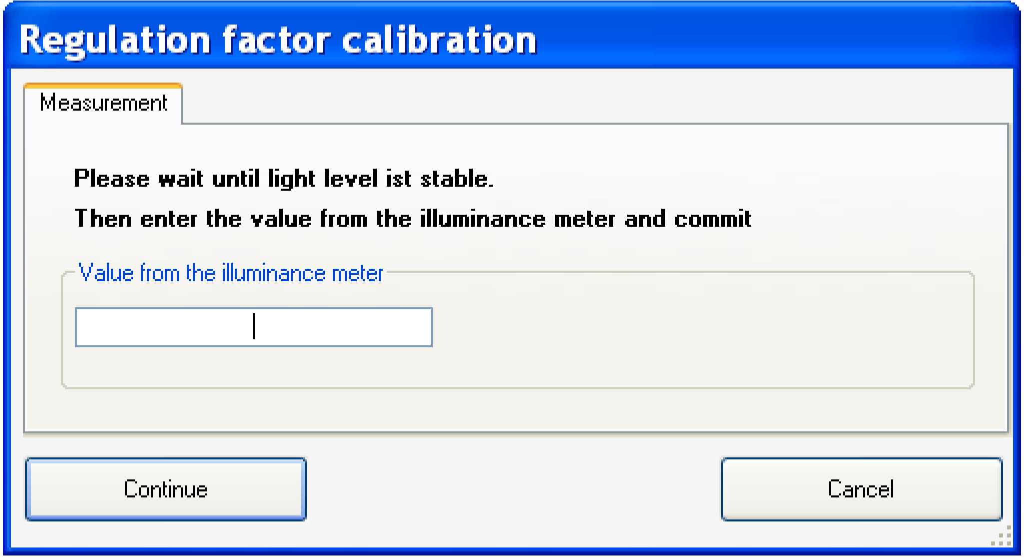


① show expert mode

② start room calibration

| Name | Value |
|---|---|
| Reference ballast | 17,4% |
| Average sensor value | 300 (29,33 %) |
| Regulation factor | 2,8 |

2x input measurement value for light ON and light OFF



**Please wait until light level ist stable.**

**Then enter the value from the illuminance meter and commit**

Value from the illuminance meter

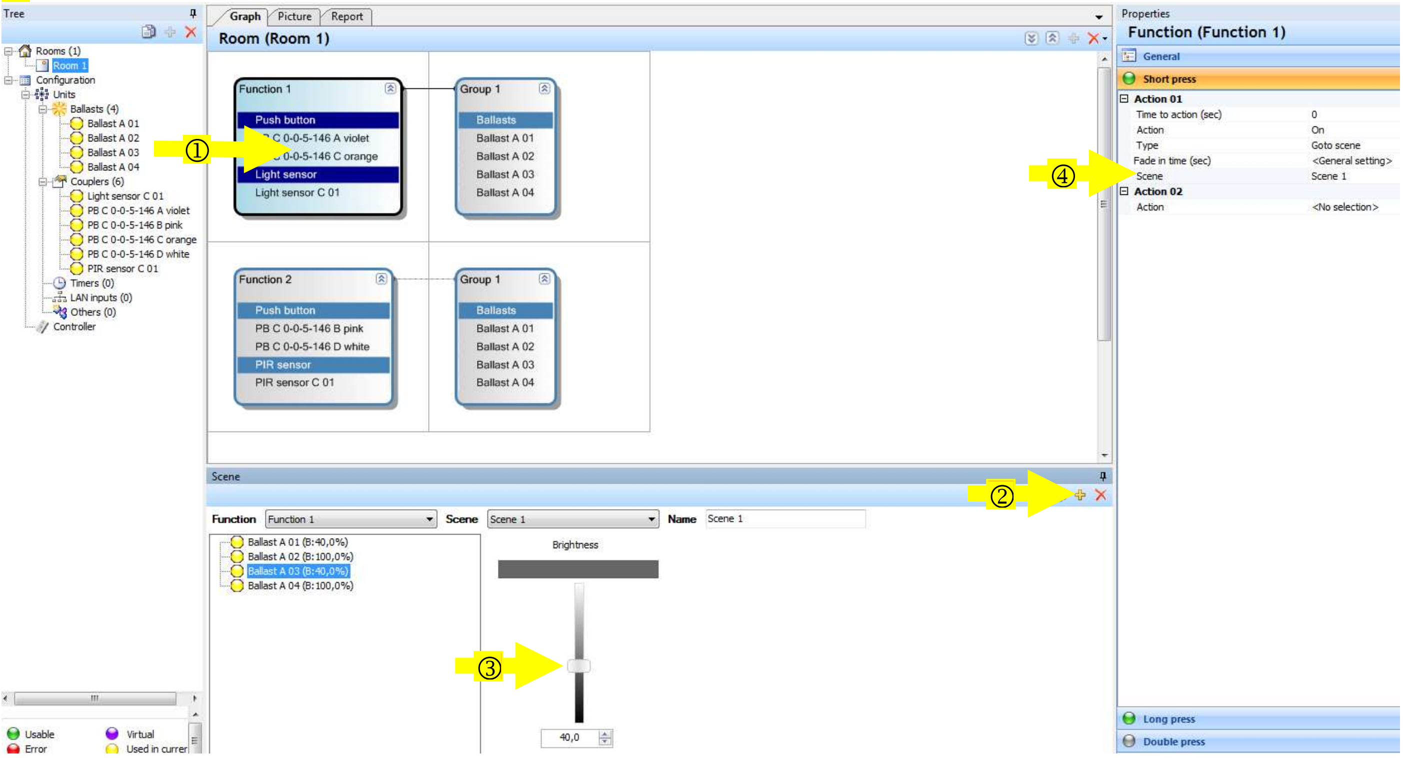
After this inputs set lightlevel as decribed in standard procedure without calibration.

Then Upload to controller (to save all created regulation values there)

## Creating and Calling Scenes

DALI scenes can be created on screen and called via pushbutton.

① Click to function
② Add new scene with ✚
③ Define light levels for each ballast
④ Define scene to be called with this button



Scene

**Function** Function 1 **Scene** Scene 1 **Name** Scene 1

Ballast A 01 (B:40,0%)
Ballast A 02 (B:100,0%)
Ballast A 03 (B:40,0%)
Ballast A 04 (B:100,0%)

Short press

**Action 01**

| | |
|---|---|
| Time to action (sec) | 0 |
| Action | On |
| Type | Goto scene |
| Fade in time (sec) | <General setting> |
| Scene | Scene 1 |

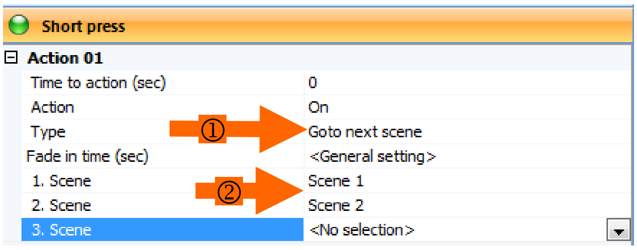
**Action 02**

| | |
|---|---|
| Action | <No selection> |

## Goto Next Scene - Call Several Scenes with one Single Pushbutton

Feature to go through several scenes with only one pushbutton.

- Each shortpress on pushbutton calls next scene in list
- If full scene loop has been called through - loop starts again with first scene in list
- Max. 16 scenes can be used
- Each scene can be used only one time in the order
- Works only in Action type = On
- If power failure occurs first scene in order will be recalled



Short press

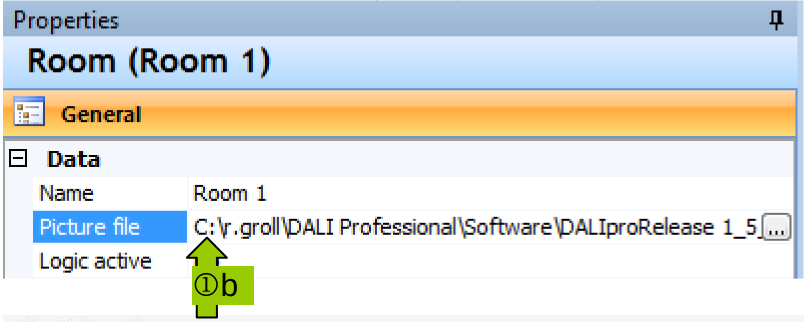
**Action 01**

| | |
|---|---|
| Time to action (sec) | 0 |
| Action | On |
| Type | Goto next scene |
| Fade in time (sec) | <General setting> |
| 1. Scene | Scene 1 |
| 2. Scene | Scene 2 |
| 3. Scene | <No selection> |

Configuration :
Scene configuration as usual with scene creation in Scene window
Then start design of scene order :
① select 'goto next scene'
② add scene# from pull-down menue to select order of scenes

# (OPTIONAL) Picture View - Arrange Devices and Create Scenes

①a,b Select room, import room picture as .jpg or .bmp
Picture can be removed again by selecting and delete.



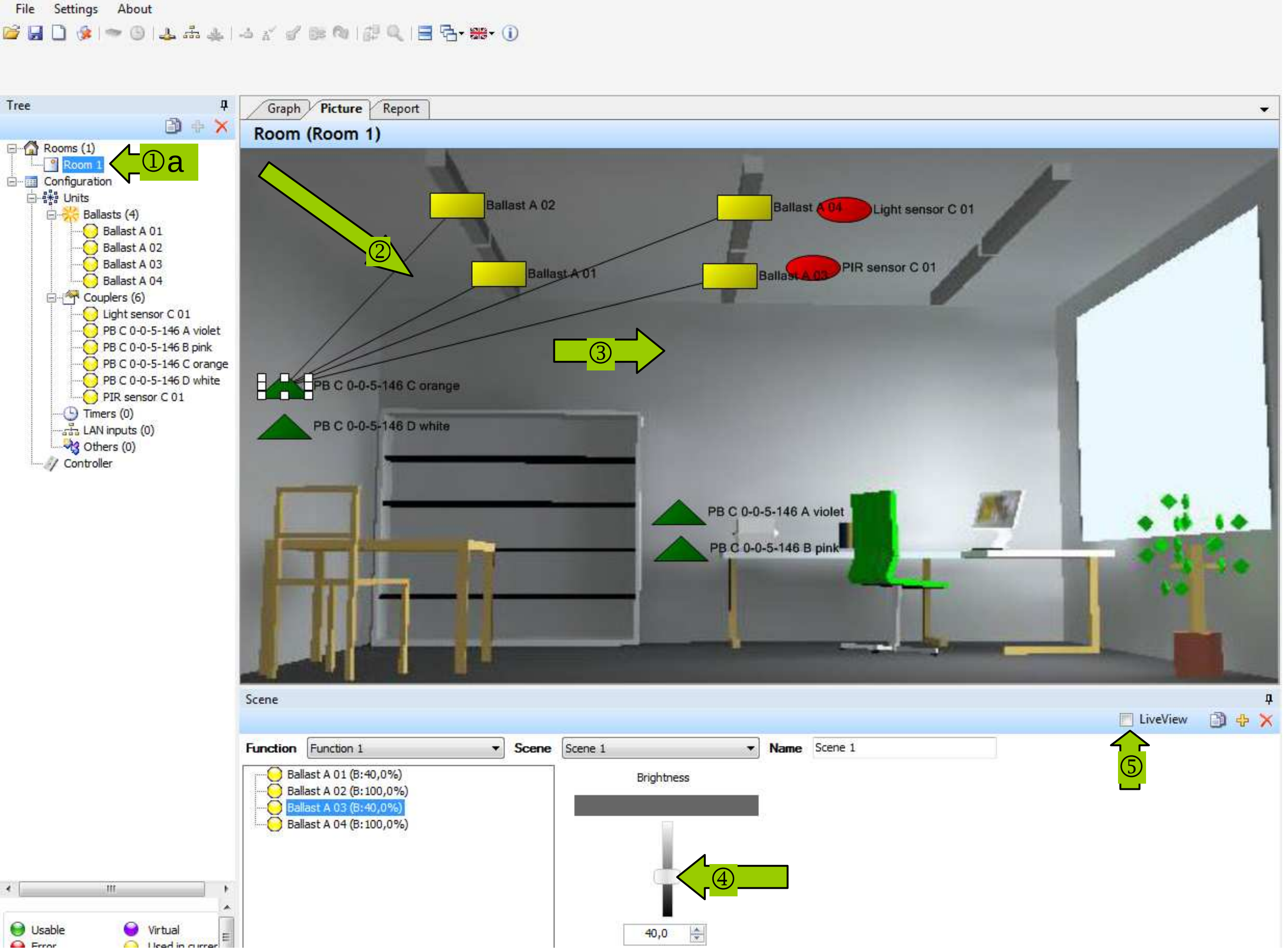
Properties

**Room (Room 1)**

**General**

**Data**

Name: Room 1
Picture file: C:\r.groll\DALI Professional\Software\DALIproRelease 1_5
Logic active



Function: Function 1
Scene: Scene 1
Name: Scene 1

Ballast A 01 (B:40,0%)
Ballast A 02 (B:100,0%)
Ballast A 03 (B:40,0%)
Ballast A 04 (B:100,0%)

Brightness: 40,0

② Pull ballast symbols (yellow rectangle) to luminaire
Analog pull sensors, pushbuttons to requested position

③ Check connection lines
In example above all devices which are functional connected with the button

④ Create scenes (with slider) and store by 'Add'. Multiple selection of luminaires is possible.

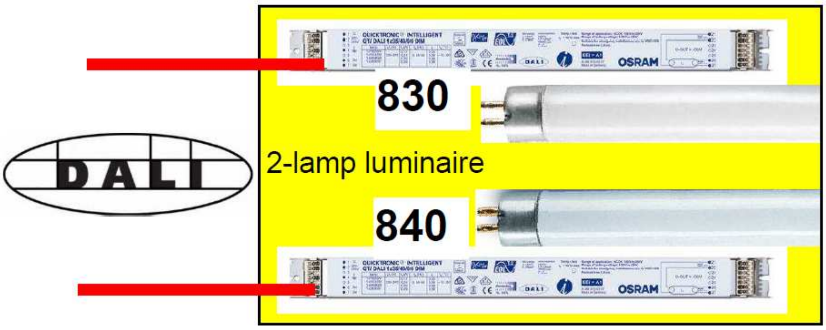
⑤ Check screen luminaire against real luminaire with 'Live view'.
Do not forget to remove 'Live view' afterwards to avoid DALI traffic reduction.

! no configuration changes possible in this view, only in Graph view

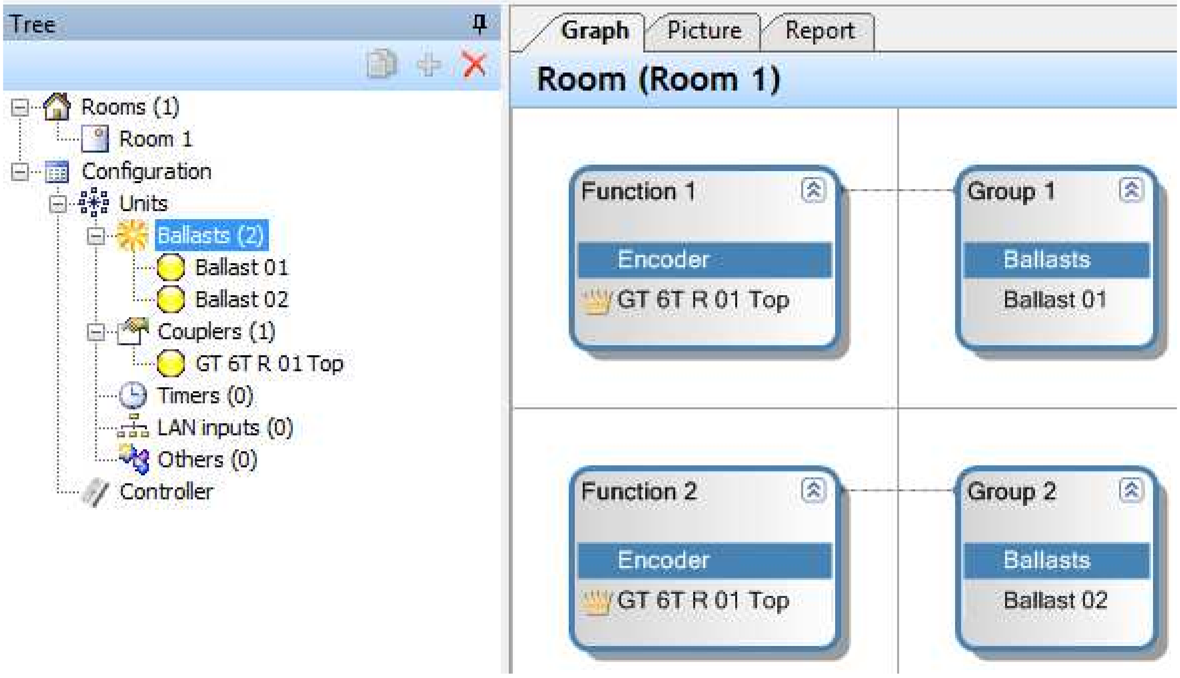
# Tunable White with Glasstouch Wheel

Use Glasstouch 6TR for continous change of colour temperature


Glass Touch 6TR
GT 6T R 01 bottom
GT 6T R 01 left top
GT 6T R 01 right top
GT 6T R 01 left middle
GT 6T R 01 right middle
GT 6T R 01 left bottom
GT 6T R 01 right bottom
GT 6T R 02 Top



Configure 'Left Long press' to Dimm down and 'Right Long Press' to Dimm up for one ECG and 'Left Long press' to Dimm up and 'Right Long Press' to Dimm down for the other


Tree
- Rooms (1)
  - Room 1
- Configuration
  - Units
    - Ballasts (2)
      - Ballast 01
      - Ballast 02
    - Couplers (1)
      - GT 6T R 01 Top
    - Timers (0)
    - LAN inputs (0)
    - Others (0)
  - Controller

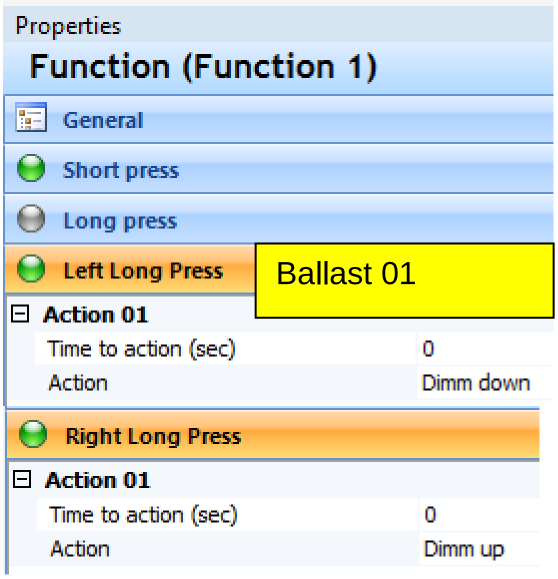
Graph | Picture | Report

Room (Room 1)

Function 1 — Encoder: GT 6T R 01 Top — Group 1 — Ballasts: Ballast 01

Function 2 — Encoder: GT 6T R 01 Top — Group 2 — Ballasts: Ballast 02

The crown occurs as reminder because same input device button is used in different functions


Properties

Function (Function 1)

General
Short press
Long press
Left Long Press — Ballast 01

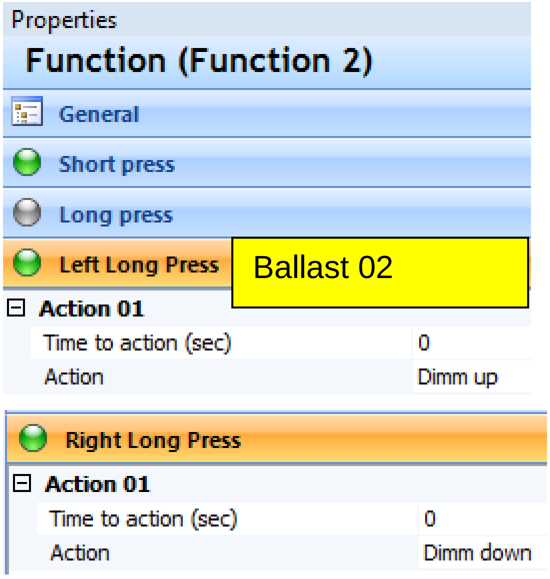
Action 01

| | |
|---|---|
| Time to action (sec) | 0 |
| Action | Dimm down |

Right Long Press

Action 01

| | |
|---|---|
| Time to action (sec) | 0 |
| Action | Dimm up |


Properties

Function (Function 2)

General
Short press
Long press
Left Long Press — Ballast 02

Action 01

| | |
|---|---|
| Time to action (sec) | 0 |
| Action | Dimm up |

Right Long Press

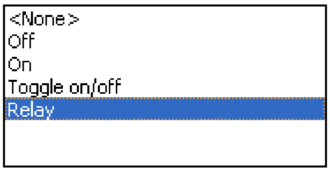
Action 01

| | |
|---|---|
| Time to action (sec) | 0 |
| Action | Dimm down |

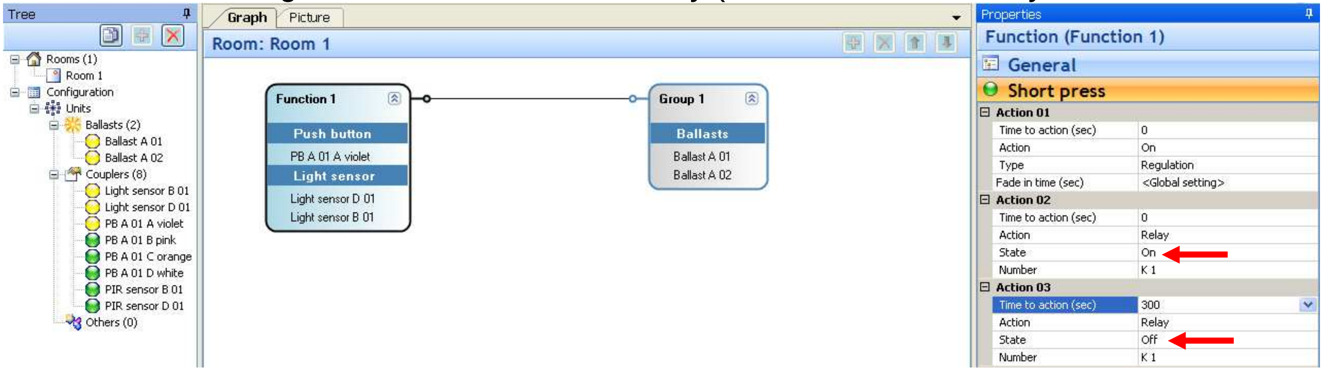
Disable Shortpress, Longpress, Doublepress for the button 'Top' to avoid unwanted activation during wheel turn by the button in the middle.

## Use of internal relay

The 4 internal relais K1...4 can be switched with pushbutton / PIR or used in action lists.
How to use : click 'Relay' in Action



Define a function e.g. with ECG and add the relay (here : ON immediately, OFF after 5 minutes)



Function (Function 1)

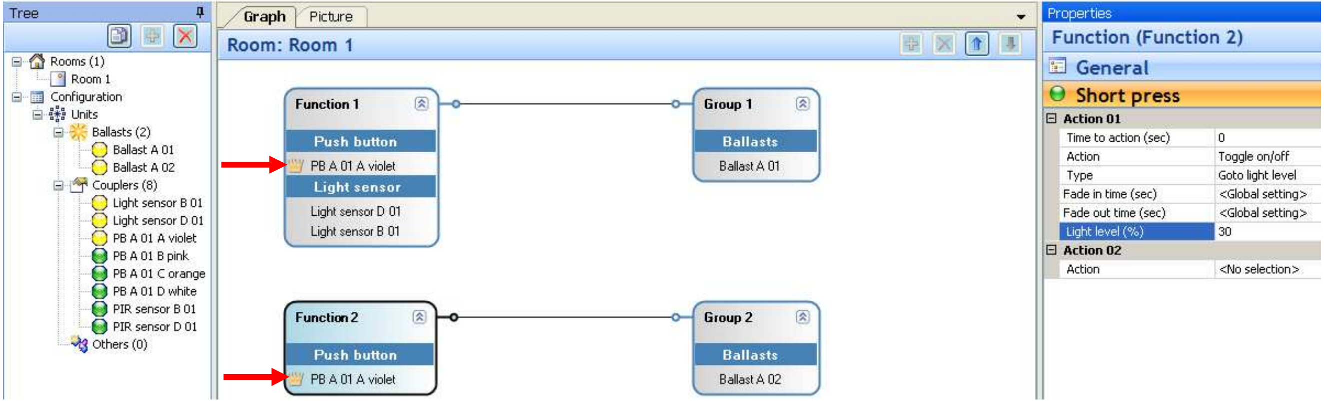
General

Short press

| Action 01 | |
|---|---|
| Time to action (sec) | 0 |
| Action | On |
| Type | Regulation |
| Fade in time (sec) | <Global setting> |
| **Action 02** | |
| Time to action (sec) | 0 |
| Action | Relay |
| State | On |
| Number | K 1 |
| **Action 03** | |
| Time to action (sec) | 300 |
| Action | Relay |
| State | Off |
| Number | K 1 |

## Multiple use of Pushbutton (Crown Function)

Start several functions from one pushbutton e.g. regulation ON for one group + lightlevel 30% for other group. With this a crown appears PB A 01 A violet to show the multiple use of the button



Function (Function 2)

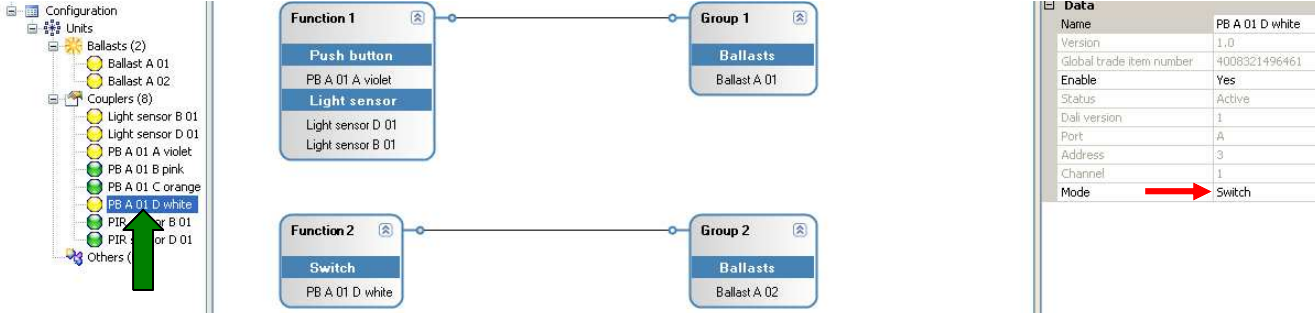
General

Short press

| Action 01 | |
|---|---|
| Time to action (sec) | 0 |
| Action | Toggle on/off |
| Type | Goto light level |
| Fade in time (sec) | <Global setting> |
| Fade out time (sec) | <Global setting> |
| Light level (%) | 30 |
| **Action 02** | |
| Action | <No selection> |

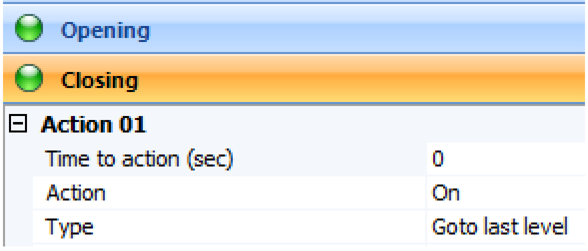
## Change Pushbutton to Switch Input

If a switch is connected
Click pushbutton in device tree, change properties from pushbutton to switch



| Data | |
|---|---|
| Name | PB A 01 D white |
| Version | 1.0 |
| Global trade item number | 4008321496461 |
| Enable | Yes |
| Status | Active |
| Dali version | 1 |
| Port | A |
| Address | 3 |
| Channel | 1 |
| Mode | Switch |

Now new handling parameter occur: Opening + Closing



Opening

Closing

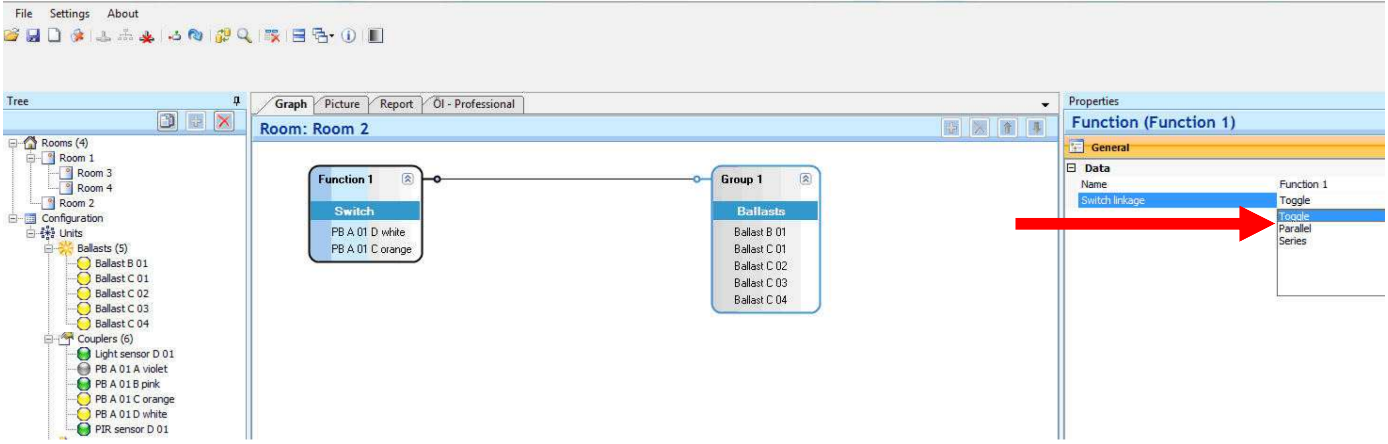
| Action 01 | |
|---|---|
| Time to action (sec) | 0 |
| Action | On |
| Type | Goto last level |

# Switch Interactions - Parallel / Serial Connection of Switches

The switch interactions functionality enables the configurator to set the behaviour of the actions for the open/close event.

- Works only for devices configured as switches
- The maximum number of switches in this function is 16
- The switch interactions are only valid for the function where it is configured
- Three types of switch interaction are defined
- The default behaviour is toggle

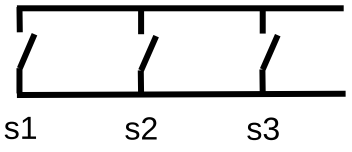
Configuration of the switch linkage in 'Function / General'



Name: Function 1
Switch linkage: Toggle

- **Toggle** (default setting)
  - Independent behaviour of each switch, triggered by event (opening/closing)
- **Parallel** (only off if all off)
  - ***Logic Table Parallel = OR***

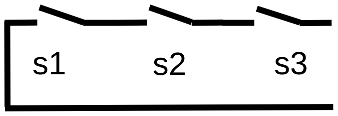
| switch status | s1 | s2 | s3 | Result |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | **0** |
| 2 | 1 | 0 | 0 | **1** |
| 3 | 0 | 1 | 0 | **1** |
| 4 | 0 | 0 | 1 | **1** |
| 5 | 1 | 1 | 0 | **1** |
| 6 | 0 | 1 | 1 | **1** |
| 7 | 1 | 0 | 1 | **1** |
| 8 | 1 | 1 | 1 | **1** |



  - 0 = open / off, 1 = closed / on
  - Every closing event from any switch (s1,s2,s3) will re-trigger the action list

- **Serial** (only on if all on)
  - ***Logic Table Serial = AND***

| switch status | s1 | s2 | s3 | Result |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | **0** |
| 2 | 1 | 0 | 0 | **0** |
| 3 | 0 | 1 | 0 | **0** |
| 4 | 0 | 0 | 1 | **0** |
| 5 | 1 | 1 | 0 | **0** |
| 6 | 0 | 1 | 1 | **0** |
| 7 | 1 | 0 | 1 | **0** |
| 8 | 1 | 1 | 1 | **1** |



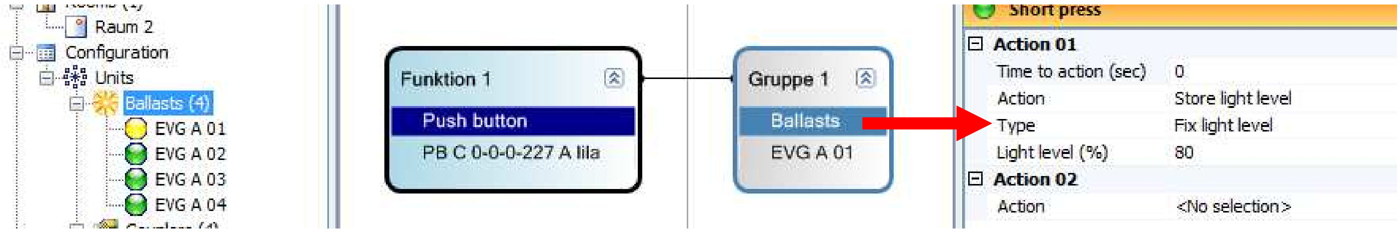
  - 0 = open / off, 1 = closed / on
  - Every opening event from any switch (s1,s2,s3) will re-trigger the action list

# Preselect Lightlevel- Option of Several Lightlevel for Events

Enables to store user defined light levels for all groups connected with a function into the controller. This lightlevels can be recalled at any time.

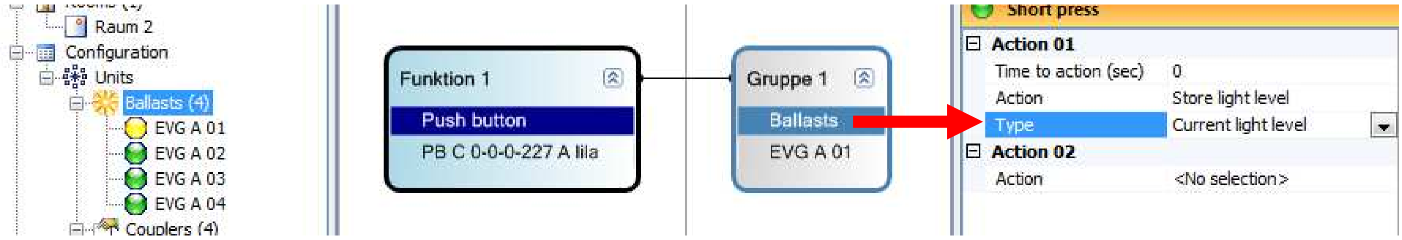
- 2 types of level can be used:
  - Fix light levels stored with configuration
  - Current light level.
    If the ballasts have different levels the maximum from all levels will be used.
- The last value stored will be recalled with 'Goto stored light level' command.
- Does NOT work for scene single ballast values, NOT for regulation values
- The default value is 80% (DALI value 246)
- New action:
  - Store light level:
    Selects light level (fixed or current) for the connected groups and stores it on the controller. But no change in the current light situation of the project
- New action type (to be used in On or Toggle action):
  - Goto stored level:
    Recall the stored lightlevel to the ballasts of all connected groups.
    The 'Goto stored level' command uses the latest value that has been saved.

Select FIX light level and store the value to controller:



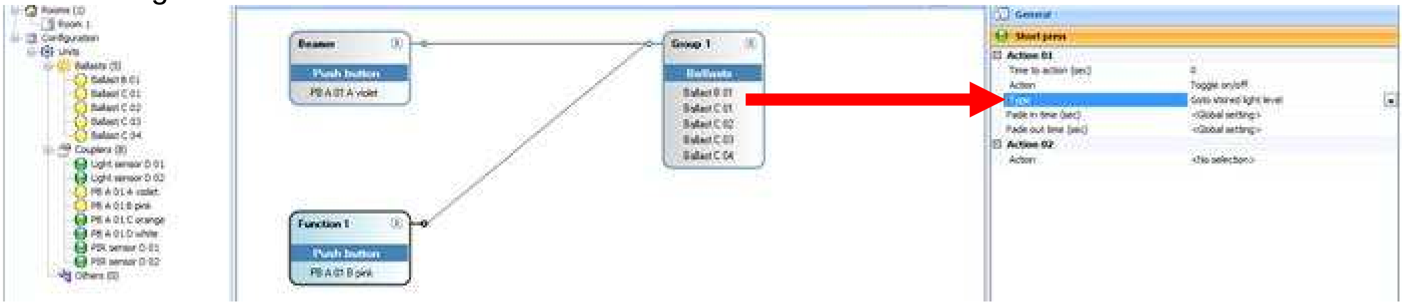
**Action 01**
Time to action (sec) 0
Action Store light level
Type Fix light level
Light level (%) 80
**Action 02**
Action <No selection>

Select CURRENT light level and store the value to controller:



**Action 01**
Time to action (sec) 0
Action Store light level
Type Current light level
**Action 02**
Action <No selection>

RECALL light level from controller:



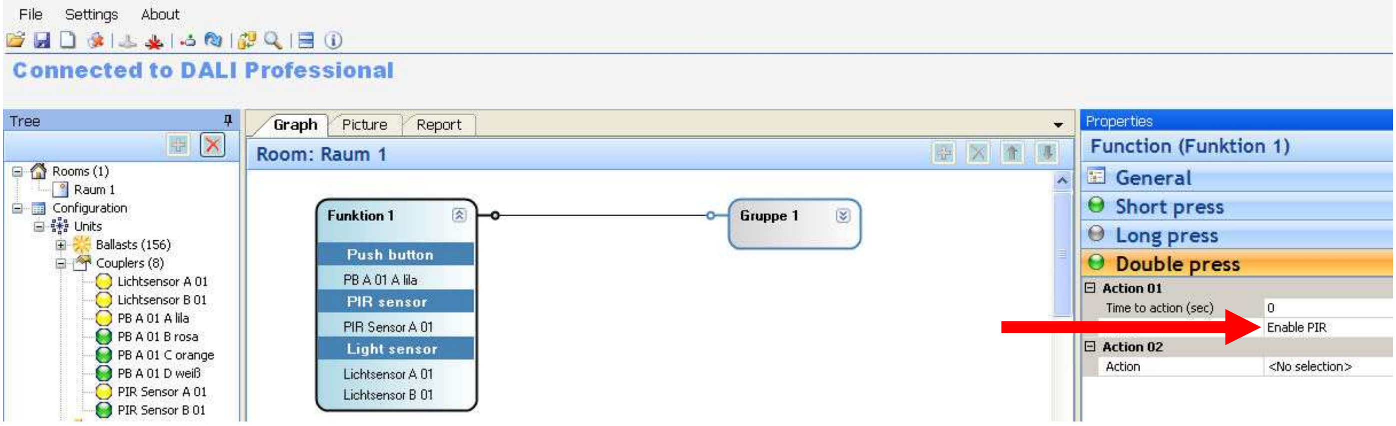
**Action 01**
Time to action (sec) 0
Action Toggle on/off
Type Goto stored light level
Fade in time (sec) <Global setting>
Fade out time (sec) <Global setting>
**Action 02**
Action <No selection>

# PIR Sleep Mode - Option to Disable Occupancy Sensor

The PIR sleep mode allows to enable and disable the PIR sensor in a function.

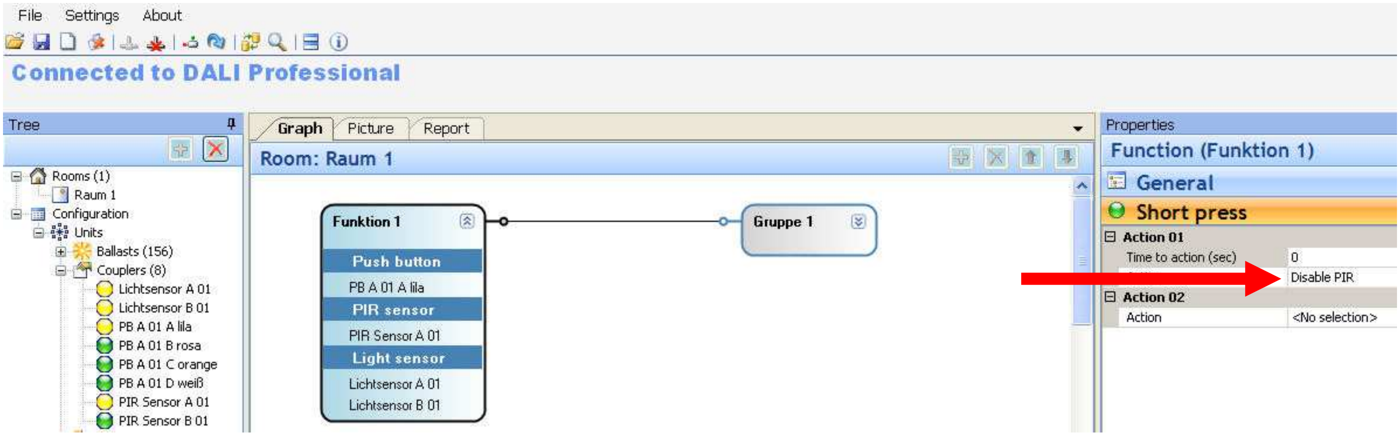
- Two new actions to be created:
  - PIR enable: activates all PIR functionality of these function
  - PIR disable: blocks all PIR functionality
- If the PIR is disabled there has to be at least one enable of the PIR, otherwise there will be an error
- Works only for sensor couplers (NOT for switches, NOT for pushbuttons)
- The function influences all connected groups of the function
- The action can be called by: Short press, Double press, Opening, Closing

Enable PIR



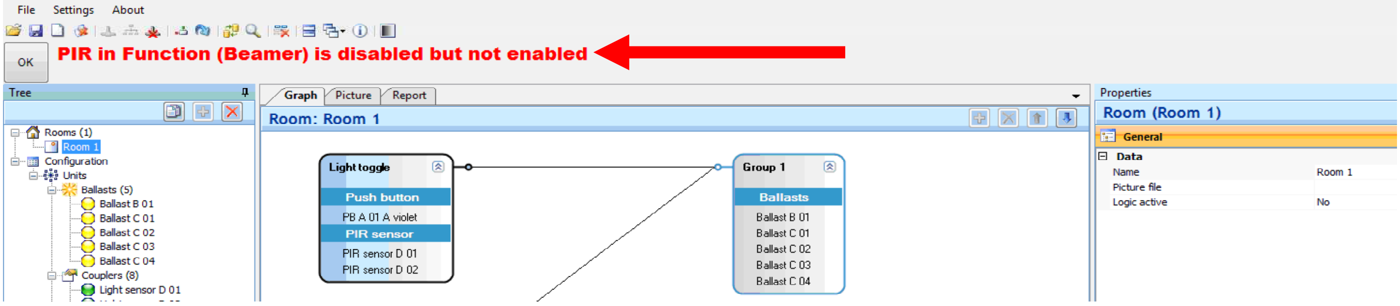
Action 01
Time to action (sec): 0
Enable PIR
Action 02
Action: <No selection>

Disable PIR:



Action 01
Time to action (sec): 0
Disable PIR
Action 02
Action: <No selection>

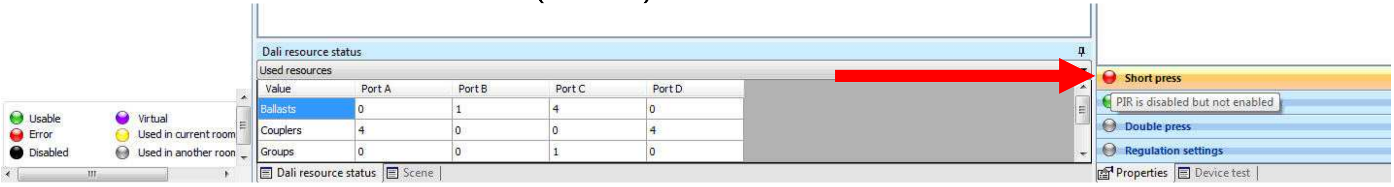
Error when disabled and not enabled:



**PIR in Function (Beamer) is disabled but not enabled**

Name: Room 1
Picture file:
Logic active: No

Error when disabled and not enabled (red dot):



| Value | Port A | Port B | Port C | Port D |
|---|---|---|---|---|
| Ballasts | 0 | 1 | 4 | 0 |
| Couplers | 4 | 0 | 0 | 4 |
| Groups | 0 | 0 | 1 | 0 |

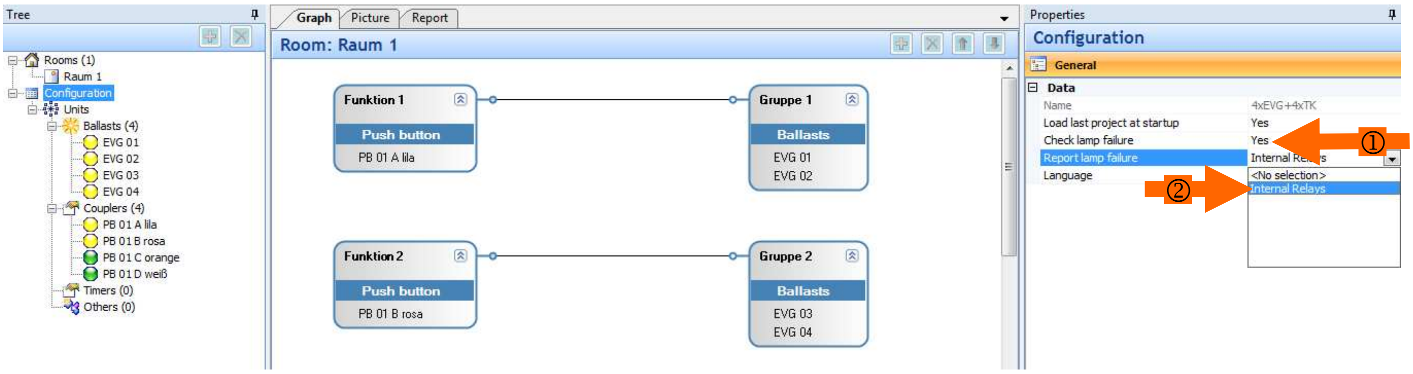
PIR is disabled but not enabled

# Report Lamp Failure to Relay

The lamp failure reporting allows to connect DALI PROFESSIONAL to a superior BMS.
A lamp failure in DALI line A..D closes the according relay K1..4

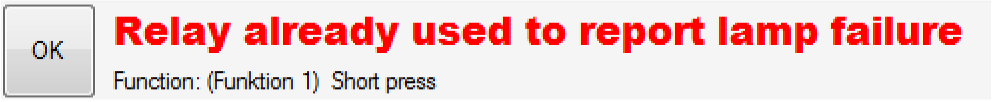
- 'Check lamp failure' has to be set to 'Yes'
- Default value = 'No'
- Controller checks all DALI lines every 10 seconds for lamp failure
- DALI line A is related to relay K1, B to K2, C to K3, D to K4
- Contact open if no lamp failure detected
- Contact closed if a lamp failure occurs
- Contact opens again if lamp failure vanishes
- If relay already used for another function a failure message occurs
  'Relay already used to report lamp failure'

Configuration process :
① set 'Check lamp failure' = 'Yes'
② set 'Report lamp failure'  = 'Internal Relays'



| | |
|---|---|
| Name | 4xEVG+4xTK |
| Load last project at startup | Yes |
| Check lamp failure | Yes |
| Report lamp failure | Internal Relays |
| Language | |

If the relays are already used for lamp failure monitoring
a second use in a function will generate a failure message



**Relay already used to report lamp failure**

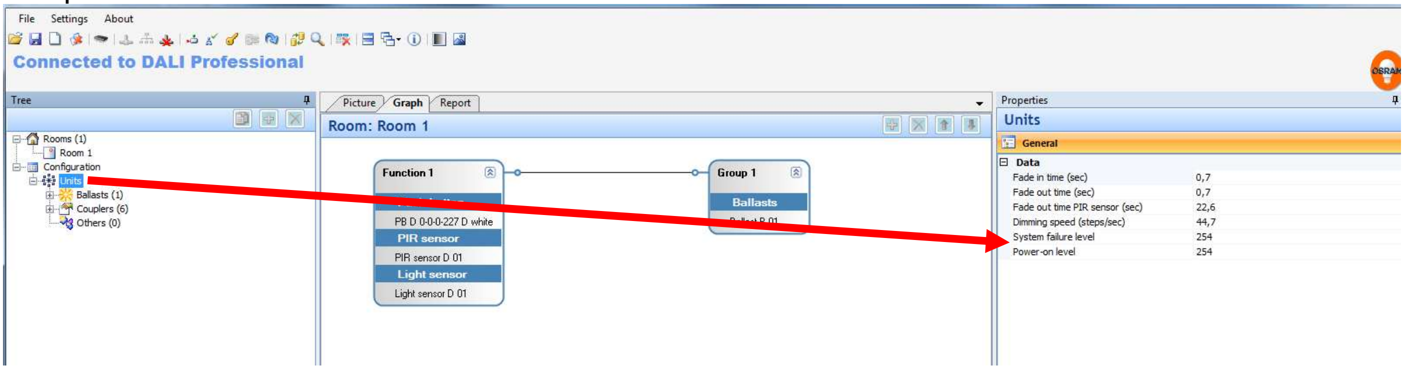
Function: (Funktion 1) Short press

# Global Change of ECG Parameters

Change of ECG Parameter is also possible on global level for the whole project at once. This avoids a lot of extra work during setup if changes for all ECG are necessary.

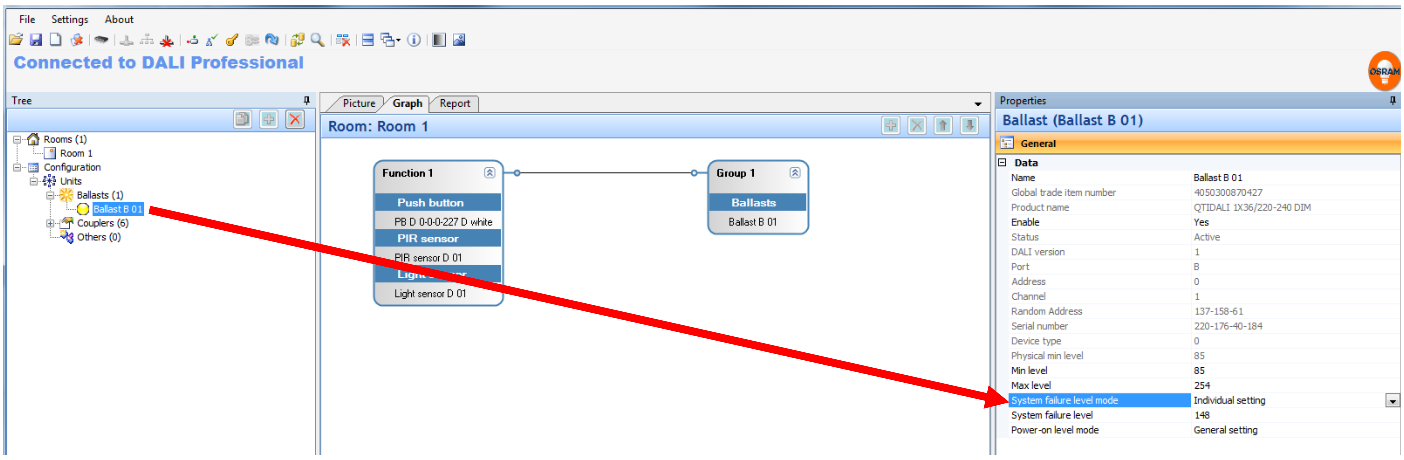
- ECG Parameters to be set : “SystemFailureLevel” and “PowerOnLevel”
- Default values = ECG factory settings
- The default value for the ballasts will be “General setting”
- When using an old configuration, all ballasts showing DALI value = 254 as “SystemFailureLevel” and / or “PowerOnLevel” will be set to use general settings. Ballasts with other values will be set to their individual settings.

“SystemFailureLevel“ and “PowerOnLevel” can be changed global for all ballasts in “Properties/Units/General”.

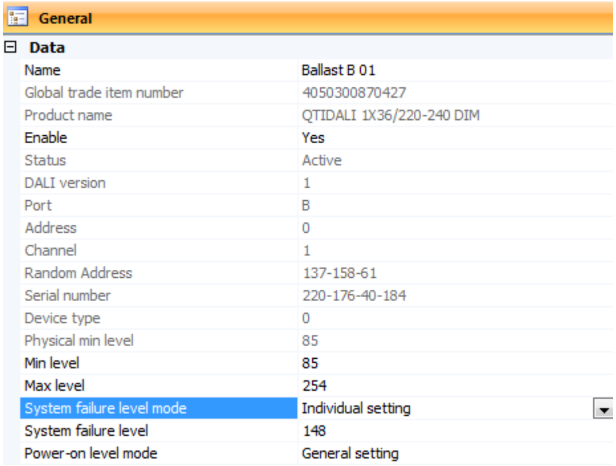


| | |
|---|---|
| Fade in time (sec) | 0,7 |
| Fade out time (sec) | 0,7 |
| Fade out time PIR sensor (sec) | 22,6 |
| Dimming speed (steps/sec) | 44,7 |
| System failure level | 254 |
| Power-on level | 254 |

To use the general settings for a individual ballast the “System failure level mode” or the “Power on level mode” has to be set to “General setting”. If set to “Individual setting” a ballast specific value can be set.



| | |
|---|---|
| Name | Ballast B 01 |
| Global trade item number | 4050300870427 |
| Product name | QTIDALI 1X36/220-240 DIM |
| Enable | Yes |
| Status | Active |
| DALI version | 1 |
| Port | B |
| Address | 0 |
| Channel | 1 |
| Random Address | 137-158-61 |
| Serial number | 220-176-40-184 |
| Device type | 0 |
| Physical min level | 85 |
| Min level | 85 |
| Max level | 254 |
| System failure level mode | Individual setting |
| System failure level | 148 |
| Power-on level mode | General setting |



| | |
|---|---|
| Name | Ballast B 01 |
| Global trade item number | 4050300870427 |
| Product name | QTIDALI 1X36/220-240 DIM |
| Enable | Yes |
| Status | Active |
| DALI version | 1 |
| Port | B |
| Address | 0 |
| Channel | 1 |
| Random Address | 137-158-61 |
| Serial number | 220-176-40-184 |
| Device type | 0 |
| Physical min level | 85 |
| Min level | 85 |
| Max level | 254 |
| System failure level mode | Individual setting |
| System failure level | 148 |
| Power-on level mode | General setting |

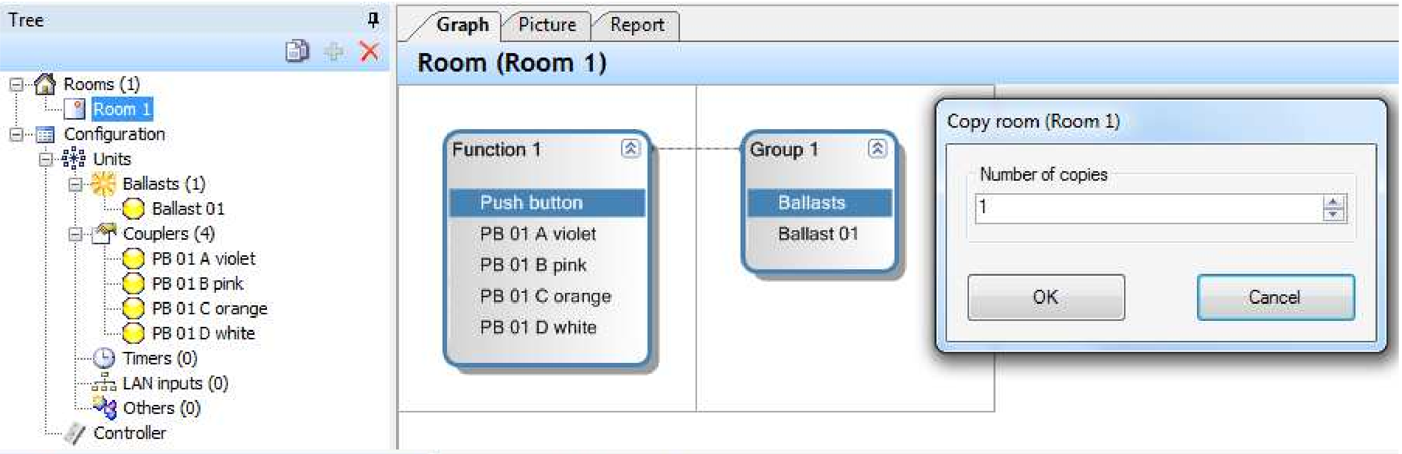
Attention Message :

Be careful with SystemFailureLevel changes in emergency relevant installations.

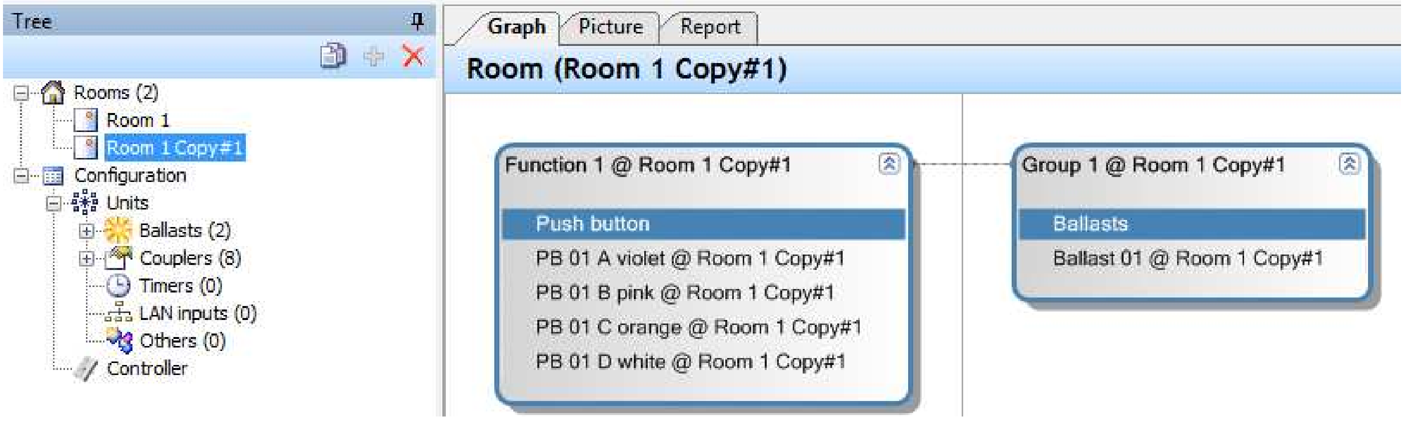
# Copy Room within Configuration

With the copy room functionality it is possible to create a copy of an existing room which contains all devices, functionalities, parameters ..

- Works for:
  - Standard rooms
  - Logic controlled rooms
- To copy a room select the room to be copied in tree and press “Copy button” in toolbar
- These settings of a room will be copied
  - Used devices (ballasts, couplers...).
    All copied devices will virtual status. They have to be merged later in setup with existing installation devices.
  - Groups
  - Functions
  - Scenes
  - Regulation settings
- Copy of a logic room will show all rooms including sub-rooms
- The name of the copied room will be the old name and added *Copy#x*, where x is the counter of the copy. E.g. *Room 1* in copy will be *Room 1 Copy#1*
- The name of the copied settings (devices, functions, groups....) will be the name plus the name of the copied room. E.g. *ECG 1* in copy will get *ECG 1 @ Room 1 Copy#1*
- The room drawing in picture view cannot be copied.

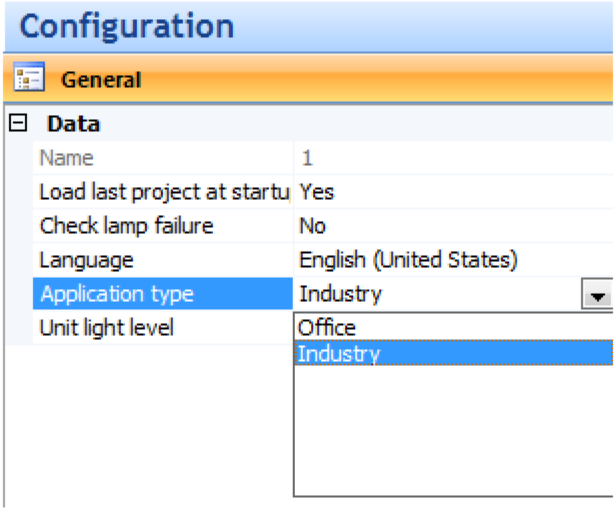


Number of copies: 1



# Application Type Setting

In industrial installations the PIR function should work in a different way than in offices.
For this reason the configuration can support different application types:



| | |
|---|---|
| Name | 1 |
| Load last project at startu | Yes |
| Check lamp failure | No |
| Language | English (United States) |
| Application type | Industry |
| Unit light level | |

## Application Type Office (default)

As already implemented in former versions

- The first PIR action will work as follows:
  - If not all lights in the group are on, the PIR action will not change the situation
  - When all lights are on the action will not be executed
    (e.g. a manual arranged dimming level will not be changed)
- There is a 30s lock time for PIR actions to give the opportunity to leave the room after switching off the light without new triggering.
- If movement is detected the PIR event is send every 10s.

## Application Type Industry

- The first PIR action will work as follows:
  - Even if not all light are on in the group, a PIR action will execute the according action
  - When all lights are on the action will not be executed
    (e.g. a manual arranged dimming level will not be changed)
- There is no 30s lock time for PIR actions, but when movement is detected the event is send only in10s frame.

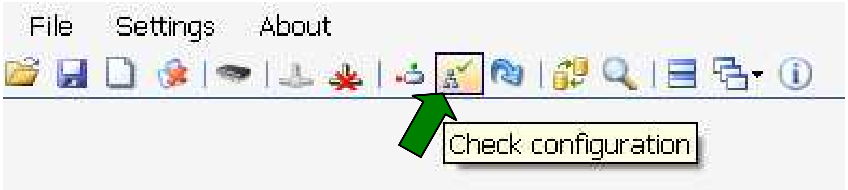
# Check Configuration - Matching Test for Configuration to Components

With the new button it is possible to check a currently used configuration against the connected physical components. Helpful if you are not sure if all ballasts / couplers are currently connected properly during an ongoing installation work.

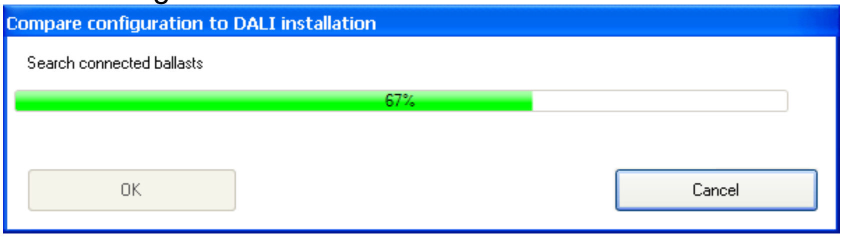
Limitations :

- if there are unused additional devices there will be no message
- only DALI device connections are checked, for e:bus only the gateway is relevant

New button in Menue Line



View during Check



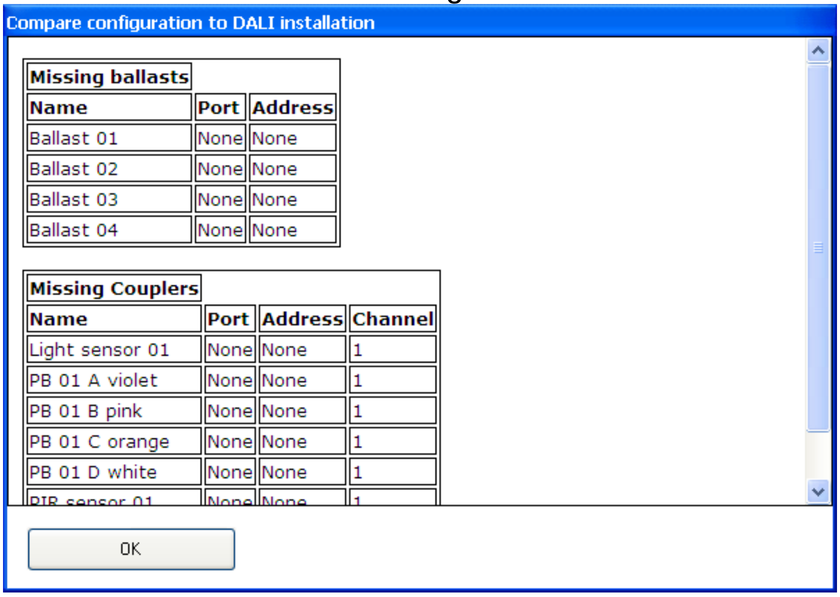
Compare configuration to DALI installation

Search connected ballasts

View if all is **o.k.**

Configuration is valid

View if **mismatches** are existing

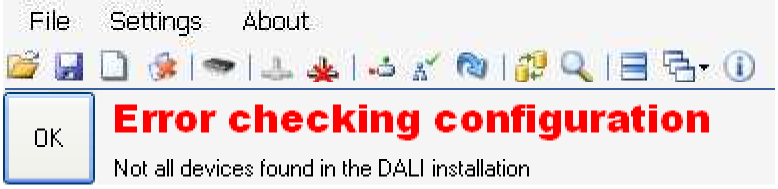


Compare configuration to DALI installation

| Missing ballasts | | |
|---|---|---|
| **Name** | **Port** | **Address** |
| Ballast 01 | None | None |
| Ballast 02 | None | None |
| Ballast 03 | None | None |
| Ballast 04 | None | None |

| Missing Couplers | | | |
|---|---|---|---|
| **Name** | **Port** | **Address** | **Channel** |
| Light sensor 01 | None | None | 1 |
| PB 01 A violet | None | None | 1 |
| PB 01 B pink | None | None | 1 |
| PB 01 C orange | None | None | 1 |
| PB 01 D white | None | None | 1 |
| PIR sensor 01 | None | None | 1 |

Result in Message Line



Error checking configuration

Not all devices found in the DALI installation

# DALI PRO Testfunctions

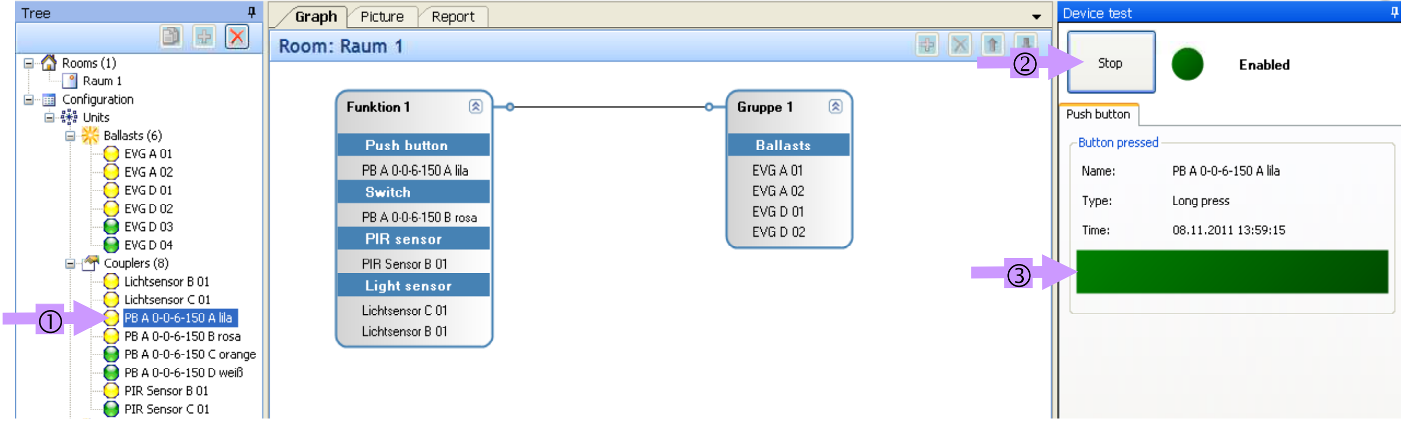
## Single Device Test - Check for Correct Device Assignment

ECG, pushbuttons, lightsensor, PIR can be tested according to correct assignment in the room.

① Click to device in device tree, use 'Device test' in right window

② Start Test, for input devices the according operation has to be done e.g. pushbutton press

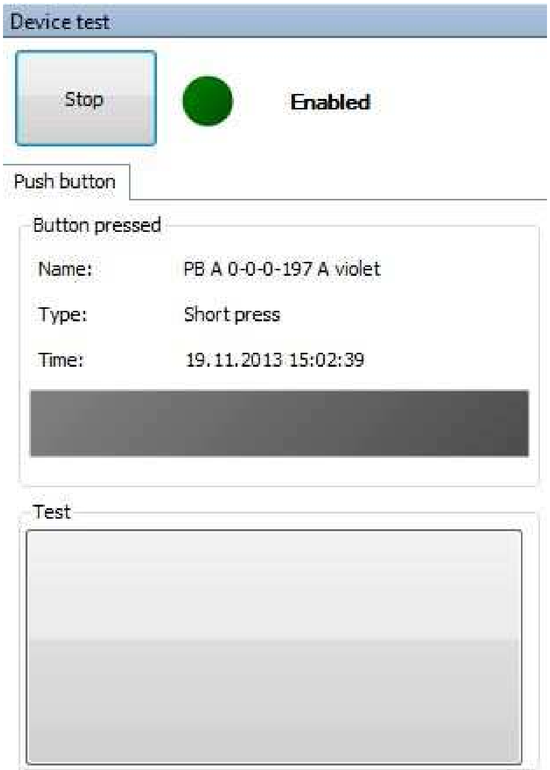
③ A green area will occur and the device name and event type is shown



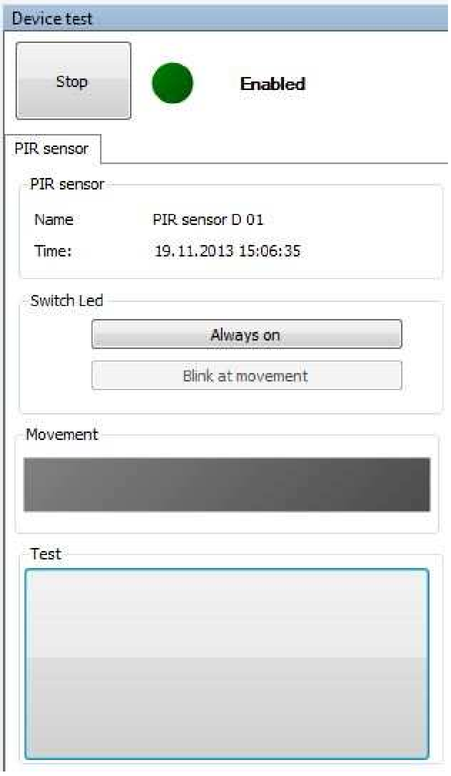
Name: PB A 0-0-6-150 A lila
Type: Long press
Time: 08.11.2011 13:59:15

## Single Device Test - Button / PIR Sensor

includes test button to start virtual the according function



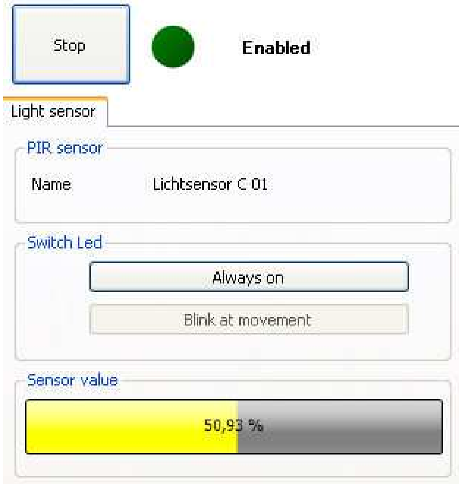
Name: PB A 0-0-0-197 A violet
Type: Short press
Time: 19.11.2013 15:02:39



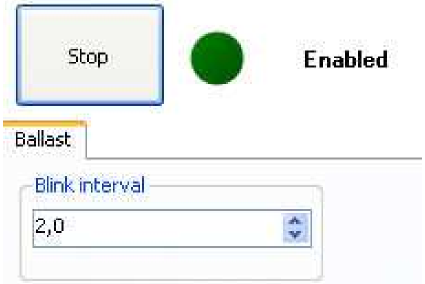
Name PIR sensor D 01
Time: 19.11.2013 15:06:35

## Single Device Test - Lightssensor / Ballast

includes magic eye for lightlevel / blink function

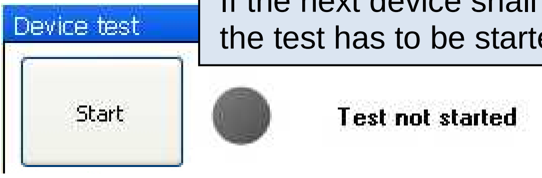


Name Lichtsensor C 01
Sensor value: 50,93 %



Blink interval: 2,0

If the next device shall be checked the test has to be started again with 'Start'



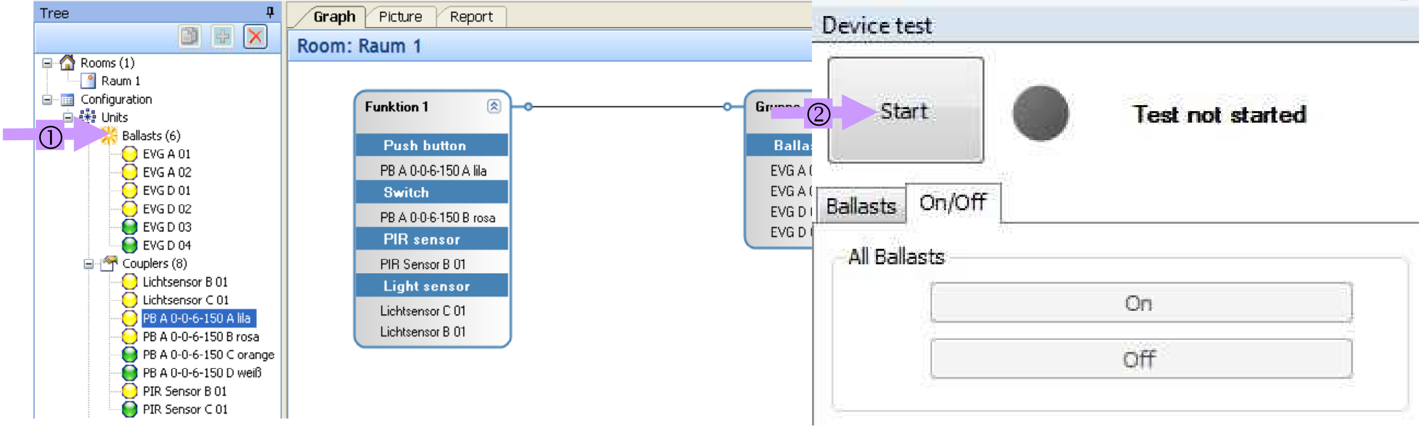
# Common Device Test - Check for Correct Device Functionality

ECG, pushbuttons, lightsensors, PIRsensors can be tested together for correct functionality

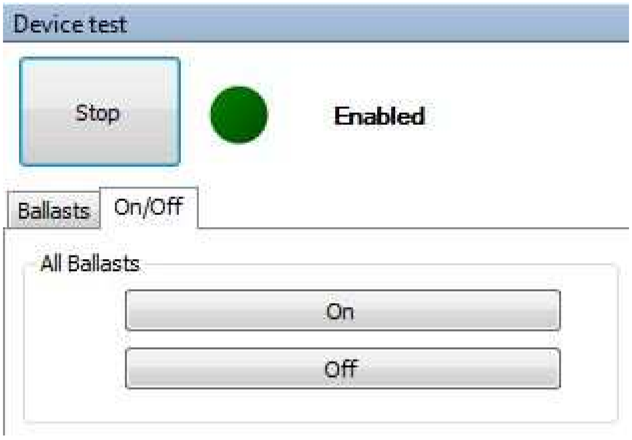
## Common Ballasts Test

① Click to Ballast in device tree, use 'Device test' in right window bottom

② Start Test



Now all ballast can be switched ON / OFF to localize non reacting luminaires

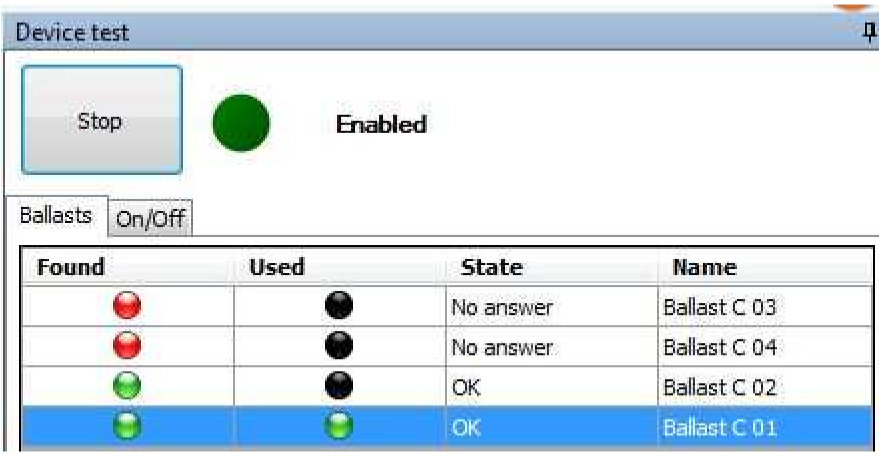


Test result for the luminaires which
- not switch on -> no mains connected
- not switch off -> no DALI connection

## Common Device Detail Test

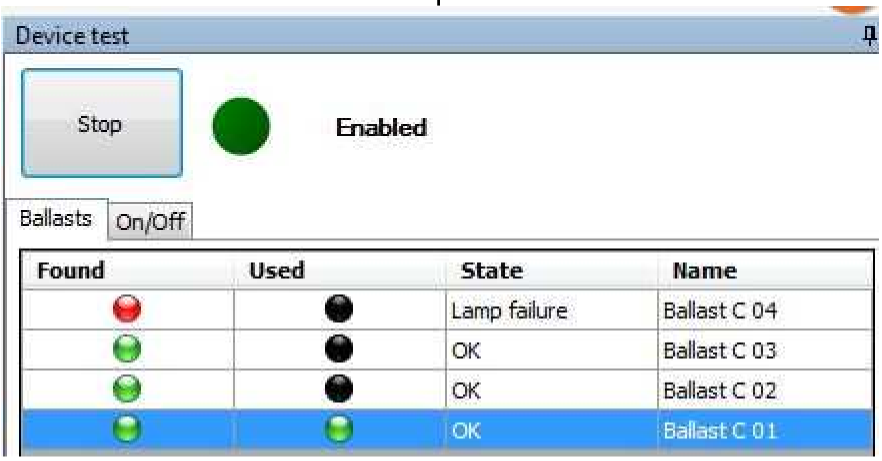
**Ballasts** can be checked for (temporary) wiring failures

ECG which do not answer to DALI commands will be shown as red dot



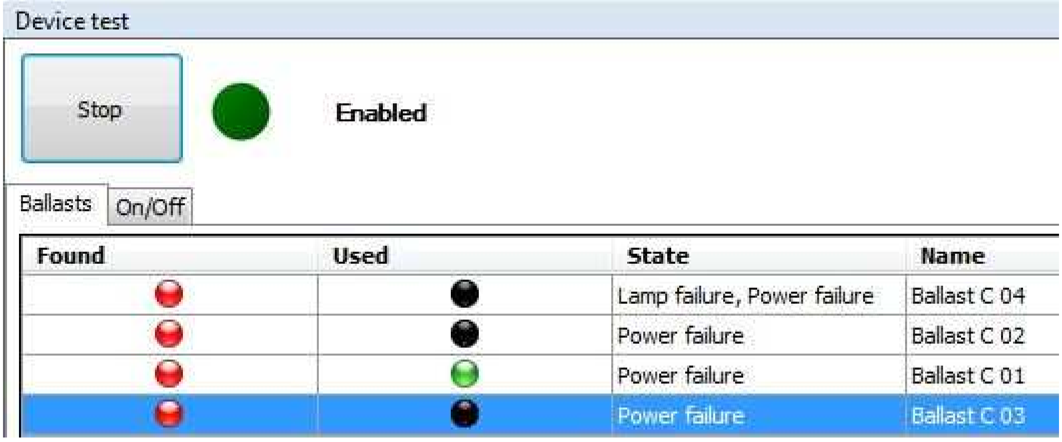
| Found | Used | State | Name |
|---|---|---|---|
| 🔴 | ● | No answer | Ballast C 03 |
| 🔴 | ● | No answer | Ballast C 04 |
| 🟢 | ● | OK | Ballast C 02 |
| 🟢 | 🟢 | OK | Ballast C 01 |

ECG connected to a failed lamp will be shown with red dot



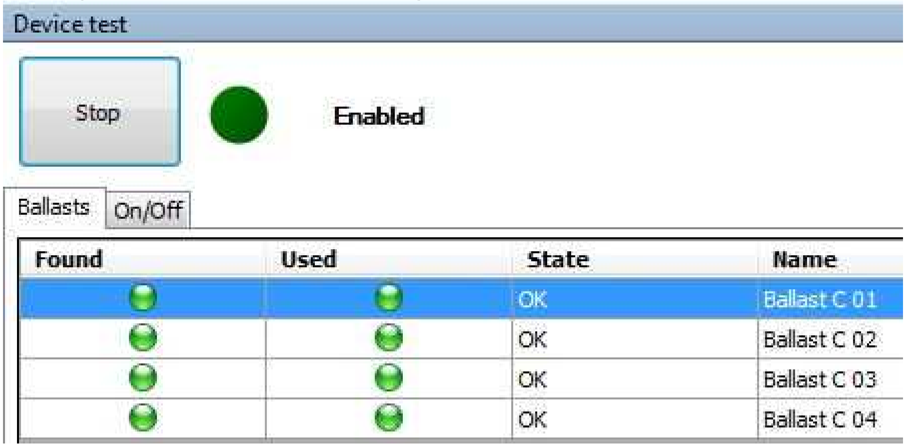
| Found | Used | State | Name |
|---|---|---|---|
| 🔴 | ⚫ | Lamp failure | Ballast C 04 |
| 🟢 | ⚫ | OK | Ballast C 03 |
| 🟢 | ⚫ | OK | Ballast C 02 |
| 🟢 | 🟢 | OK | Ballast C 01 |

ECG which temporary lost connection to mains voltage will be found
Power failure message is shown even after recover until next light change (e.g. ON/OFF)



| Found | Used | State | Name |
|---|---|---|---|
| 🔴 | ⚫ | Lamp failure, Power failure | Ballast C 04 |
| 🔴 | ⚫ | Power failure | Ballast C 02 |
| 🔴 | 🟢 | Power failure | Ballast C 01 |
| 🔴 | ⚫ | Power failure | Ballast C 03 |

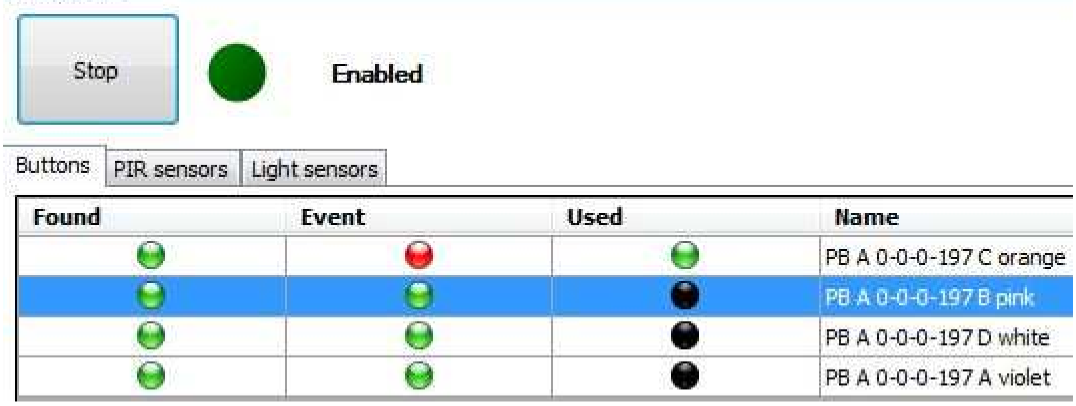
Finally all ECG should show green dots



| Found | Used | State | Name |
|---|---|---|---|
| 🟢 | 🟢 | OK | Ballast C 01 |
| 🟢 | 🟢 | OK | Ballast C 02 |
| 🟢 | 🟢 | OK | Ballast C 03 |
| 🟢 | 🟢 | OK | Ballast C 04 |

**Button Test**

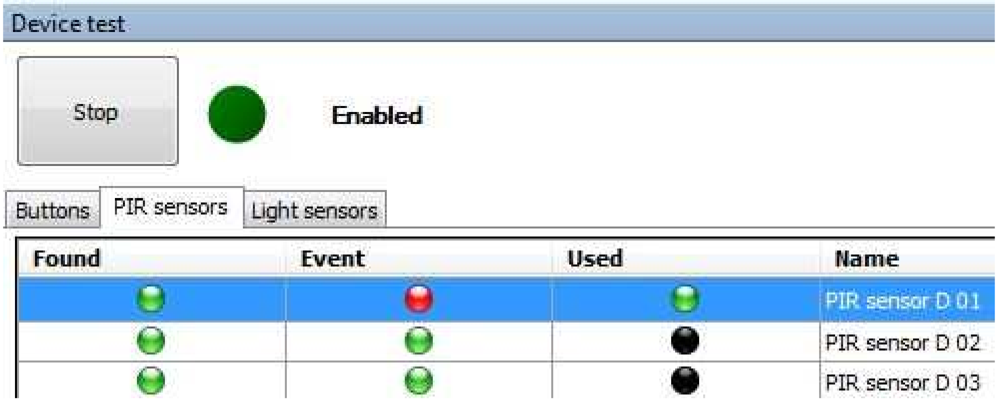
Start Test and press each button to create according events.
Automatic sort concerning failure / no event (red dot) to top of row



| Found | Event | Used | Name |
|---|---|---|---|
| 🟢 | 🔴 | 🟢 | PB A 0-0-0-197 C orange |
| 🟢 | 🟢 | ⚫ | PB A 0-0-0-197 B pink |
| 🟢 | 🟢 | ⚫ | PB A 0-0-0-197 D white |
| 🟢 | 🟢 | ⚫ | PB A 0-0-0-197 A violet |

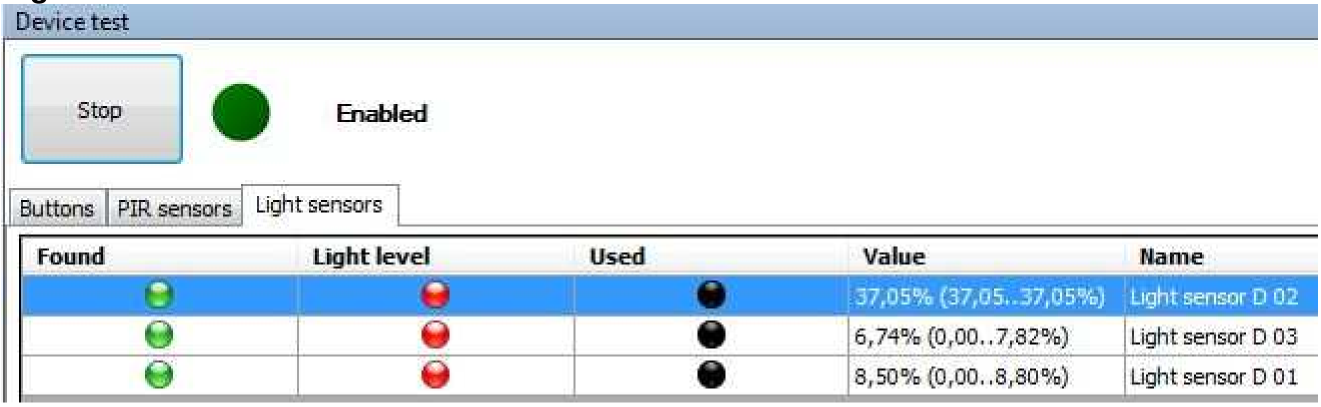
**PIR Sensor Test**

Activate all PIR by movement to create events.
Automatic sort concerning failure / no event (red dot) to top of row



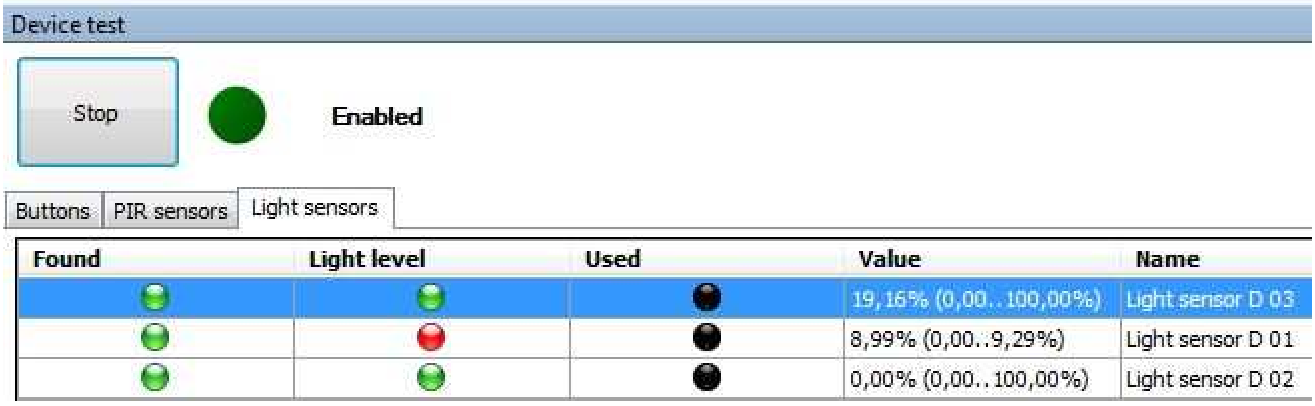
| Found | Event | Used | Name |
|---|---|---|---|
| 🟢 | 🔴 | 🟢 | PIR sensor D 01 |
| 🟢 | 🟢 | ⚫ | PIR sensor D 02 |
| 🟢 | 🟢 | ⚫ | PIR sensor D 03 |

**Lightsensor Test**



| Found | Light level | Used | Value | Name |
|---|---|---|---|---|
| 🟢 | 🔴 | ⚫ | 37,05% (37,05..37,05%) | Light sensor D 02 |
| 🟢 | 🔴 | ⚫ | 6,74% (0,00..7,82%) | Light sensor D 03 |
| 🟢 | 🔴 | ⚫ | 8,50% (0,00..8,80%) | Light sensor D 01 |

Value changes >20% result in green level dot
when sensor reacted on change (e.g. light torch / shadow)

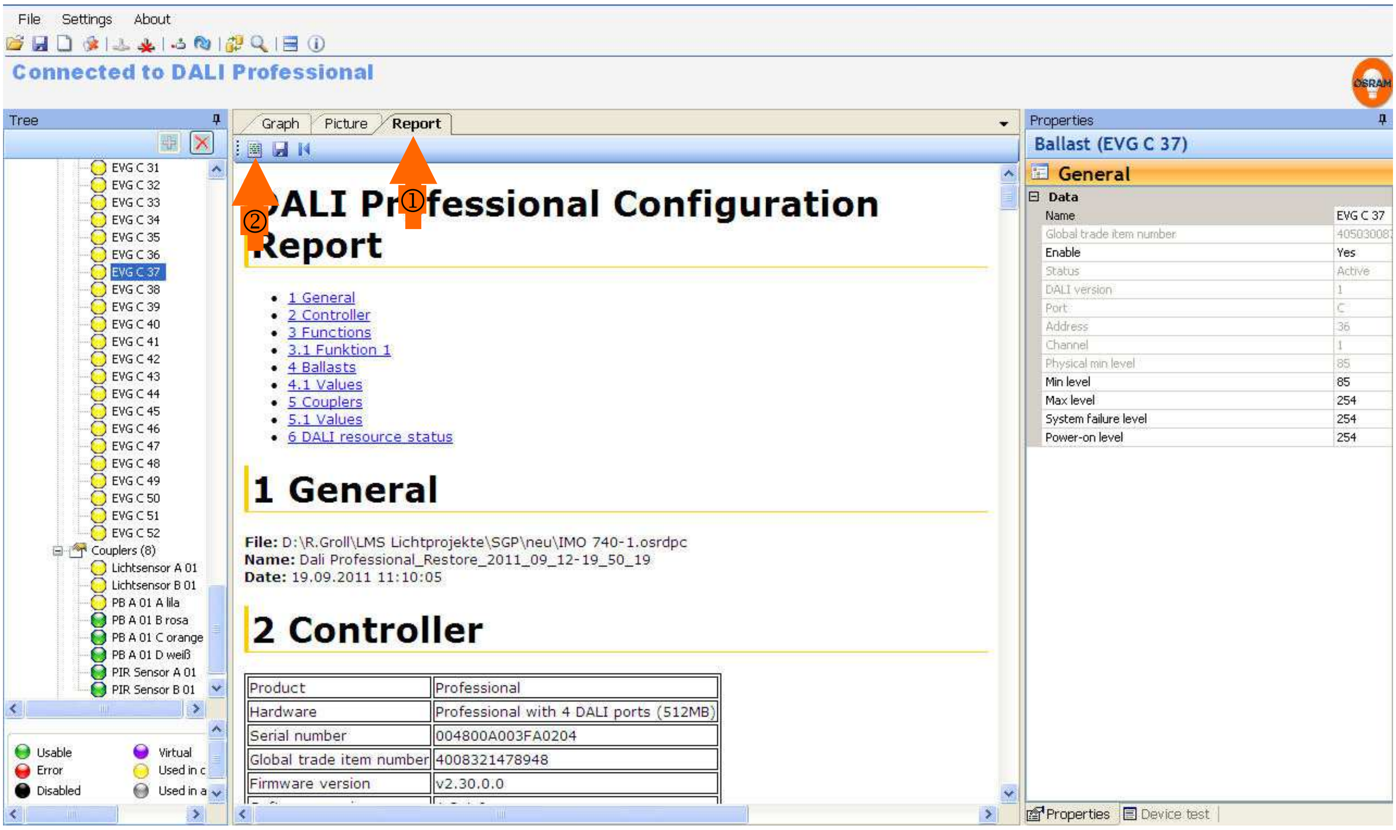


| Found | Light level | Used | Value | Name |
|---|---|---|---|---|
| 🟢 | 🟢 | ⚫ | 19,16% (0,00..100,00%) | Light sensor D 03 |
| 🟢 | 🔴 | ⚫ | 8,99% (0,00..9,29%) | Light sensor D 01 |
| 🟢 | 🟢 | ⚫ | 0,00% (0,00..100,00%) | Light sensor D 02 |

# DALI PROFESSIONAL Configuration Report

Documentation of Configuration as HTML Report

① Go into menue folder 'Report'
② Use 'Create Report' to generate a HTML file of the current configuration



DALI Professional Configuration Report

- 1 General
- 2 Controller
- 3 Functions
- 3.1 Funktion 1
- 4 Ballasts
- 4.1 Values
- 5 Couplers
- 5.1 Values
- 6 DALI resource status

1 General

**File:** D:\R.Groll\LMS Lichtprojekte\SGP\neu\IMO 740-1.osrdpc
**Name:** Dali Professional_Restore_2011_09_12-19_50_19
**Date:** 19.09.2011 11:10:05

2 Controller

| | |
|---|---|
| Product | Professional |
| Hardware | Professional with 4 DALI ports (512MB) |
| Serial number | 004800A003FA0204 |
| Global trade item number | 4008321478948 |
| Firmware version | v2.30.0.0 |

Properties

Ballast (EVG C 37)

General

Data

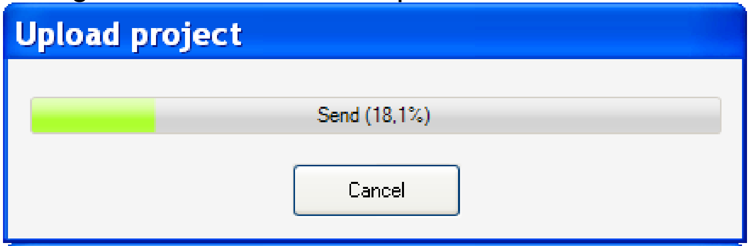
| | |
|---|---|
| Name | EVG C 37 |
| Global trade item number | 40503008 |
| Enable | Yes |
| Status | Active |
| DALI version | 1 |
| Port | C |
| Address | 36 |
| Channel | 1 |
| Physical min level | 85 |
| Min level | 85 |
| Max level | 254 |
| System failure level | 254 |
| Power-on level | 254 |

Then view or store the HTML document for documentation of final project status.
Document also can be printed with right mouse button menue.

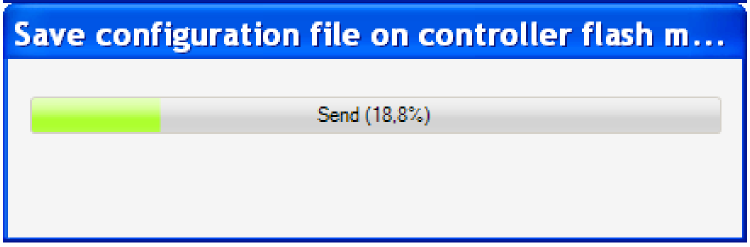
## Upload Configuration to Controller

Store DALI PROFESSIONAL configuration with

With this the controller first will get configured by upload project, then automatically the original configuration file xxxxx.osrdpc will be stored additional on the controller.


Upload project

Send (18,1%)


Save configuration file on controller flash m...

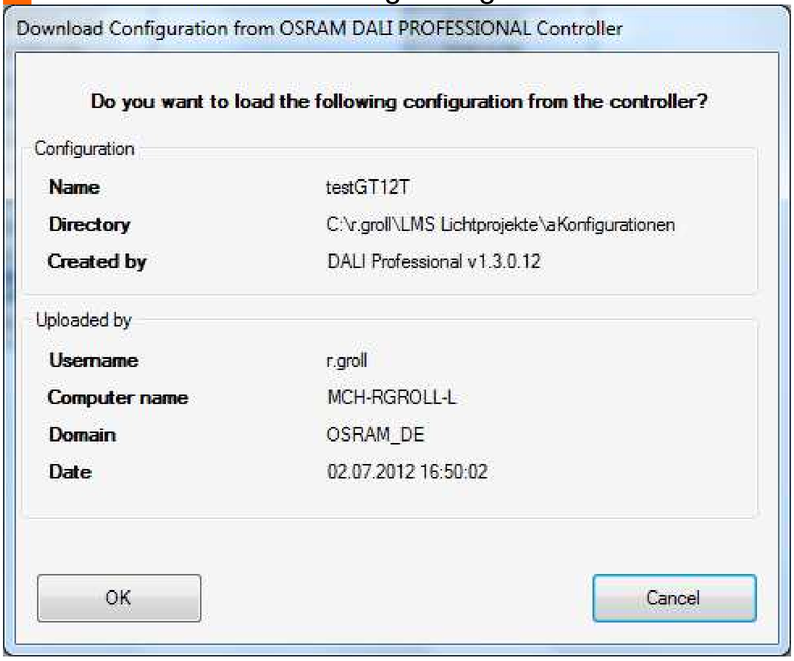
Send (18,8%)

A warning message will occur if the project size will exceed 200K (the largest projects we have created show 70K). If this message occurs the configuration is uploaded to the controller, but the project file is only stored on the PC.

## Download current Configuration from Controller

① connect by USB with PC, click to the connection symbol

② click to download existing configuration file from controller


Download Configuration from OSRAM DALI PROFESSIONAL Controller

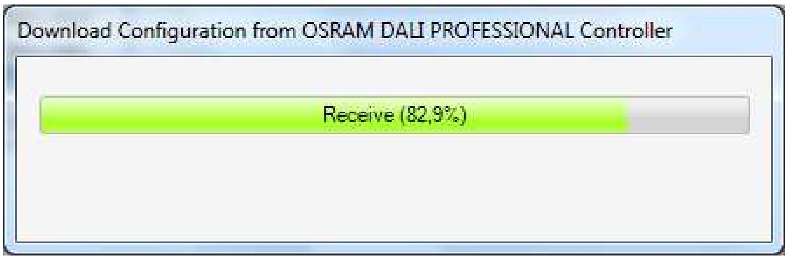
**Do you want to load the following configuration from the controller?**

Configuration

| | |
|---|---|
| **Name** | testGT12T |
| **Directory** | C:\r.groll\LMS Lichtprojekte\aKonfigurationen |
| **Created by** | DALI Professional v1.3.0.12 |

Uploaded by

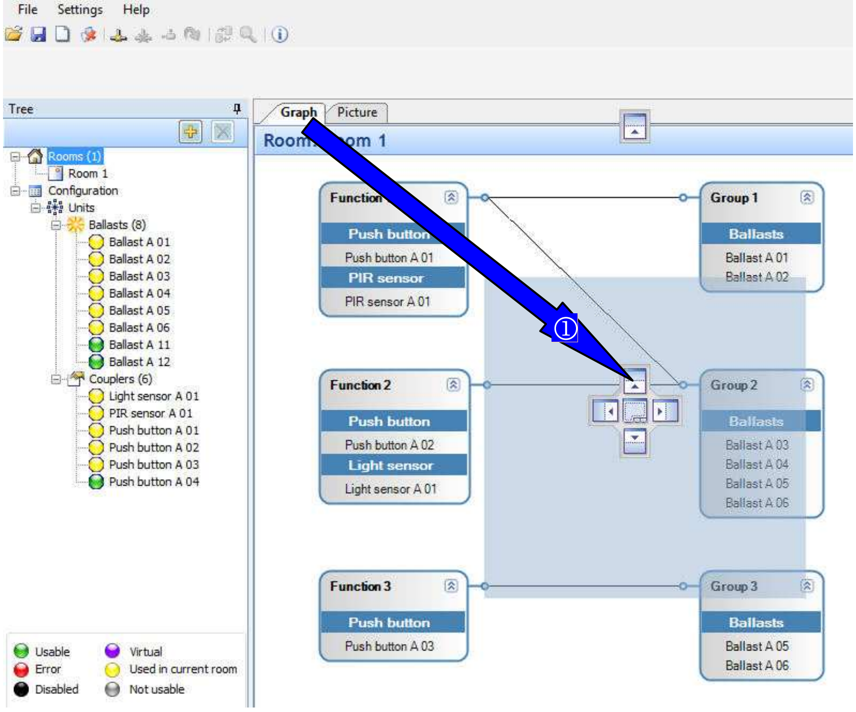
| | |
|---|---|
| **Username** | r.groll |
| **Computer name** | MCH-RGROLL-L |
| **Domain** | OSRAM_DE |
| **Date** | 02.07.2012 16:50:02 |


Download Configuration from OSRAM DALI PROFESSIONAL Controller

Receive (82,9%)

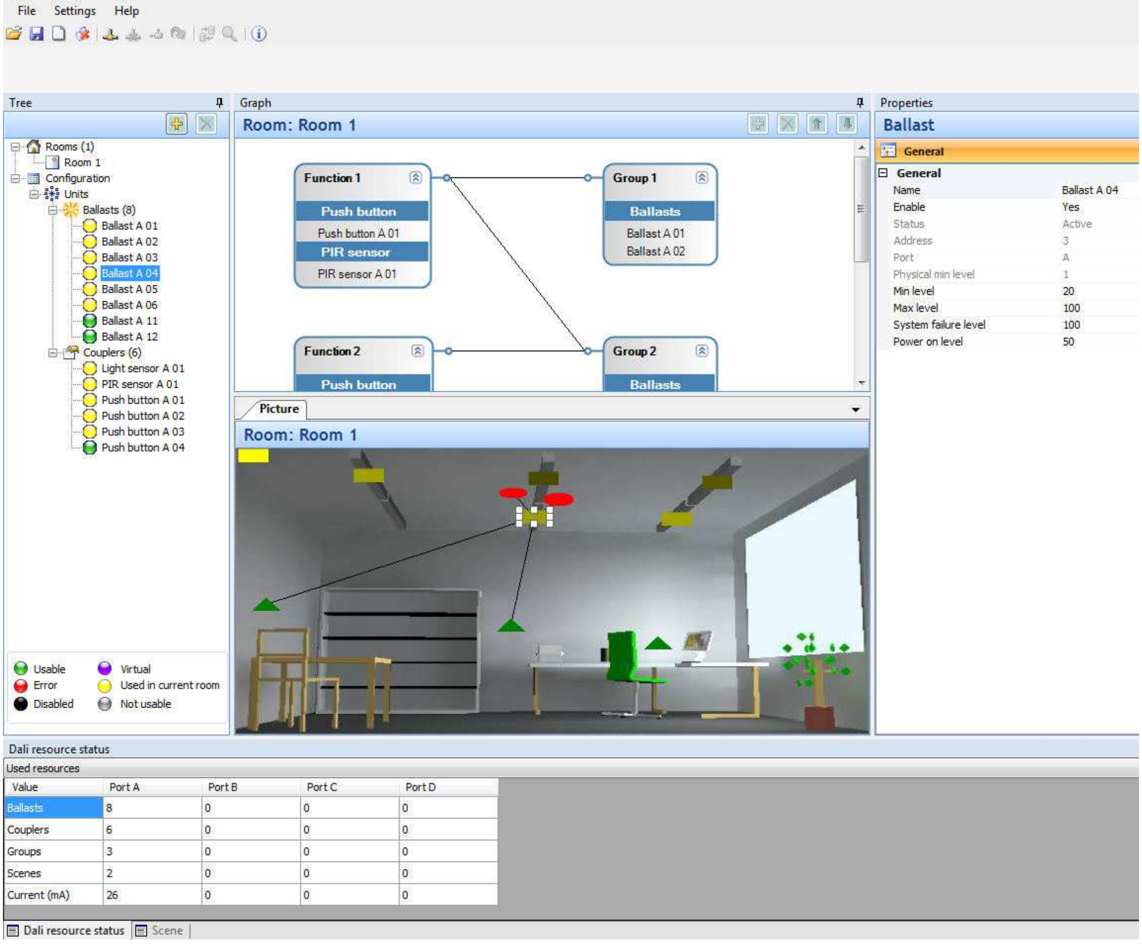
Download only works if project is uploaded before with DALIpro ≥ v1.3.0.0.

# Simultaneous View of Picture and Graph - Design of View Window



① click marker tab and pull to requested position
in this case above Picture view

② result :



**Ballast**

General

General

| | |
|---|---|
| Name | Ballast A 04 |
| Enable | Yes |
| Status | Active |
| Address | 3 |
| Port | A |
| Physical min level | 1 |
| Min level | 20 |
| Max level | 100 |
| System failure level | 100 |
| Power on level | 50 |

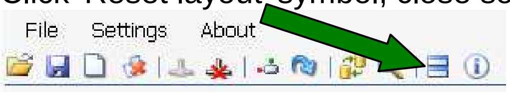
Dali resource status

Used resources

| Value | Port A | Port B | Port C | Port D |
|---|---|---|---|---|
| Ballasts | 8 | 0 | 0 | 0 |
| Couplers | 6 | 0 | 0 | 0 |
| Groups | 3 | 0 | 0 | 0 |
| Scenes | 2 | 0 | 0 | 0 |
| Current (mA) | 26 | 0 | 0 | 0 |

## *Reset of window design*

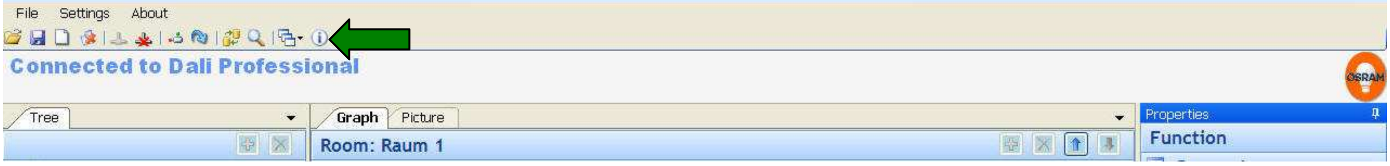
Click 'Reset layout' symbol, close software and start software again



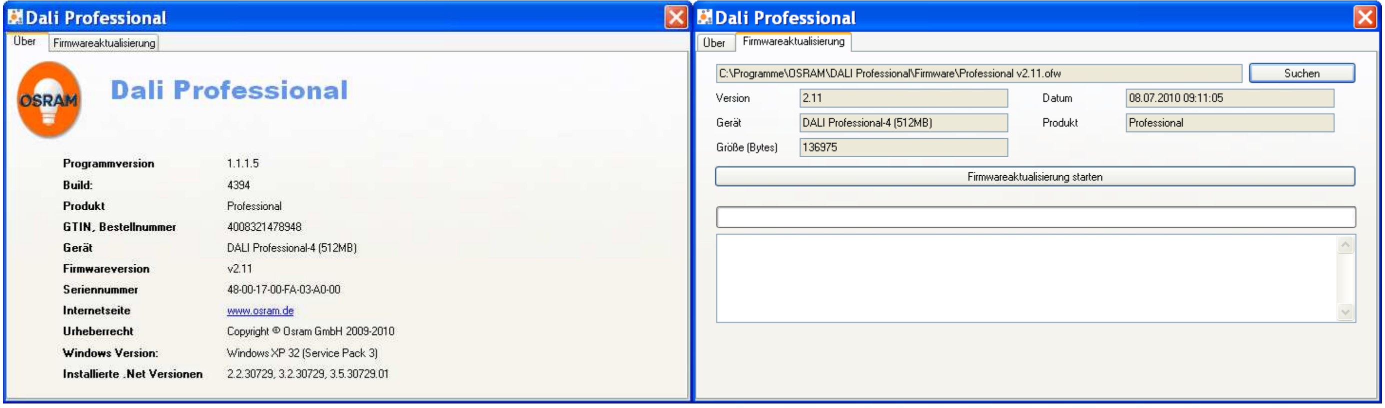
# Firmwareupgrade Controller

With every new GUI-Softwareupgrade e.g. from OSRAM Internet www.osram.com/software) the latest firmware for the controller is automatically included. The upgrade is done by USB connection to controller

Open OSRAM DALI Professional software, click ⓘ in menue line
click marker tab "firmware update' -> search, choose, update



Screens for start of firmwareupgrade

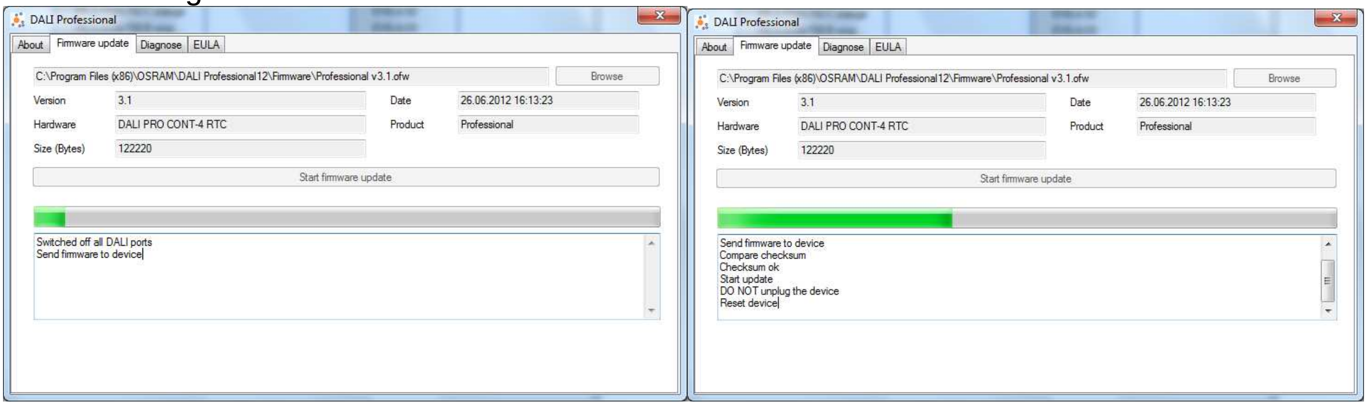


**Programmversion** 1.1.1.5
**Build:** 4394
**Produkt** Professional
**GTIN, Bestellnummer** 4008321478948
**Gerät** DALI Professional-4 (512MB)
**Firmwareversion** v2.11
**Seriennummer** 48-00-17-00-FA-03-A0-00
**Internetseite** www.osram.de
**Urheberrecht** Copyright © Osram GmbH 2009-2010
**Windows Version:** Windows XP 32 (Service Pack 3)
**Installierte .Net Versionen** 2.2.30729, 3.2.30729, 3.5.30729.01

C:\Programme\OSRAM\DALI Professional\Firmware\Professional v2.11.ofw
Version 2.11
Datum 08.07.2010 09:11:05
Gerät DALI Professional-4 (512MB)
Produkt Professional
Größe (Bytes) 136975

Default path for firmware (stored there with software installation)
C:\Program Files\OSRAM\DALI Professional\Firmware

Screen during installation



C:\Program Files (x86)\OSRAM\DALI Professional12\Firmware\Professional v3.1.ofw
Version 3.1
Date 26.06.2012 16:13:23
Hardware DALI PRO CONT-4 RTC
Product Professional
Size (Bytes) 122220

```
Switched off all DALI ports
Send firmware to device
```

C:\Program Files (x86)\OSRAM\DALI Professional12\Firmware\Professional v3.1.ofw
Version 3.1
Date 26.06.2012 16:13:23
Hardware DALI PRO CONT-4 RTC
Product Professional
Size (Bytes) 122220

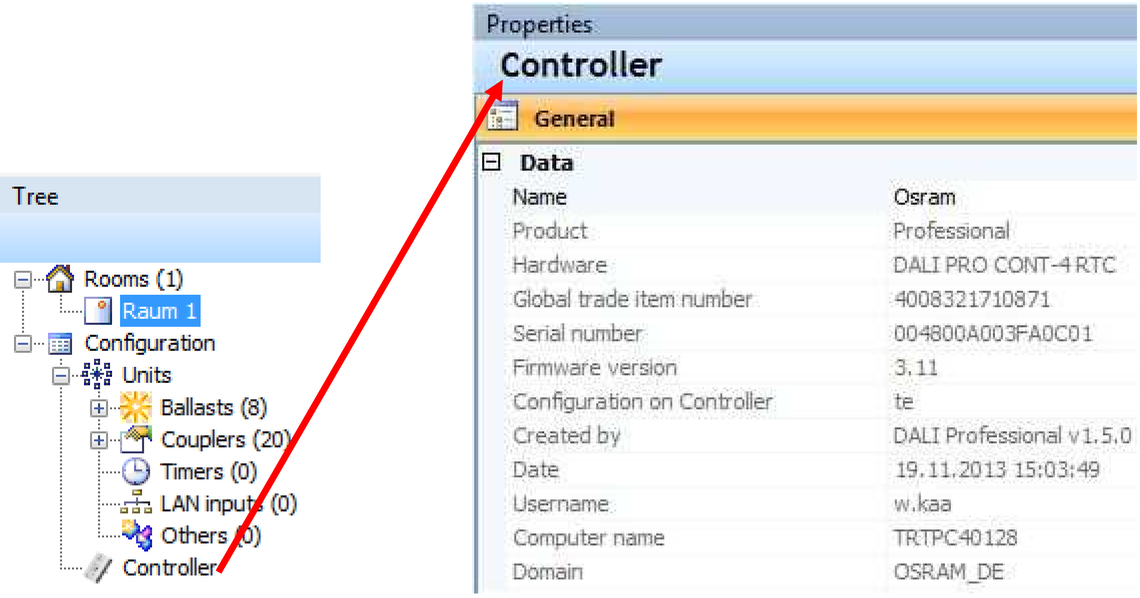
```
Send firmware to device
Compare checksum
Checksum ok
Start update
DO NOT unplug the device
Reset device
```

When update finished - close window, reset controller by mains voltage / USB interruption
Wait minimum 10 seconds, connect controller mains voltage / USB again.

Now the installation is available with new firmware
with click to ⓘ in menue line the new loaded version number shows up.

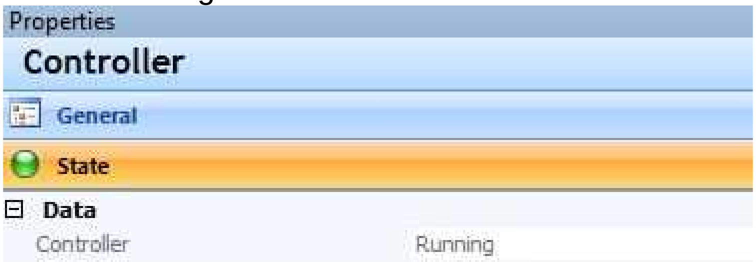
## Detailed Controller Informations

Click on controller on bottom of device tree - General Controller Data visible

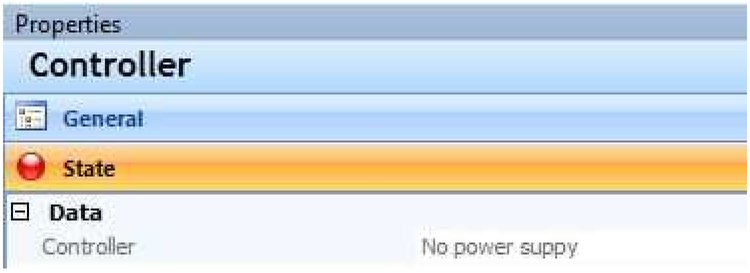


| | |
|---|---|
| Name | Osram |
| Product | Professional |
| Hardware | DALI PRO CONT-4 RTC |
| Global trade item number | 4008321710871 |
| Serial number | 004800A003FA0C01 |
| Firmware version | 3.11 |
| Configuration on Controller | te |
| Created by | DALI Professional v1.5.0 |
| Date | 19.11.2013 15:03:49 |
| Username | w.kaa |
| Computer name | TRTPC40128 |
| Domain | OSRAM_DE |

Status Messages



| | |
|---|---|
| Controller | Running |



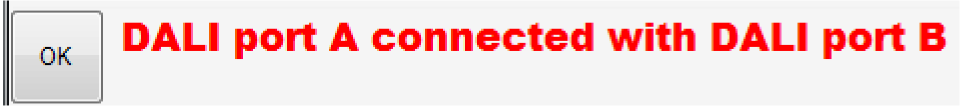
| | |
|---|---|
| Controller | No power suppy |

| | |
|---|---|
| Controller | OK |
| Port A | Short circuit |
| Port B | OK |
| Port C | OK |
| Port D | OK |

## Wiring Check in Ballast Test

Click to Ballasts in Device Tree, Start Device Test.

Shortcut with between DALI lines will be detected (correct polarity required)



DALI port A connected with DALI port B

# APPENDIX
# DALI PROFESSIONAL System and Configuration Software

**Wires**
We recommend to carry the 2-pole DALI line with the usual electrical installation e.g. NYM 5-wire. The DALI bus is no safety low voltage and has to be handeled like mains voltage.

**Mains Interruption**
After mains voltage interruption the last project light status will be re-established

**Mains Voltage Sensitivity of the DALI Connections**
During switch-on the Controller is protected against mains voltage on DALI terminals, but there is no protection during operation. The couplers are not protected against wrong wiring with mains voltage and can be destroyed.

**DALI Supply**
OSRAM DALI PRO CONT-4 supplies max. 200 mA to each DALI line

**DALI Linefailure**
In case of a shortcut in a DALI line the according LED of the Controller will show this by flashing.
The remaining DALI lines still have full functionality in a finished project. But during device search DALI shortcuts can cause problems in the whole process -> solve wiring failures first before commissioning.

**System Reset**
To bring the controller into the delivery status (plug & play functionality) an empty configuration has to be uploaded. After this the connected devices can be reset to delivery status by longpress on button ON/OFF/DIM until PowerLED flashes. With this the function of the system is the same as in a new installation without configuration, means all connected pushbuttons / PIR sensors act parallel to create default action in the according DALI line.

**Setup with Plug&Play**
see Controller manual

**Select Language**
Click 'Configuration' in left tree, select language in properties on the right side of the screen
or click on according flag in Menue Line. Then close software and, open it again

**Addressing**
ECG are addressed and operated according DALI Standard IEC 62386-101, -102
Coupler are used acc. status of IEC 62386 (2010 OSRAM / Siemens proposal)

**Groups, Functions**
are created visually in Graph view

**Scenes**
Creation of scenes and visualisation in Picture view

**Eventcontrol - Stairway Function, Corridor Function**
Use PIR Sensor with function Movement and configure Actions

**Sequences** see Eventcontrol
**Time dependent control** see Eventcontrol

**Central OFF**
Create additional room and group containing all ECGs and connect according pushbutton

**Energysaving by Daylight Harvesting**
see Light Regulation page 10

**ECG Exchange**
replace a defect ECG by merging with exisiting configuration (Merge function)

**Lampdefect**
If ERROR-LED is flashing at the Controller there is a lampfailure (missing or defect lamp).
Related DALI Port and ECG name is reported in message line. Lampfailure message can be disabled by 'Check lampfailure' = 'no' in Configuration / Properties / General.
Lampfailure message can be reported to BMS, details see chapter 'Report Lamp Failure to Relay'

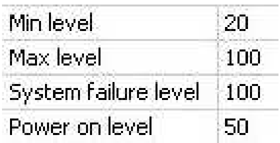
**Remote Connection of PC to Controller - USB to LAN / WLAN**
successfully tested with BELKIN Hub F5L009 (USB to LAN) and D-Link DAP 1160 (LAN to WLAN)

**Supported Windows Versions**
Successfully tested with Windows XP, Windows Vista, Win7, Win8.

**Use of Competitor Products**
Non-OSRAM devices e.g. ECGs can be used if DALI-Standards are fulfilled. But for these devices we cannot ensure the full functionality. For DALI couplers the standartisation is ongoing and not finished (IEC 62386-103,-104 Input Devices), therefore only OSRAM and Siemens products are well defined in this system.

**ECG Parameter Setting**
Standard DALI ECG parameters e.g. System Failure Level can be set directly within the software

- Ballast A 05
- Ballast A 06
- Ballast A 11
- Ballast A 12

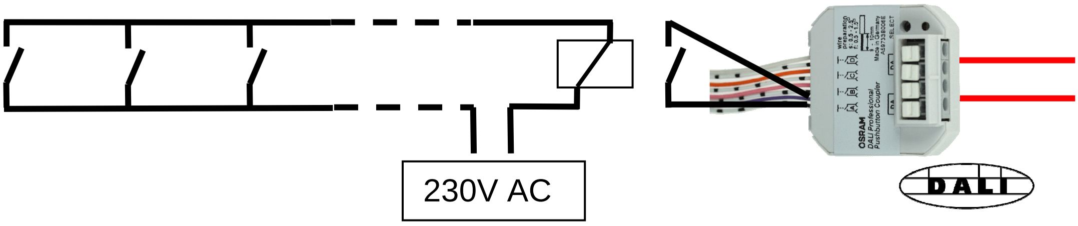


| | |
|---|---|
| Min level | 20 |
| Max level | 100 |
| System failure level | 100 |
| Power on level | 50 |

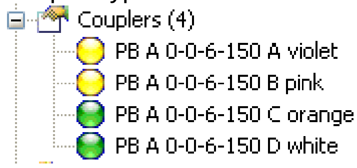
Also a common change can be created for all ECG on 'Units' level in device tree.

**Use of already adressed ECGs**
If during setup there are found used ECGs which carry e.g. already a DALI short adress so this will be unchanged. Should there be 2 identical addresses the conflict will be solved by automatical address shift.

**Wire Length Pushbutton to Pushbutton Coupler**
The maximum wire length of Pushbutton to Pushbutton Coupler is 2 meter. Direct extension is not possible because the power of the coupler and sensor is supplied from DALI line and with this there is a lower EMI tolerance. But the coupler input can be used with a relais dry contact output and the relais is controlled with a mains voltage signal from longer distance.



**Pushbutton Coupler Connector - Graphic Representation in Tree for Pushbuttons**
During a perfect setup a selfexplaining name shall be given e.g. ' Room2_PushbuttonRight'.
The automatic predefined names show :
Coupler type + DALI Linie + Unique serial number of the coupler + Input name (see label) + Color of connected cable.



- Couplers (4)
  - PB A 0-0-6-150 A violet
  - PB A 0-0-6-150 B pink
  - PB A 0-0-6-150 C orange
  - PB A 0-0-6-150 D white

**Only One Sensor per Sensorcoupler**
In case of MULTI3 controller up to 4 sensors can be connected because the device is directly conneted to mains voltage. In the DALI Professional system the power of the coupler and sensor is supplied from DALI line. To maximize the total number of possible sensors per DALI line and to avoid additional circuit complication only one Sensor per Sensorcoupler is allowed. But 10 Sensors/Sensorcoupler can be used together in one regulation (level averaging).

**Wire Length Sensor**
The maximum wire length of LS/PD Sensor to Sensorcoupler is 5 meter. An extension up to 50 m like with MULTI3 is not possible because the power of the coupler and sensor is supplied from DALI line and with this there is a lower EMI tolerance.

**Lightsensor Installation**
The OSRAM LS/PD MULTI lightsensor is optimized for 2..4 m distance to the measurement area.
With OSRAM DALI HIGHBAY ADAPTER up to 13 m can be achieved.

**Sensorcoupler Setup**
The configuration software recognizes the requested PIR by movement in the related area.
-> 2 blinking dots (together with combined lightsensor)
for advanced users : naming of PIR / LS also possible after setup with Testfunction

## PIR Sensor Application Specialities in Application Type Office (default)

If in a room with PIR sensor the light is already on, the PIR event will not change the current light situation.
Reason : No override for manual changes by movement / occupancy detection.
Furthermore the PIR sensor action is blocked for 30s after manual off to give the chance to leave the room.
Application type setting Industry is different - see chapter 'Application Type Setting'

## Use of MULTIeco functionality in DALI Professional System

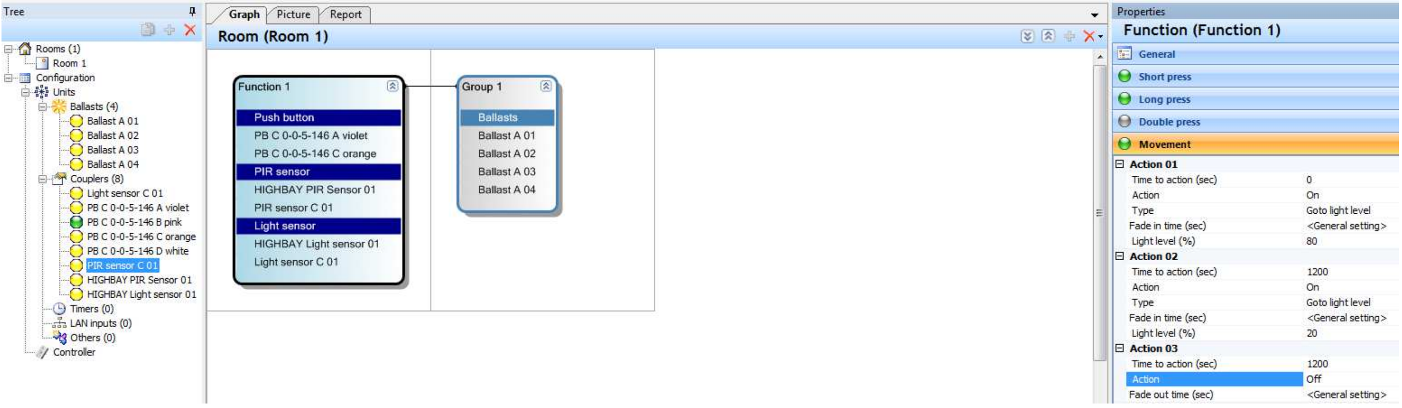
PIR can be inactivated by not using an action in ‚Movement'
PIR only for shut-off can be achieved by setting ‚time to action' e.g. 300 s und Action = OFF.
With this the timer starts with each movement and after 5 minutes without presence the light will switch off.
In both cases a pushbutton should be configurated with 'Shortpress' for manual operation.

## Energysaver Function by Mains Switching with Controller Integrated Relay

To to be solved by later updates.
New : OSRAM DALI EVG standby power losses reduced to 200 mW (1 and 2-lamp)

## Corridorfunction

with OSRAM DALI Sensorcoupler - independent configuration with flexible steps, delays, ramps
with other devices e.g. OSRAM HIGHBAY Sensor use floating contact / input of DALI HIGHBAY Adapter



Function (Function 1)

| | |
|---|---|
| **Action 01** | |
| Time to action (sec) | 0 |
| Action | On |
| Type | Goto light level |
| Fade in time (sec) | <General setting> |
| Light level (%) | 80 |
| **Action 02** | |
| Time to action (sec) | 1200 |
| Action | On |
| Type | Goto light level |
| Fade in time (sec) | <General setting> |
| Light level (%) | 20 |
| **Action 03** | |
| Time to action (sec) | 1200 |
| Action | Off |
| Fade out time (sec) | <General setting> |

## Project Documentation

as whole project date in DALIpro dataformat - xxxxx.osrdpc
as project document incl. all devices and functions - print HTML document from Configuration Report

## Create Diagnostic File

To enable a better analysis of problems a diagnostic file can be created und sent via email.
How to use : click ⓘ in menue line, click 'Diagnose' -> create file in predefined folder

## DALI Logo

The official DALI Logo DALI is not allowed on the product because the standartisation of Input Devices IEC 62386 (Input Devices) is not finally signed by the committee.
Conformity with the requirements to control DALI ECG IEC 62386-101, 102 is already given.

## Emergency Lighting

not implemented

## Firmwareupgrade Controller

Together with each upgrade of the software (e.g. via OSRAM internetpage www.osram.com/software)
there is transported automatically the latest firmware of the controller. Installation via USB cable to controller
(no mains supply required for this upgrade)

Procedure : open OSRAM DALI Pro Software, click ⓘ in menue line
-> submenue 'update firmware' -> search, select -> Update
-> details see chapter 'Firmwareupgrade Controller'

## DALI Professional System features with DALIpro Software 1.5.0
## Limits, maximum values per DALI PROFESSIONAL Controller CONT-4 (RTC)

- 4x maximum 64 ECG addresses
- 4x maximum 64 input device addresses (sensors / pushbuttons)
- Current limitation 200mA per DALI port
  -> total limit of number of ECG + input devices depending on mix
- 4x max. 300m DALI line length, wires ≥ 1.5mm$^2$
- max. 5m Sensor to Sensorcoupler
- max. 5m Lightsensor distance to measurement area (depending on reflection characteristic)
- max. 2m Pushbutton to Pushbutton Coupler
- 4x switch-over relais maximum 5A ohmic load each

## System Features

- out-of-the-box plug & play functionality if no configuration loaded
- 4x 16+ Groups, line overlapping allowed
  '+' means additional 'virtual' groups possible by software, but uses addressed commands
  Final max. number of groups only limited by controller memory
- 4x 16 scenes, line overlapping allowed, but then one scene used for each line
- 4x 8 active light regulation loops
  more possible when noticeable delay accepted, limited by reaction times
- full- and semi-automatic energy saver function with occupancy- and light-sensor
- up to 10 lightsensors / sensorcouplers per regulation
- corridor function with unlimited steps
- PIR disable / enable function
- sequences consisting of scenes, fade control, loops
- scene stepping
- visible ressource status message
- switch function e.g. for Highbay Sensor integration
- serial / parallel configuration of grouped switches
- programmable internal relay to be used in action list
- testfunction for all DALI devices
- configuration check against physical available devices
- simple 'failed ECG' replacement
- retrieve configuration by download from controller
- full project documentation in HTML file
- up to 50 timers can be configured (RTC version only)

## Perfect for

- industry hall
- warehouse
- classrooms
- single office
- large office
- meeting room
- corridor

**Version**:
December 2013

**Please note**:
All information in this manual has been prepared with great care. OSRAM, however, does not accept liability for possible errors, changes and/or omissions. Please check www.osram.com or contact your sales partner for an updated copy of this manual.

**Software updates:**
To ensure the latest software version is used please consult the OSRAM website www.osram,com in regular intervals (once a month).New versions will be released due to software improvements, additional supported devices and bug fixing.

# Lighting a brighter future – an intelligent approach

PHILIPS

sense and simplicity

# Contents

Graduate with First Class

# Honours in Lighting

## Adopting new technology for competitive advantage

With recent cuts in government funding now taking effect, we understand the increased challenges facing universities. There has never been a more important time to make sure the investments you make are worthwhile and add value, so we've put together this guide to help you understand the benefits of reviewing an area you might not have considered could make a significant impact on the quality of your environment, your sustainability goals and your staff and student wellbeing – lighting.

Some of the advantages of adopting a sustainable lighting solution may not be immediately obvious. Visual impact will of course be the most noticeable, but increasingly students are likely to be making their choice of university on not just the quality of its academic environment, but also its commitment to sustainability.

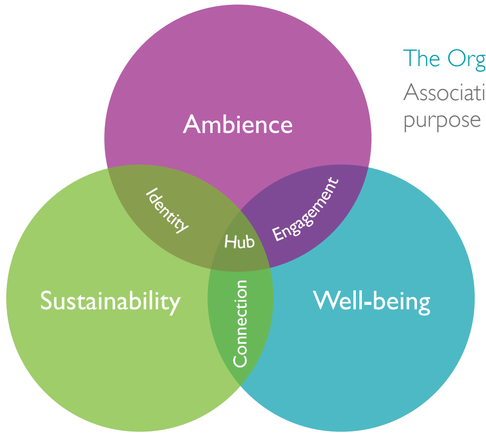
Choosing a 'green' university could become a major decision factor for the next generation of students. Likewise business partners will be more attracted to research facilities or spaces available to hire for corporate events if they match with their own company's environmental commitments. From a purely financial point of view, investing in an energy efficient lighting strategy using LED lighting and controls will start to yield benefits right away in terms of reduced energy bills and ongoing maintenance costs.

This brochure will show you in more detail how lighting can:

- Enhance the university learning and teaching environment
- Help to reduce carbon emissions, energy consumption and maintenance to meet sustainability and financial targets
- Improve safety and comfort for everyone on campus

By exploring the needs and desires of students and staff in universities, we have identified three key aspects that need to exist to create benefit:

## The lighting trinity



The Organisation
Associative identity organisational purpose and culture

The Building
Function and efficiency sustainability

The People
Emotional and biological needs experiences and activities

# Investing in a sustainable future

Universities who can demonstrate that they have a strong sustainability policy forming part of their corporate and social responsibility policy (CSR) can often use this as an advantage to:

- Give transparency and visibility to potential investors or students
- Increase access to research funding
- Enhance stakeholder relations and credibility
- Protect and strengthen their identity and brand image

A growing trend; 'sustainability' issues are becoming increasingly focused upon by the government, businesses and academic institutions alike. Increasing pressures are being put on organisations to comply with various legislation, regulations, codes, schemes and initiatives. All of which encourage organisations to look at their business processes and operations, to identify where they can become more sustainable, these include:

- Carbon Reduction Commitment
- Energy Performance and Building Directive
- Energy Services Directive
- BREEAM Ratings
- CIBSE Guidelines

Energy efficient lighting and management systems can help towards businesses meeting these legislations or achieving these guidelines and targets by reducing energy consumption, carbon emissions and the associated cost of carbon.

# Create your own identity

First impressions count for a lot. How potential students and parents first view your university can make a huge difference and will affect the choices they make.

In today's competitive environment, students want to know they're getting the best. Effective lighting can help you reinforce your brand and strengthen your appeal to students, parents and business partners alike.

With light you can easily transform any space. Imagine a space that can be altered, at literally the flick of a switch, to look like a completely different space. Your environments can be 'changed' through the use of different coloured lighting and light levels – meaning you can:

- Project or reflect your university colours to reinforce your brand identity
- Make an impression on visitors in your public spaces – potential students and their parents will notice your visual presentation
- Support a significant occasion, event or theme in the campus year
- Create an ambience or mood that can improve productivity and creativity within the student population
- Attract commercial interest by offering a high-tech, attractive and flexible space for hire

The creative possibilities achievable through lighting are endless. These include: changing the lighting levels, frequency and colours and employing intelligent lighting management systems. You can use the same space for a multitude of activities – simply by changing the ambience or function through light.

For example:

- Change a simple lecture room into a multi-media theatre
- Alter the colour or intensity of the lighting to stimulate debate or calm the environment during a lecture or at times during the day when people feel low in energy
- Theme a reception, for example new students beginning their first term

All of this is possible through the flexibility of intelligent lighting – and it's low energy too, so it won't impact on your sustainability aspirations.

Lighting can improve student and staff experience and the perceptions of your university. These features also help to reduce space costs, as they can be used for multiple purposes, giving flexibility and also the potential of earning commercial revenue.

# Lighting for learning

Normal

Calm

Energy

Focus

The visual effects of artificial lighting are highly important, be it at work or leisure. But light affects more than just our eyes – it affects our mood, concentration level, activity and sleep; it truly has a biological effect.

All functions within the human body are influenced by the rhythm of night and day. Light has a profound effect on the hormones that control our 'body clocks', that's why:

- We generally sleep at night
- We find it more difficult to get up when it's dark in the mornings
- We get jet lag when we change time zones
- Our general feeling of wellbeing varies throughout the day

Light affects all of this and that's why it is important to get the right amount of light, in the right place, at the right time.

For most businesses, over 70% of its costs are its people, so it makes perfect sense that businesses want to look after them and to ensure that they are also as productive as possible, hence the increasing adoption of quality & flexible lighting. For a university environment, the wellbeing of your students, lecturers and office staff and their ability to perform as well as they possibly can to reach their full potential is paramount.

Giving your students and staff the right amount of light throughout the working day to perform their activities can be achieved by choosing and managing the lighting correctly. And studies show that this leads to tangible results in students.

A study conducted by Hamburg-Eppendorf University showed significant improvements in concentration levels and reduction in mistakes made, by adopting intelligent, programmable lighting. The SchoolVision system allows the lecturer or students to change the lighting in the learning environment to suit the activity being undertaken. There are 4 settings, all of which have a different level of light and colour: developed to stimulate different reactions through cortisone and melatonin levels in the body, which are stimulated by light entering the eye.

They can choose from Energy, Focus, Calm or Normal – depending on what they are doing and how they are feeling.

The system has been implemented successfully in schools throughout Europe and was piloted in the UK for the first time in 2010. Initial research findings in the UK by City University London follow the trend and indicate an overall improvement in students' attention levels and achievement.

### SchoolVision – the research figures at a glance

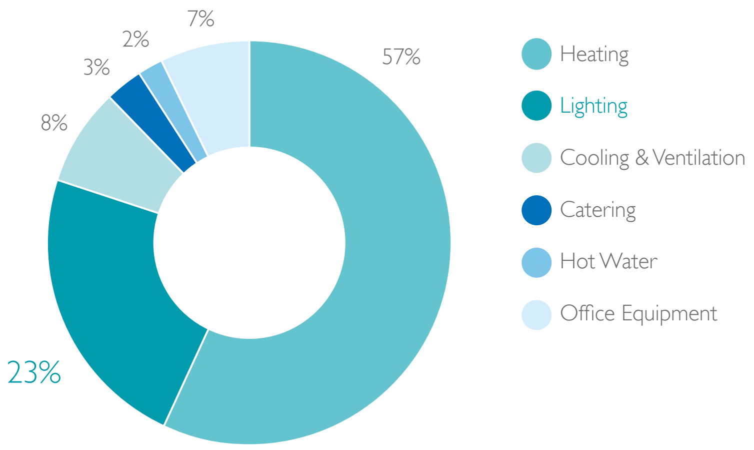
The results of a year-long scientific study by Universitätsklinikum Hamburg-Eppendorf with 166 pupils and 18 teachers showed that:

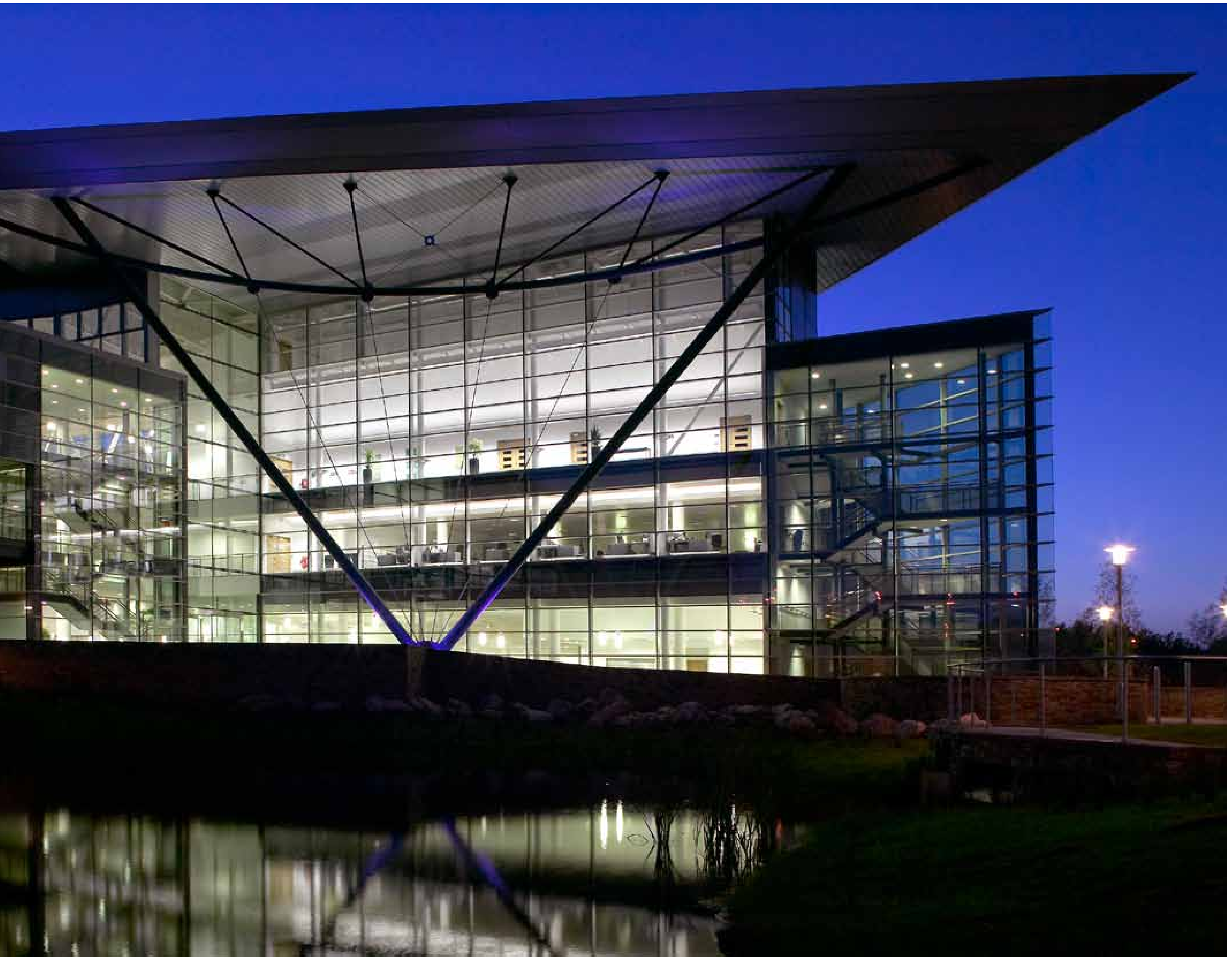
- Reading speed increased by almost 35%
- Frequency of errors reduced by almost 45%
- Hyperactive behaviour also dropped by an astonishing 76%

For more information on the SchoolVision solution, full research findings and testimonials, please visit: http://www.lighting.philips.co.uk/application_areas/school/schoolvision/schoolvision_solution.wpd

# The real cost of inefficient lighting

Breakdown of C0$_2$ emissions for a typical University campus





It's well known that lighting accounts for around 23% of a university's energy costs, or put another way, that's nearly a quarter of a typical energy bill.

Here are some examples of scenarios where lighting can become an unnecessary cost to your university.

- Lights are left on when they're not needed. A typical office is only occupied between 25-30% of a week. If it is lit constantly around the clock, that equates to a staggering 70-75% energy wastage in those office areas.
- No lighting control systems have been installed, or if they have, they haven't been programmed or maintained correctly to supply light only where and when needed.
- Older, energy hungry lighting systems are in place. Research indicates that over 75% of Europe's education sector lighting is based on inefficient or outdated lighting systems.

These illustrations are not unique to one or two sectors – any lit environment can suffer from the associated consequences of increased costs and higher carbon emissions – both of which can be tackled effectively with energy efficient lighting sources and managed lighting systems, programmed correctly.

Energy efficient lighting systems also create benefits that are sometimes not immediately obvious. For example, by managing your building's lighting so that it's only in use when it's needed, less heat is generated. Less air conditioning is required – an overall reduction in use means reduced energy consumption and lower emissions, a smaller energy bill and a 'greener' carbon footprint. Also, by using lighting less, the sources last longer – reducing maintenance requirements, landfill and costs associated with replacement.

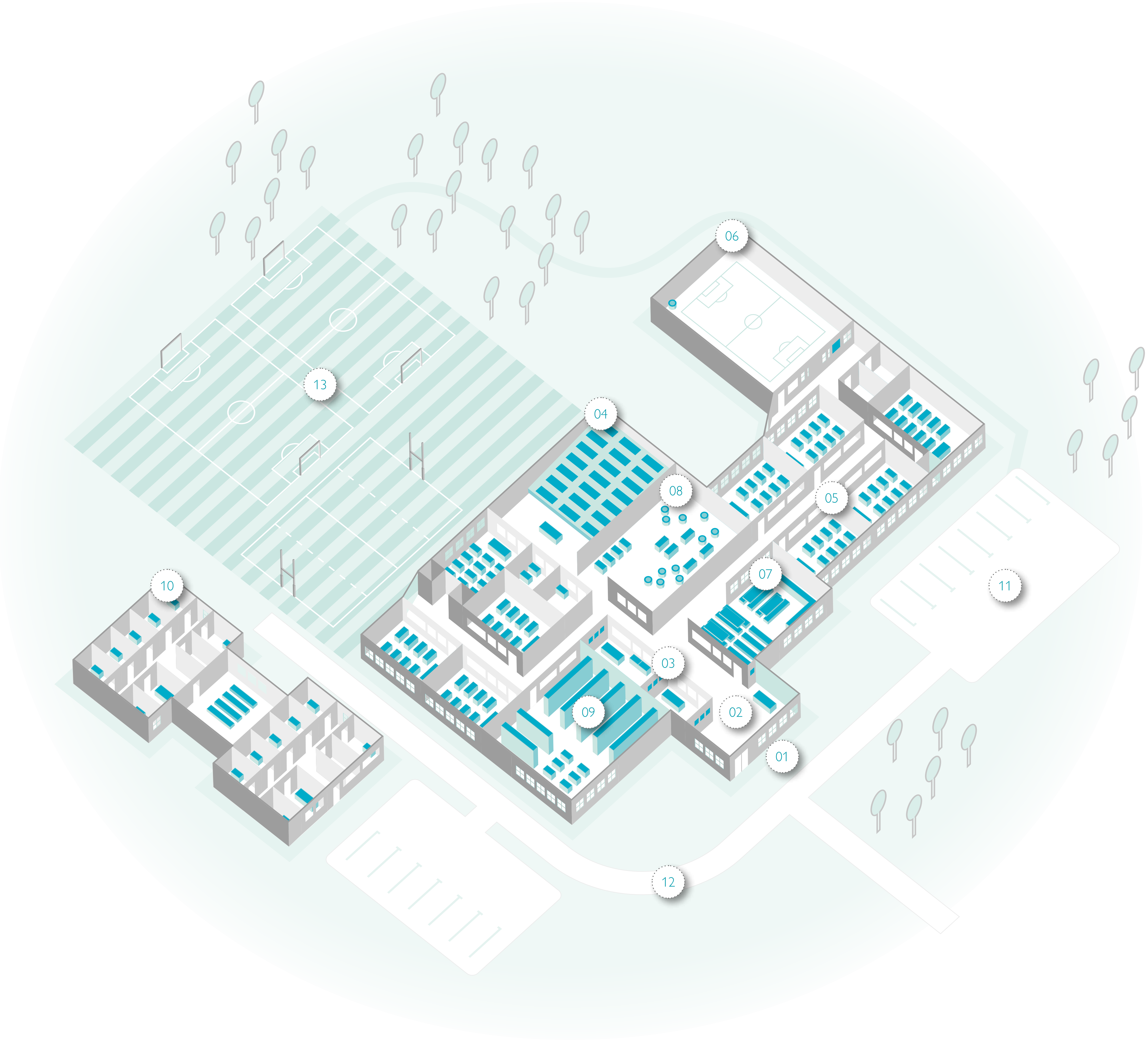
So how do your ensure you can monitor your energy use throughout the whole university environment and how can you reduce your consumption in areas of high demand? For most universities this is no easy task: it's difficult to know how much energy is being consumed by area and how to measure it.

Installing a lighting management system allows you to see and monitor lighting energy consumption by area. By having this information to hand, it's clearly visible where energy is being consumed. It's then possible to look at how this consumption could be reduced, as you'll know which areas are being occupied, for what and how frequently. You can then ascertain if having the lighting on permanently is necessary, or whether presence detection sensors, timed switching, dimming or daylight harvesting strategies could be utilised to effect – to drive down the energy consumption and ultimately cost.

# Campus

## overview

| | |
|---|---|
| 01 | Façade |
| 02 | Reception |
| 03 | Offices |
| 04 | Lecture theatres |
| 05 | Teaching rooms / laboratories |
| 06 | Sports hall |
| 07 | Restaurant / refectory |
| 08 | Student Union (bar) |
| 09 | Library |
| 10 | Accommodation (halls) |
| 11 | Car parks |
| 12 | Outdoor walkways / paths |
| 13 | Sports fields / courts |



# Stand out

## from the crowd

Creating lasting first impressions, highlighting architectural details, using your building exterior as a 'canvas' for light – however you view it, using modern, programmable colour-changing lighting systems can help to create a unique atmosphere, 'wow' visitors and promote your university's brand and identity.

Making a statement about yourself through lighting is an effective way to create a lasting impression on new visitors to your campus. 'Light washing' buildings with your university colours for example. Solid state or LED lighting offers more design freedom than ever before in terms of colour, miniaturisation, architectural integration and energy efficiency, opening up new ways to enhance and promote your brand.

### Students as customers

Choosing a university has always been a major decision for students. The process of finding the right place to invest in further education has never been so competitive or the battle for the best students more intense. Increasingly factors like sustainability and the environment are playing an important role in attracting and converting students: having a sustainable lighting strategy is not just good for the planet – it's great for business too.

# First impressions count

The first point of contact for visitors, new students and parents, your reception area needs to create the right experience and set the tone for further interactions within the university. This is also the place to 'wow' visitors – to instill confidence and reassure them of the quality of your academic environment and to use as a place to showcase your university.

## The right ambiance

A programmable LED lighting system can create a flexible, energy efficient solution that makes the right first impression. It can also adjust to ambient lighting conditions that vary throughout the day. Combining functional and decorative lighting in an entrance area will immediately reinforce your university's identity and your commitment to the students' educational experience.

# Are you sitting comfortably?

Good office lighting is about quality and comfort – the lighting should be bright enough for staff to be able to perform visual tasks, but not so bright that it causes glare and discomfort. In addition to this, it's now clear that light has a biological effect and there are valuable emotional benefits gained by adjusting light in office environments. For example, increasing levels of blue light on a dull Winter's day can promote alertness, enhance productivity and the feeling of wellbeing.

## Work smarter, save energy

In any university the library may be open 24 hours a day, but for offices operating core working hours the potential to waste energy is very real. Energy bills and carbon footprint can be dramatically reduced by adopting programmable lighting that dims automatically in response to bright daylight and switches off when no-one is present at the beginning and end of the day.

This approach to lighting offices promotes sustainability by using the latest LED lighting technology alongside sophisticated control systems, with the added benefits of less landfill, longer lifetime, reduced maintenance costs and less disruption to the workplace.

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# Perfect presentations

From detailed and technical, to thought provoking and inspirational – how you present your ideas to an audience can make the difference between being forgotten or remembered for years to come. Effective lighting can help set the stage. Our solutions are flexible and take into account the need to complement whiteboard presentations, lectures when films may be shown or work with practical demonstrations where bright lighting is essential for clarity. The use of lighting control systems means you can customise every presentation to maximise its chances of success.

## Commercial benefits

Turning your lecture theatres into revenue streams is another way that you can help balance the cost of your energy efficient lighting investment. Flexible and hi-tech presentation spaces are always in demand – especially for businesses looking to hire a suitable venue to impress clients or to deliver effective presentations to their own workforce. Spaces can be themed to fit with a corporate event or colour changing lighting can be used to emulate a company's brand colours.

# Brighter spaces

Creating the right environment for learning is essential for any university. The goal to create spaces that are comfortable for students and lecturers and are flexible enough to suit different tutorial needs can be achieved through advanced lighting systems. Alongside an increased emphasis on energy efficiency, your lighting solution should also offer low maintenance for minimum disruption, something made entirely possible by the new generation of LED lighting.

## Light learnings

The right ambience can make all the difference. For example, our SchoolVision system gives lecturers control over 4 different lighting settings: 'calm', 'energy', 'focus' and 'normal', allowing users to adjust the lighting mood to suit the activity, or respond to typically 'low' times of the day. After lunch or late in the afternoon, when energy levels are down and students would benefit from an increase in blue light through the 'energy' setting for example.

The SchoolVision solution has achieved impressive results in test studies in Europe, with concentration levels increasing significantly and incidents of mistakes being reduced by almost 45%. There is also valuable anecdotal research indicating that students simply enjoy the process of learning in SchoolVision spaces more than in conventional classrooms.

# Making lighting a key player

One of the main priorities in any sports hall is the creation a safe, well-lit environment for physical activities. Our contemporary lighting solutions, using impact-resistant materials and efficient lighting technology can help achieve this, offering bright, white light and a 'shadow free' playing environment.

## Smarter tactics

The use of 'intelligent' presence detection means that when a sports hall is unoccupied, the lights turn themselves off. Add to this automatic dimming when ambient levels are high and it can equate to incredible energy savings of up to 60%, significantly reducing costs. Especially with high ceilings in sports halls, the low maintenance offered by 'long lifetime' LED lighting really comes into its own.

# Food glorious food!

When you're hungry, there's nothing quite like seeing tasty, appetising food, well lit and tempting, right there in front of you. It's important that lighting enables good colour rendering, so food looks just as it should. By using energy efficient LED lighting there's almost no heat emitted, which in turn means food stays fresher for longer and there are less air conditioning costs, reducing carbon impact still further.

## A lunchtime refectory, an evening bar

One of the ongoing benefits you can enjoy with modern energy efficient lighting is flexibility. Transforming a space purely by lighting to look like another space gives you the ability to change a mood at the literally touch of a button. From a bright, inviting lunch area, to something more low key with a different feel later on. What would you like to turn your space into this evening? It's all possible with the latest technology.

# The best bar none

The hub of any university campus, the Union bar is easily overlooked as somewhere that can really benefit from a flexible lighting system. Making a statement through lighting, for example by using university colours, creating mood lighting for themed nights, brighter lighting for quiz nights or that special ambience for a seasonal event – the possibilities are endless.

## Last orders for non-eco lighting

While the flexibility of modern lighting systems that give you infinite options of colour and mood is a huge bonus in terms of creating something special, there is also the energy efficient aspect to it as well – so while your student population is enjoying time at the bar, you can drink a toast to the savings you're making. Given all the reasons to adopt new, sustainable solutions, old and inefficient technology has clearly had its day. Time gentlemen please!

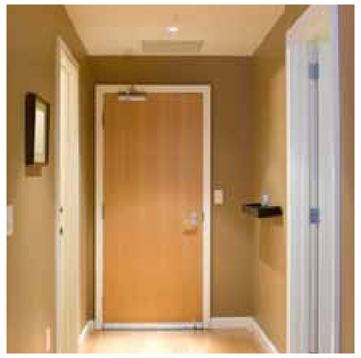
# A brighter space

## 24 hours a day

Gone are the days of dingy corners and straining your eyes to see. Whatever time of day, students in modern university libraries can benefit from the best technology and bright lighting, enabling comfortable, easy reading without glare. In common with university office areas, the possibilities modern lighting offers of 'daylight harvesting', means the system will utilise natural daylight by dimming automatically at times of bright sunlight. It can also be programmed to boost the use of blue light during the darker months of Winter, to promote feelings of wellbeing when we're naturally more tired and less energised.

### Lighting, but only when you need it

Busy during the day, less so at night (except around exam time!) – this is where motion activated lighting, designed to save energy, really comes into its own. Using controllable systems means you can use lighting only where and when it's needed, giving you ultimate flexibility and helping to reduce your carbon impact.



# Home from home

Freshers students traditionally start their university careers in student halls. With a constant throughput of new students and with students often moving rooms termly, it pays to know the lighting systems you install will be reliable and tough. Our energy efficient lighting systems for halls are both low maintenance and tamper resistant, to give you additional peace of mind. Also with much longer lifetimes, modern LED lighting solutions reduce maintenance and the need for intrusion into student life.

## Presence detection and safety 24/7

Safety in student halls is clearly a major concern, so alongside motion sensitive lighting, our emergency lighting systems also feature self-testing and monitoring, ensuring they are always functional and tested through a central hub. This dramatically reduces disruption and time otherwise spent doing conventional tests and at the same time ensures students have visibility for safety should the mains power fail.

# Safer parking

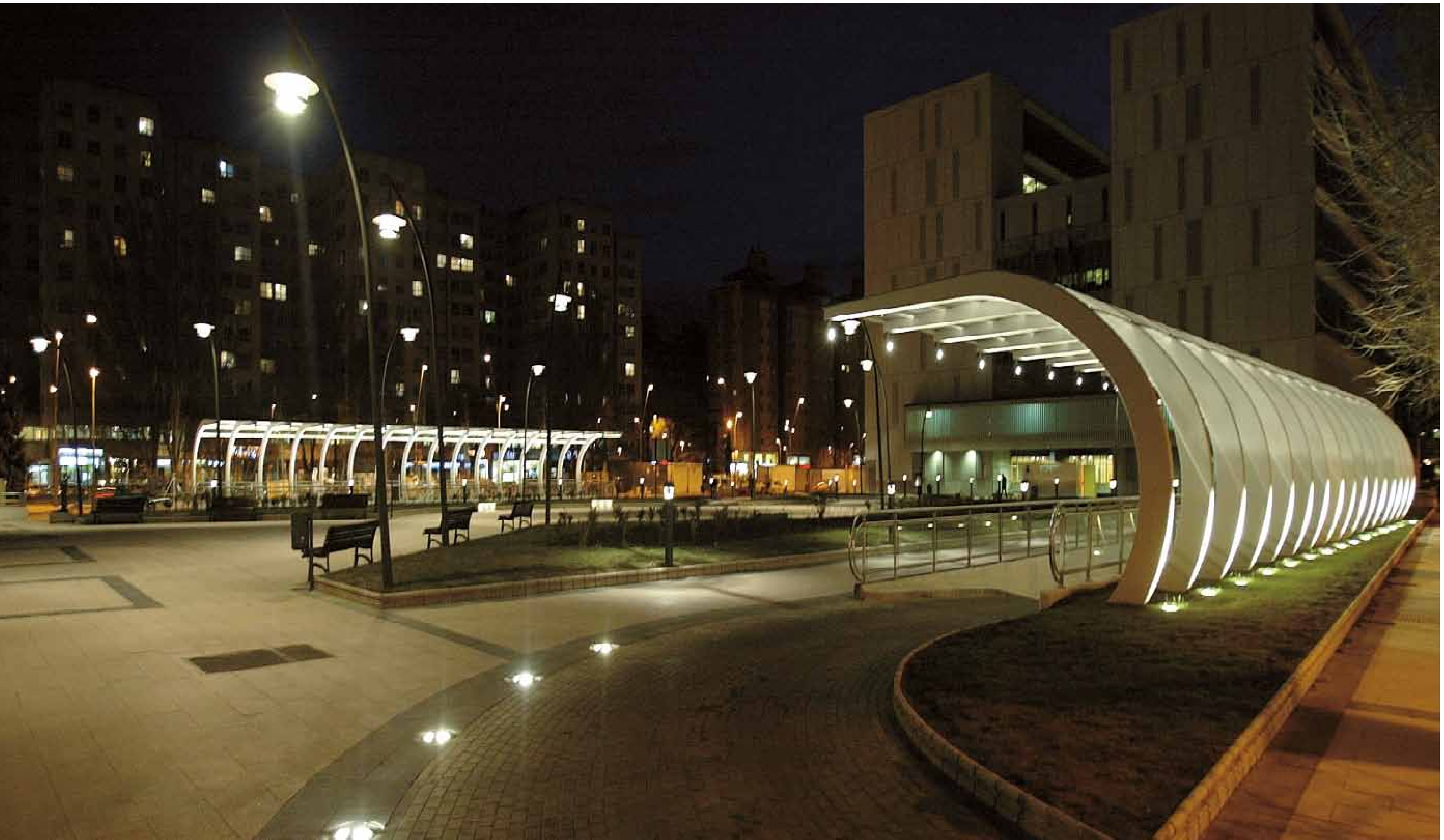
Advances in LED technology also means better, safer car parks. Bright white light makes judging distances much easier than with old style lighting. Overall, safety is improved for pedestrians too as colour and movement is easier to see for both drivers and those on foot, with even light ensuring no shadows or 'dark spots'. Our car park lighting solutions are waterproof, shockproof, dust proof and vandal resistant.

## Controllable environments

Your system can be programmed to switch on and off at dusk and dawn. There is real flexibility here too. By using sensors, the system can adjust light levels to meet variable light conditions and by employing motion sensors, it can sense people approaching and brighten lighting instantly in response, before returning to a 'dimmed' setting – especially useful in off-peak hours. This is also an effective solution to potential light pollution issues for any surrounding residential areas.

Lower energy use means you can stay in control of costs too. Long lamp lifetimes ensure low maintenance costs, plus the use of advanced LED technology means up to 50% energy savings are achievable.

# A walk on the
# bright side



Student safety is all important. Our latest lighting solutions can transform your communal walkways into a better lit and brighter places to walk. LEDs offer improved colour rendering and clearer visual recognition, leading to safer journeys during the hours of darkness. Like our car park solutions, effective walkway lighting will ensure no 'dark spots' and a clean, crisp and consistent lighting experience.

## Colour your journey

There are more choices than white – the possibilities using coloured lighting means you have a range of options and solutions as broad as your imagination. For example you could design your exterior space so that you follow coloured low energy LED recessed ground lights to different areas on campus, perfect for new kids on the block!

# Be outstanding

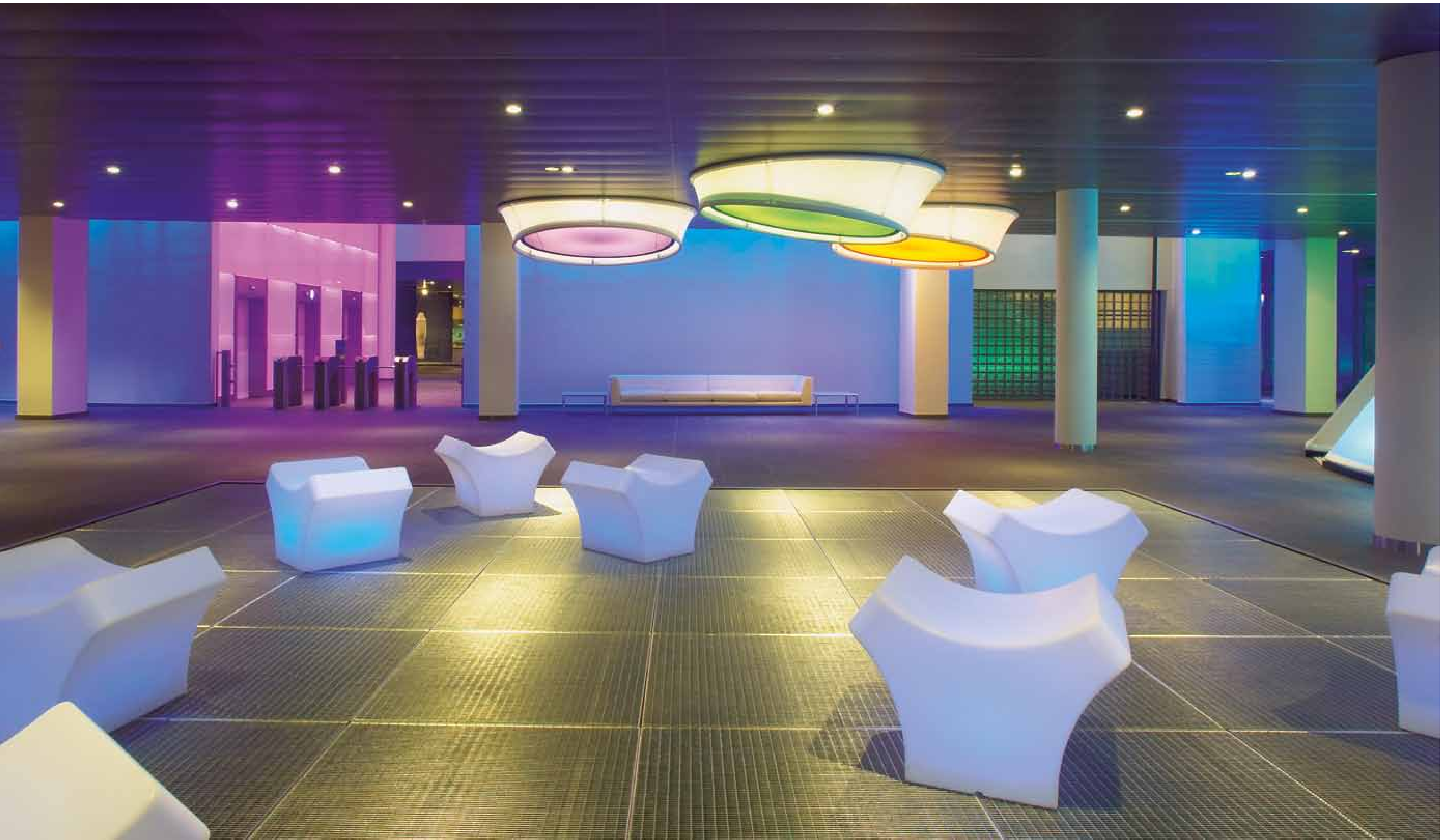
## in your field

Ideal outside spaces for sport should be well lit, but also with limited glare, to ensure comfort for teams or individuals playing sport in hours of reduced ambient light or darkness. Our lighting solutions create a 'shadow free' environment and a bright, even light. They are also directional and focused on the space they are intended to light, minimising potential light pollution issues for any surrounding residential areas.

### Less maintenance, lower costs

With potential maintenance costs being high, the use of advanced lighting technology offers significant savings not just in terms of running costs. With the difficulty of access on both sports fields and high ceilings in sports halls, the low maintenance offered by modern lighting solutions really pays off.

# Why choose Philips as a lighting partner?



## Advanced, affordable, sustainable

With the whole of the lighting industry making a 'seismic shift' towards energy efficient lighting, especially focused on LED and control, you need to know that the lighting partner you choose will offer you more than just the latest ideas in lighting. You should have the confidence of knowing that the products you choose are well designed, reliable, and crucially, come with the kind of support and advice you can depend on when making such a major investment in advanced, sustainable technology.

## Creating value by making the right investment

As pioneers of LED lighting, Philips is ideally placed to help you transform your university environment. Our extensive experience in innovative lighting design and installation means that whatever solutions you need, we're confident we can create something special for you. We can also advise on how to raise the necessary capital if that's a factor – our innovative range of funding options means there should be no barrier to your making a sustainable investment in energy efficient lighting. An investment that will start to repay itself the moment it's installed.

That's good news for your budget, your staff and students' wellbeing and also your carbon emissions targets.

## Swapping ordinary for extraordinary

If you'd like to discuss how Philips energy efficient lighting systems might improve life on your campus, please get in touch with one of the Philips Lighting team.

**Call us: 0870 601 0101**
**Email us: intelligentlighting@philips.com**

For more information:

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# Enjoy the comfort of energy saving

Somfy and Philips control light to optimize the working environment in buildings

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**Philips**

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Philips Controls (Canada)
Email: controls.support@philips.com
Phone: (514) 636-0670
www.canlyte.com

Light Balancing

PHILIPS | somfy

# Somfy and Philips control light in buildings to optimize occupants' wellbeing while saving energy

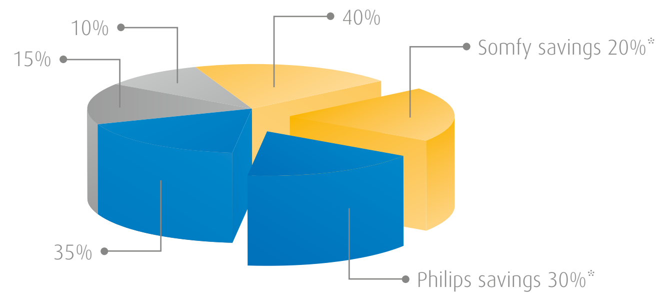
Somfy and Philips control light to optimize the working environment in buildings

## Two global market leaders

Somfy controls incoming natural daylight, while Philips controls artificial indoor light. The two companies' complementary solutions allow optimal control of both.

Together, Somfy and Philips can substantially reduce energy usage: 75% of a building's energy consumption is used for lighting and heating/cooling.

Integrated light and shading control can contribute up to a 50% savings in the energy consummation of lighting and HVAC.



### Equipment Energy Consumption

- 🟡 Heating, ventilation, air-conditioning & refrigeration
- 🔵 Lighting
- ● Office equipment / information technology
- ○ Water heating

Source:
US Energy Information Administration (EIA) - www.eia.doe.gov/consumption/

* Potential savings of integrated controls

## Somfy

- Somfy has been the world leader in motors and controls for openings and closures in commercial and residential buildings for 40 years
- With the presence in 51 countries, every year hundreds of buildings are equipped with Somfy solutions
- Bioclimatic Façades is based around 3 unique areas of expertise in façade technologies: Dynamic InsulationTM - Natural light managment - Natural ventilation

### Natural light management in buildings can:

- Reduce the need for artificial light
- Provide glare control, increase user comfort and productivity
- Reduce the cooling demand and cooling load

Annual savings with automated solar protection*

| | Interior shades | | Exterior shades |
|---|---|---|---|
| | Normal fabric | High reflective fabric | |
| Cooling demand (kWh) | 15% | 35% | 35% |
| Cooling load (Watt) | 20% | 45% | 45% |

- reduce the energy consumption of cooling and heating systems resulting in reduced investment and maintenance costs

(source: ES-SO Study Dec. 05)

* The figures shown are average values. Savings will vary according to climate, shading device, building type, etc...

## Philips

- Global market leader in lighting solutions since 1891
- Offers complete lighting solutions (controls, luminaires, lamps) for all lighting needs
- 65% of the world's top airports, 30% of commercial buildings and hospitals, one out of three cars and landmarks such as the Eiffel Tower, the Sydney Opera House and the Great Pyramids are lit by Philips
- Is externally recognized as a green leader by various global organizations

### Artificial light management in buildings can:

- Realize substantial energy savings e.g. through the use of controls

| | Presence detection | Daylight regulation | Presence detection + Dayligt regulation |
|---|---|---|---|
| Energy saving | 30% | 30% | 50% |

- Maximize occupant comfort,
- Ensure compliance with applicable building energy codes (for e.g. ASHRAE, California Title 24),
- Promote sustainability with green building designs (for e.g. LEED certification)

## Light Balancing

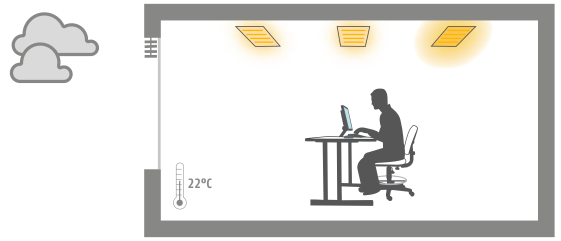
### The symbiosis between natural and artificial light management

As global market leaders in their respective fields, both Somfy and Philips seek to deliver user benefits through the efficient control of light. Their systems work naturally together: when the outside light is blocked to provide thermal comfort and glare control, the artificial light will automatically compensate the light levels and vice versa. This results in maximum comfort at the lowest possible energy consumption.

> "Intelligent solutions from Somfy and Philips control the balance of light in buildings, and combine optimal visual comfort with energy saving."

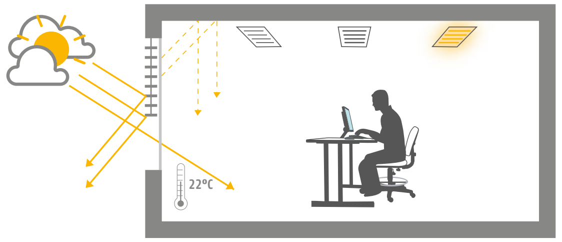
Systems from Somfy and Philips function interdependently without any undesired interference.

### No sun, cloudy



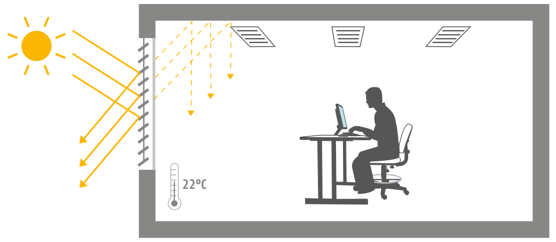
Natural light: minimum
Artificial light: maximum

### A little sun, some clouds



Natural light: medium
Artificial light: medium

### Sunny



Natural light: maximum
Artificial light: minimum

# Fan Coil Unit Controller

Networked heating, ventilation and air conditioning control

# User Guide

Version 1.0

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# Background

Philips Dynalite is a highly specialized company whose principal occupation is to provide 'cutting edge' solutions for lighting control. Our achievements have been recognized worldwide and Philips Dynalite is generally the system of choice for projects involving integration with third-party vendor's equipment and for large-scale applications.

Philips Dynalite's philosophy is to provide the best solution possible for each and every project. This is the key to our success. Our considerable investment in Research & Development ensures that we remain at the forefront of our industry. Our position as a world leader in lighting management systems for the future is sustained through our total commitment to innovation.

We are represented around the world by distributors and dealers who are handpicked for their ability to provide the highest possible level of service.

> From a stock exchange in Shanghai, to a luxury resort in Dubai, a smart home in Sao Paulo to limestone caves in New Zealand, Philips Dynalite's innovative solutions deliver intelligent light.

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# Contents

# About this guide

## Guide Overview

This guide is designed to assist in the configuration of the DDFCUC010 and DDFCUC010 fan coil unit controllers.

A working knowledge of EnvisionProject and Dynalite commissioning processes is required to effectively use this document. For more information on EnvisionProject and commissioning processes, consult the EnvisionProject User Guide.

Parameters in this controller require information that must be sourced from third party manufacturer's device details and specifications. HVAC knowledge is required

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# 1 Fan Coil Unit Controller (FCUC)

## 1.1 Introduction

The DDFCUC010 and DDFCUC024 Fan Coil Unit Controllers are designed to control heating, ventilation and air conditioning (HVAC) systems.

Conceptually the FCUC consists of two controllers, one for heating and one for cooling. Outputs are provided for controlling heating liquid valves and cooling liquid valves as well as relays for driving fan motors and a high capacity relay for electrical heaters.

An input is provided for a resistive type temperature sensor and the device can also use data from a networked temperature sensor such as the Philips Dynalite DTS900. Programmable dry contact inputs are provided for peripherals such as smoke detectors, motion detectors, window open/close sensors, drip tray overflows, dirty air filters and airflow detectors.

## 1.2 Features

- Can be networked with other equipment via the onboard RS485 DyNet port
- Powerful Internal PLC - Custom scripts can be written to provide process control based or conditional logic
- Temperature Sensor Input - 20K NTC (Negative Temperature Coefficient). Networked temperature sensors also supported.
- Dry Contact Inputs - three programmable inputs for devices including; window sensor, motion detector, smoke detector, drip tray and air filter
- Many Control Options—Control of this device can be via a combination of methods, eg. serial control port (DyNet), relay contacts, push button wall stations, infrared receivers and time clocks
- Simple Installation—DIN rail mount facilitates installation. All connection terminals are accessible without disassembly

## 1.3 Connections

Both FCU controllers have the same fan, Auxiliary output, temperature sensor and input options. Therefore, the selection of fan coil unit controller will depend on the type of valve being controlled.

DDFCUC010

Modulating analogue valve, 0-10V DC.

Valve position set by applied voltage.

DDFCUC024

Electromotive (raise/lower) valve.

Valve position set by travel time.

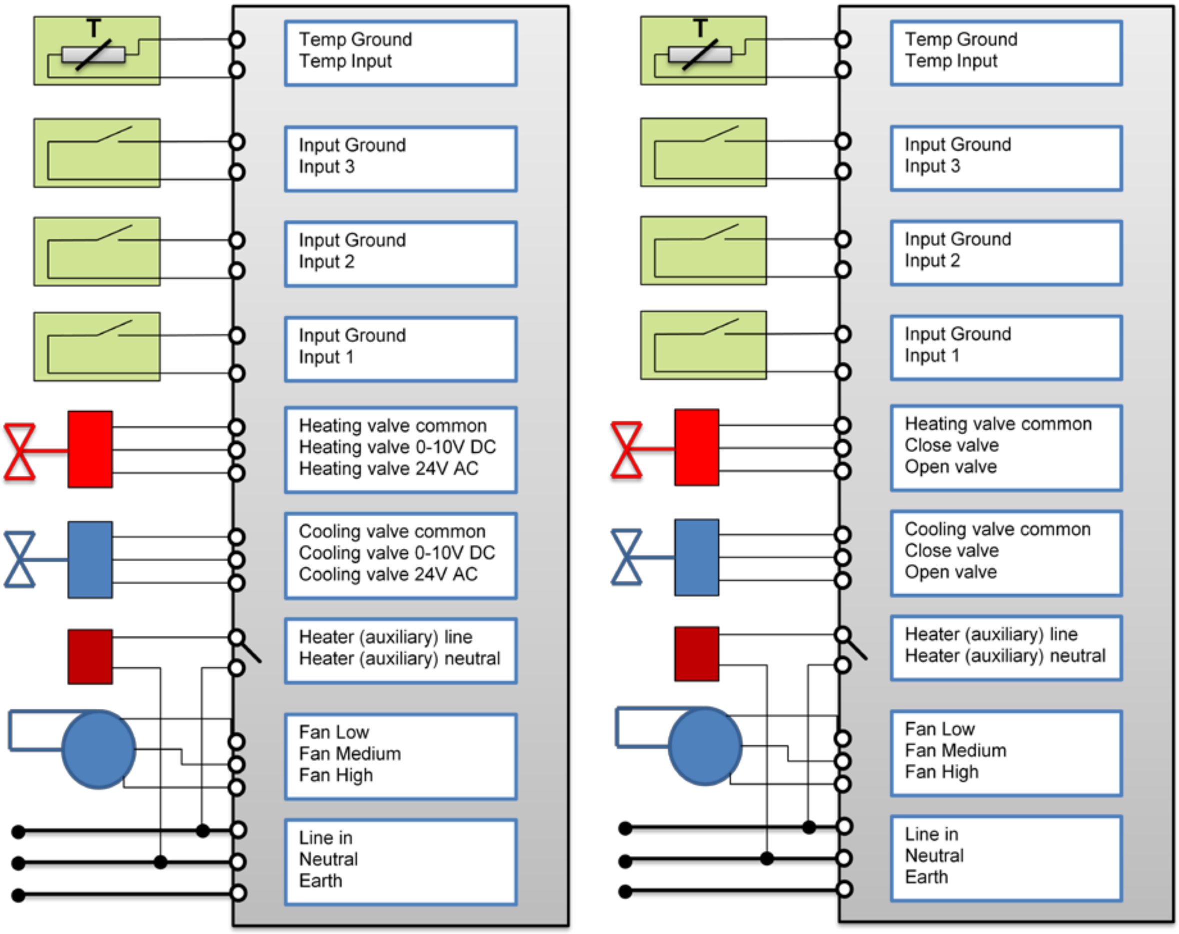


**Figure 1 – Controller Comparison**

The controller has the following connections:

Inputs (selectable x3):

- Airflow Sensor
- Custom
- Dirty air filter
- Drip tray overflow
- Energy Hold off for Window switch
- Fire trip for smoke detector
- Hot water on cold valve
- Preset

Input (Dedicated):

- Temperature sensor

Outputs:

- Cold Valve Actuator
- Hot Valve Actuator
- Auxiliary Feed Through relay output(For Electric Heat Relay)
- 3 Speed Fan Relays.

| Connection | Description |
|---|---|
| Selectable inputs | Eight types of device can be connected to any of the 3 inputs. They must be configured using the EnvisionProject software. |
| Temperature Sensor | A local temperature sensor can be connected to the temp sensor input. |
| Hot / Cold Valves | Valve outputs provide control signals suitable for 24V AC floating or staged valve actuators (1, 2 or 3 stages).<br>• For the DDFCUC010, the valve position is controlled directly by the 0-10V DC control voltage applied (floating valve only)<br>• For the DDFCUC024, the valve position is inferred from the valve travel time specified |
| Heater Switch | If electric heating coil control is used, then it can be connected to the 16A feed-through heater relay. Where the electric heater is not required, this relay can be used as a general-purpose auxiliary output. |
| Fan speed control | A fan of up to 3 stages can be connected to the fan output; the low, medium and high outputs may be activated individually to control the airflow. |
| Network Connection | The RS485 DyNet port and additional RJ12 socket are located on the underside of the unit. |

**Note:** Third party device data sheets are required for configuration.

## 1.4 Plant Structure

Typically, an FCU consists of a single fan, and one or more heat-exchanging coils.
The coils may be fed with hot or cold water, steam or electricity.

The thermal output of the FCU can be controlled by varying fan speed, water coil flow and electric coil current. Measurement of the air temperature in the surrounding environment and comparison to a user set-point allows a feedback control system to be implemented.

The controller requires the following information about the plant

- Valve configuration
- Fan configuration
- Aux output
- Input/fault signals
- Temperature sensor data

To facilitate the use of a single platform for all electrical services the controller also integrates local HVAC control with DyNet, enabling interaction with the entire control network

**Note:** to save energy, simultaneous active heating and active cooling is disabled.

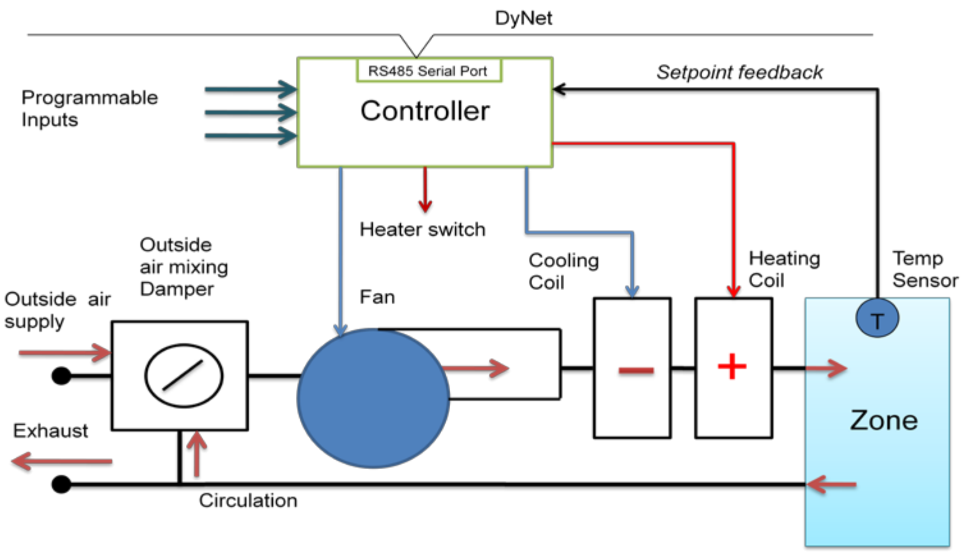


Figure 2 – Controller and Plant Structure

## 1.5 Commissioning

To complete the process of commissioning you will need to consider the following factors:

- Area climate specifications
- Environmental and usage factors
- Selection of areas to be controlled
- Number and location of controller units required (typically one per area)
- Plant hardware interface, capacity and limitations
- Lag times between control signal and effect
- Lower energy solutions
- Control scheme to be used
    - PID control or
    - Staged control
- Type of user interface

**Note:** you will need to refer to third party equipment specifications for performance parameter figures.

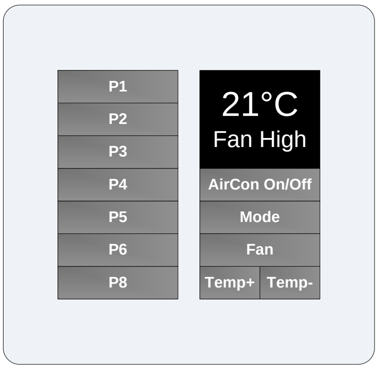


Figure 3 – Typical user interface for HVAC control

Standard setpoint range is approximately:

- 20° to 24° in winter
- 23° to 27° in summer

# 2 FCUC Initial Configuration

This topic covers configuration of the DDFCUC010 and DDFCUC024 Fan Coil Unit Controller using EnvisionProject. To end up with a fully configured controller perform the following tasks:

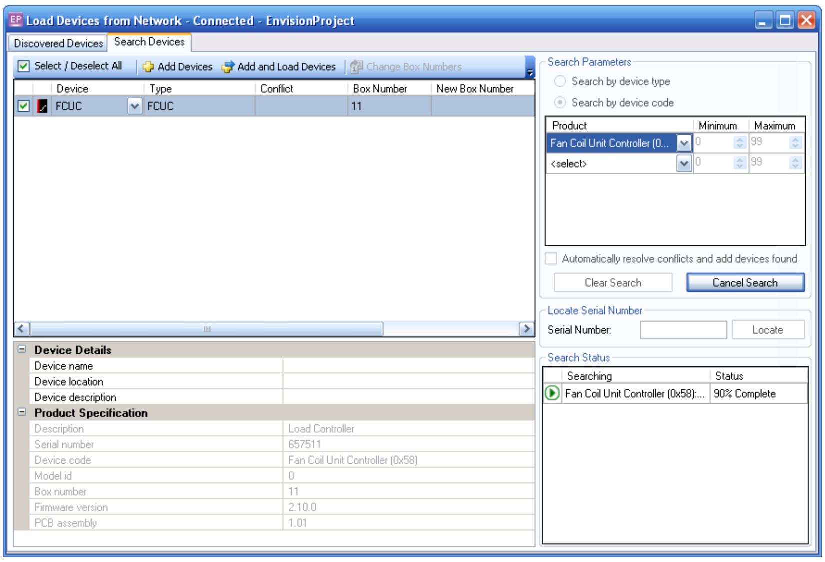
1. **Load the device**
2. **Run the Configuration Wizard, FCUC Diagnostics and PID Tuning Wizard, if required**
3. **Configure Plant**
4. **Configure Temperature Control**
5. **Configure Switches**

## 2.1 Load Device

Load the FCUC into EnvisionProject

1. Run EnvisionProject and open your project
2. In Network View
3. Click Insert Devices from Network or press Ctrl+L
4. In the Search Devices tab/Search Parameters section, check Search by device code
5. Click the Product dropdown box and select Fan Coil Unit Controller
6. Click the Start Search button
7. When the FCUC device appears in the list, click the checkbox next to the device
8. Click Add Devices or Add and Load Devices

The FCUC controller now appears in the project



| | Device | Type | Conflict | Box Number | New Box Number |
|---|---|---|---|---|---|
| ☑ | FCUC | FCUC | | 11 | |

| Device Details | |
|---|---|
| Device name | |
| Device location | |
| Device description | |
| **Product Specification** | |
| Description | Load Controller |
| Serial number | 657511 |
| Device code | Fan Coil Unit Controller (0x58) |
| Model id | 0 |
| Box number | 11 |
| Firmware version | 2.10.0 |
| PCB assembly | 1.01 |

Search Parameters

○ Search by device type
● Search by device code

| Product | Minimum | Maximum |
|---|---|---|
| Fan Coil Unit Controller (0... | 0 | 99 |
| <select> | 0 | 99 |

☐ Automatically resolve conflicts and add devices found

Locate Serial Number

Serial Number:

Search Status

| Searching | Status |
|---|---|
| Fan Coil Unit Controller (0x58):... | 90% Complete |

Figure 4 – Load Device Page

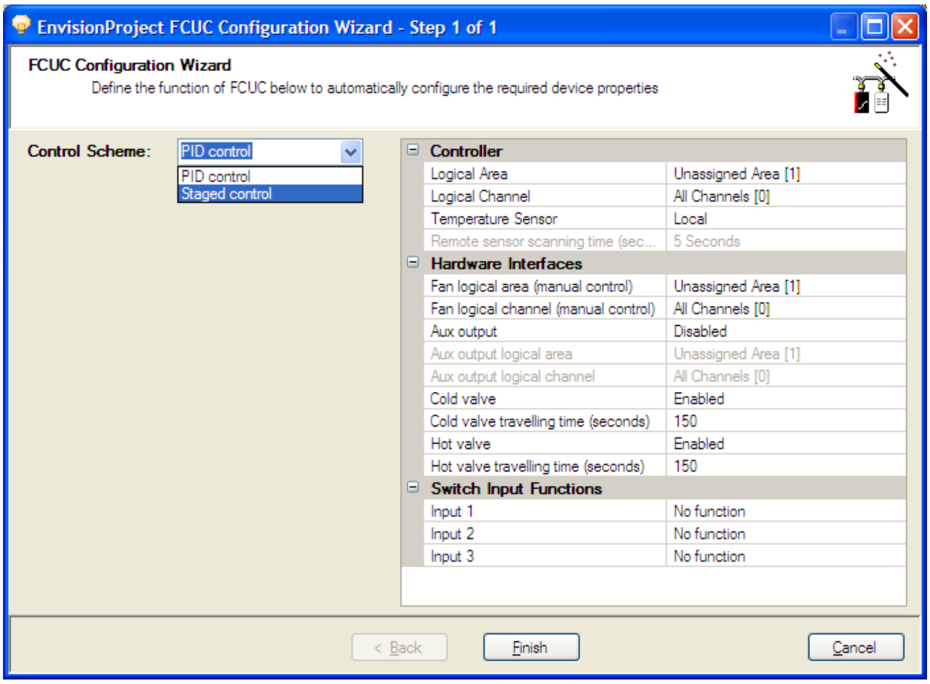
## 2.2 Run the FCUC Configuration Wizard

The controller can be configured manually or using the FCUC Configuration Wizard. The wizard can also be used initially with manually configuration performed afterwards.

Run the FCUC Configuration Wizard

1. Right-click the FCUC device in the Network View
2. Select FCUC Configuration Wizard from the shortcut menu

To simplify setup, the wizard displays the main settings required by the controller.



EnvisionProject FCUC Configuration Wizard - Step 1 of 1

**FCUC Configuration Wizard**

Define the function of FCUC below to automatically configure the required device properties

Control Scheme: PID control

| | |
|---|---|
| **Controller** | |
| Logical Area | Unassigned Area [1] |
| Logical Channel | All Channels [0] |
| Temperature Sensor | Local |
| Remote sensor scanning time (sec... | 5 Seconds |
| **Hardware Interfaces** | |
| Fan logical area (manual control) | Unassigned Area [1] |
| Fan logical channel (manual control) | All Channels [0] |
| Aux output | Disabled |
| Aux output logical area | Unassigned Area [1] |
| Aux output logical channel | All Channels [0] |
| Cold valve | Enabled |
| Cold valve travelling time (seconds) | 150 |
| Hot valve | Enabled |
| Hot valve travelling time (seconds) | 150 |
| **Switch Input Functions** | |
| Input 1 | No function |
| Input 2 | No function |
| Input 3 | No function |

Figure 5 – FCUC Configuration Wizard

Configure the following parameters for each section of the wizard and then click the Finish button

For a detailed explanation of the following parameters refer to the Plant Configuration, Temperature Control and Switch Configuration topics.

The wizard will:

- For all logical addresses set Join = 0xFF and BLA= 0xFFFF
- Set logical addresses of the dry contact inputs to match the controller logical address
- Configure Cold and Hot valves configuration types = Floating
- Enable all types of faults / signals and set their restart counts = Infinite Restart Attempts
- All other configuration parameters will match the default (factory set) values

## 2.3 Control Scheme

Select the required scheme:

***Control Scheme***
PID control/Staged control

## 2.4 Controller

Define the controller parameters:

***Controller logical area***
Assigned logical Area for plant control

***Controller logical channel***
Assigned logical channel for plant control

***Temperature Sensor***
Local/Remote (directly connected to the controller or connected via the DyNet network).

***Remote sensor scanning time (seconds)***
Polling period for remote sensor(eg DTS9900). The default is 5.

## 2.5 Hardware Interfaces

Define the hardware interfaces:

***Fan logical area (manual control)***
Assigned logical Area for manual fan control

***Fan logical channel (manual control)***
Assigned logical channel for manual fan control

***Aux output***
Disabled/Manual/Heating/Cooling.  If manual then specify Aux Output Logical Address

***Aux output logical area (Aux output is set to Manual)***
Assigned logical Area for auxiliary output

***Aux output logical channel (Aux output is set to Manual)***
Assigned logical channel auxiliary output

***Cold valve***
Enabled/Disabled

Cold valve travelling time (seconds)
***Hot valve***
Enabled/Disabled

***Hot valve travelling time (seconds)***
Enter parameter from plant manufacturers' data sheet

## 2.6 Switch Input Functions

Define the Switch Input Functions:

***Input 1, 2 or 3***

Airflow sensor/Dirty air filter/Drip tray overflow/Energy holdoff/Fire trip/Hot water on cold valve/Preset/No function

# 3 Configure Plant

## 3.1 Plant configuration tab

The Plant Configuration Tab contains settings for the Logical address, Temperature sensor, Valves, Fan, Aux output, faults/signals and runtime parameters.

The following buttons are available on the Plant Configuration toolbar.

- Displayed fields can be sorted in one of two ways by using the following buttons:

  Categorized

  Alphabetically

- Initially only the basic fields are shown. To reveal all fields click the Advanced button. Most standard setups will not require the use of advanced parameters.

- The controller remembers the current settings for the setpoint, fan, aux output and Mode. Click the Clear Runtime Parameters button and then press F12 (Save to Device) to reset the currently operating values back to the default.

- To create a new setpoint temperature, enter a temperature in degrees Celsius in the box on the toolbar and click the Send Temperature Setpoint button. This is the desired temperature given to the FCUC to maintain. The setpoint can be overridden by DyNet logical opcode 0x48 until next message or reset.

The following fields are available on the Plant Configuration page.

**Note:** Standard Fields are shown in ***bold italics***. Advanced fields are shown in *standard italics*.

## 3.2 Logical Address

***Controller logical area***
Set the area in which temperature control is to be used.

***Controller logical channel***
Set the channels to be affected. Use the channel number or use All Channels (0).

*Controller join*
Assign any join rows that are applicable using the join byte.

*Controller BLA*
Enable/Disable Base Link Area.

Temperature Sensor

***Use local sensor***

True for a sensor directly connected to the DDFCUC010 and False when using a DTS900 on the network (the FCU controller can send logical DyNet messages to retrieve the temperature of the area from devices like DTS900).

*Type of local sensor*

Type of local sensor. This option is to inform the device that, on-board temperature sensing circuitry is being used to retrieve the temperature of the area. Only NTC (Negative Temperature Coefficient) is supported at the moment

*Remote sensor scanning time (Seconds)*

Polling period for DTS9900

*Use initial setpoint on startup*

Use the initial setpoint temperature (°C) on plant start up

***Initial setpoint (°C)***

Initial setpoint temperature (°C). This parameter defines the (starting) temperature set point for device whenever device resets. This set point is in effect until set point is changed by DyNet message. The parameter supports temperature in 0.01°C resolution. The range is -127.99°C to +127.99°C. The default is 22.00°C.

*Measured temperature offset (°C)*

0.1 degree increments to offset the temperature value of the sensor. The value defined for this parameter shall be added to the measured temperature before it is used by the FCUC. The valid range is -12.7°C to +12.7°C. The default is 0.0°C

*Local sensor*

Enable / Disable direct sensor

*Local sensor logarithmic*

True for Logarithmic and False for Linear

*Local sensor logarithmic constant*

Value for logarithmic configuration, details available from sensor manufacturer

*Local sensor logarithmic resistance*

Value for logarithmic configuration, details available from sensor manufacturer

*Local sensor pullup resistor*

Value for local pull up resistor fitted on board, To change value; remove cover, use Jumper selection 1k or 22k (22k default)

## 3.3 Valves

***Cold valve***

Enable/Disable cold valve. This option enables cooling control in FCU controller using a cold water system which is controlled by an electronically operated valve. The default is enabled

***Cold valve configuration type***

Type of cold valve, choose from floating, 1 stage, 2 stage and 3 stage

- **floating valve:**
    - This is the only option for the DDFCO010
    - For the DDFCO024 this option is used to drive a valve which is controlled by two separate signals, either to open or close the valve. Specify the travel time to control the valve position and specify the ON & OFF Delay to prevent valve wear and tear.
- **1 stage valve:** This option is used where a cooling system is controlled by only two states – ON and OFF. The non-zero value will activate both output signals, while the zero value will deactivate both output signals. User enters the On & Off time delay.
- **2 stage valve:** This option is used if the cooling system has two ON stages. The zero value deactivates both output signals, 1-50% activate only one of output signal (i.e. valve open) and 51-100% activates both output signals. User enters On & Off time delay.
- **3 stage valve:** This option will be used if the cooling system has three ON stages. The zero value deactivates both output signals, 1-33% activates only one of output signals (i.e. valve open), 34-66% activates only another output signal (i.e. valve close) and 67-100% activates both output signals. User enters the On & Off time delay.

*Cold valve active high state*

True or false for staged valves only, used to set the default starting position for the valve

*Allow hot water on cold valve*

True or False to allow heating and cooling using one valve

***Cold valve travelling time (seconds)***

Time taken to go from fully closed to fully open. Valid time range is 1-600 seconds with 150 seconds as default. This time is used by FCUC to precisely control the valve position. The value for the parameter can be found in the valve datasheet.

*Cold valve minimum on time (seconds)*

Minimum time the valve must be on before turning back off to prevent valve damage. The valid value range is 0-1200 seconds with 0 seconds used as default

*Cold valve minimum off time (seconds)*

Minimum time the valve must be off before turning back on to prevent valve damage. The valid value range is 0-1200 seconds with 0 seconds used as default.

*Cold valve scheduled overrun period (hours)*
Default set to 24hrs, used to reset the valve to home position Range is 0-168 hours.

***Hot valve***
Enable/Disable hot valve. This option enables heating control in FCU controller using a hot water system which is controlled by an electronically operated valve. The default is enabled

***Hot valve configuration type***
Type of hot valve, choose from floating, 1 stage, 2 stage and 3 stage

- **floating valve:**
    - This is the only option for the DDFCO010
    - For the DDFCO024 this option is used to drive a valve which is controlled by two separate signals, either to open or close the valve. Specify the travel time to control the valve position and specify the ON & OFF Delay to prevent valve wear and tear.
- **1 stage valve:** This option is used where a heating system is controlled by only two states – ON and OFF. The non-zero value will activate both output signals, while the zero value will deactivate both output signals. User enters the On & Off time delay.
- **2 stage valve:** This option is used if heating system has two ON stages. The zero value deactivates both output signals, 1-50% will activate only one of output signals (i.e. valve open) and 51-100% will activate both output signals. User enters the On & Off time delay.
- **3 stage valve:** This option is used if heating system has three ON stages. The zero value will deactivate both output signals, 1-33% will activate only one of output signals (i.e. valve open), 34-66% will activate only another output signal (i.e. valve close) and 67-100% will activate both output signals. User enters the On & Off time delay.

*Hot valve active high state*
True or false for staged valves only, used to set the default starting position for the valve

***Hot valve travelling time (seconds)***
Time taken to go from fully closed to fully open. Valid time range is 1-600 seconds with 150 seconds as default. This time is used by FCUC to precisely control the valve position. The value for the parameter can be found in the valve datasheet.

*Hot valve minimum on time (seconds)*
Minimum time the valve must be on before turning back off to prevent valve damage. The valid value range is 0-1200 seconds with 0 seconds used as default

*Hot valve minimum off time (seconds)*
Minimum time the valve must be off before turning back on to prevent valve damage. The valid value range is 0-1200 seconds with 0 seconds used as default.

*Hot valve scheduled overrun period (hours)*
Default set to 24hrs, used to reset the valve to home position. Range is 0-168 hours.

*Valve min control efforts (%)*

Minimum % change in position required before the valve will be activated Prevents excessive valve wear

## 3.4 Fans

***Fan***

Enable/Disable. This option enables the fan control by FCUC. The default is enabled.

***Fan logical area***

Assigned logical Area for fan control. Only used in manual mode

***Fan logical channel***

Assigned logical channel for fan control. Only used in manual mode

*Fan join*

Fan control join byte. Only used in manual mode

*Fan BLA*

Enable/Disable Base Link Area for fan control. Only used in manual mode

*Fan active high state*

True will close the relay when driver and False will open the relay when driven

***Fan configuration type***

Fan type, select from 1 speed, 2 speed and 3 speed. Default option is 3 speeds.

**1 speed fan:** This option is used where fan only has ON and OFF control. The non-zero value will activate the Fan-L output signal, while zero value will deactivate the Fan-L output signal. Fan-M and Fan-H always remain deactivated.

**2 speed fan:** This option is used where fan has two ON states and OFF control. The value of 1-50% activates the Fan-L output signal, while values from 51-100% activates Fan-M output signal. Only one output signal is activated at any given time, while Fan-H will always remain deactivated.

**3 speed fan:** This option is used where fan has three ON states and OFF control. Values of 1-33% activate the Fan-L output signal, values from 34-66% activate the Fan-M output signal, while values from 67-100% activate the Fan-H output signal. Only one output signal can be activated at any given time.

*Fan minimum on time (seconds)*

Minimum time the fan must be on before turning back off to prevent fan damage. The valid value range is 0-2400 seconds with 0 seconds used as default.

*Fan minimum off time (seconds)*

Minimum time the fan must be off before turning back on to prevent fan damage. The valid value range is 0-2400 seconds with 0 seconds used as default.

***Fan runup time (seconds)***

Used to build up required air pressure in ducts, the airflow switch won't work till the overrun time expires. During the run up time, both valves remain off. The valid value range is 0-1200 seconds with 0 seconds used as default.

***Fan overrun time (seconds)***

The length of time the fan will run on after valve is closed. This period defines the extended period of time for which the fan will run once plant is shutdown, i.e. plant shut down request is received and both valves are in the fully closed position. Upon completion of the overrun time, the fan enters into an off delay period. This period will not apply in trip conditions. The valid value range is 0-1200 seconds with 0 seconds used as default.

## 3.5 Aux Output

***Aux output***

Enable/Disable Aux output

***Aux output logical area***

Assigned logical Area for Aux output. Only used in manual mode

***Aux output logical channel***

Assigned logical Channel for Aux output. Only used in manual mode

Aux output join

Aux output join byte. Only used in manual mode

Aux output BLA

Enable/Disable Base Link Area for Aux output. Only used in manual mode

Aux output active high state

True will close the relay when driven and False will open the relay when driven

***Aux output min on time (seconds)***

Minimum time the Aux output to remain on before turning back off to prevent damage. The valid value range is 0-7200 seconds with 0 seconds used as default

Aux output min off time (seconds)

Minimum time the Aux output to remain off before turning back on to prevent damage. The valid value range is 0-7200 seconds with 0 seconds used as default.

Aux Output control

Aux output control type. Choose from Manual, Temperature Controller Heating and Temperature Controller Cooling. Manual (by DyNet) is the default.

**Note:** If Aux Output control is set to Temperature Controller Heating/Cooling with PID control in effect, then the auxiliary output relay shall be used for heating/cooling purposes and not the hot/cold water valves.

## 3.6 Fault Signals

*Fire trip*
Enable/Disable fire trip. This input is designed to integrate smoke detector devices to FCU. If enabled, plant (i.e. FCU control operation) will be tripped when the input is active.

*Fire trip auto restart count*
Number of restarts allowed within one hour. This allows the plant to re-start automatically whenever fire trip condition is restored to normal

*Fire trip fan off*
True/False. When smoke is detected, the fan speed is set to off if true or runs at high speed if false.

*Energy holdoff*
Enable/Disable holdoff. This input is designed to integrate (room) window sensor to FCU controller. If enabled, plant (i.e. FCU control operation) will be tripped when input is active, i.e. window open.

*Energy holdoff auto restart count*
Number of restarts allowed within one hour. This allows the plant to re-start automatically whenever window is closed.

*Energy holdoff fan off*
True/False. When window open is detected, the fan speed is set to off if true or the fan runs at high speed if false

*Air flow fault*
Enable/Disable air flow fault. This input is designed to integrate air flow sensing, i.e. fan failure to the FCU. If enabled, plant (i.e. FCU control operation) will be tripped when the input is active. This fault is not active during fan runup time.

*Air flow fault auto restart count*
Number of restarts allowed within one hour

*Air flow fault fan off*
True/False, Fan speed to full

*Sensor fault*
Enable/Disable sensor fault. Refers to temperature sensor

*Sensor fault auto restart count*
Number of restarts allowed within one hour. Refers to temperature sensor

*Sensor fault fan off*
True/False, Refers to temperature sensor. True is fan speed to off. False is fan speed to full.

*Drip tray*
Enable/Disable drip tray

*Drip tray auto restart count*
Number of restarts allowed within one hour

*Drip tray fan off*
True/False, Fan speed to full

*Dirty filter*
Enable/Disable dirty filter

*Dirty filler auto restart count*
Number of restarts allowed within one hour

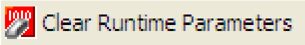
*Dirty filter fan off*
True/False, Fan speed to full

**Note:** By default all fault signals are enabled and auto restart is enabled.

Auto restart count allows the user to configure, how many reset attempts can be made before the plant is permanently shut down. The possible values are None, One, Two and Infinite. The default option is Infinite restart attempts.

Once plant permanently shuts down, then user needs to reset the fault state (to normal) by sending DyNet message (physical DyNet message opcode - 0x5B) once fault is restored and plant needs to start again.

## 3.7 Runtime Parameters

These parameters are read-only. They can be cleared by clicking the  button and then pressing F12 (Save to Device).

*Last known valid preset*
Last known preset used

*Last known manual fan speed*
Last known fan speed used

*Last known aux output level*
Last known aux output level used

*Last known temperature setpoint (°C)*
Last known temperature used

# 4 Configure Temperature Control

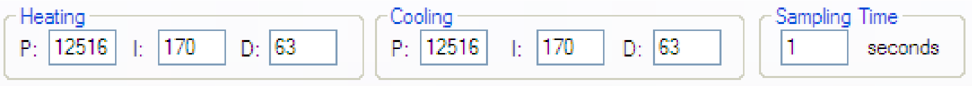
## 4.1 Temperature Control Tab

The Temperature Control Tab contains settings to configure temperature control using PID settings or staged settings.

The ● PID, ● Staged and FCUC Diagnostics buttons are available on the Temperature Control toolbar.

● PID Selecting the PID control scheme opens PID control page and reveals the following toolbar functions.

- The PID parameter settings



Heating P: 12516 I: 170 D: 63
Cooling P: 12516 I: 170 D: 63
Sampling Time 1 seconds

Refer to Tuning Wizard topic for explanation of parameters.

- The Tuning Wizard button Tuning Wizard

● Staged Selecting the Staged control scheme opens the staged control page and reveals the following toolbar functions

- Displayed fields can be sorted in one of two ways by using the following buttons:

  Categorised

  A Z ↓ Alphabetically

- Initially only the basic fields are shown. To reveal all fields click the Advanced button. Most standard setups will not require the use of advanced parameters

FCUC Diagnostics Selecting the FCUC Diagnostics button opens the FCUC Diagnostics page.

## 4.2 PID Control Scheme

PID control precisely maintains the temperature based on the PID algorithm to determine the temperature error and calculate the control effort required

The different Modes (PID settings) must be assigned to a Preset

Click the Add, Remove or Copy Preset buttons to create the number of Presets required.

If no configuration is defined for a received preset then the preset is ignored and the controller will continue to operate in the same mode as it was before preset was received.

### 4.2.1 Modes

Each page of temperature control parameters can be assigned to a mode of operation and the controller can be configured for up to ten modes.

Each mode must be assigned to one or more presets and is launched whenever the configured preset is observed by the FCUC. Although a mode can be assigned to multiple presets, a preset can only refer to one mode. Different modes of operation can be configured for energy savings, for example:

- **Occupied mode** — the temperature may be configured to track closely to the setpoint (i.e. small setpoint offset).
- **Unoccupied mode** — the setpoint may be less rigidly followed, this allows for cost savings as air conditioning does not need to run continually (i.e. larger setpoint offset).
- **Auto mode** — setting Manual fan control to FALSE allows the fan to be controlled by the temperature control scheme (PID or Staged)
- **Manual mode** — setting Manual fan control to TRUE allows the fan to be controlled by the user over DyNet
- **Off Mode** — to turn off the FCUC:
    - for PID control, set deadband fan speed to off and disable heating control and cooling control
    - for staged control, set deadband fan speed to off and set stage counts to zero for both heating and cooling

### 4.2.2 General Settings

***Mode***
Enable/Disable PID mode

*Thresholds relative to manual set point*
True / False. Default is True. It is recommended to use relative thresholds to easily adapt parameters for different setpoints.

***Manual fan control***

True / False. False is the default value. Setting the manual fan control to true will disable PID control of the fan and fan will be controlled directly over DyNet.

*Heating/Cooling switch over delay (seconds)*

Time in seconds to delay switching between heating and cooling modes. If setpoint change switches over then this delay is not applied. The default is 1800 seconds and range is 0-65534 seconds.

*Dead band fan speed*

This field defines the fan speed when neither heating nor cooling is in operation. This typically happens when the measured temperature is between the (effective) heating & cooling set point. Refer to Cooling/Heating offset for effective dead band. The fan shall also run on dead band speed, whenever system is inside the heating/cooling switch over delay period. The possible fan speeds are High, Mid, Low or Off

### 4.2.3 Cooling Parameters

***Cooling control***

Enable/Disable

***Cooling setpoint offset (°C)***

Offset to temperature cooling setpoint. This parameter accepts value in units of 0.1 °C with the range of 0.0 to 10.0 °C. The default is 0.5 °C.

***Cooling temperature error to run fan at low speed (°C)***

Temperature differential to use low fan speed setting

***Cooling temperature error to run at mid speed (°C)***

Temperature differential to use med fan speed setting

***Cooling temperature error to run at high speed (°C)***

Temperature differential to use high fan speed setting

### 4.2.4 Heating Parameters

***Heating control***

Enable/Disable

***Heating setpoint offset (°C)***

Offset to temperature heating setpoint. This parameter accepts value in units of 0.1 °C with the range of 0.0 to 10.0 °C. The default is 0.5 °C.

***Heating temperature error to run at low speed (°C)***

Temperature differential to use low fan speed setting

***Heating temperature error to run at mid speed (°C)***

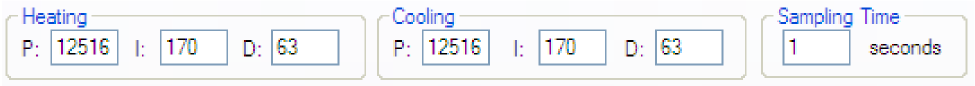
Temperature differential to use med fan speed setting

***Heating temperature error to run at high speed (°C)***

Temperature differential to use high fan speed setting

## 4.3 Tuning Wizard

It is recommended to use the Tuning Wizard to find and set the PID parameters.



Heating P: 12516 I: 170 D: 63
Cooling P: 12516 I: 170 D: 63
Sampling Time 1 seconds

**_Sampling Time_**

This parameter (in terms of seconds) defines time interval to run the PID algorithm, hence it defines time interval between two calculated control efforts to be transferred to plant. Valid range is 0.1-25.4 seconds. The default is 1.0 seconds.

**_Heating_**

This section defines the PID gains for heating operation.

- P: This parameter defines the proportional gain for heating operation of PID. The value is in units of 1 with range of 0-65534. The default is 12516.
- I: This parameter defines the integral gain for heating operation of PID. The value is in units of 0.1 with range of 0-6553.4. The default is 170.0.
- D: This parameter defines the derivative gain for heating operation of PID. The value is in units of 0.01 with range of 0-655.34. The default is 63.00.

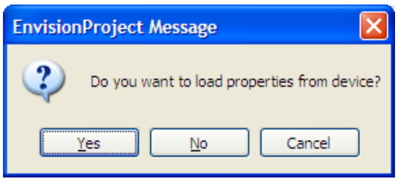
**_Cooling_**

This section defines the PID gains for cooling operation.

- P: This parameter defines the proportional gain for cooling operation of PID. The value is in units of 1 with range of 0-65534. The default is 12516.
- I: This parameter defines the integral gain for cooling operation of PID. The value is in units of 0.1 with range of 0-6553.4. The default is 170.0.
- D: This parameter defines the derivative gain for cooling operation of PID. The value is in units of 0.01 with range of 0-655.34. The default is 63.00.

Run the Tuning Wizard

1. Click the Tuning Wizard button



EnvisionProject Message

Do you want to load properties from device?

2. Click yes/no to load the properties from the FCUC device or not.

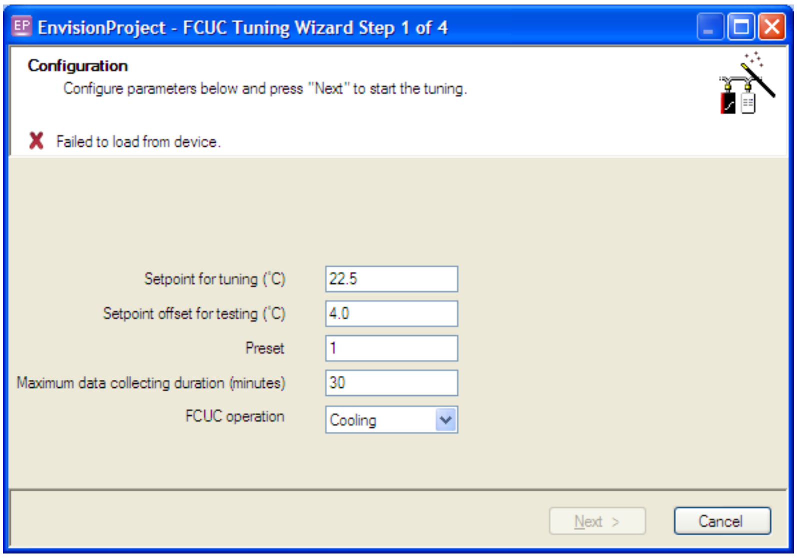
When the wizard starts-up it can optionally load the temperature control settings from the device. Otherwise it will take the existing configuration from the EnvisionProject job.

The tuning of each function should be performed under real operating conditions for example, tuning for the heating function may not be appropriate during summer or tuning for cooling in winter will not simulate real operating conditions.

Tuning the controller consists of setting some initial parameters and using these parameters over a period of time to collect the measured room temperature and observe the performance of the controller.

Tuning heating and cooling cannot be performed at the same time. Active heating and cooling is not permitted by the controller.

Step 1. The user inputs the initial parameters and limits for the tuning test



EnvisionProject - FCUC Tuning Wizard Step 1 of 4

**Configuration**

Configure parameters below and press "Next" to start the tuning.

Failed to load from device.

Setpoint for tuning (°C): 22.5
Setpoint offset for testing (°C): 4.0
Preset: 1
Maximum data collecting duration (minutes): 30
FCUC operation: Cooling

Figure 6 – FCUC Tuning Wizard Step 1

***Setpoint for tuning °C***
Choose a value in the middle of your expected working range. Standard range is approximately 20° to 24° in winter and 23° to 27° in summer. This is only used for tuning the controller. It is should be reasonable close to your working set point. Does not automatically set the initial set point.

***Setpoint offset for testing*** ° C
Used to set the positive and negative extremes of the setpoints used for the test relative to the Setpoint for tuning °C.

***Preset***

This is the preset used during the tuning test.

PID parameters found during the tuning are applicable in all operating modes however, the function selected for tuning (heating or cooling) should match mode assigned to the preset.

Operation of controller is preset based and the controller must be in preset at any given time. This preset is used during the tuning

***Maximum data collecting duration (minutes)***

This is when the wizard will stop collecting data.

The tuning wizard looks for 3 full periods of oscillation around the setpoint for a successful test. Normally the test is completed once the test criteria are met. Otherwise the test will fail at the time limit set.

***FCUC operation***

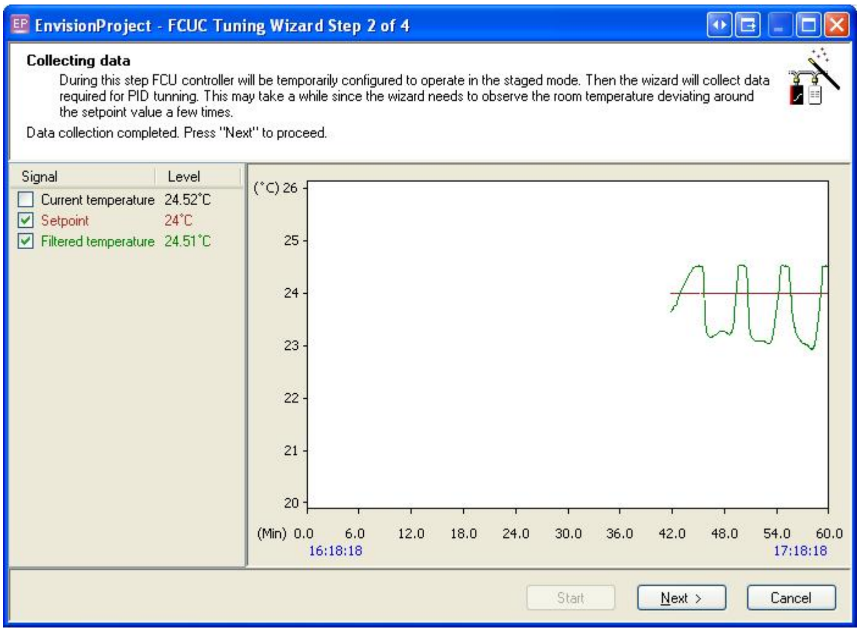
Used to set the appropriate function (heating or cooling). The controller can only tune for heating and cooling independently.

Step 2.

The controller is configured to staged mode using the setpoint and FCUC operation parameters (Heating or Cooling) The tuning uses these parameters over a period of time for collecting the measured room temperature and observing the performance of the controller.

During the tuning the setpoint, temperature and filtered temperature values are plotted on the graph

Click the signal checkbox to display the chart for each signal.



EnvisionProject - FCUC Tuning Wizard Step 2 of 4

**Collecting data**

During this step FCU controller will be temporarily configured to operate in the staged mode. Then the wizard will collect data required for PID tunning. This may take a while since the wizard needs to observe the room temperature deviating around the setpoint value a few times.

Data collection completed. Press "Next" to proceed.

| Signal | Level |
|---|---|
| ☐ Current temperature | 24.52°C |
| ☑ Setpoint | 24°C |
| ☑ Filtered temperature | 24.51°C |

Figure 7 – FCUC Configuration Wizard Step 2

Press the Start button to begin data collection

Press the skip button to go to the next step. You can skip data collection if you already have some approximate values for PID. It will save time if you have used another tuning tool or have commissioned similar areas before.

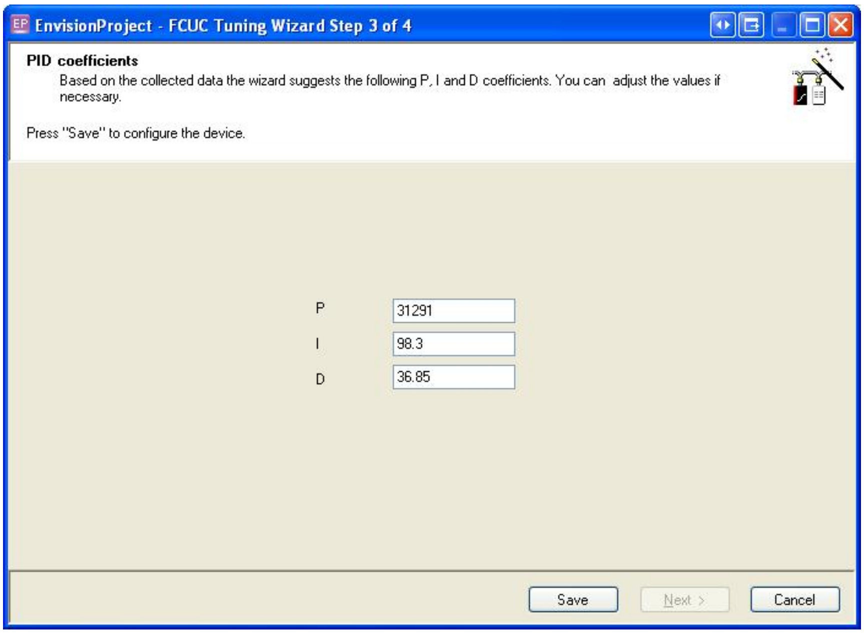
Once the data collection is started the wizard configures FCUC to single stage mode with no hysteresis and hot or cold valves and fan set to 100 %. Then the wizard starts collecting data required to evaluate PID coefficients. This includes polling the temperature, the setpoint and status of the FCUC.

If the value of setpoint changes or the function changes between cooling and heating then the tuning wizard will stop and display an error message.

When enough data is collected then the "Next" button becomes enabled. The "Start" button remains disabled while the data is being collected.

Step 3.

The tuning wizard calculates the optimal PID values. The wizard evaluates the coefficients and presents them to the user.



EnvisionProject - FCUC Tuning Wizard Step 3 of 4

**PID coefficients**

Based on the collected data the wizard suggests the following P, I and D coefficients. You can adjust the values if necessary.

Press "Save" to configure the device.

P 31291

I 98.3

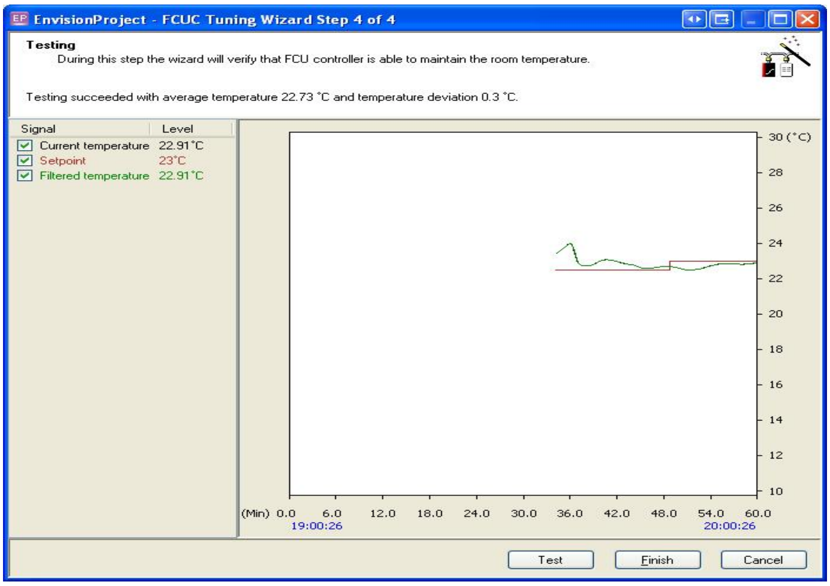
D 36.85

Figure 8 – FCUC Configuration Wizard Step 3

Check or edit the PID values and save them to the device.

The Next button becomes enabled after the data is saved to the controller

Step 4. In this step the controller uses the newly calculated PID values to test its ability to maintain the room temperature


EnvisionProject - FCUC Tuning Wizard Step 4 of 4

**Testing**

During this step the wizard will verify that FCU controller is able to maintain the room temperature.

Testing succeeded with average temperature 22.73 °C and temperature deviation 0.3 °C.

| Signal | Level |
|---|---|
| ☑ Current temperature | 22.91°C |
| ☑ Setpoint | 23°C |
| ☑ Filtered temperature | 22.91°C |

Figure 9 – FCUC Configuration Wizard Step 4

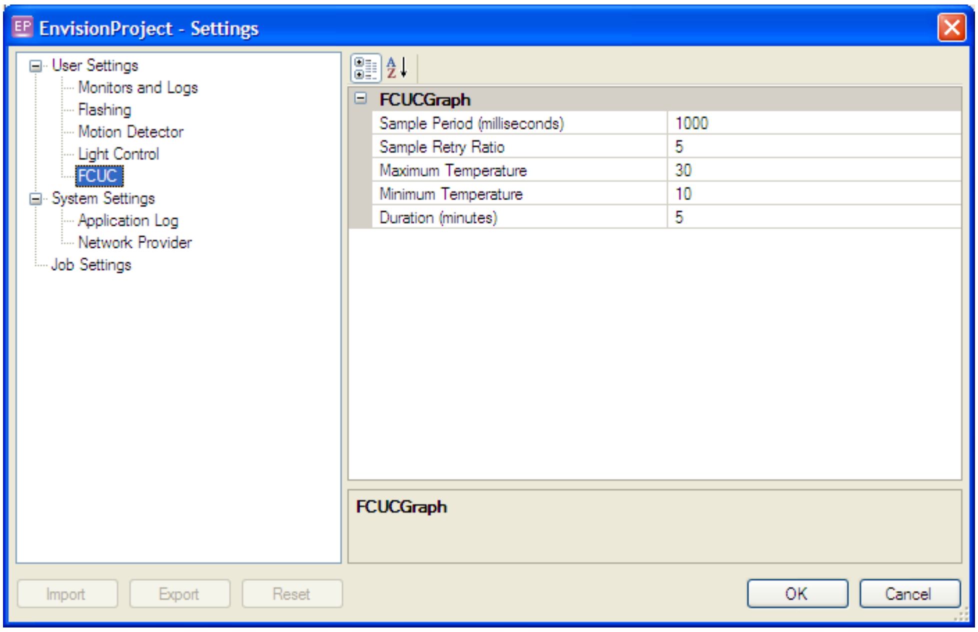
The test succeeds if the standard deviation of the temperature does not exceed the value of cooling (or heating) setpoint offset. Assuming normal distribution of the temperature readings this means that more than 66% of the temperature readings collected are within the configured setpoint offset.

The test can be repeated at anytime by pressing the test button. The extreme values for the setpoint offset alternate each time the test is run.

The test can be finished by the user at any time by the "Finish" button.

## 4.4 FCUC Graph Settings

The Chart scale can be changed by clicking the Tools menu and selecting Settings and FCUC.



| FCUCGraph | |
|---|---|
| Sample Period (milliseconds) | 1000 |
| Sample Retry Ratio | 5 |
| Maximum Temperature | 30 |
| Minimum Temperature | 10 |
| Duration (minutes) | 5 |

**Figure 10 – EnvisionProject FCUC Graph Settings**

## 4.5 Staged Control Scheme

Staged control operates in stages where each stage is based on the temperature error calculated by FCU controller at run-time. FCU controller allows up to 3 stages (for cooling and heating each) per configuration of stage control. Stage controller mode calculates the temperature error at the interval defined by responsiveness and will automatically jump to the stage so that desired temperature can be achieved as quickly as possible

The different Modes (Staged settings) must be assigned to a Preset

Click the Add, Remove or Copy Preset buttons to create the number of Presets required.

If no configuration is defined for a received preset then the preset is ignored and the stage controller will continue to operate in the same mode as it was before preset was received.

### 4.5.1 Modes

Each page of temperature control parameters can be assigned to a mode of operation and the controller can be configured for up to ten modes. Each mode must be assigned to one or more presets and is launched whenever the configured preset is observed by FCUC. Although a mode can be assigned to multiple presets, a preset can only refer to one mode.

Different modes of operation can be configured for energy savings, for example:

- **Occupied mode** — the temperature may be configured to track closely to the setpoint (i.e. small setpoint offset).
- **Unoccupied mode** — the setpoint may be less rigidly followed, this allows for cost savings as air conditioning does not need to run continually (i.e. larger setpoint offset).
- **Auto mode** — setting Manual fan control to FALSE allows the fan to be controlled by the temperature control scheme (PID or Staged)
- **Manual mode** — setting Manual fan control to TRUE allows the fan to be controlled by the user over DyNet
- **Off Mode** — to turn off the FCUC:
    - for PID control, set deadband fan speed to off and disable heating control and cooling control
    - for staged control, set deadband fan speed to off and set stage counts to zero for both heating and cooling

### 4.5.2 General Settings

***Mode***
Enable/Disable

Thresholds relative to manual set point
True / False

***Manual fan control***
True / False

*Responsiveness (seconds)*
Default or time setting. This parameter defines the time delay to re-evaluate the stage. Valid range is 1-30 seconds with default of 5 seconds

*Cooling stage hysteresis (°C)*
The intention of heating hysteresis is to avoid oscillation between two heating stages whenever the heating stage boundary is approached. The hysteresis applies in both directions. For example, if the heating stage changes from 2nd to 3rd at 15 °C, then by adding 0.5 hysteresis the heating effort for stage-3 starts when temperature falls below 14.5°C then moves to stage-2 when the temperature rises to 15.5°C. The value is in units of 0.25°C with range of 0.0-3.5°C. The default is 0.25°C

*Heating stage hysteresis (°C)*

The intention of cooling hysteresis is to avoid oscillation between two cooling stages whenever the cooling stage boundary is approached. The hysteresis applies in both directions. For example, if the cooling stage changes from 2nd to 3rd at 25°C then by adding 0.5 hysteresis the cooling effort for stage-3 starts when the temperature exceeds 25.5 °C then moves to stage-2 when the temperature drops to 24.5°C. The value is in units of 0.25 °C with range of 0.0-3.5 °C. The default is 0.25 °C.

### 4.5.3 Stage Counts

***Cooling stage count***

Number of stages available for configuration (0-3). Zero disables cooling

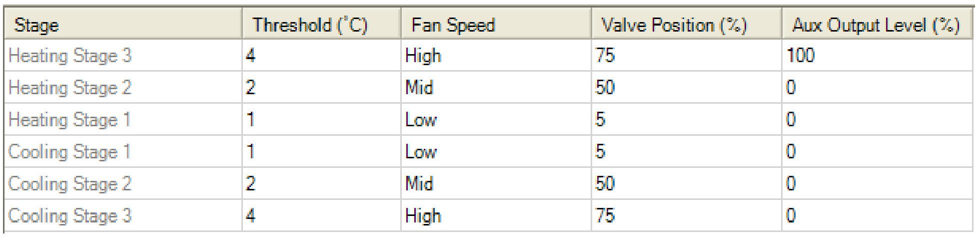
***Heating stage count***

Number of stages available for configuration (0-3). Zero disables heating

### 4.5.4 Stages Table

The Stages Table configures the control effort required depending on the relative temperature error from the setpoint.

Enter the parameters required for each heating and cooling stage.



| Stage | Threshold (°C) | Fan Speed | Valve Position (%) | Aux Output Level (%) |
|---|---|---|---|---|
| Heating Stage 3 | 4 | High | 75 | 100 |
| Heating Stage 2 | 2 | Mid | 50 | 0 |
| Heating Stage 1 | 1 | Low | 5 | 0 |
| Cooling Stage 1 | 1 | Low | 5 | 0 |
| Cooling Stage 2 | 2 | Mid | 50 | 0 |
| Cooling Stage 3 | 4 | High | 75 | 0 |

*Threshold (°C)*

This parameter defines relative temperature difference with respect to setpoint temperature for the given control stage. The value shall increase as stage index increases with respect to dead band. The default values are 1 Degree Celsius, 2 Degree Celsius and 4 Degree Celsius for 3 stages in an incremental index.

*Fan Speed*

This parameter defines the fan speed in a given control stage or dead band. The selection can be High, Mid, Low or Off. The fan speed may be overridden by DyNet if manual fan control is enabled. That means any non-zero fan speed received over DyNet as logical channel level message shall override the value specified in stage control's configuration.

*Valve Position (%)*

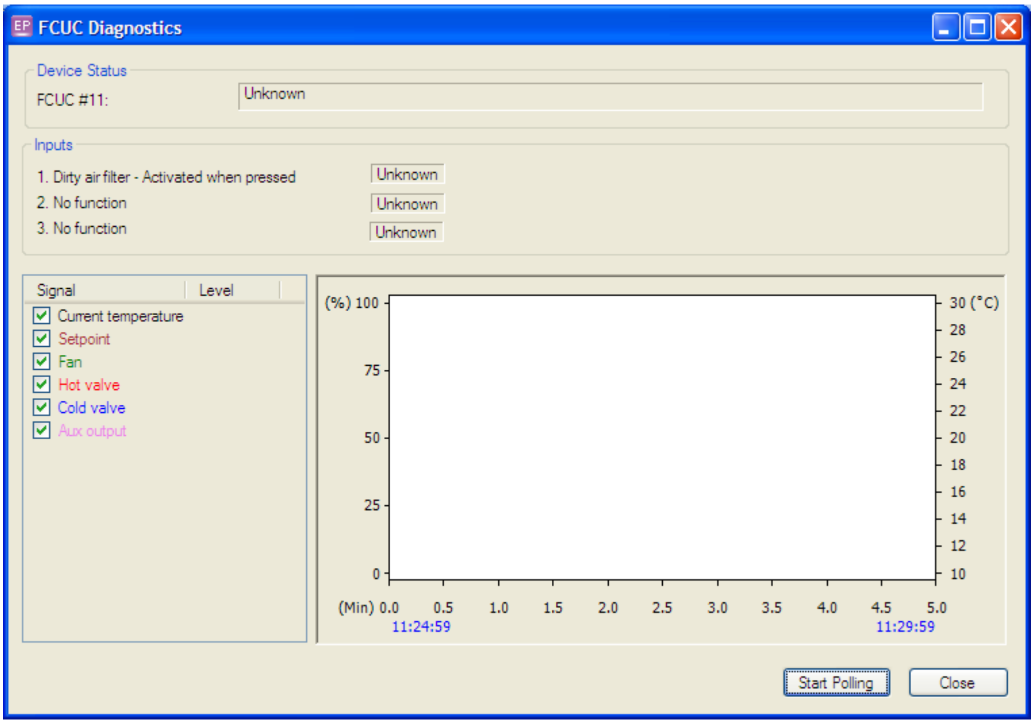
This value defines the valve opening position in terms of percentage. For cooling stages, valve refers to cooling valve; while in heating stages, valve refers to heating valve. Value of 100% means valve is fully opened, while 0% means valve is fully closed.

*Aux Output Level (%)*

This value defines the state of the auxiliary output relay state. A non-zero value shall activate the relay while a zero value shall deactivate the relay.

## 4.6 FCUC Diagnostics

The FCUC Diagnostics page displays a real-time chart of the temperature and plant status



FCUC Diagnostics

Device Status

FCUC #11: Unknown

Inputs

1. Dirty air filter - Activated when pressed: Unknown
2. No function: Unknown
3. No function: Unknown

| Signal | Level |
|---|---|
| ☑ Current temperature | |
| ☑ Setpoint | |
| ☑ Fan | |
| ☑ Hot valve | |
| ☑ Cold valve | |
| ☑ Aux output | |

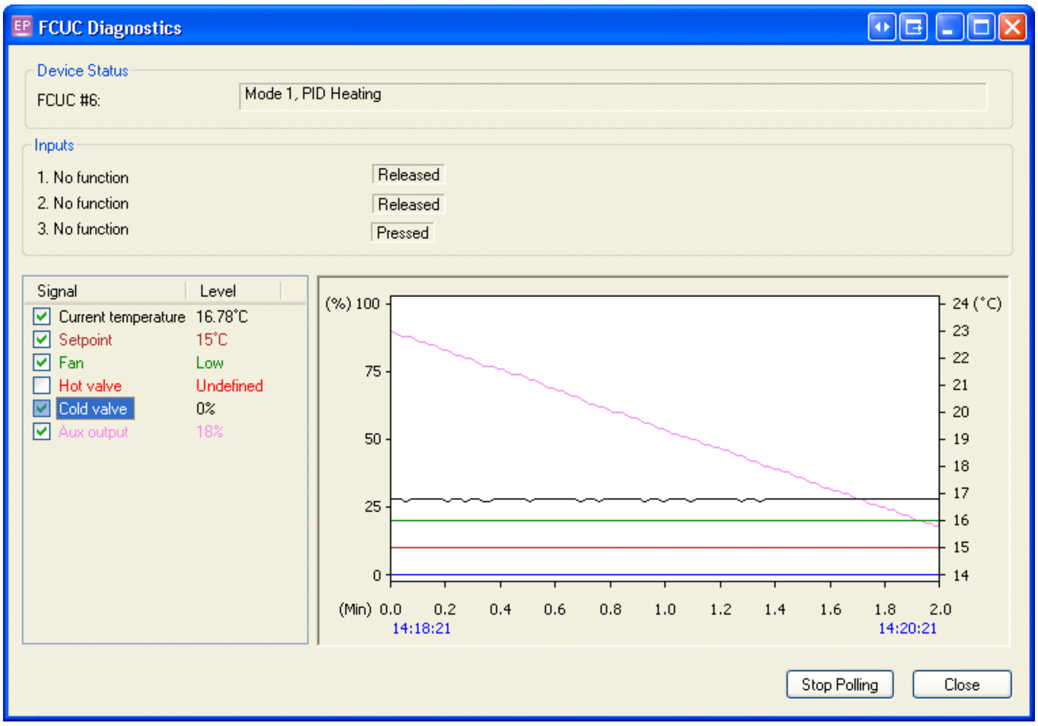
Figure 11 – FCUC Diagnostics Wizard

The information displayed by the FCUC Diagnostics page is customized to the project depending on the:

- Setpoint
- Mode selected
- Defined Switch Inputs
- Polling Period
- FCUC Graph Settings

The graph will be blank when the FCUC Diagnostics page initially loads. Polling will begin automatically and for each polling period the graph will chart the status and variables of the controller functions.

To pause and restart polling click the Stop Polling and Start Polling buttons.



Device Status

FCUC #6: Mode 1, PID Heating

Inputs

1. No function Released
2. No function Released
3. No function Pressed

| Signal | Level |
|---|---|
| ☑ Current temperature | 16.78°C |
| ☑ Setpoint | 15°C |
| ☑ Fan | Low |
| ☐ Hot valve | Undefined |
| ☑ Cold valve | 0% |
| ☑ Aux output | 18% |

Figure 12 – FCUC Diagnostics Wizard Chart

# 5 Configure Switches

## 5.1 Switch Configuration Tab

The Switches tab contains settings to configure the input switches for the controller.

The following buttons are available on the Switch Configuration toolbar.

- Displayed fields can be sorted in one of two ways by using the following buttons:

  Categorized

  Alphabetically

- Initially only the basic fields are shown. To reveal all fields click the Advanced button. Most standard setups will not require the use of advanced parameters.

### 5.1.1 General

***Switches***
Enable/Disable. Affects all switches

### 5.1.2 Logical Addresses

***logical Area***
Set the area where the switch will be used.

***logical Channel***
Set the channels to be affected. Use the channel number or use All Channels (0).

*Controller join*
Assign any join rows that are applicable using the join byte.

*Controller BLA*
Enable/Disable Base Link Area.

### 5.1.3 Advanced

*Channel*
Enable/Disable

*Enabled when panel disabled*
True/False. Function is still available in panic mode

*Trigger at startup*
True/False. Switch action is force triggered at startup. Defined action will be executed based on switch state (ie pressed or released) when device is reset.

## 5.1.4 Function

Select the input function from one of the following choices:

- **Airflow Sensor**
- **Custom**
- **Dirty air filter**
- **Drip tray overflow**
- **Energy Holdoff**
- **Fire trip**
- **Hot water on cold valve**
- **Preset**
- **No function**

The available parameters differ for each type of function selected

## 5.1.5 Airflow sensor

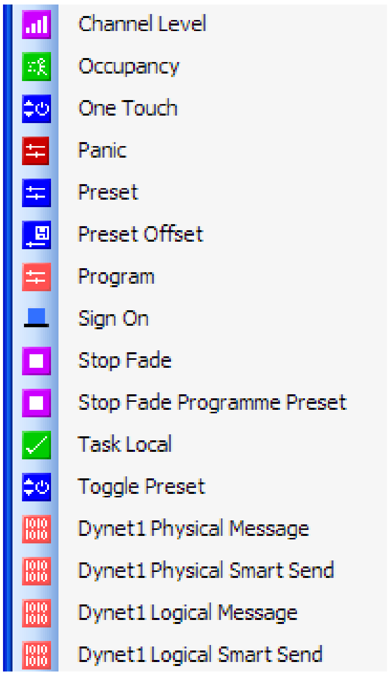
***Function***
Airflow sensor. Used to detect fan failure.

***Activated when***
Pressed/Released

*DyNet mute*
True/False. Stop DyNet messages being created by this function

## 5.1.6 Custom

***Function***
Custom. You can select from any of the options in the Action Chain Editor



*Standard function name*
Enable/Disable Base Link Area.

***Press actions***
Opens the Action Chain Editor

***Release Actions***
Opens the Action Chain Editor

***Extended press actions***
Opens the Action Chain Editor

***Extended release Actions***
Opens the Action Chain Editor

### 5.1.7 Dirty air filter

***Function***
Dirty air filter. Used to indicate air filter is dirty and requires cleaning.

***Activated when***
Pressed/Released

*DyNet mute*
True/False. Stop DyNet messages being created by this function.

### 5.1.8 Drip tray overflow

***Function***
Drip tray overflow. The drip tray is full with water and needs draining.

***Activated when***
Pressed/Released

*DyNet mute*
True/False. Stop DyNet messages being created by this function.

### 5.1.9 Energy Holdoff

***Function***
Energy Holdoff. Also known as window switch. Used to turn off the plant when window is open to conserve energy.

***Activated when***
Pressed/Released

*DyNet mute*
True/False. Stop DyNet messages being created by this function

### 5.1.10 Fire trip

***Function***
Fire trip. Used to detect smoke.

***Activated when***
Pressed/Released

*DyNet mute*
True/False. Stop DyNet messages being created by this function.

### 5.1.11 Hot water on cold valve

***Function***

Hot water on cold valve. Used to specify that hot water is available on the cold water valve.

***Activated when***

Pressed/Released

*DyNet mute*

True/False. Stop DyNet messages being created by this function.

### 5.1.12 Preset

***Function***

Preset. Used to recall a preset function over DyNet.

***Preset***

Pressed/Released

***Fade (rounded to 10 ms)***

00:00:00:010 (hh:mm:ss:fff)

*DyNet mute*

True/False. Stop DyNet messages being created by this function.

### 5.1.13 No function

***Function***

No function. Switch is not used

***Activated when***

Pressed/Released

*DyNet mute*

Enable/Disable Base Link Area.

# 6 DyNet Interface

This section lists DyNet messages added for FCUC which are not readily accessible from EnvisionProject using the GUI. It also lists some of the other DyNet messages intended for use in typical HVAC situations.

## 6.1 FCUC User Preferences

The FCU controller allows the user to change plant capability and user preferences at run time. A logical DyNet message is implemented to set/retrieve the status of plant capabilities.

| **Message Frame** | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0x1C | Area | **User Preference** | **Opcode** | **DataHi** | DataLo | Join | Checksum |

| **Message Frame Details** | | |
|---|---|---|
| **Opcode** | | |
| | 0x48 | Set/Reset User Preference |
| | 0x49 | Reset User Preference |
| | 0x4A | User Preference |
| **User Preference** | | |
| | 0x06 | Actual Temperature, 16 bit in 0.25 deg Celsius steps |
| | 0x07 | User Temperature set point, 16 bit in 0.25 deg Celsius steps |
| | 0x09 | Air Conditioning Plant Capability |
| | 0x0C | Actual Temperature, 16 bit in 0.01 deg Celsius steps (Range -127.99 to 127.99) |
| | 0x0D | User Temperature set point, 16 bit in 0.01 deg Celsius steps (Range -127.99 to 127.99) |
| **DataHi** | | **Bit Mask** |
| | For user preference 0x09 | b0: 1 – Heating available, 0 – Heating |
| | | b1: 1 – Cooling available, 0 – Cooling not available |
| | | b2 to b7: Unused |

## 6.2 Fault states

Request a fault state from the device over DyNet. This also clears the fault state. A physical DyNet message is implemented to set/retrieve the fault status of plant.

| **Message Frame** | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0x5C | 0x58 | Box Number | **Opcode** | **Fault Type** | **Fault Status** | **Fault Details** | Checksum |

| **Message Frame Details** | | |
|---|---|---|
| **Opcode** | | |
| | 0x59 | Request Device Fault State |
| | 0x5A | Reply/Report Device Fault State |
| | 0x5B | Set/Reset Device Fault State |
| **Fault Type** | | |
| | 0x00 | Fire Trip |
| | 0x01 | Airflow |
| | 0x02 | Energy Holdoff (i.e. Window switch) |
| | 0x06 | Temperature Sensor faulty |
| | 0x08 | Drip Tray |
| | 0x09 | Dirty Air Filter |
| **Fault Status** | | |
| | 0x00 | Normal |
| | 0x01 | Alarm (fault input is activated) |
| | 0x04 | Acknowledge alarm (force alarm to return to normal) |
| **Fault Details** | | 0 – Fault not present, 1 – Fault present |
| | For | Bit 0 = Local sensor Open circuit |
| | 0x06 | Bit 1 = Local sensor Short circuit |
| | Fault | Bit 2 = remote sensor time out |
| | Type | Bit 3-7 not used |

## 6.3 Task Port Interface

| **Task Port** | **Task Sub-port** | **Description** |
|---|---|---|
| 0x11 | 0 | Bit Mask (b0: Switch 1, b1: Switch 2, b2: Switch 3, b3-b7: Unused) |
| 0x1D | 0 | Measured temperature in 0.25 Degree Celsius - Lo byte (Initiate Reading at source) |
| | 1 | Measured temperature in 0.25 Degree Celsius - Hi byte |
| 0x1E | 0 | Desired temperature in 0.25 Degree Celsius - Lo byte (Initiate Reading at source) |
| | 1 | Desired temperature in 0.25 Degree Celsius - Hi byte |
| 0x1F | 0 | Measured temperature in 0.01 Degree Celsius - Lo byte provides integer part (Initiate Reading at source) |
| | 1 | Measured temperature in 0.01 Degree Celsius - Hi byte provides fractional part |
| 0x20 | 0 | Desired temperature in 0.01 Degree Celsius - Lo byte provides integer part (Initiate Reading at source) |
| | 1 | Desired temperature in 0.01 Degree Celsius - Hi byte provides fractional part |

# 7 Field Descriptions

## 7.1 Plant Configuration

| Field Name | Description |
|---|---|
| **Logical Address** | |
| Controller logical area | Assigned logical Area for plant control |
| Controller logical channel | Assigned logical channel for plant control |
| Controller join | Join byte |
| Controller BLA | Enable/Disable Base Link Area |
| **Temperature Sensor** | |
| Use local sensor | True for a sensor directly connected to the DDFCUC024 and DDFCUC010 and False when using a DTS900 on the network |
| Type of local sensor | Type of local sensor. Only NTC (Negative Temperature Coefficient) currently supported |
| Remote sensor scanning time (Seconds) | Polling period for DTS900 remote sensor |
| Use initial setpoint on startup | True - Use the initial setpoint temperature (°C) on plant start up<br>False – use previously known setpoint |
| Initial setpoint (°C) | Initial setpoint temperature (°C) |
| Measured temperature offset (°C) | 0.1 degree increments to offset the temperature value of the sensor |
| Local sensor | Enable / Disable direct sensor |
| Local sensor logarithmic | True for Logarithmic and False for Linear |
| Local sensor logarithmic constant | Value for logarithmic coefficient, details available from sensor manufacturer |
| Local sensor logarithmic resistance | Value for sensor resistance, details available from sensor manufacturer |
| Local sensor pullup resistor | Value for onboard pullup resistor. 1k or 22k jumper setting. Default 22k. |
| **Valves** | |
| Cold valve | Enable/Disable cold valve |
| Cold valve configuration type | Type of cold vale, choose from Floating, 1 stage, 2 stage and 3 stage |
| Cold valve active high state | True or False for stage type cold valve configuration |
| Allow hot water on cold valve | True or False to allow heating and cooling both on cold valve |
| Cold valve travelling time (seconds) | Time taken to go from fully closed to fully open |
| Cold valve minimum on time (seconds) | Minimum time the valve must remain on before turning back off to prevent valve damage |
| Cold valve minimum off time (seconds) | Minimum time the valve must remain off before turning back on to prevent valve damage |
| Cold valve scheduled overrun period (hours) | Default set to 24hrs, used to reset the valve to home position |
| Hot valve | Enable/Disable hot valve |
| Hot valve configuration type | Type of hot vale, choose from Floating, 1 stage, 2 stage and 3 stage |
| Hot valve active high state | For staged valves only, used to set the default starting position for the valve |
| Hot valve travelling time (seconds) | Time taken to go from fully closed to fully open |
| Hot valve minimum on time (seconds) | Minimum time the valve must remain on before turning back off to prevent valve damage |

| | |
|---|---|
| Hot valve minimum off time (seconds) | Minimum time the valve must remain off before turning back on to prevent valve damage |
| Hot valve scheduled overrun period (hours) | Default set to 24hrs, used to reset the valve to home position |
| Valve min control efforts (%) | Minimum % change in control effort required before the valve will be activated. Prevents excessive valve wear |
| **Fan** | |
| Fan | Enable/Disable |
| Fan logical area | Assigned logical Area for fan control |
| Fan logical channel | Assigned logical channel for fan control |
| Fan join | Fan control join byte |
| Fan BLA | Enable/Disable Base Link Area for fan control |
| Fan active high state | True will close the relay when driven and False will open the relay when driven |
| Fan configuration type | Fan type, select from 1 speed, 2 speed and 3 speed |
| Fan minimum on time (seconds) | Minimum time the fan must be on before turning back off to prevent fan damage |
| Fan minimum off time (seconds) | Minimum time the fan must be off before turning back on to prevent fan damage |
| Fan runup time (seconds) | Used to build up required air pressure in ducts, the airflow switch won't work till the runup time expires. Also valve cannot be operated during this period. |
| Fan overrun time (seconds) | The length of time the fan will continue running after valve is closed |
| **Aux output** | |
| Aux output | Enable/Disable Aux output |
| Aux output logical area | Assigned logical Area for Aux output |
| Aux output logical channel | Assigned logical Channel for Aux output |
| Aux output join | Aux output join byte |
| Aux output BLA | Enable/Disable Base Link Area for Aux output |
| Aux output active high state | True will close the relay when driven and False will open the relay when driven |
| Aux output min on time (seconds) | Minimum time the Aux output must be on before turning back off to prevent damage |
| Aux output min off time (seconds) | Minimum time the Aux output must be off before turning back on to prevent damage |
| Aux Output control | Aux output control type, choose from manual, temperature controller heating and temperature controller cooling |
| **Faults/Signals** | |
| Fire trip | Enable/Disable fire trip |
| Fire trip auto restart count | Number of restarts allowed within one hour |
| Fire trip fan off | True/False, Fan speed to full when input is activated |
| Energy holdoff | Enable/Disable holdoff |
| Energy holdoff auto restart count | Number of restarts allowed within one hour |
| Energy holdoff fan off | True/False, Fan speed to full when input is activated |
| Air flow fault | Enable/Disable air flow fault |
| Air flow fault auto restart count | Number of restarts allowed within one hour |
| Air flow fault fan off | True/False, Fan speed to full when input is activated |

| | |
|---|---|
| Sensor fault | Enable/Disable sensor fault |
| Sensor fault auto restart count | Number of restarts allowed within one hour |
| Sensor fault fan off | True/False, Fan speed to full when input is activated |
| Drip tray | Enable/Disable drip tray |
| Drip tray auto restart count | Number of restarts allowed within one hour |
| Drip tray fan off | True/False, Fan speed to full when input is activated |
| Dirty filter | Enable/Disable dirty filter |
| Dirty filler auto restart count | Number of restarts allowed within one hour |
| Dirty filter fan off | True/False, Fan speed to full when input is activated |
| **Runtime parameters** | |
| Last known valid preset | Last known preset used |
| Last known manual fan speed | Last known fan speed used |
| Last known aux output level | Last known aux output level used |
| Last known temperature setpoint (°C) | Last known temperature setpoint used |

## 7.2 Temperature Control

### 7.2.1 PID control

| **Field Name** | **Description** |
|---|---|
| **General** | |
| Mode | Enable/Disable PID mode |
| Thresholds relative to manual setpoint | True or false. True allows for relative threshold values. False allows for absolute thresholds values |
| Manual fan control | True or false manual fan control |
| Heating/Cooling switch over delay (seconds) | Number of seconds before changing between heating and cooling |
| Dead band fan speed | High, Mid, Low and Off |
| **Cooling Parameters** | |
| Cooling control | Enable/Disable |
| Cooling setpoint offset (°C) | Dead band for temperature cooling setpoint |
| Cooling temperature error to run fan at low speed (°C) | Temperature differential to use low fan speed setting |
| Cooling temperature error to run at mid speed (°C) | Temperature differential to use med fan speed setting |
| Cooling temperature error to run at high speed (°C) | Temperature differential to use high fan speed setting |
| **Healing Parameters** | |
| Heating control | Enable/Disable |
| Heating setpoint offset (°C) | Dead band for temperature heating setpoint |
| Heating temperature error to run at low speed (°C) | Temperature differential to use low fan speed setting |
| Heating temperature error to run at mid speed (°C) | Temperature differential to use med fan speed setting |
| Heating temperature error to run at high speed (°C) | Temperature differential to use high fan speed setting |

### 7.2.2 Staged control

| **Field Name** | **Description** |
|---|---|
| **General** | |
| Mode | Enable/Disable |
| Thresholds relative to manual set point | True / False |
| Manual fan control | True / False |
| Responsiveness (seconds) | Default or time |
| Cooling stage hysteresis (°C) | 0.25 Default |
| Heating stage hysteresis (°C) | 0.25 Default |
| **Stage Counts** | |
| Cooling stage count | Number of stages available for configuration |
| Heating stage count | Number of stages available for configuration |


PHILIPS

# Thermia Atria
# Atria Duo

## Atria

## La Bomba de Calor aire-agua capaz de extraer energía bajo las condiciones más extremas, hasta -20ºC

Nuestra gama de soluciones **ATRIA** se presentan como la solución más acertada en los supuestos donde no pueden realizarse perforaciones o no se dispone de suficiente espacio para los colectores de energía.

Su rendimiento, medido de forma constante a lo largo de un año, hace que su factura energética pueda reducirse hasta un 75%.

Los modelos Atria son capaces de operar bajo las condiciones climatológicas más adversas, su unidad exterior extrae calor exterior hasta los -20 ºC; a partir de ahí se activa su calentador adicional en cinco etapas (3,6,9,12 y 15 kW).

El equipo consta de dos partes, una unidad exterior y la unidad central, compuesta por todos los elementos críticos del sistema, en el interior de la vivienda.La formación de escarcha en la unidad exterior se evita por medio de la unidad de control.

Thermia Atria incorpora de serie acumuladores de agua caliente de 180 litros que desarrollan la patente desarrollada por Thermia TWS** permitiendo producir más agua caliente en menor tiempo.

A través de su módulo accesorio Thermia Online, usted podrá controlar su equipo por medio de una conexión a internet. En el hipotético caso de producirse una anomalía usted o su instalador será avisado de manera automática por medio de un SMS o correo electrónico.

**Thermia Atria Duo** es una variante de nuestro modelo Thermia Atria, lo que la diferencia es el acumulador independiente de ACS haciendo que se reduzcan las dimensiones del sistema siendo más accesible en espacios reducidos.

## Atria Duo

---

* TWS . Tap Water Stratification.Patente desarrollada en exclusiva por Thermia Varme AB

GIROD
GEOTERMIA

C/Campoamor 18
28004 Madrid
www.girodgeotermia.com

# Ficha Técnica Thermia Atria, Atria Duo

## Conexiones Atria

1) Salida de brine de bomba, 28 Cu
2) Retorno de brine a bomba, 28 Cu
3) Suministro sistema de calefacción, 22 Cu: 6-10 kW, 28 Cu:12 kW
4) Retorno sistema de calefación 22 Cu: 6-10 kW, 28 Cu: 12 kW
5) Conexión tanque expansión calefacción, 22 Cu
6) Argolla
7) Salida agua caliente sanitaria 22 Cu o acero inoxidable
8) Suministro agua fria 22 Cu o acero inoxidable
9) Registro entrada suministro eléctrico, sensores y comunicación externa
10) Tanque expansión circuito brine,DN25 int

## Conexiones Atria Duo

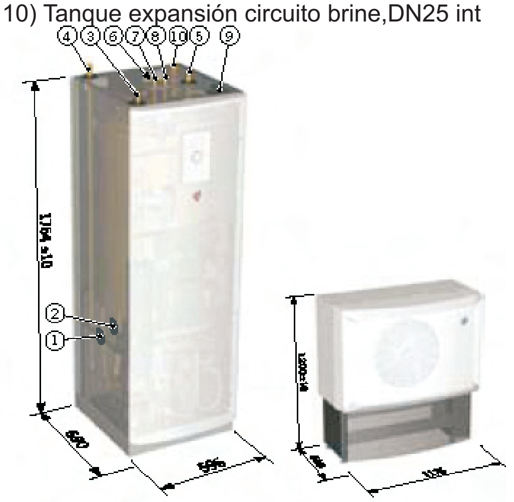
**Bomba de Calor:**

1) Salida de brine en desescarche,28 Cu
2) Retorno acumulador, 28 Cu
3) Entrada brine
4) Suministro sistema de calefacción, 22 Cu: 6-10 kW, 28 Cu 12 kW
5) Retorno sistema de calefación 22 Cu: 6-10 kW, 28 Cu: 12 kW
6) Salida brine
7) Registro entrada suministro eléctrico, sensores y comunicación externa

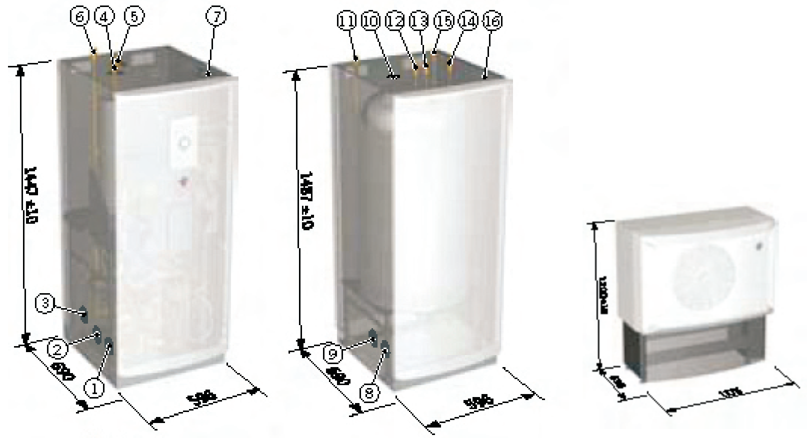
**Acumulador de agua:**

8) Salida de brine en desescarche,28 Cu
9) Retorno acumulador
10) Válvula mezcladora
11) Salida de brine en desescarche,28 Cu
12) Salida de agua caliente, 22 Cu ó acero inoxidable
13) Entrada agua de red, 22 Cu ó acero inoxidable
14) Entrada acumulador
15) Entrada brine (unidad exterior situada a superior altura que la unidad interior)
16) Registro entrada suministro eléctrico, sensores y comunicación externa

Las conexiones de brine se pueden realizar tanto por la parte derecha como izquierda del equipo



Atria



Atria Duo

| Atria | 6 | 8 | 10 | 12 | 6 ES | 8 ES | 10 ES | 12 ES |
|---|---|---|---|---|---|---|---|---|
| Refrigerante,R407C | 0,95 Kg | 1,45 Kg | 1,5 Kg | 1,6 Kg | 0,95 Kg | 1,45 Kg | 1,5 Kg | 1,6 Kg |
| Suministro | 400 V 3-N | 400 V 3-N | 400 V 3-N | 400 V 3-N | 230V 1-N | 230V 1-N | 230V 1-N | 230V 1-N |
| Calentador adicional | 3/6/9/12/15 kW | 3/6/9/12/15 kW | 3/6/9/12/15 kW | 3/6/9/12/15 kW | 1,5[2)]/3[3)]/4,5[4)] kW | 1,5[2)]/3[3)]/4,5[4)] kW | 1,5/3/4,5 kW | 1,5/3/4,5 kW |
| Potencia | 5,7 kW | 7,7 kW | 10,6 kW | 10,8 kW | 5,7 kW | 7,7 kW | 10,6 kW | 10,8 kW |
| Rendimiento (COP) 1) | 2,7 | 2,9 | 2,9 | 2,7 | 2,7 | 2,9 | 2,9 | 2,7 |
| Automático | 10[2)]/16[3)]/20[4)]<br>20[5)]/25[6)] A | 16[2)]/16[3)]/20[4)]<br>20[5)]/25[6)] A | 16[2)]/16[3)]/20[4)]<br>20[5)]/25[6)] A | 16[2)]/20[3)]/25[4)]<br>25[5)]/25[6)] A | 25[2)]/32[3)]/40[4)] A | 25[2)]/32[3)]/40[4)] A | 32[2)]/40[3)]/50[4)] A | 32[2)]/40[3)]/50[4)] A |
| Volumen Acumulador | 180 L | 180 L | 180 L | 180 L | 180 L | 180 L | 180 L | 180 L |
| Peso | 260 Kg | 260 Kg | 260 Kg | 268 Kg | 260 Kg | 260 Kg | 260 Kg | 268 Kg |

| Atria Duo | 6 | 8 | 10 | 12 | 6ES | 8ES | 10ES | 12ES |
|---|---|---|---|---|---|---|---|---|
| Refrigerante,R407C | 0,95 Kg | 1,45 Kg | 1,5 Kg | 1,6 Kg | 0,95 Kg | 1,45 Kg | 1,5 Kg | 1,6 Kg |
| Suministro | 400 V 3-N | 400 V 3-N | 400 V 3-N | 400 V 3-N | 230V 1-N | 230V 1-N | 230V 1-N | 230V 1-N |
| Calentador adicional | 3/6/9/12/15 kW | 3/6/9/12/15 kW | 3/6/9/12/15 kW | 3/6/9/12/15 kW | 1,5[2)]/3[3)]/4,5[4)] kW | 1,5[2)]/3[3)]/4,5[4)] kW | 1,5[2)]/3[3)]/4,5[4)] kW | 1,5[2)]/3[3)]/4,5[4)] kW |
| Potencia | 5,7 kW | 7,7 kW | 10,6 kW | 10,8 kW | 5,7 kW | 7,7 kW | 10,6 kW | 10,8 kW |
| Rendimiento (COP) 1) | 2,7 | 2,9 | 2,9 | 2,7 | 2,7 | 2,9 | 2,9 | 2,7 |
| Automático | 10[2)]/16[3)]/20[4)]<br>20[5)]/25[6)] A | 16[2)]/16[3)]/20[4)]<br>20[5)]/25[6)] A | 16[2)]/16[3)]/20[4)]<br>20[5)]/25[6)] A | 16[2)]/16[3)]/20[4)]<br>20[5)]/25[6)] A | 25[2)]/32[3)]/40[4)] A | 25[2)]/32[3)]/40[4)] A | 32[2)]/40[3)]/50[4)] A | 32[2)]/40[3)]/50[4)] A |
| Peso | 154 Kg | 154Kg | 154 Kg | 154 Kg | 154 Kg | 154 Kg | 154 Kg | 162 Kg |

1) Prueba realizada según EN 14511 en A+7W45 (incluyendo bombas de circulación y unidad externa
2) Bomba de calor con calentador eléctico adicional de 3 kW (1-N 1,5 kW)
3) Bomba de calor con calentador eléctrico adicional de 6 kW (1-N 3 kW)
4) Bomba de calor con calentador eléctrico adicional de 9 kW (1-N 4,5 kW)
5) Bomba de calor con calentador eléctrico adicional de 12 kW sin compresor
6) Bomba de calor con calentador eléctrico adicional de 15 kW sin compresor

## THERMOSTATS

Thermostat allows you to keep an eye on your temperature settings in your home and make changes without leaving your desk. Review and reverse temporary temperature overrides, and set your thermostat to the temperature that best suits you.

**Basic Edition:**

- Review thermostat settings and schedule at a glace
- Display indoor temperature, target temperature, or outside temperature in the taskbar
- Automatically connect to multiple wireless thermostats in your home, change thermostat network settings, and diagnose connectivity issues
- Talk directly to devices over your wireless network, without need for remote internet access

**Premium Edition: ***

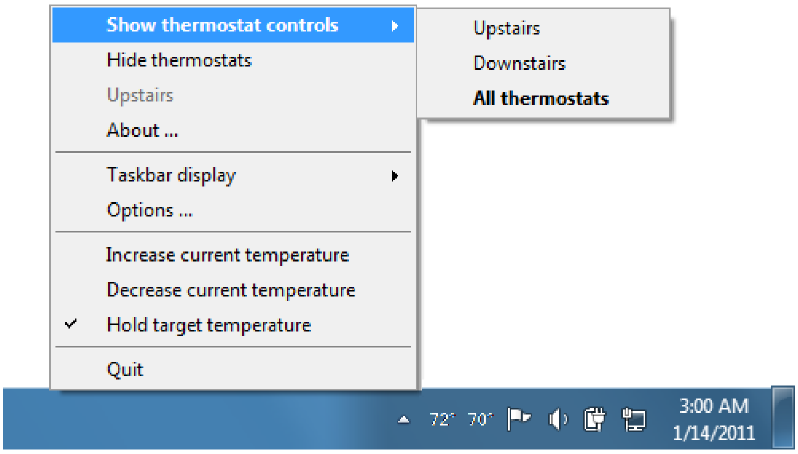
- Advanced control of your wireless thermostat from your pc
- Improve air circulation by automatically operating the fan a percentage of each half-hour
- Create temperature and fan program schedules
- Enable automatic mode changeover
- Track heating and cooling runtime history, outdoor weather, solar radiation and more with Excel export

**New in version 1.14:**

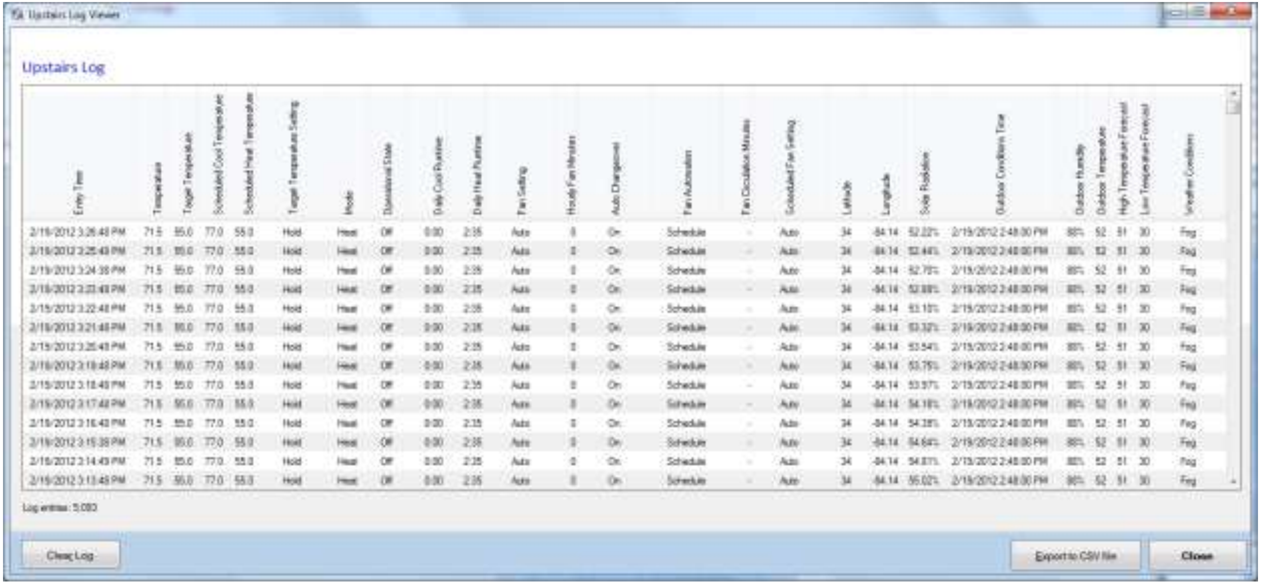
- Away fan and temperature settings

- Celsius is now supported throughout

## Manage multiple thermostats with ease



## More than 25 data points are logged



* Thermostat for Windows Premium is licensed for a single thermostat. Each thermostat requires a seperate license.

Wi-Fi enabled Radio Thermostat installation is required.

Radio Thermostat
Radio Thermostat Company of America

**SIEMENS**

RDF301, RDF600KN

RDF301.50

# Semi-flush mount room thermostats with KNX communications
# RDF301, RDF301.50, RDF600KN

## Basic Documentation

Edition: 2.0

CE1P3171en
2012-10-04

**Building Technologies**

# Contents

# 1. About this document

## 1.1 Revision history

| Edition | Date | Changes | Section | Pages |
|---|---|---|---|---|
| **2.0** | **Oct 2012** | **Added RDF600…** | **All** | **All** |
| 1.0 | 22 Jun 2010 | First edition | | |

## 1.2 Reference documents

| Subject | Ref | Doc No. | Description |
|---|---|---|---|
| Semi-flush mount room thermostats with KNX communications, RDF301, RDF301.50, RDF600KN | [1] | CE1N3171 | Data Sheet |
| | [2] | CE1B3171... | Operating Instructions |
| | [3] | CE1M3171 | Mounting Instructions RDF301... |
| | [3a] | CE1M3076.1 | Mounting Instructions RDF600KN |
| KNX Manual | [4] | | Handbook for Home and Building Control – Basic Principles (www.knx.org/uk/news-press/publications/publications/) |
| Synco and KNX (see www.siemens.com/synco) | [5] | CE1N3127 | KNX bus, Data Sheet |
| | [6] | CE1P3127 | Communication via the KNX bus for Synco 700, 900 and RXB/RXL, Basic Documentation |
| | [7] | XLS template in HIT | Planning and commissioning protocol, communication Synco 700 |
| | [8] | CE1N3121 | RMB795 central control unit, Data Sheet |
| | [9] | CE1Y3110 | KNX S-mode data points |
| | [10] | -- | Product data for ETS |
| | [11] | CE1J3110 | ETS product data compatibility list |
| | [12] | 0-92168en | Synco Application Manual |
| Desigo engineering documents | [13] | CM1Y9775 | Desigo RXB integration – S-mode |
| | [14] | CM1Y9776 | Desigo RXB / RXL integration – Individual Addressing |
| | [15] | CM1Y9777 | Third-party integration |
| | [16] | CM1Y9778 | Synco integration |
| | [17] | CM1Y9779 | Working with ETS |
| Apogee engineering documents (RDF301... only) | [18] | 565-132 | Installation Instructions: KNX driver for PXC Modular |
| | [19] | 127-1676 | Technical Spec Sheet: KNX driver for PXC Modular |
| | [20] | 140-0804 | Technical reference for KNX driver |
| | [21] | 140-0804 | Application 6205 point map for RDF |

## 1.3 Before you start

### 1.3.1 Copyright

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- Any corrections necessary are included in subsequent versions
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## 1.4 Target audience, prerequisites

This document assumes that users of the RDF KNX thermostats are familiar with the ETS and/or Synco ACS tools and able to use them.

It also presupposes that these users are aware of the specific conditions associated with KNX.

In most countries, specific KNX know-how is conveyed through training centers certified by the KNX Association (see www.konnex.org/).

For reference documentation, see section 1.2.

## 1.5 Glossary

The inputs, outputs and parameters of an application can be influenced in various ways. These are identified by the following symbols in this document:

**ETS**

Parameters identified by this symbol are set using ETS.

**ACS**

Parameters identified by this symbol are set using the ACS tool.

STOP **Note!**

**Setting RDF KNX parameters is only supported by the following tool versions:**

- ETS3f or higher
- ACS version 5.11 or higher

Inputs and outputs identified by this symbol communicate with other KNX devices. They are called communication objects (CO).

The communication objects of the RDF KNX thermostats work partly in S-mode, partly in LTE mode, and partly in both. These objects are described accordingly.

A list of the parameters is shown in section 3.13.

# 2. Summary

## 2.1 Types

| Product no. | Stock no. | Operating voltage | Control outputs | | | | Suitable conduit box [2] |
|---|---|---|---|---|---|---|---|
| | | | 3-pos | ON/OFF | DC 0..10 V | KNX switching groups | |
| RDF301 | S55770-T104 | AC 230 V | 1 [1] | 2 [1] | -- | | rectangular |
| RDF301.50 | S55770-T105 | AC 230 V | 1 [1] | 2 [1] | -- | ✓ | rectangular |
| RDF600KN | S55770-T293 | AC 230 V | 1 [1] | 2 [1] | -- | | round |

1) Selectable: ON/OFF or 3-position
2) Rectangular conduit box e.g. ARG71.
Round CEE conduit box min 60 mm diameter and min 40 mm depth

## 2.2 Ordering

- When ordering, please indicate both product no. / stock no. and name:
  E.g. **RDF301 / S55770-T104 room thermostat**
- Order valve actuators separately

## 2.3 Functions

**Use**

**Fan coil units** via ON/OFF or modulating control outputs:
- 2-pipe system
- 2-pipe system with electric heater
- 4-pipe system

**Chilled / heated ceilings (or radiators)** via ON/OFF or modulating control outputs:
- Chilled / heated ceiling
- Chilled / heated ceiling with electric heater
- Chilled / heated ceiling and radiator / floor heating

**Compressors**: Via ON/OFF control
- 1-stage compressors in DX type equipment
- 1-stage compressors in DX type equipment with electric heater

The room thermostats are delivered with a fixed set of applications.
The relevant application is selected and activated during commissioning using one of the following tools:

- Synco ACS
- ETS
- Local DIP switch and HMI

**Features**

- Operating modes: Comfort, Economy (Energy Saving) and Protection
- ON/OFF or 3-position control outputs (relay)
- Output for 3-speed or 1-speed fan
- Automatic or manual heating / cooling changeover
- Backlit display
- AC 230 V operating voltage

**Type of mounting / suitable conduit boxes**

- RDF600KN for round CEE box, with min 60 mm diameter, min 40 mm depth
- RDF301… for recessed rectangular box with 60.3 mm fixing centers

**Functions**

- Room temperature control via built-in temperature sensor or external room temperature / return air temperature sensor
- Changeover between heating and cooling mode (automatic via local sensor or bus, or manually)
- Selection of applications via DIP switches or commissioning tool (ACS).
- Select operating mode via operating mode button on the thermostat
- Temporary Comfort mode extension
- 1- or 3-speed fan control (automatically or manually)
- Display of current room temperature or setpoint in °C and/or °F
- Minimum and maximum limitation of room temperature setpoint
- Button lock (automatically or manually)
- 2 multifunctional inputs, freely selectable for:
  - Operating mode switchover contact (keycard, window contact, etc.)
  - Sensor for automatic heating / cooling changeover
  - External room temperature or return air temperature sensor
  - Dew point sensor
  - Electric heater enable
  - Fault input
  - Monitor input for temperature sensor or switch state
- Advanced fan control function, e.g. fan kick, fan start, selectable fan operation (enable, disable or depending on heating or cooling mode)
- “Purge” function together with 2-port valve in a 2-pipe changeover system
- Reminder to clean fan filters (adjust with P62)
- Floor heating temperature limitation
- Reload factory settings for commissioning and control parameters

## 2.4 Integration via KNX bus

The RDF room thermostats can be integrated as follows:

- Integration into Synco 700 system via LTE mode (easy engineering)
- Integration into Synco living via group addressing (ETS)
- Integration into Desigo and Apogee via group addressing (ETS) or individual addressing
- Integration into third-party systems via group addressing (ETS)

The following KNX functions are available:

- Central time program and setpoints, e.g. when using the RMB795 central control unit
- Outside temperature or time of day via bus displayed on thermostat
- Remote operation and monitoring, e.g. using the RMZ792 bus operator unit
- Remote operation and monitoring with web browser using the OZW772 or OZW775 web server
- Maximum energy efficiency due to exchange of relevant energy information, e.g. with Synco 700 controllers (e.g. heating demand, cooling demand)
- RDF301.50 only: 4 buttons to control KNX actuators via KNX S-mode ("switching groups" with functions such as switching, dimming, blinds control, 8-bit scene)
- Alarming, e.g. external fault contact, condensation, clean filter, etc.
- Monitoring input for temperature sensor or switch

Engineering and commissioning can be done using…

– local DIP switches / HMI
– Synco ACS service tool
– ETS

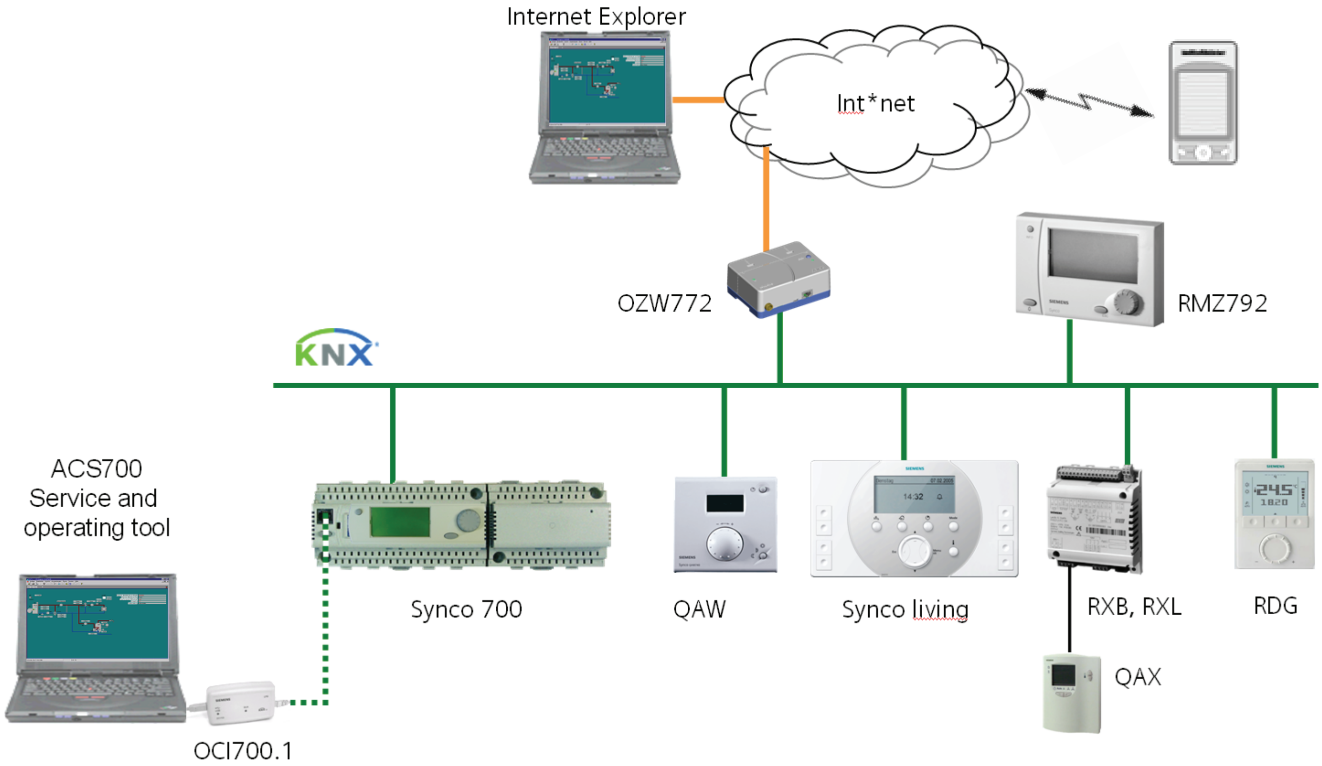
Synco 700

The RDF room thermostats are especially tailored for integration into the Synco 700 system and operate together in LTE mode. This extends the field of use of Synco for individual room control in conjunction with fan coil units, VAV, chilled ceilings and radiators.

Synco living

Thanks to S-mode extension to the QAX9x3 central apartment unit, communicating room thermostats can be easily integrated into Synco living systems. Using the S-mode data points of the central apartment unit, additional room information can be exchanged with the room thermostat via KNX TP1 (RF function is not available on the room thermostats). To make the integration, the ETS engineering tool is required.

## Synco topology



Legend:

| | |
|---|---|
| Synco 700 | Building automation and control system (BACS) |
| Synco living | Room automation and control system |
| RDG..., RDF…, RDU… | Room thermostats |
| OZW772 (or OZW775) | Web server |
| RMZ792 | Bus operator unit |
| QAW... | Room unit |
| ACS | Service tool using OCI700.1 (OCI700.1 is delivered with a service cable which can be plugged into the service connector on a Synco controller) |
| RXB, RXL | Room controllers |
| QAX | Room unit for RXB / RXL room controllers |

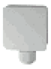
**Desigo, Apogee and third-party systems**

The RDF KNX devices can be integrated into the Siemens building automation and control systems (BACS) Desigo / Apogee or into 3rd-party systems. For integration, either S-mode (group addressing) or individual addressing can be used.

## 2.5 Equipment combinations

On / off actuators

3-position actuators

| Description | Product no. | Data sheet |
|---|---|---|
| Cable temperature sensor  | **QAH11.1** | 1840 |
| Room temperature sensor  | **QAA32** | 1747 |
| Condensation detector / extension module  | **QXA2000 /**<br>**QXA2001 /**<br>**AQX2000** | 1542 |
| Electromotoric ON/OFF actuator  | **SFA21...** | 4863 |
| Electromotoric ON/OFF valve and actuator<br>(only available in AP, UAE, SA and IN)  | **MVI… / MXI…** | 4867 |
| Zone valve actuator<br>(only available in AP, UAE, SA and IN)  | **SUA…** | 4832 |
| Thermal actuator (for radiator valves)  | **STA23...**<br>**STA21... *)** | 4884<br>4893 *) |
| Thermal actuator<br>(for small valves 2.5 mm)  | **STP23...**<br>**STP21... *)** | 4884<br>4893 *) |
| Electrical actuator, 3-position<br>(for radiator valves)  | **SSA31...** | 4893 |
| Electrical actuator, 3-position<br>(for small valves 2.5 mm)  | **SSP31…** | 4864 |
| Electrical actuator, 3-position<br>(for small valves 5.5 mm)  | **SSB31...** | 4891 |
| Electrical actuator, 3-position<br>(for small valve 5.5 mm)  | **SSD31...** | 4861 |
| Electromotoric actuator, 3-position<br>(for valves 5.5 mm)  | **SQS35…** | 4573 |

*) Not available any more

## 2.6 Accessories

| Description | Product no / SSN | Data sheet |
|---|---|---|
| Changeover mounting kit<br>(50 pcs/package)  | **ARG86.3** | N3009 |
| Plastic mounting bracket for semi-flush-mount thermostats RDF301... for increasing the headroom in the conduit box by 10mm  | **ARG70.3** | N3009 |
| Conduit box for semi-flush mounted thermostat RDF301...  | **ARG71 /**<br>**S55770-T137** | N3009 |
| KNX Power supply 160 mA (Siemens BT LV) | **5WG1 125-1AB02** | -- |
| KNX Power supply 320 mA (Siemens BT LV) | **5WG1 125-1AB12** | -- |
| KNX Power supply 640 mA (Siemens BT LV) | **5WG1 125-1AB22** | -- |

# 3. Functions

## 3.1 Temperature control

**General note: Parameters**

Setting of the control parameters (P01, etc., mentioned throughout the document) is described in section 3.13.

**Temperature control**

The thermostat acquires the room temperature via built-in sensor, external room temperature sensor (QAA32), or external return air temperature sensor (QAH11.1), and maintains the setpoint by delivering actuator control commands to heating and/or cooling equipment. The following control outputs are available:

- ON/OFF control (2-position)
- Modulating PI/P control with 3-position control output (only for 2-pipe applications)

The switching differential or proportional band is 2 K for heating mode and 1 K for cooling mode (adjustable via parameters P30 and P31).
The integral action time for modulating PI control is 5 minutes (RDF301...) and 45 minutes (RDF600KN), adjustable via parameter P35.

**Display**

The display shows the acquired room temperature or the Comfort setpoint, selectable via parameter P06. The factory setting displays the current room temperature. Use parameter P04 to change the room temperature display from °C to °F as needed.

Room temperature

The acquired room temperature (internal or external sensor) is also available as information on the bus.

♨ / ❄

- With **automatic** changeover or continuous heating / cooling, symbols ♨ / ❄ indicate that the system currently heats or cools (heating or cooling output is activated).
- With **manual** changeover (P01 = 2), symbols ♨ / ❄ indicate that the system currently operates in heating or cooling mode. Thus, the symbols are displayed even when the thermostat operates in the neutral zone.

Concurrent display of °C and °F

Concurrent display of the current temperature or setpoint in °C and °F (parameter P07 = 1) is possible on the thermostats.

Outside temperature via bus

The outside temperature can be displayed on the room thermostat by setting parameter P07 = 2. This temperature value has only information character.
In LTE mode, the outside temperature can only be received on outside temperature zone 31.
In S-mode, the corresponding communication object needs to be bound with a KNX sensor device.

Time of day via bus

Time of day via bus can be displayed on the room thermostat by setting parameter P07 = 3 or 4. The display format is either in 12- or in 24-hour format.
The information can be received from a Synco controller with time master functionality or any other KNX device if the corresponding communication object is bound.

Note

When an application program is downloaded to the Synco devices via ETS, the correct group addresses need to be downloaded as well to display the time of day on the room thermostat. (see Synco Knowledge Base - KB771)

## 3.2 Operating modes

The thermostat's operating mode can be influenced in different ways (see below). Specific heating and cooling setpoints are assigned to each operating mode.

KNX
Room operating mode:
State

The thermostat sends the effective room operating mode on the bus.

The following operating modes are available:

**Auto Timer** Auto

In Auto Timer mode the room operating mode is commanded via bus.
Auto Timer is replaced by Comfort when no time schedule via bus is present

**Comfort** ☼

In Comfort mode, the thermostat maintains the Comfort setpoint. This setpoint can be defined via parameters P8, P9 and P10.
It can be locally adjusted via the **+/-** buttons or via bus.
In Comfort mode, the fan can be set to automatic or manual fan speed: Low, medium or high.

**Economy** ☾

The setpoints (less heating and cooling than in Comfort mode) can be defined via parameters P11 and P12.
The thermostat switches to Economy mode when...

- the operating mode button is pressed (only possible if parameter P02 is set to 2)
- Economy is sent via bus
- an operating mode switchover contact (e.g. keycard contact presence detector, window contact) is active.
  The contact can be connected to multifunctional input X1, X2.
  Set parameter P38 / P40 to 3 (P02 is irrelevant) *)
- "Window state" is sent via bus, e.g. from a KNX switch or a KNX presence detector (P02 is irrelevant) *)

KNX
Room operating mode:
Window state

Note: *) Operating mode switchover: *Only one input source must be used, either local input X1/X2or KNX bus.*
*User operations are ineffective and “OFF” is displayed if the operating mode switchover contact is active, or if "Window state" is sent via bus.*

**Protection** ⏻

In Protection mode, the system is...

- protected against frost (factory setting 8 °C, can be disabled or changed via P65)
- protected against overheating (factory setting OFF, can be enabled or changed via P66)

No other operating mode can be selected locally if Protection mode is commanded via bus. Auto and ⏻ are displayed.

### 3.2.1 Different ways to influence the operating mode

**Source for change of operating mode**

**ACS**

The operating mode can be influenced by different interventions.
The source of the effective room operating mode state can be monitored using the "Cause" diagnostic data point in the ACS tool, operator unit RMZ792 or web server OZW772 / 775.

| Source | Description | Value of DP "Cause" |
|---|---|---|
| Local operation via operating mode button | • Operating mode is not Auto Timer<br>• No time schedule via bus | Room operating mode selector (preselection) |
| | • Temporary Comfort extension is active | “Timer” function |
| | • Operating mode switchover contact | Room operating mode contact |
| Bus command<br>KNX<br>Room op. mode | • "Window state" sent via bus | Room operating mode contact |
| | • Time schedule available via bus<br>→ local operating mode is set to Auto Timer<br>• Time schedule sends Protection mode via bus<br>→ operating mode cannot be changed locally | Time switch |

**Priority of operating mode interventions**

The following table shows the priorities of different interventions.
A lower number means a higher priority.

| Priority | Description | Remark |
|---|---|---|
| ① | Commissioning | In parameter setting mode (highest priority), you can always command an operating mode independent of all other settings or intervention via bus and local input. |
| ② | Protection mode via bus from time schedule | Protection mode, sent by a time schedule, has priority 2.<br>It cannot be overridden by the user nor by an operating mode switchover contact. |
| ③ | Operating mode switchover contact | If the contact is closed, the operating mode changes to Economy. This overrides the operating mode on the thermostat. |
| ③ | "Window state" via bus | "Window state" sent via bus has the same effect as the operating mode switchover contact. |
| | | *Note: Only one input source must be used, either local input X1/X2 or KNX bus.* |
| ④ | Operating mode button | The user can switch the operating mode using the operating mode button. |
| ④ | Operating mode via bus | The operating mode can be changed via bus |
| ④ | Temporary extended Comfort mode via operating mode button | The operating mode can be temporarily set from Economy to Comfort by pressing the operating mode button, if...<br>– Economy was sent via bus<br>– extended Comfort period >0 (parameter P68) |
| | | *The last intervention wins, either locally or via bus* |
| ④ | Time schedule via bus | The operating mode sent via bus can be overridden by all other interventions. *Exception: Protection mode has priority 2.* |

**Auto Timer mode 🕓 with time schedule via bus**

If a time schedule via bus is present, e.g. from central control unit, then the Auto Timer mode 🕓 is active. The thermostat automatically changes between Comfort and Economy according to the time schedule via bus.
The display shows the Auto Timer mode symbol 🕓 along with the symbol for the effective room operating mode (Comfort ☼ or Economy ☾ ).
By pressing the operating mode button, you can change to another operating mode.
Automatic fan is the default fan speed in Auto Timer mode.

**Behavior when bus sends new operating mode**

Each time the time schedule sends a new operating mode (switching event), the operating mode of the thermostat is set back to Auto Timer mode. This is to assure that the room temperature is maintained according to the time schedule.

**Precomfort via bus**

If the time schedule sends Precomfort mode, then this mode will be transformed either into Economy (factory setting) or Comfort (selectable via parameter P88).

**Behavior when bus sends Protection**

No intervention is possible neither by the user nor by an operating mode switchover contact, if Protection mode is set by the time schedule. OFF flashes on the display when the user presses a button.

**Availability of Economy mode**

The operating mode can be selected locally via the operating mode button.
The behavior of the operating mode button (user profile) can be defined via parameter P02, factory setting is P02 = 1.

| P02 | Without time schedule | With time schedule via bus | Description |
|---|---|---|---|
| 1 | ⏻→☼ | ⏻→🕓 | • Switching manually between **2** modes, Economy is not available (factory setting)<br>• Suited for hotel guest rooms or commercial buildings.<br>• If a time schedule via bus is available, then the Comfort mode can be temporarily extended (see below) |
| 2 | ⏻→☼→☾ | ⏻→🕓→☼→☾ | • Switching manually between **3** modes<br>• Suited for homes and rooms where manual switching to Economy mode is desired |

**Operating mode switchover contact (window contact)**

The thermostat can be forced into Economy mode (e.g. when a window is opened, when a presence detector signals "no one present", when the keycard of a hotel room is withdrawn, etc). The contact can be connected to multifunctional input X1, X2. Set parameter P38, P40 to 3.

KNX

Room operating mode: Window state

The function is also available via the KNX signal "Window state", e.g. from a KNX switch or a KNX presence detector.

*Note: Only one input source must be used, either local input X1/X2 or KNX bus. User operations are ineffective and “OFF” is displayed if the operating mode switchover contact is active, or if "Window state" is sent via bus.*

### Temporary timer to extend the Comfort mode

Comfort mode can be temporarily extended (e.g. working after business hour or on weekends) when the thermostat is in Economy mode. The operating mode button switches the operating mode back to Comfort for the period preset in P68.
Press the operating mode button again to stop the timer.

The following conditions must be fulfilled:
- mode selection via operating mode button is set to “Protection-Auto” (P02 = 1) and the time schedule via bus is Economy
- Parameter P68 (extend Comfort period) is greater than 0

During the temporary Comfort mode extension, symbol 🕒 appears.

If parameter P68 (extend Comfort period) = 0, extended Comfort cannot be activated; pressing the operating mode button will switch the thermostat to Protection.
If the operating mode switchover contact is active, pressing the operating mode button will show “OFF” (blinking).

## 3.2.2 Communication examples

The following examples show two typical applications of a central time schedule in conjunction with local control of the room operating mode.
The room operating mode in rooms 1…2 of a building is determined by the time schedule. Window contacts are fitted in all rooms.

The following conditions are specified:

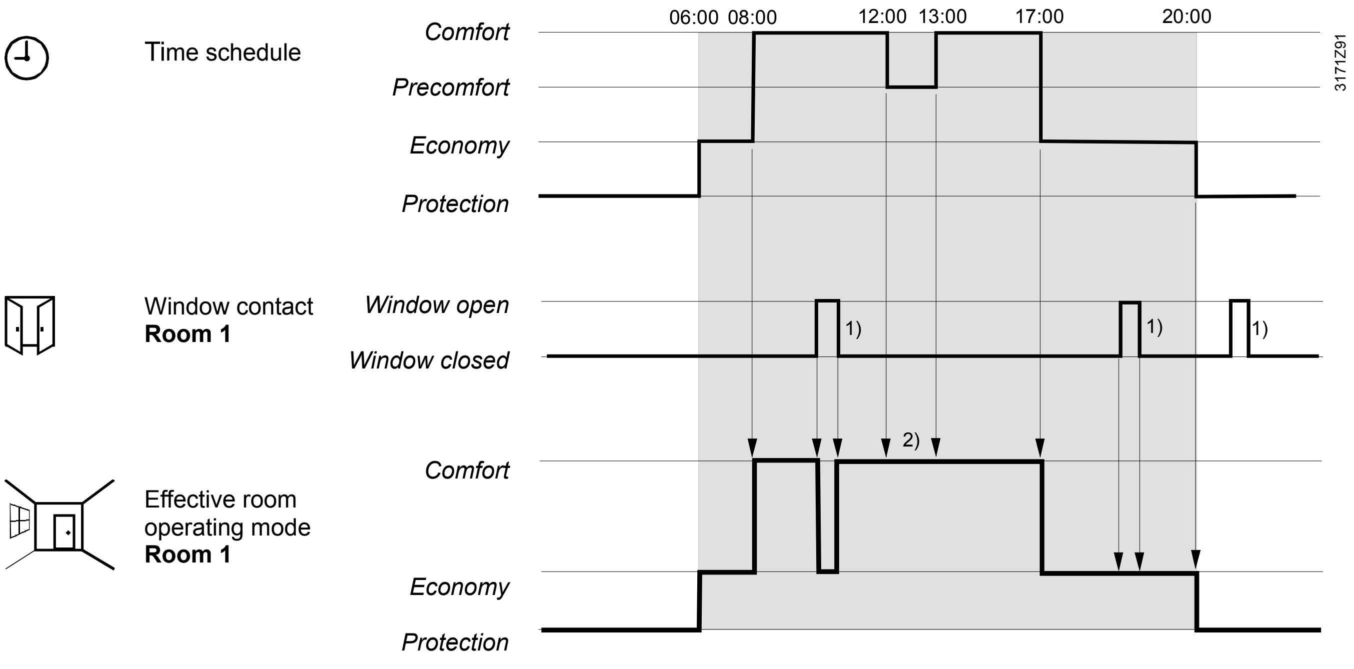
The rooms are used and controlled by the time schedule as follows:
- Night setback from 17:00 to 08:00 (Economy)
- Protection from 20:00 to 06:00
- Lunch break from 12:00 to 13:00 (Precomfort)

The substitution (parameter P88) for Precomfort via bus is set on the thermostats as follows:
- Room 1: Comfort (1)
- Room 2: Economy (0)

**Example 1**

**Operating mode switchover**

In **room 1,** the window is opened briefly, once in the morning, once in late afternoon and once at night (1). Only the opening in the morning has a direct impact on the effective room operating mode.
During lunch break, the time schedule changes to Precomfort. The mode remains in Comfort as set by parameter “Transformation Precomfort” (P88 = 1).



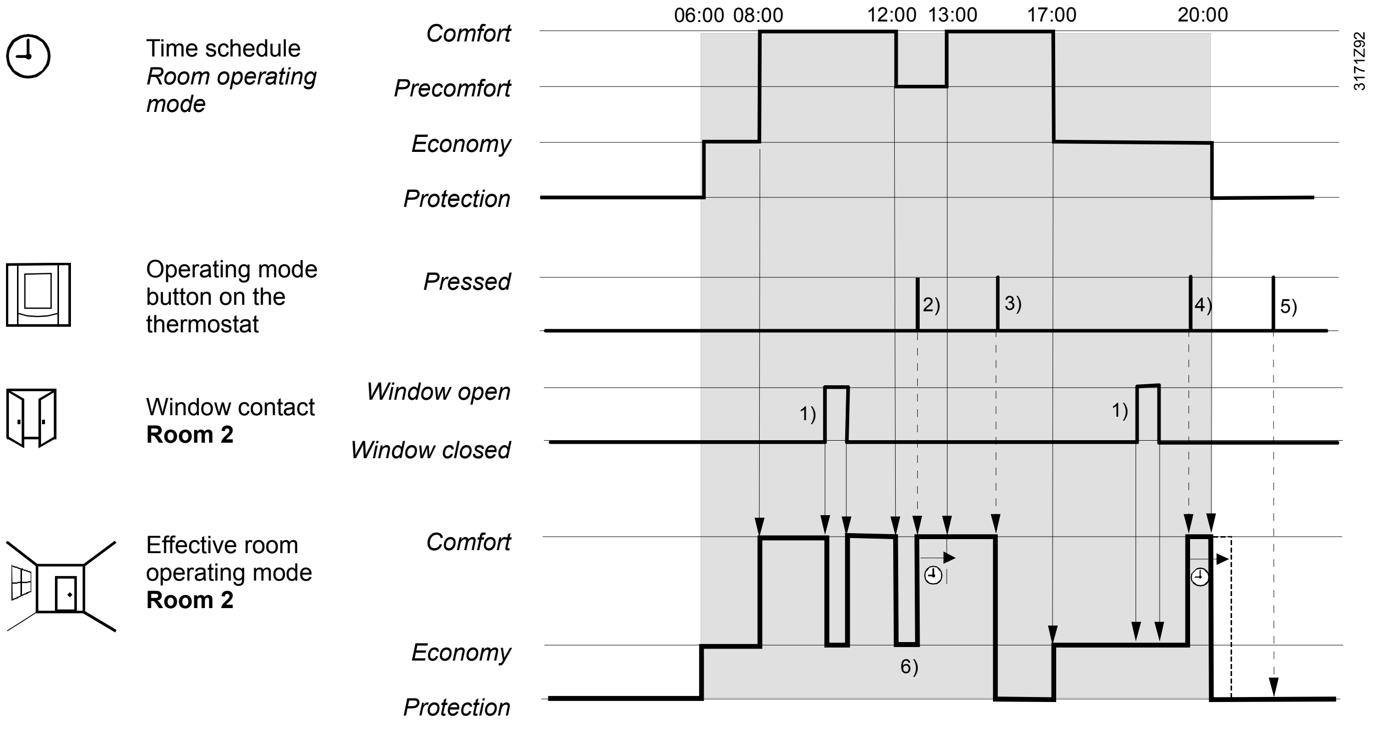
**Example 2**

### Interaction of user operation (operating mode button) and central time schedule

In **room 2,** the window is opened briefly, once in the morning and once at night (1). Only the opening in the morning has a direct impact on the effective room operating mode.

With the operating mode button, the operating mode can be changed between OFF and Auto or temporary Comfort extension respectively.

- During lunch break, the time schedule changes to Precomfort. The mode of the thermostat changes to Economy as set by parameter “Transformation Precomfort” (P88 = 0) (6)
- During lunch break, the user changes the operating mode to Comfort (temporary Comfort extension) by pressing the operating mode button (2).
  At 13:00, the timer is reset due to mode change of the central time schedule
- In the afternoon, the user switches the thermostat off by pressing the operating mode button (3). At 17:00 the user setting is reset to Economy by the time schedule
- At 19:30, the user again extends the Comfort mode (4). At 20:00, the timer is reset by the time schedule
- After 20:00, pressing the operating mode button has no effect, as the central time switch sets the thermostat to Protection (5)



## 3.3 Room temperature setpoints

### 3.3.1 Description

**Comfort mode**

The factory setting for the Comfort basic setpoint is **21 °C** and can be changed in the thermostat’s EEPROM via parameter P08 or via bus with communication object " Comfort basic setpoint". The last intervention always wins.

The Comfort setpoint can be adjusted via the **+/-** buttons,
or via bus from a remote device like a touchpanel, operating unit, etc.
The last intervention always wins.

Temporary setpoint

If the “Temporary setpoint” function is enabled via parameter P69, the Comfort setpoint adjusted via the +/- buttons or via bus is set back to the Comfort basic setpoint stored in P08 when the operating mode changes.

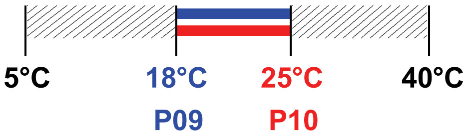
Setpoint limitation

For comfort or energy saving purposes, the setpoint setting range can be limited to minimum (P09) and maximum (P10).

P09 < P10
(comfort concept)

- If the minimum limit **P09 is set lower** than the maximum limit P10, both heating and cooling are adjustable between these 2 limits
- The customer adjusts the desired setpoint and the thermostat controls the room temperature accordingly.
- For 4-pipe applications *), the selected comfort setpoint is in the middle of the dead zone (P33). The unit stops to energize the heating / cooling outputs as soon as the room temperature reaches the dead zone.

Example



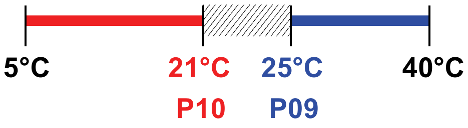
Cooling setpoint adjustable 18…25 °C
Heating setpoint adjustable 18…25 °C

P09 ≥ P10
(energy saving concept)

- If the minimum limit **P09 is set higher** than the limit P10, then
  - The setting range of cooling setpoint is from **P09…40 °C** in place of 5…40 °C
  - The setting range of heating setpoint is from **5…P10 °C** in place of 5…40 °C.

  This allows the user to limit the maximum heating setpoint and the minimum cooling setpoint. This concept helps to save energy costs.
- For **4-pipe applications** *):
  - The thermostat runs with the setpoint of the active sequence:
    In heating mode, the heating setpoint is active and adjustable via rotary knob.
    In cooling mode, the cooling setpoint is active and adjustable via rotary knob.
  - Switching from the heating setpoint to the cooling setpoint and vice-versa occurs when the room temperature reaches the adjusted limitation (P09 or P10) of the **inactive** sequence. E.g. the thermostat is in heating sequence and runs with the heating setpoint. When the room temperature reaches P09, the thermostat switches to cooling mode and runs with the cooling setpoint, as long as the room temperature does not drop below P10.

Example



Cooling setpoint adjustable 25…40 °C
Heating setpoint adjustable 5…21 °C

*) Note: RDF301...
for 4-pipe with P09 ≥ P10

For heating **and** cooling applications (e.g. 4-pipe):
– **P09** is the setpoint for cooling and **P10** the setpoint for heating
– The setpoint can not be adjusted via the rotary knob

**Economy mode** ☾

Use control parameters P11 and P12 to adjust the Economy mode setpoints.
The heating setpoint is factory-set to **15 °C**, and the cooling setpoint to **30 °C**.

**Protection mode** ⌂

Use control parameters P65 and P66 to adjust the Protection mode setpoints.
The heating setpoint is factory-set to **8 °C** (frost protection) and to **OFF** for cooling.

**Caution** ⚠

If a setpoint (Economy or Protection) is set to OFF, the thermostat does not control the room temperature in the corresponding mode (heating or cooling).
This means no protective heating or cooling function and thus risk of frost in heating mode or risk of overtemperature in cooling mode!

The Economy setpoints are accessible at the service level (P11, P12); the Protection setpoints at the expert level (P65, P66).

### 3.3.2 Setting and adjusting setpoints

Room temperature setpoints can be
- set during commissioning
- adjusted during runtime

**Comfort basic setpoint**
**Comfort setpoint**

The source can be
- the local HMI
- a tool
- a central control unit

The thermostat stores the setpoints
- in EEPROM in the form of parameters
- in the runtime memory

The table below shows the interrelations:

| **Setpoint setting** | | |
|---|---|---|
| **Commissioning<br>– HMI<br>– Tool download** | **Input LTE mode** | **Input S-mode** |
| Comfort basic setpoint<br>Dead zone Comfort **1)** | Setpoints Heating<br>Setpoints Cooling | Comfort basic setpoint |
| Setpoint Economy Heating<br>Setpoint Economy Cooling | Setpoints Heating<br>Setpoints Cooling | |
| Setpoint Protection Heating<br>Setpoint Protection Cooling | | |

| **Stored in EEPROM of thermostat** |
|---|
| P08 Comfort basic setpoint<br>P33 Dead zone Comfort 1) |
| P11 Economy Heating<br>P12 Economy Cooling |
| P65 Protection Heating<br>P66 Protection Cooling |

| **Current runtime setpoints in thermostat** |
|---|
| Comfort setpoint |
| Economy Heating<br>Economy Cooling |
| Protection Heating<br>Protection Cooling |

| **Setpoint adjustment** | | |
|---|---|---|
| **Input LTE mode 2)** | **Input S-mode 3)** | **Local operation** |
| Setpoint shift H<br>Setpoint shift C | Comfort setpoint | + / - buttons |
| Setpoint shift H<br>Setpoint shift C | | |

| **New current runtime setpoints in thermostat** |
|---|
| Comfort setpoint |
| Economy Heating<br>Economy Cooling |
| Protection Heating<br>Protection Cooling |

**Effective room operating mode** → **Current setpoint** (used by the thermostat for temperature control)

1) Only required for heating AND cooling applications (see section 3.6.8)
2) LTE mode: **the shift is added** to the local shift
3) S-Mode: **the last intervention wins**, either S-Mode input or local operation

**Current setpoint**

The current setpoint (used by the thermostat for temperature control) is available on the bus for use in the central control unit.

**General notes:**

- The supported communication objects are different in LTE mode and S-mode
- Changes via the local HMI or via tool have the same priority (last always wins)
- Setting the Comfort basic setpoint will reset the runtime Comfort setpoint to the basic setpoint

**Notes on setpoint adjustment (LTE mode with Synco only)**

- Central setpoint shift is used for summer / winter compensation in particular
- Setpoint shift does not affect the setpoints stored in parameters P08, P11, P12, P33
- Local shift and central shift are added together
- Applies only to Comfort and Economy setpoints; Protection setpoints are not shifted centrally
- The resulting (current) setpoint heating and cooling is limited by the Protection setpoint; if Protection setpoint is OFF, then minimum 5 °C and maximum 40 °C are used
- The resulting setpoints for cooling and heating of the same operating mode have a minimum distance of 0.5 K between them
- The result of local and central shift, together with the room operating mode, is used by the thermostat for temperature control (current setpoint)

## 3.4 Applications overview

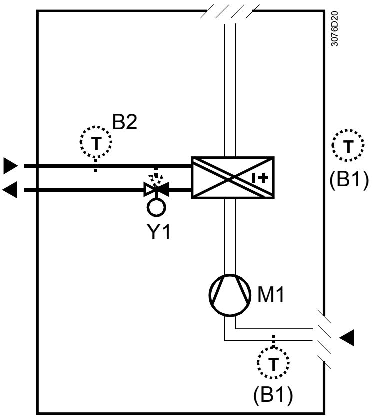
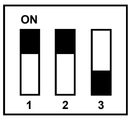
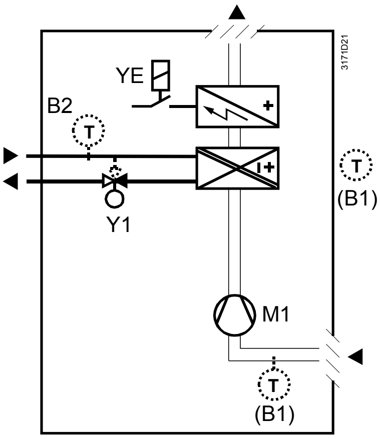
The thermostats support the following applications, which can be configured using the DIP switches inside the front panel of the unit or a commissioning tool.

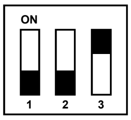
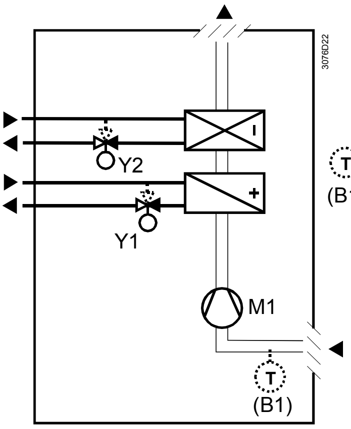
All DIP switches need to be set to OFF (remote configuration, factory setting) to select an application via commissioning tool.

The tool offers the applications printed in bold text (basic applications).

For universal applications (chilled ceiling, etc.), refer to section 3.6.6.

For compressor applications, refer to subection 3.6.7.

| Application and output signal | DIP switches | Diagram |
|---|---|---|
| **Remote configuration**<br>via commissioning tool (factory setting)<br>• Synco ACS<br>• ETS |  | |
| **Heating or cooling**<br>• **2-pipe fan coil unit** ON/OFF<br>(heating **or** cooling)<br>• Chilled / heated ceiling ON/OFF<br>(heating **or** cooling)<br>• 1-stage compressor ON/OFF<br>(heating **or** cooling) |  |  |
| • **2-pipe fan coil unit** 3-position<br>(heating **or** cooling)<br>• Chilled / heated ceiling 3-position<br>(heating **or** cooling) |  | |
| **Heating or cooling with electric heater**<br>• **2-pipe fan coil unit with electric heater**<br>(heating **or** cooling) ON/OFF<br>• Chilled / heated ceiling with electric heater,<br>(heating **or** cooling) ON/OFF<br>• 1-stage compressor with electric heater,<br>(heating **or** cooling) ON/OFF |  |  |

| Application and output signal | DIP switches | Diagram |
|---|---|---|
| **Heating and cooling**<br>• **4-pipe fan coil unit** (heating **and** cooling) ON/OFF<br>• Chilled ceiling and radiator (heating **and** cooling) ON/OFF<br>• 1-stage compressor (heating **and** cooling) ON/OFF |  |  |

|  |  |  |  |  |
|---|---|---|---|---|
| Key | Y1 | Heating or heating / cooling valve actuator | M1 | 3- or 1-speed fan |
|  | Y2 | Cooling valve actuator | B1 | Return air temperature sensor or external room temperature sensor (optional) |
|  | YE | Electric heater | B2 | Changeover sensor (optional) |

## 3.5 Additional functions

**Heating / cooling changeover via bus**

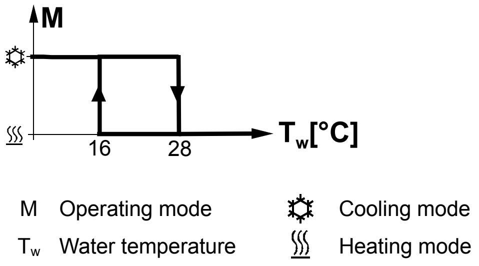
The heating / cooling changeover information can be received via bus. This is only possible if the control sequence is set to automatic heating / cooling changeover (parameter P01 = 3) and no local input X1, X2 is assigned with this function.

Heating/cooling changeover

In the absence of the required information (e.g. due to problems with data communication, power failure, etc.), the thermostat operates in the last valid room operating mode (heating or cooling).

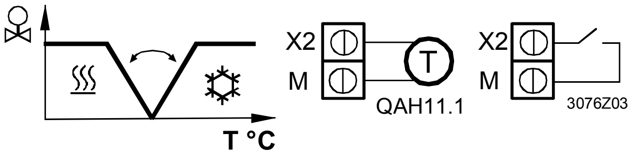
**Automatic heating / cooling changeover via changeover sensor**

If a cable temperature sensor (QAH11.1 + ARG86.3) is connected to X1 / X2, and parameter P38 / P40 is =2, the water temperature acquired by the changeover sensor is used to change over from heating to cooling mode, or vice versa. When the water temperature is above 28 °C (parameter P37), the thermostat changes over to heating mode, and to cooling mode when below 16 °C (parameter P36).
If the water temperature is between the 2 changeover points immediately after power-up, the thermostat starts in the previously active mode.
The water temperature is acquired at 30-second intervals and the operating state is updated accordingly.



**Changeover switch**

The QAH11.1 cable temperature sensor for automatic heating / cooling changeover can be replaced by an external switch for manual, remote changeover:



Contact open → heating mode
Contact closed → cooling mode

The sensor or switch can be connected to input terminal X2 or X1, depending on the commissioning of the inputs (P38, P40).
See also section 3.9 “Multifunctional input”.

**Manual heating / cooling changeover**

If manual heating / cooling changeover is commissioned (P01 = 2), then heating / cooling mode cannot be changed via bus / changover sensor / switch; it will remain in the last mode as selected locally via button.

**External / return air temperature sensor**

The thermostat acquires the room temperature via built-in sensor, external room temperature sensor (QAA32), or external return air temperature sensor (QAH11.1) connected to multifunctional input X1 or X2.
Inputs X1 or X2 must be commissioned accordingly. See section 3.9 “Multi-functional input”.

**Purge function**

The changeover sensor ensures changeover from heating to cooling mode based on the acquired water temperature. We recommend activating the “Purge” function (parameter P50) with 2-port valves. This function ensures correct acquisition of the medium temperature even if the 2-port valve is closed for an extended period of time. The valve is then opened for 1 to 5 minutes (adjustable) at 2-hour intervals during off hours.

**Caution ⚠**

The “Purge” function (parameter P50) must be disabled if the thermostat is used in compressor-based applications.

**Avoid damage from moisture**

In very warm and humid climates, the fan can be run periodically or continuously at a low fan speed (e.g. in empty apartments or shops) in Economy mode by setting parameter P61, in order to avoid damage from moisture due to lack of air circulation. See also section 3.8 “Fan control”, under “Fan kick function”.

**Minimum output ON-time / OFF-time**

Limit the ON/OFF switching cycle to protect the HVAC equipment, e.g. compressor and reduce wear and tear. The minimum output on-time and off-time for 2-position control output can be adjusted from 1 to 20 minutes via parameters P48 and P49.
The factory setting is 1 minute.
Readjusting the setpoint or heating / cooling mode changeover immediately results in calculation of the output state; the outputs may not hold the minimum 1-minute ON/OFF time.
If parameter P48 or P49 is set to above 1 minute, the minimum ON/OFF time for the control output is maintained as set, even if the setpoint or changeover mode is readjusted.

**Floor heating / Floor cooling**

All heating sequences can also be used for floor heating.
You can use fan coil unit heating / cooling sequences for floor heating or cooling by disabling the fan via parameter P52.

**Floor temperature limitation function**

The floor temperature should be limited for 2 reasons: Comfort and protection of the floor.

The floor temperature sensor, connected to multifunctional input X1 or X2, acquires the floor temperature. If the temperature exceeds the parameterized limit (parameter P51), the heating valve is fully closed until the floor temperature drops to a level 2 K below the parameterized limit.
This function is factory-set to OFF (disabled).
Input X1 or X2 must be commissioned accordingly (P38 or P40 = 1).
See section 3.9 “Multifunctional input”.

Recommended values for P51:

Living rooms:
Up to 26 °C for long-time presence, up to 28 °C for short-time presence.
Bath rooms:
Up to 28 °C for long-time presence, up to 30 °C for short-time presence.

The table below shows the relation between parameter, temperature source and temperature display:

| Parameter P51 | External temp. sensor available | Source for display of room temperature | Output control according to | Floor temp. limit function |
|---|---|---|---|---|
| OFF | No | Built-in sensor | Built-in sensor | Not active |
| OFF | Yes | External temp. sensor | External temp. sensor | Not active |
| 10...50 ˚C | No | Built-in sensor | Built-in sensor | Not active |
| 10…50 ˚C | Yes | Built-in sensor | Built-in sensor + limit by external sensor | Active |

The “Floor temperature limitation” function influences the outputs listed in the table below:

| | | | “Floor temp. limit” function has impact on | | | |
|---|---|---|---|---|---|---|
| **Application** | **Output Y11** | **Output Y21** | **Heating (P01 = 0/2/3)** | **Cooling (P01 = 1/2/3)** | **Heat. and cool. (P01 = 4)** | **Remark** |
| 2-pipe | H/C valve | | Y11 | N/A | | |
| 2-pipe & el heater | H/C valve | El heater | Y21 | Y21 *) | | Only el heater |
| 4-pipe | Heating valve | Cooling valve | Y11 | N/A | Y11 | |

*) If P13 = ON
→ electric heater in cooling mode

Note Either floor temperature sensor or external room temperature sensor can be used.

**Dew point monitoring**

Dew point monitoring is essential to prevent condensation on the chilled ceiling (cooling with fan disabled, parameter P52). It helps avoid associated damage to the building.
A dew point sensor with a potential-free contact is connected to multifunctional input X1 or X2. If there is condensation, the cooling valve is fully closed until no more condensation is detected, and the cooling output is disabled temporarily.

Fault state
Fault information

The condensation symbol “💧” is displayed during temporary override and the fault “Condensation in room” will be sent via bus.

The input must be commissioned accordingly (P38, P40).

See section 3.9 “Multifunctional input”.

**Button lock**

If the “Button lock” function is enabled by parameter P14, the buttons will be locked or unlocked by pressing the operating mode button for 3 seconds.
If “Auto lock” is configured, the thermostat will automatically lock the buttons 10 / 20 seconds after the last adjustment (RDF301... / RDF600KN).

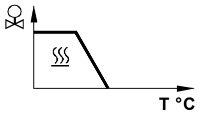
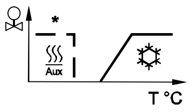
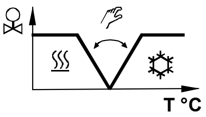
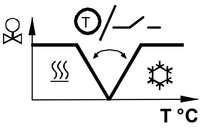
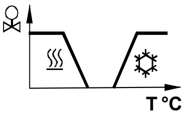
# 3.6 Control sequences

## 3.6.1 Sequences overview (setting via parameter P01)

The main control sequence (i.e. the water coil sequence of the fan coil unit) can be set via **parameter P01**.

The following sequences can be activated in the thermostats (each without or with auxiliary heating).

The available sequences depend on the application (selected via DIP switch, see section 3.4).

| **Parameter** | **P01 = 0** | **P01 = 1** | **P01 = 2** | **P01 = 3** | **P01 = 4** |
|---|---|---|---|---|---|
| **Sequence** |  |  |  |  |  |
| | Heating | Cooling<br>*) 2-pipe with el. heater | Manually select heating or cooling sequence | Automatic heating / cooling changeover via external water temperature sensor or remote switch | Heating and cooling sequence, i.e. 4-pipe |
| **Available for basic application** 1) **:** ↓ | | | | | |
| 2-pipe,<br>2-pipe & el heater | ✓ | ✓ | ✓ | ✓ | |
| 4-pipe | | | ✓ 2) | ✓ 2) | ✓ |

Notes:

1) For chilled / heated ceiling and radiator applications, see section 3.6.6; for compressor applications, see section 3.6.7

2) For manual and automatic changeover with 4-pipe applications, see section 3.6.5:
   - 4-pipe **manual** changeover (P01 = 2) means activating either cooling or heating outputs
   - 4-pipe **automatic** changeover (P01 = 3) means swapping the control outputs according to a heating / cooling sensor or remote switch ("main and secondary" application), see section 3.6.5

For the relation between setpoints and sequences, see section 3.6.8.

### 3.6.2 Application mode

KNX

Application mode

The behavior of the thermostat can be influenced by a building automation and control system (BACS) via bus with the command “Application mode”.
With this signal, cooling and/or heating activity can be enabled or disabled.
Application mode is supported in LTE mode and S-mode.

The RDF KNX thermostats support the following commands:

| # | Application mode | Description | Control sequence enabled |
|---|---|---|---|
| 0 | Auto | Thermostat automatically changes between heating and cooling | Heating and/or cooling |
| 1 | Heat | Thermostat is only allowed to heat | Heating only |
| 2 | Morning warm-up | If “Morning warm-up” is received, the room should be heated up as fast as possible (if necessary). The thermostat will only allow heating | Heating only |
| 3 | Cool | Thermostat is only allowed to provide cooling | Cooling only |
| 4 | Night purge | Not supported by fan coil applications | N/A (= Auto) |
| 5 | Pre-cool | If “Pre-cool” is received, the room should be cooled down as fast as possible (if necessary). The thermostat will only allow cooling | Cooling only |
| 6 | Off | Thermostat is not controlling the outputs, which means all outputs go to off or 0% | Neither heating nor cooling |
| 8 | Emergency heat | The thermostat should heat as much as possible. The thermostat will only allow heating | Heating only |
| 9 | Fan only | All control outputs are set to 0% and only the fan is set to high speed.<br>Function will be terminated by any operation on the thermostat | Run fan in high speed |

With all other commands, the thermostat behaves like in Auto mode, i.e. heating or cooling according to demand.

**ACS**

The state (heating or cooling) of the thermostat can be monitored with the ACS tool (diagnostic value “Control sequence”). The last active mode is displayed when the thermostat is in the dead zone or temperature control is disabled.

**Heating OR cooling**

With a 2 pipe application, the control sequence state is determined by the application mode (see section 3.6.2) and by the state of the heating / cooling changeover signal (via local sensor or bus), or fixed according to the selected control sequence (P01 = heating (0) / cooling (1)).

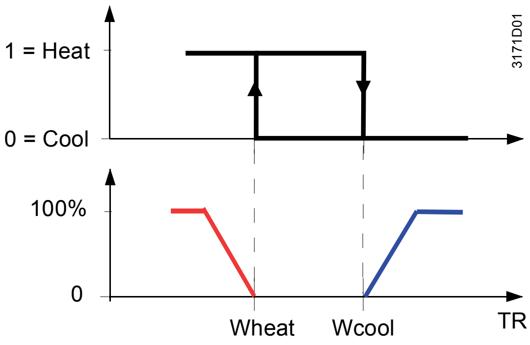
| Application mode (via bus) | State changeover / continuous heating or cooling | Control sequence state |
|---|---|---|
| Auto (0) | Heating | Heating |
| | Cooling | Cooling |
| Heat (1), (2), (8) | Heating | Heating |
| | Cooling | **Heating** |
| Cool (3), (5) | Heating | **Cooling** |
| | Cooling | Cooling |
| Night purge (4), Fan only (9) | Heating | Heating |
| | Cooling | Cooling |

**Heating AND cooling**

With a 4-pipe, 2-pipe with electric heater, and 2-pipe with radiator application, the control sequence state depends on the application mode and on the heating / cooling demand.

| Application Mode (via bus) | Heating / cooling demand | Control sequence state |
|---|---|---|
| Auto (0) | Heating | Heating |
| | No demand | Heating / cooling depending on last active sequence |
| | Cooling | Cooling |
| Heat (1), (2), (8) | Heating | Heating |
| | No demand | **Heating** |
| | Cooling | **Heating** |
| Cool (3), (5) | Heating | **Cooling** |
| | No demand | **Cooling** |
| | Cooling | Cooling |
| Night purge (4), Fan only (9) | No temperature control active | Heating / cooling depending on last active sequence |

The value of the output as a function of the room temperature is shown in the following diagram in case of a heating and cooling system:



Wheat = current heating setpoint
Wcool = current cooling setpoint

### 3.6.3 2-pipe fan coil unit

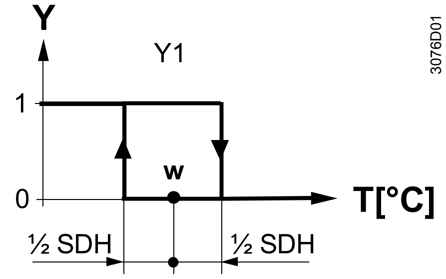
On 2-pipe applications, the thermostat controls a valve in heating / cooling mode with changeover (automatically or manually), heating only, or cooling only. Cooling only is factory-set (P01 = 1).

**ON/OFF control**

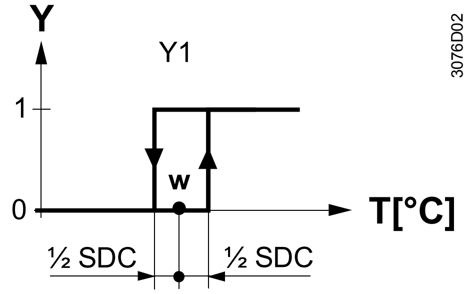
Control sequence ON/OFF output

The diagrams below show the control sequence for 2-position control.

Heating mode



Cooling mode



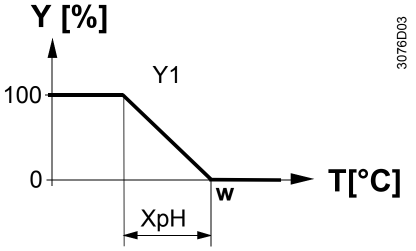
| | | | |
|---|---|---|---|
| T[°C] | Room temperature | SDH | Switching differential “Heating” (P30) |
| w | Room temperature setpoint | SDC | Switching differential “Cooling” (P31) |
| Y1 | Control command “Valve” or “Compressor” | | |

**Modulating control: 3-position**

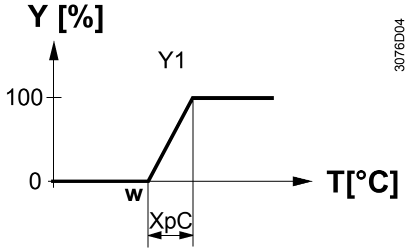
Control sequence modulating output

The diagrams below show the control sequence for modulating PI control.

Heating mode



Cooling mode



| | | | |
|---|---|---|---|
| T[°C] | Room temperature | XpH | Proportional band “Heating” (P30) |
| w | Room temperature setpoint | XpC | Proportional band “Cooling” (P31) |
| Y1 | Control command “Valve” | | |

Notes:
- The diagrams only show the PI thermostat’s proportional part.
- For the fan sequence see section 3.8.

**Setting the sequence and the control outputs**

Refer to sections 3.4 "Applications", 3.6.1 "Sequences", and 3.7 "Outputs".

### 3.6.4 2-pipe fan coil unit with electric heater

Heating or cooling with auxiliary heater

On 2-pipe applications with electric heater, the thermostat controls a valve in heating / cooling mode with changeover, heating only, or cooling only plus an auxiliary electric heater.
Cooling only is factory-set (P01 = 1) with enabled electric heater (P13).

Electric heating, active in cooling mode

In cooling mode, the valve receives an **OPEN** command if the acquired temperature is above the setpoint.
The electric heater receives an **ON** command if the acquired room temperature drops below “setpoint” minus “dead zone” (= setpoint for electric heater) while the electric heater is enabled (parameter P13 = ON).

Note: “Setpoint for electric heater” is limited by parameter “Maximum setpoint for Comfort mode” (P10).

Electric heating in heating mode

In heating mode, the valve receives an **OPEN** command if the acquired temperature is below the setpoint. The electric heater is used as an additional heating source when the heating energy controlled by the valve is insufficient.
The electric heater receives an **ON** command, if the temperature is below “setpoint” minus “setpoint differential” (= setpoint for electric heater).

Electric heating and manual changeover

The electric heater is active in heating mode only and the control output for the valve is permanently disabled when manual changeover is selected (P01 = 2).

Digital input “Enable electric heater”

Remote enabling / disabling of the electric heater is possible via input X1 or X2 for tariff regulations, energy savings, etc.
Input X1 or X2 must be commissioned accordingly (parameters P38, P40). See section 3.9 “Multifunctional input”.

Enable electric heater

The electric heater can also be enabled / disabled via bus.

Note: If “Enable electric heater” input is used via bus, then the function **must not** be assigned to a local input X1 or X2.

**Caution** ⚠ An electric heater must always be protected by a safety limit thermostat!

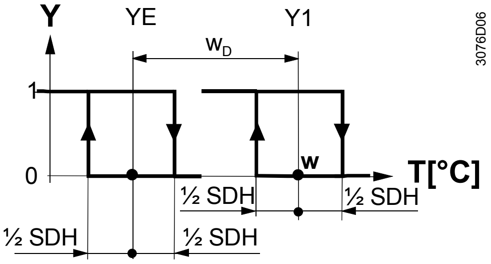
### ON/OFF control

Control sequence ON/OFF output

The diagrams below show the control sequence for 2-position.

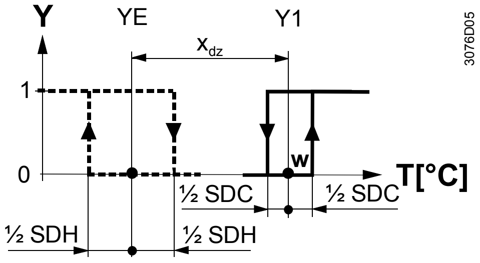
Heating mode

*(automatic changeover = heating or heating only)*

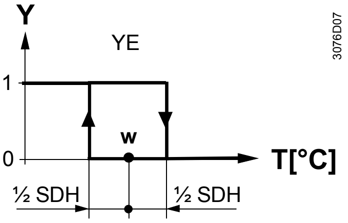


Cooling mode

*(man. / auto. changeover = cooling or cooling only)*



Heating mode with manual changeover (P01 = 2) *(manual changeover = heating)*



| | |
|---|---|
| T[°C] | Room temperature |
| W | Room temperature setpoint |
| Y1 | Control command “Valve” or “Compressor” |
| YE | Control command “Electric heater” |
| SDH | Switching differential “Heating” (P30) |
| SDC | Switching differential “Cooling” (P31) |
| $X_{dz}$ | Dead zone (P33) |
| $w_D$ | Setpoint differential (P34) |

Notes:

- The diagrams only show the PI thermostat’s proportional part.
- For the fan sequence see section 3.8.
- For better temperature control performance with 2-pos electrical heater, we suggest to set the switching differential heating (P30) to 1K

### Setting the sequence and the control outputs

Refer to sections 3.4 "Applications", 3.6.1 "Sequences", and 3.7 "Outputs".

### 3.6.5 4-pipe fan coil unit

**Heating and cooling**

On 4-pipe applications, the thermostat controls 2 valves in heating and cooling mode, heating / cooling mode by manual selection, or heating and cooling mode with changeover. Heating and cooling mode (P01 = 4) is factory-set.

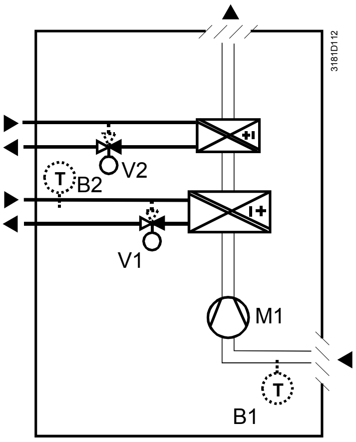
4-pipe application with manual changeover

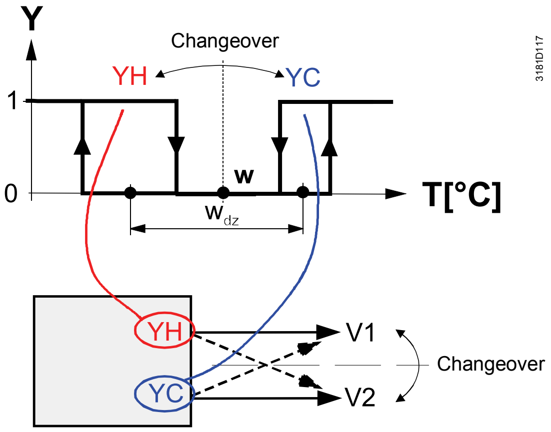
The heating or cooling output can be released via operating mode button if parameter P01 is set to Manual (P01 = 2).

"Main and secondary" application (4-pipe with changeover)

If parameter P01 is set to changeover (P01 = 3), the heating and cooling output is swapped according to the input state of the changeover sensor / switch / bus input (see automatic heating and cooling changeover sensor in section 3.5). This mode is used for the so-called “Main and secondary” application. This is a 4-pipe fan coil unit system with different capacities of the 2 coils. The water circuit is changed to optimize the energy exchange depending on the season (summer / winter):

– Winter: Large coil (V1) for heating, small coil (V2) for cooling
– Summer: Large coil (V1) for cooling, small coil (V2) for heating





Note:
This example shows ON/OFF control; for modulating control, connect the appropriate output terminals

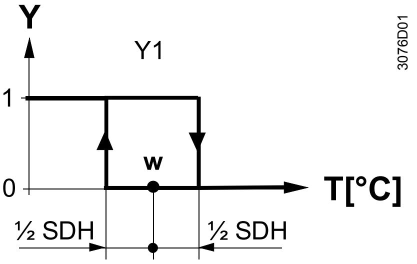
Notes:

- The parameter for the heating and cooling changeover sensor (B2 in the above diagram) must be set to 2 (X1 or X2, P38 or P40)
- The thermostat assumes winter operation when B2 > P37 (factory setting 28 °C)
- The thermostat assumes summer operation when B2 < P36 (factory setting 16 °C)

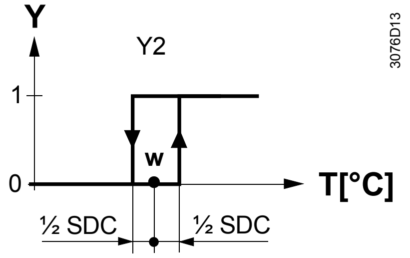
**ON/OFF control**

The diagrams below show the control sequence for 2-position control.

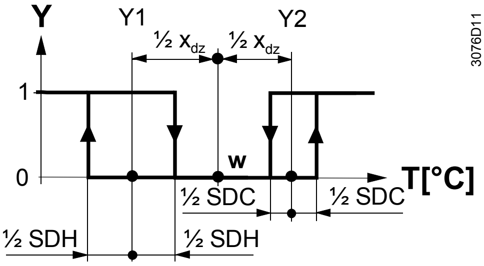
Heating mode with manual selection (P01 = 2)



Cooling mode with manual selection (P01 = 2)



Heating and cooling mode (P01 = 04)



| | |
|---|---|
| T[°C] | Room temperature |
| w | Room temperature setpoint |
| Y1 | Control command “Valve” or “Comp.” (H) |
| Y2 | Control command “Valve” or “Comp.” (C) |
| SDH | Switching differential “Heating” (P30) |
| SDC | Switching differential “Cooling” (P31) |
| $X_{dz}$ | Dead zone (P33) |

Notes:

- The diagrams only show the PI thermostat’s proportional part.
- For the fan sequence see section 3.8.

**Setting the sequence and the control outputs**

Refer to sections 3.4 "Applications", 3.6.1 "Sequences", and 3.7 "Outputs".

### 3.6.6 Chilled / heated ceiling and radiator applications

For chilled / heated ceiling and radiator,

- set the corresponding basic application
- disable the fan (P52)

The following applications are available:

| **Application for chilled / heated ceiling, radiator** | **Set basic application** | **See section** | **Sequences** |
|---|---|---|---|
| Chilled / heated ceiling with changeover | 2-pipe | 3.6.3 | H ( \ )<br>C ( / ) |
| Chilled / heated ceiling & el heater (cooling only: disable el heater via P13) | 2-pipe and electric heater | 3.6.4 | El H + H ( ↯\ \ )<br>El H + C ( ↯\ / )<br>C ( / ) |
| | | | |
| Chilled ceiling and radiator | 4-pipe | 3.6.5 | H + C ( \ / ) |
| | | | |

### 3.6.7 Compressor applications

For compressor applications,

- set the corresponding basic application
- disable the fan (P52) or set the fan speed (P53)

The following applications are available:

| **Application for compressor** | **Set basic application** | **See section** | **Sequences** |
|---|---|---|---|
| 1-stage compressor for heating or cooling | 2-pipe | 3.6.3 | H ( \ )<br>C ( / ) |
| 1-stage compressor and electric heater *(for cooling only: disable electric heater via P13)* | 2-pipe and electric heater | 3.6.4 | El H + H ( ↯\ \ )<br>El H + C ( ↯\ / )<br>C ( / ) |
| 1-stage compressor for heating and cooling | 4-pipe | 3.6.5 | H + C ( \ / ) |

Notes:

| | |
|---|---|
| Minimum ON/OFF time: | P48 / P49 |
| Fan operation: | P52 (0 = disabled, 1 = enabled) |
| Fan speed: | P53 (1 = 1-speed, 2 = 3-speed) |

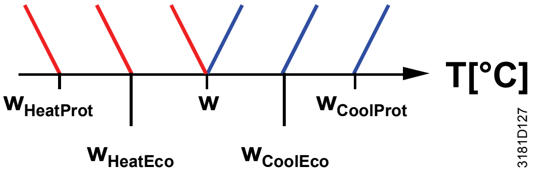
### 3.6.8 Setpoints and sequences

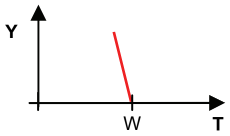
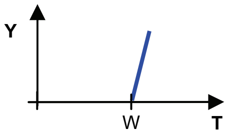
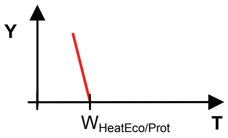
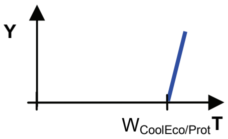
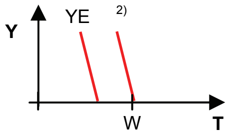
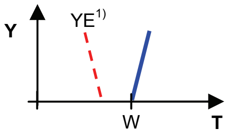
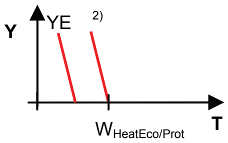
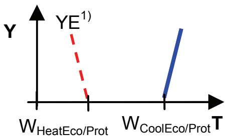
**2-pipe applications**

On changeover applications, the Comfort setpoints for heating and cooling sequence are the same (w).

On 2-pipe applications with electric heater, the Comfort setpoint is either at the first heating sequence (in heating mode) or at the cooling sequence (in cooling mode).

The setpoints for Economy and Protection mode are below the Comfort setpoints (heating) and above the Comfort setpoints (cooling).
They can be set via parameters P11, P12 (Economy mode) and P65, P66 (Protection mode).



| **Application** | **Comfort mode** | | **Economy / Protection mode** | |
|---|---|---|---|---|
| | Heating | Cooling | Heating | Cooling |
| 2-pipe |  |  |  |  |
| 2-pipe and electric heater |  |  |  |  |

1) If P13 = ON

2) In case of manual changeover (P01 = 2), the first heating sequence is disabled to prevent heating (electric heater) and cooling (coil) at he same time

W = setpoint in Comfort mode

$W_{HeatEco/Prot}$ = setpoint heating in Economy or Protection mode

$W_{CoolEco/Prot}$ = setpoint cooling in Economy or Protection mode

YR = radiator sequence

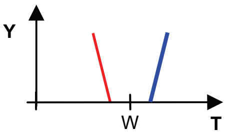
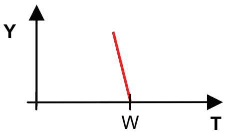
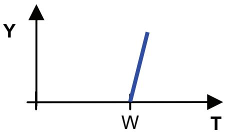
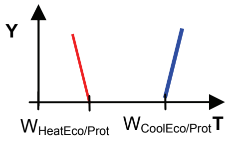
YE = electric heater sequence

**4-pipe applications**

On 4-pipe applications, the Comfort setpoint (w) is in the middle of the dead zone, between the heating and cooling sequence.

The dead zone can be adjusted via parameter P33.

If manual changeover is selected, then either the cooling sequence or the heating sequence is released. In this case, the Comfort setpoint is at the selected heating or cooling sequence.

| | **Comfort mode** | | | **Economy / Protection mode** |
|---|---|---|---|---|
| **Application** | Heating and cooling | Heating only 1) | Cooling only 1) | Heating and/or cooling |
| 4-pipe |  |  |  |  |

1) Manual changeover, P01 = 2

W = setpoint in Comfort mode

$W_{HeatEco/Prot}$ = heating setpoint for Economy or Protection mode

$W_{CoolEco/Prot}$ = cooling setpoint for Economy or Protection mode

YE = electric heater sequence

## 3.7 Control outputs

### 3.7.1 Overview

**Overview of control outputs**

Different control output signals are available. They need to be defined during commissioning (see below).

| Control output / Product no. | 2-position | 2-position PWM | 3-position | DC 0…10 V |
|---|---|---|---|---|
| RDF301, RDF301.50, RDF600KN | Y11, Y21<br>(2 x SPST) | --- | Y11, Y21 *)<br>(1 x ▲ / ▼) | --- |

*) Only on 2-pipe application

Note

In the ACS tool, Y11 and Y21 are called Y1 and Y2.

**ON/OFF control signal**
(2-position)

The valve or compressor receives the **OPEN/ON** command via control output Y11 or Y21 when…

1. the acquired room temperature is below the setpoint (heating mode) or above the setpoint (cooling mode).
2. the control outputs have been inactive for more than the “Minimum output OFF-time” (factory setting 1 minute, adjustable via parameter P48).

**OFF** command when…

1. the acquired room temperature is above the setpoint (heating mode) or below the setpoint (cooling mode).
2. the valve has been active for more than the “Minimum output on-time” (factory setting 1 minute, adjustable via parameter P49).

**Electric heater control signal**
(2-position)

The electric heater receives an **ON** command via the auxiliary heating control output (Y…, see Mounting Instructions) when…

1. the acquired room temperature is below the “Setpoint for electric heater”
2. the electric heater has been switched off for at least 1 minute

The **OFF** command for the electric heater is output when…

1. the acquired room temperature is above the setpoint (electric heater)
2. the electric heater has been switched on for at least 1 minute

**Caution** ⚠

A safety limit thermostat (to prevent overtemperatures) must be provided externally.

**3-position control signal**

Output Y11 provides the **OPEN** command, and Y21 the **CLOSE** command to the 3-position actuator.
The factory setting for the actuator's running time is 150 seconds. It can be adjusted via parameter P44.
The parameter is only visible if 3-position is selected via DIP switches.

Synchronization

1. When the thermostat is powered up, a closing command for the actuator running time + 150% is provided to ensure that the actuator fully closes and synchronizes to the control algorithm.
2. When the thermostat calculates the positions "fully close" or "fully open", the actuator's running time is extended + 150% to ensure the right actuator position is synchronized to the control algorithm.
3. After the actuator reaches the position calculated by the thermostat, a waiting time of 30 seconds is applied to stabilize the outputs.

### 3.7.2 Control outputs configuration (setting via DIP switches or tool)

---

The type of the control outputs on 2-pipe applications (2- or 3-position) is set via DIP switches (see section 3.4).

The DIP switches have no impact if the application is commissioned via tool. Control outputs need to be set via ACS in this case.

Note In the tool, the parameter is called "Output Y1 / Y2", not Y11 / Y21).

# 3.8 Fan control

The fan operates in automatic mode or at the selected speed with manual mode. In automatic mode, the fan speed depends on the setpoint and the current room temperature. When the room temperature reaches the setpoint, the control valve closes and the fan switches off or stays at fan speed 1 (parameter P60).
Factory setting for P60:

| | |
|---|---|
| • RDF600KN | fan Off in dead zone |
| • RDF301... | fan speed1 in dead zone |

Fan command value
Enable fan command value

The fan speed and mode can be changed via bus.

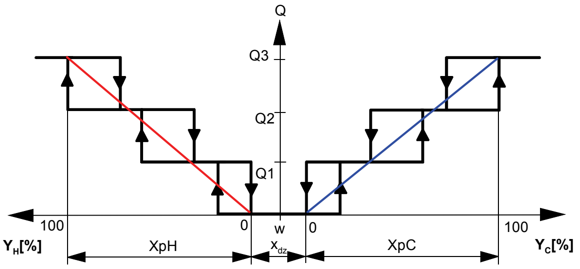
For this purpose, the fan command value needs to be enabled.

Fan operation
Fan stage 1-2-3
Fan output

The fan speed and mode can be monitored via bus.

**3-speed fan control with modulating heating / cooling control**

The individual switching points for **ON** of each fan stage can be adjusted via control parameters P55…P57. The fan speed switch off point is 20% below the switch on point. The diagrams below show fan speed control for modulating PI control.



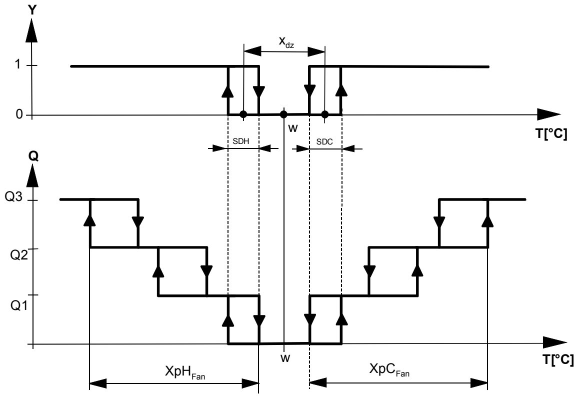
| | |
|---|---|
| w | Room temperature setpoint |
| Q | Fan speed |
| $Y_H$ ╲ | Control demand “Heating” |
| $Y_C$ ╱ | Control demand “Cooling” |
| XpH | Proportional band “Heating” |
| XpC | Proportional band “Cooling” |
| $X_{dz}$ | Dead zone |

Note: The diagram only shows the PI thermostat’s proportional part.

**3-speed fan control with ON/OFF heating / cooling control**

On applications with 2-position control:

1) The switching point for low fan speed (Q1) is synchronized to the heating / cooling output. Parameter “Switching point fan speed low” P57 is not relevant.
2) The maximum switching range of the fan ($XpH_{Fan}$ / $XpC_{Fan}$) is defined by the switching differential (SDH/SDC) via a look-up table.



| | |
|---|---|
| T[°C] | Room temperature |
| w | Room temperature setpoint |
| Q | Fan speed |
| Y | Control command “Valve” |
| SDH | Switching differential “Heating” |
| SDC | Switching differential “Cooling” |
| $X_{dz}$ | Dead zone |
| $XpH_{Fan}$ | Switching range for fan “Heating” |
| $XpC_{Fan}$ | Switching range for fan “Cooling” |

Look-up table with ON/OFF control

| SDH/SDC [K] | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | >4.5 |
|---|---|---|---|---|---|---|---|---|---|
| $XpH_{Fan}/XpC_{Fan}$ [K] | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**1-speed / 3-speed fan**

The thermostat can control a 1- or 3-speed fan (selected via control parameter P53). A 1-speed fan is connected to terminal Q1, a 3-speed fan to terminals Q1, Q2 and Q3.

**Fan operation as per heating / cooling mode, or disabled**

Fan operation can be limited to be active with cooling only or heating only, or even be totally disabled via control parameter “Fan operation” P52.
When fan operation is disabled, the fan symbol on the display disappears and pressing the fan button has no impact.
This function allows you to use the thermostat on universal applications such as chilled / heated ceilings and radiator, etc. (see section 3.6.6).

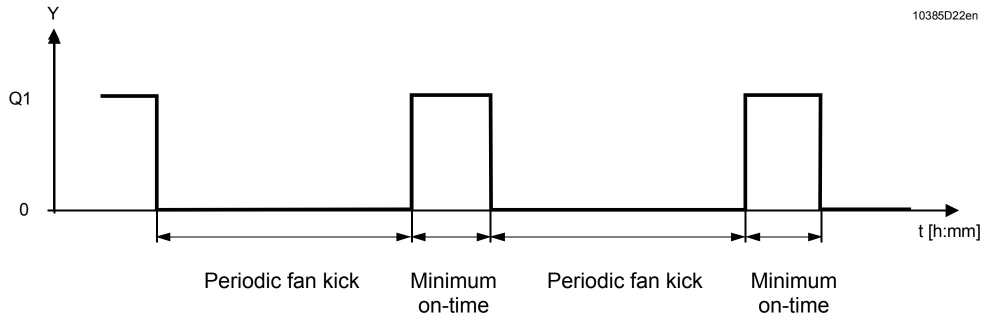
**Fan minimum on- time**

In automatic mode, a dwelling time of 2 minutes (factory setting) is active. The fan maintains each speed for at least 2 minutes before it changes to the next speed. This minimum on-time can be adjusted from 1…6 minutes via parameter P59.

**Fan operation in dead zone (fan kick)**

In automatic fan mode and with the room temperature in the dead zone, the control valve is normally closed and the fan disabled. With the “Fan kick” function, the fan can be released from time to time at low speed for minimum on-time (see above) even if the valve is closed.

This function can be used to avoid damage from moisture due to a lack of air circulation, or to allow a return air temperature sensor to acquire the correct room temperature.

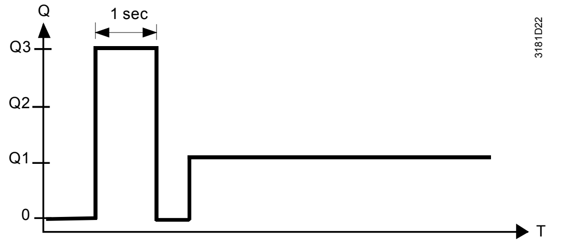


The periodic fan kick time can be selected individually for Comfort mode via parameter P60, and for Economy mode via parameter P61.

Note: Fan kick value “0” means the fan runs continuously in the dead zone.
Fan kick value “OFF” means the fan does not run in the dead zone.

**Fan start**

When the fan starts from standstill, it starts at speed 3 for 1 second to ensure safe fan motor start by overcoming inertia and friction (selected via parameter P58).



**Fan overrun for electric heater**

When the electric heater is switched off, the fan overruns for 60 seconds (parameter P54) to avoid overtemperature of the electric heater or prevent the thermal cutout from responding.

⚠ Fan failure

In case of fan failure, the thermostat cannot protect the electric heater against overtemperature. For this reason, the electric heater must feature a separate safety device (thermal cutout).

**Clean fan filter reminder**

The “Clean fan filter reminder” function counts the fan operating hours and displays message “FIL 🔔 “ to remind the user to clean the fan filter as soon as the threshold is reached. This does not impact the thermostat's operation, which continues to run normally. The function is set via parameter P62 (default = Off (0)).

KNX®
Fault information

The “Clean filter reminder” is reset when the operating mode is manually set to Protection and back.

**Fan in Auto Timer mode**

In Auto Timer mode ⌚Auto, the default fan mode is automatic. The fan mode can be changed to Manual by pressing the FAN button. The fan returns to the automatic default mode after each switchover from Comfort to Economy mode, and vice versa.

## 3.9 Multifunctional input, digital input

The thermostat has 2 multifunctional inputs X1 and X2
An NTC type sensor like the QAH11.1 (AI, analog input) or a switch (DI, digital input) can be connected to the input terminals. The functionality of the inputs can be configured via parameters P38 + P39 for X1 and P40 + P41 for X2.

The current temperature or state of the inputs X1/X2 is available on bus for monitoring purposes.

The parameters can be set to the following values:

Heating/ cooling changeover

Window state

Enable electric heater

| # | Function of input | Description | Type X1/X2 |
|---|---|---|---|
| 0 | Not used | No function. | -- |
| 1 | External / return air temperature | Sensor input for external room temperature sensor or return air temperature sensor to acquire the current room temperature, or floor heating temperature sensor to limit the heating output.<br>*Note:* The room temperature is acquired by the built-in sensor if the floor temperature limitation function is enabled via parameter P51. | AI |
| 2 | Heating / cooling changeover | Sensor input for “Automatic heating / cooling changeover” function.<br>A switch can also be connected rather than a sensor (switch closed = cooling, see section 3.5).<br>Heating / cooling changeover is also possible via bus. In this case, the function must not be assigned to any local input X1, X2. See also section 3.5.<br>Diagnostic value 00 is displayed for closed contact / 100 for open contact, if a switch is connected. | AI / DI |
| 3 | Operating mode switchover | Digital input to switch over the operating mode to Economy.<br>If the operating mode switchover contact is active, user operations are ineffective and “OFF” is displayed.<br>Operating mode switchover is also possible via bus. In this case, the function must not be assigned to any local input X1, X2. See also section 3.2. | DI |
| 4 | Dew point monitor | Digital input for a dew point sensor to detect condensation. Cooling is stopped if condensation occurs. | DI |
| 5 | Enable electric heater | Digital input to enable / disable the electric heater via remote control.<br>Enable electric heater is also possible via bus. In this case, the function must not be assigned to any local input X1, X2. See also section 3.6. | DI |

Fault information

X1, X2 (Digital)

X1, X2 (Temp.)

| # | Function of input | Description | Type X1/X2 |
|---|---|---|---|
| 6 | Fault | Digital input to signal an external fault (example: dirty air filter).<br>If the input is active, “ALx” is displayed and a fault is sent on the bus. See also section 3.11.8.<br>(Alarm x, with x = 1 for X1, x = 2 for X2).<br>*Note*: Fault displays have no impact on the thermostat's operation. They merely represent a visual signal. | DI |
| 7 | Monitor input (Digital) | Digital input to monitor the state of an external switch via bus, e.g. to send a local alarm via KNX to the central controller. | DI |
| 8 | Monitor input (Temperature) | Sensor input to monitor the state of an external sensor (e.g. QAH11.1) via bus, e.g. to send a local temperature (0...49°C) via KNX to the central controller. | AI |

- Operational action can be changed between normally open (NO) and normally closed (NC) via parameter P39, P41
- Each input X1 or X2 must be configured with a different function (1…5). Exception: 1 or 2 inputs can be configured as fault (6) or monitor input (7,8)
- X1 is factory-set to “Operating mode switchover” (3), X2 to “External sensor” (1)

For more detailed information, refer to section 3.4 “Applications”.

## 3.10 Handling faults

**Temperature out of range**

When the room temperature is outside the measuring range, i.e. above 49 °C or below 0 °C, the limiting temperatures blink, e.g. “0 °C” or “49 °C”.
In addition, the heating output is activated if the current setpoint is not set to “OFF”, the thermostat is in heating mode and the temperature is below 0 °C.
For all other cases, no output is activated.

The thermostat resumes Comfort mode after the temperature returns to within the measuring range.

For fault status messages on the bus, see section 3.11.8.

**Power failure**

In the event of a power failure, all working conditions (operating mode, setpoint, fan stage, all control parameter settings) are stored without time limitation.
When power returns, the thermostat reloads this data and continues to work in the same conditions as before.

## 3.11 KNX communications

The RDF KNX thermostats support communications as per the KNX specification.

| | |
|---|---|
| S-mode | Standard mode; engineering via group addresses. |
| LTE mode | Logical Tag Extended mode, for easy engineering, is used in conjunction with Synco. |

### 3.11.1 S-mode

This mode corresponds to KNX communications.
Connections are established via ETS by assigning communication objects to group addresses.

### 3.11.2 LTE mode

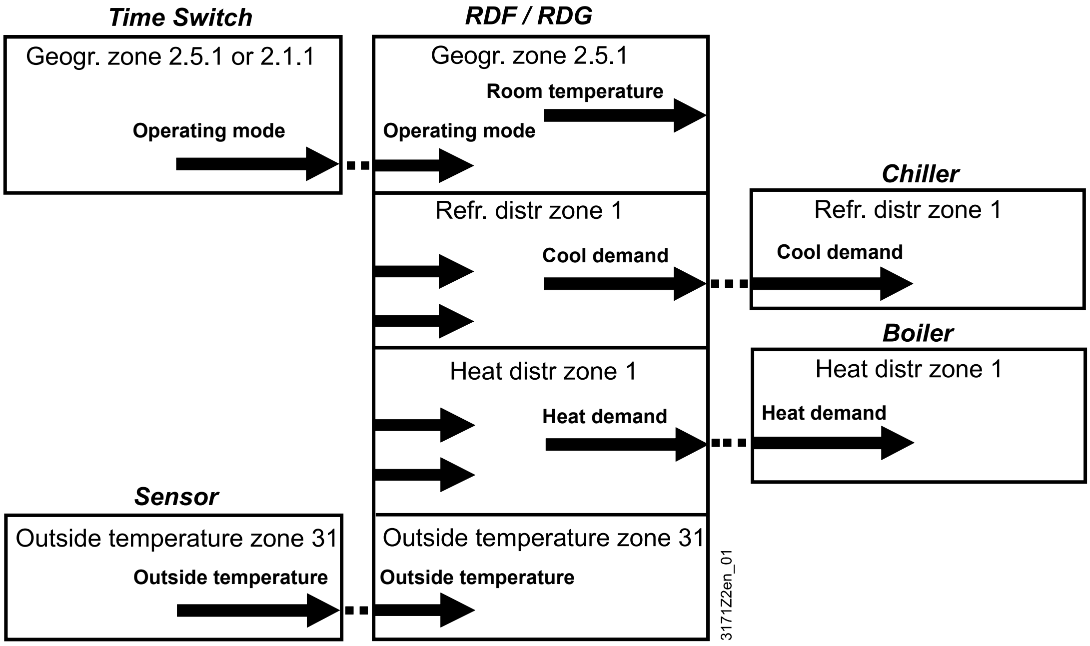
LTE mode was specifically designed to simplify engineering. Unlike with S-mode, there is no need to create the individual connections (group addresses) in the tool. The devices autonomously establish connections.

**Definitions**

To make this possible, the following circumstances are predefined:

- Every device or subdevice is located within a zone
- Every data point (input or output) is assigned to a zone
- Every data point (input or output) has a precisely defined "name"

Whenever an output and an input with the same "name" are located in the same zone, a connection is established automatically, as shown in the following diagram.



**Engineering and commissioning**

- For a detailed description of KNX (topology, bus supply, function and setting of LTE zones, filter tables, etc.), see "Communication via the KNX bus for Synco 700, 900 and RXB/RXL, Basic Documentation" [6]
- LTE mode data points and settings are described in the Synco Application Manual [12]
- To engineer and commission a specific system, use the Synco700 planning and commissioning protocol (XLS table in HIT, [7])

### 3.11.3 Zone addressing in LTE mode (in conjunction with Synco)

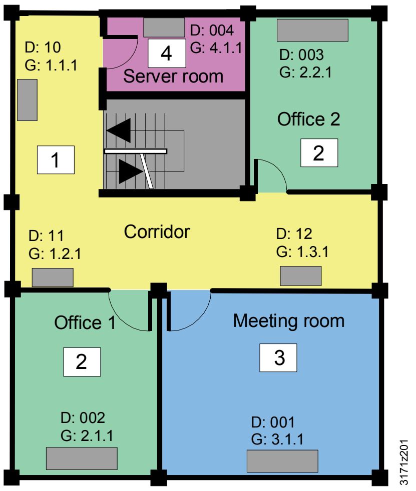
In cases where RDF KNX room thermostats are used in LTE mode (e.g. in conjunction with Synco), zone addresses need to be allocated.
The following zone address must be defined together with the Synco devices at the planning stage depending on the application.

| Short description | Factory setting | Parameter |
|---|---|---|
| Geographical zone (apartment) | --- (out of service) | P82 |
| Geographical zone (room) | 1 | P83 |
| Heat distr zone heating coil | 1 | P84 |
| Refr distr zone cooling coil | 1 | P85 |

Note: “Subzone” of “Geographical zone” is fix 1 (not adjustable)

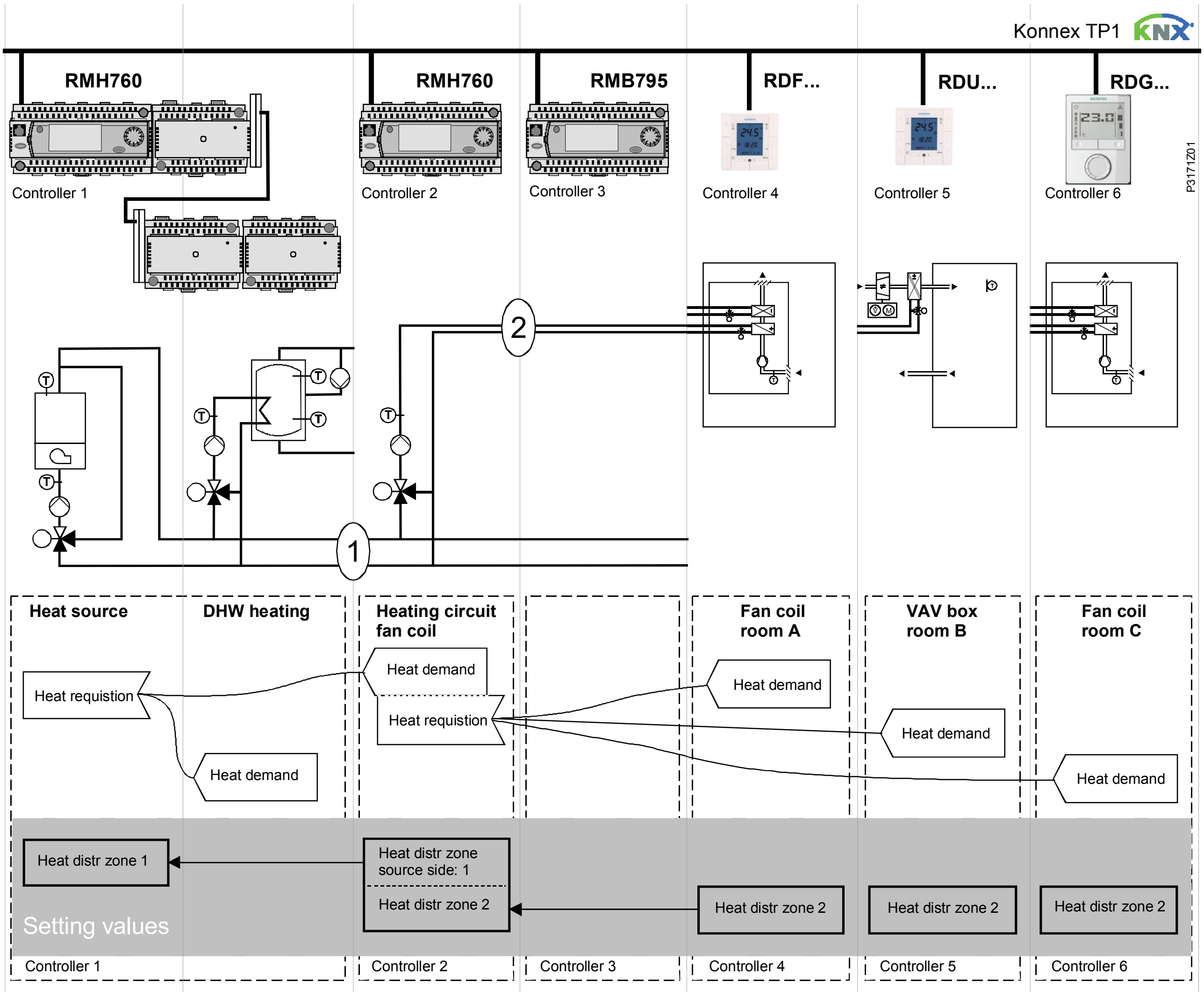
The device will send and receive LTE communication signals only if the zone address is valid (not OSV = out of service).

The zones to be defined are as follows:

| | |
|---|---|
| **Geographical zone (space zone)**<br>(Apartment . Room . Subzone)<br>Apartment = ---, 1...126<br>Room = ---, 1...63<br>*Subzone = fix 1* | Zone in which an RDF KNX thermostat is physically located. Other room-specific devices may also be located in this zone.<br>Information exchanged in this zone is related specifically to the device like operating mode, setpoints, room temperature, etc.<br>The designations "Apartment", "Room" and "Subzone" do not need to be taken literally. For example, Apartment can be used to refer to a group of rooms, floor or section of a building. ”Room", however, really does refer to a room.<br>Subzone is not used for HVAC devices. It is more relevant to other disciplines, such as lighting. Subzone is fix at “1” and not visible.<br>The time switch information is expected from the same zone where the thermostat is located (Residential).<br>If no time switch information is received from the same zone, the thermostat will use the information received from the same apartment but with room “1“ A.1.1 (Office).<br>**Example:**<br>**Commercial building**<br>In a commercial building, the time switch information is sent by the RMB795 central control unit. The zones are divided in so called “Room groups” (e.g. 1...4), where each “Room group” can have an individual schedule. A room thermostat in the same “Room group” need to have the same Apartment Address.<br> <br>Legend:<br>D = device address (P81)<br>G = geographical zone (P82, P83)<br>(Apartment.Room.Subzone) |
| **Heat distribution zone heating coil**<br>Zone = ---, 1...31 | Information related specifically to the hot water system in heating coils is exchanged within this zone. The zone also includes a Synco device to process the information (e.g. RMH7xx or RMU7xx with changeover). |
| **Refrigeration distribution zone cooling coil**<br>Zone = ---, 1...31 | Information related specifically to the chilled water system is exchanged within this zone (e.g. cooling demand). This zone also includes a Synco device to process the information (e.g. RMU7xx). |
| **Outside temperature zone**<br>*Zone = fixed to 31*<br>*RDF301...: SW < V3.7: fixed to 1* | Outside temperature received in outside temperature zone 31 will be / can be displayed on the room thermostat when commissioned accordingly (parameter P07 = 2). |

### 3.11.4 Example of heating and cooling demand zone

The building is equipped with Synco controls on the generation side and RDF / RDG thermostats on the room side.



**Explanation relating to the illustration**

In the case of a typical application, the individual RDF / RDG room thermostats send their heat demand directly to the primary controller (in the above example to the RMH760).

(1) and (2) designate the numbers of the distribution zone.

Notes:

- This type of application can analogously be applied to refrigeration distribution zones
- If no 2-pipe fan coil is used, heat and refrigeration demand signals are sent simultaneously to the primary plant

### 3.11.5 Send heartbeat and receive timeout

In a KNX network, S-mode and LTE mode communication objects can be exchanged between individual devices. The *Receive timeout* defines the period of time within which all the communication objects requested from a device must have been received at least once. If a communication object is not received within this period, a predefined value is used.

Similarly, the *Send heartbeat* defines the period of time within which all the communication objects requested must be transmitted at least once.

**LTE mode / S-mode**

Fixed times are specified as follows:

- Receive timeout: 31 minutes
- Send heartbeat: 15 minutes

**Reducing the bus load**

Individual zones can also be disabled (out of service) via control parameter if they are not being used. In disabled zones, the LTE signal will no longer be periodically sent, and will therefore reduce bus load.

### 3.11.6 Startup

**Startup response**

The application is restarted after every reset, so that all the connected motorized valve actuators are synchronized (see "Control outputs", 3.7).

**Startup delay**

After a reset, it takes up to 5 minutes for all the connected room thermostats to restart. This is designed to avoid overloading the mains power supply when restarting. At the same time, it reduces the load on the KNX network, as not all thermostats transmit data at the same time. The delay ($T_{WaitDevice}$) is determined by the thermostat's device address. After the delay, the device starts to send.

### 3.11.7 Heating and cooling demand

Heating output primary
Heating output secondary
Cooling output primary

In conjunction with Synco, the heating and/or cooling demand from each room is transmitted to the BACS to provide the required heating or cooling energy.

An example for LTE mode is described in section 3.11.4.

In S-mode, the current state signals of the control outputs are available.

## 3.11.8 Fault function on KNX

If a fault occurs (e.g. digital fault input, dew point, communication configuration, etc.) then a fault will be sent on the bus.

An RDF thermostat listens on the bus and sends its fault when the fault has the highest alarm priority. This ensures that the management station does not miss any alarms.
If alarms occur at the same time, the alarm with the highest priority will be first displayed and sent on the bus.

Fault transmission is different in LTE mode and S-mode:

| S-mode | LTE mode |
|---|---|
| Fault state | Alarm info (error code + internal information) |
| Fault information (internal information) | Alarm text (default text can be edited with ACS tool) |

The table below shows the error code and default alarm texts.

| | | Thermostat | Fault information on bus | | |
|---|---|---|---|---|---|
| **Prio** | **Fault** | **Display** | **Error code** | **Default fault text** | **Text adjustable *)** |
| - | No fault | --- | 0 | No fault | ✓ |
| 1 | Bus power supply**) | 🔔BUS,<br>🔔BUSF | 5000 | No bus power supply | --- |
| 2 | Device address error | 🔔Addr | 6001 | >1 id device address | --- |
| 3 | Condensation | 🔔💧 | 4930 | Condensation in the room | ✓ |
| 4 | External fault input X1 | 🔔AL1 | 9001 | Fault input 1 | ✓ |
| 5 | External fault input X2 | 🔔AL2 | 9002 | Fault input 2 | ✓ |
| 6 | Clean filter reminder | 🔔FIL | 3911 | Dirty filter | ✓ |

*) Default alarm texts are stored in the thermostat’s non-volatile memory and can be adjusted using the ACS commissioning tool

**) This error will not be sent on bus (because there is no bus, not enough bus power supply, bus is overloaded or bus signal is distorted)

**Priority of alarms**

- Priority order is #1…6
- External faults #4…5: If faults are active, the display will show AL1, AL2, alternating. On the bus, only the fault with the highest priority will be sent

Fault transmission

A supervisor alarm system may command the thermostat to stop sending faults to the bus via the communication object “Fault transmission” (disable / enable).
This has no impact on the local display of faults.

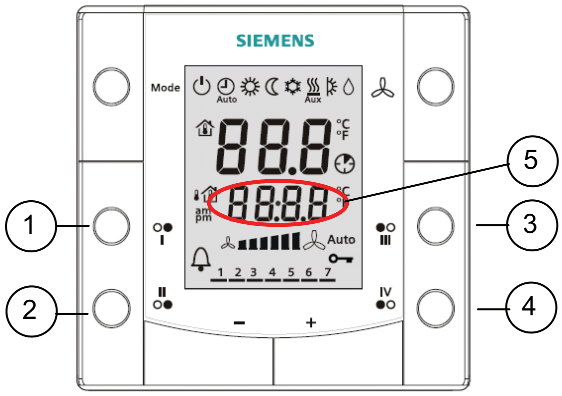
After a timeout of 48 hours, the sending of faults will automatically be enabled again.

### 3.11.9 KNX switching groups (RDF301.50 only)

Buttons ...

Light and blinds as well as scenes are operated via switching groups.

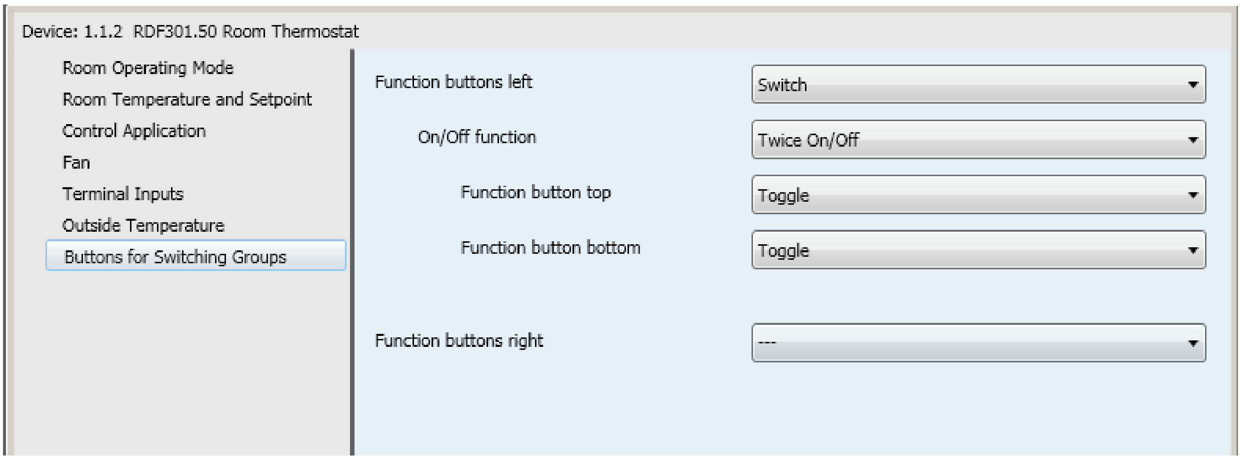
The communication objects of the buttons need to be bound to a corresponding KNX actuator module.



| | |
|---|---|
| 1, 2 | Buttons of switching group left (1) |
| 3, 4 | Buttons of switching group right (2) |
| 5 | Display for indication while pressing buttons |

RDF301.50 has 2 switching groups with a pair of button each, which can be configured via ETS.

**Commissioning of switching groups (ETS)**



Device: 1.1.2 RDF301.50 Room Thermostat

- Room Operating Mode
- Room Temperature and Setpoint
- Control Application
- Fan
- Terminal Inputs
- Outside Temperature
- Buttons for Switching Groups

| | |
|---|---|
| Function buttons left | Switch |
| On/Off function | Twice On/Off |
| Function button top | Toggle |
| Function button bottom | Toggle |
| Function buttons right | --- |

Parameters per switching group

| # | Parameter | | Parameter value |
|---|---|---|---|
| | Function left / right buttons | 0 | Inactive (factory setting) |
| | | 1 | Switch |
| | | 2 | Dim |
| | | 3 | Shutter |
| | | 4 | Scene |

Parameters per single button

| # | Function | Parameter | | **Parameter value**<br>***Child Parameter:*** | |
|---|---|---|---|---|---|
| 1 | Switch | "ON/OFF" functions | 0 | Top: ON; bottom: OFF | |
| | | | 1 | 2 "ON/OFF" functions | |
| | | | | ***Function top button:*** | |
| | | | | 0 | Toggle (ON/OFF) |
| | | | | 1 | ON |
| | | | | 2 | OFF |
| | | | | ***Function bottom button:*** | |
| | | | | 0 | Toggle (ON/OFF) |
| | | | | 1 | ON |
| | | | | 2 | OFF |

| # | Function | Parameter | | Parameter value |
|---|---|---|---|---|
| 4 | Scene | Scene number top button | | 1…63 |
| | | Scene number bottom button | | 1…63 |

**Operating switching groups**

The following functions are available:

- **Switching**: Toggle ON/OFF with 1 button or ON/OFF with 2 buttons (1 + 2 or 3 + 4). "ON" or "OFF" is displayed
- **Dim lights** with 2 buttons (1 + 2 or 3 + 4):
  On/Off with a short pulse (<0.5 s); "ON" or "OFF" is displayed.
  Brighter / darker with a long pulse (>1 s); "dI" is displayed
- **Operate blinds** with 2 buttons (1 + 2 or 3 + 4):
  A long pulse (>1 s) starts the up/down motor; "UP" or "DOWN" is displayed.
  A short pulse (<0.5 s) stops the motor or slightly adjusts the position of blinds; "ON" or "OFF" is displayed
- **Scene** (button 1, 2, 3 or 4):
  A scene can be used to recall certain states of all actuators involved, as well as to save new states as needed. E.g. differently dimmed lights and blind positions considered adequate for certain events / times.
  A short pulse (<0.5 s) starts the scene. "CALL" is displayed, the scene is read from the bus.
  A long pulse (>3 s) saves the actual position of all actuators involved as adjusted previously; "SAVE" is displayed, the new scene is sent on the bus.

Note: If commissioned as **inactive**, then pressing the buttons has no effect.

## 3.12 Communication objects (S-mode)

### 3.12.1 Overview

| Page | Object # and name | | Thermostat | | Object # and name | Page |
|---|---|---|---|---|---|---|
| 12 | 1 System time | → | | | | |
| 12 | 3 Time of day | → | | | | |
| 12 | 44 Outside temperature | → | | → | 21 Room temperature | 12 |
| | | | | → | 16 Room operating mode: State 1) | 13 |
| 14 | 12 Room operating mode: Time switch 1) | → | | → | 24 Room temperature: Current setpoint | 21 |
| 14 | 7 Room operating mode: Preselection 1) | ↔ | | | | |
| 13, 15, 44 | 20 Room operating mode: Window state | → | | → | 33 Fan operation (0 = Auto / 1 = Manual) | 41 |
| | | | | → | 35 Fan output | 41 |
| 21 | 22 Room temperature: Comfort basic setpoint | → | | → | 36 Fan stage 1 | 41 |
| 21 | 23 Room temperature: Comfort setpoint | ↔ | | → | 37 Fan stage 2 | 41 |
| | | | | → | 38 Fan stage 3 | 41 |
| 29 | 31 Application mode | → | | | | |
| | | | | → | 25 Heating output primary 2) | 50 |
| 41 | 32 Enable fan command value | → | | → | 26 Heating output secondary 2) | 50 |
| 41 | 34 Fan command value | → | | → | 27 Cooling output primary 2) | 50 |
| 32, 44 | 29 Enable electric heater | → | | | | |
| | | | | → | 39/40 X1 (temperature / digital) | 45 |
| 25, 44 | 30 Heating/cooling changeover | → | | → | 41/42 X2 (temperature / digital) | 45 |
| 51 | 6 Fault transmission | → | | → | 5 Fault state | 27, 51 |
| | | | | → | 4 Fault information | 27, 43, 45, 51 |
| | | | | → | 45.. Buttons left: ON/OFF | 52 |
| | | | | ↔ | 45.. Button top left: ON/OFF | 52 |
| | | | | ↔ | 46.. Button bottom left: ON/OFF | 52 |
| | | | | → | 47 Buttons left: Dim up/down | 52 |
| | | | | → | 48 Buttons left: Blind step/stop | 52 |
| | | | RDF301.50 only | → | 49 Buttons left: Blind up/down | 52 |
| | | | | → | 50 Buttons left: Scene | 52 |
| | | | | → | 51.. Buttons right: ON/OFF | 52 |
| | | | | ↔ | 51.. Button top right: ON/OFF | 52 |
| | | | | ↔ | 53.. Button bottom right: ON/OFF | 52 |
| | | | | → | 53 Buttons right: Dim up/down | 52 |
| | | | | → | 54 Buttons right: Blind step/stop | 52 |
| | | | | → | 55 Buttons right: Blind up/down | 52 |
| | | | | → | 56 Buttons right: Scene | 52 |

→ Input communication object
→ Output communication object
↔ Input & output communication object
1) 8-bit and 1-bit object available, selectable via parameter in ETS
2) Availability depending on selected application / function

## 3.12.2 Description of communication objects

| Obj | Object name | Function | Type/ length | Flags |
|---|---|---|---|---|
| 1 | **System time** | Time and date | 19.001<br>8 Byte | CWU |
| System time for display on the room thermostat. See parameter P07 (3 or 4) | | | | |
| 3 | **Time of day** | Time and date | 10.001<br>3 Byte | CWU |
| Another object for receiving the time of day for display on the room thermostat. See parameter P07 (3 or 4) | | | | |
| 4 | **Fault information** | Alarm Info | 219.001<br>6 Byte | CT |
| Common alarm output. If an alarm occurs, the alarm number is transmitted | | | | |
| 5 | **Fault state** | Faulty / normal | 1.005<br>1 bit | CT |
| Common alarm output. If an alarm occurs, the alarm flag is set | | | | |
| 6 | **Fault transmission** | Enable / disable | 1.003<br>1 bit | CWU |
| A supervisor alarm system can disable the broadcasting of alarms by the devices. This has no impact on the local display of alarms. After a timeout of 48 hours, the sending of faults will automatically be enabled again. | | | | |
| 7 | **Room operating mode: Preselection** | Auto<br>Comfort<br>PreComf.<br>Economy<br>Protection | 20.102<br>1 Byte | CWTU |
| Controls the room operating mode selection of the thermostat via bus.<br>The command can also be submitted as four 1-bit communication objects (8...11). The last interaction wins – either from local operating mode button or via bus.<br>Note: The thermostat will transform Precomfort either into Economy or Comfort (selectable via P88). | | | | |
| <br>8<br>9<br>10<br>11 | **Operating mode: Preselection**<br>**Auto**<br>**Comf**<br>**Eco**<br>**Prot** | Trigger | 1.017<br>1 bit | CW |
| Switch room operating mode to either Auto, Comfort, Economy or Protection.<br>The last interaction wins – either from the local operating mode button or via bus. | | | | |
| 12 | **Room operating mode: Time switch** | Comfort<br>Economy<br>PreComf.<br>Protection | 20.102<br>1 Byte | CWU |
| This information is provided by a central time switch or a supervisor and defines the actual HVAC operating mode.<br>The command can also be submitted via three 1-bit communication objects (13...15).<br>Protection has the highest priority and cannot be overridden.<br>Note: The thermostat will transform Precomfort either into Economy or Comfort (selectable P88). | | | | |
| <br>13<br>14<br>15 | **Time switch**<br>**Comfort**<br>**Economy**<br>**Protection** | Trigger | 1.017<br>1 bit | CW |
| Switch the HVAC mode to either Comfort, Economy or Protection mode. | | | | |

| Obj | Object name | Function | Type/ length | Flags |
|---|---|---|---|---|
| 16 | **Room operating mode: State** | Comfort<br>Economy<br>Protection | 20.102<br>1 Byte | CRT |
| Effective room operating mode used by the thermostat (considering time switch, user selection, window contact, etc.) This state information is available via one 8-bit enumeration or three 1-bit communication objects (17...19). Note: The thermostat does not support Precomfort. | | | | |
| <br>17<br>18<br>19 | **Room operating mode:**<br>**State Comfort**<br>**State Economy**<br>**State Protection** | ON<br>OFF | 1.002<br>1 bit | CT |
| Corresponding communication object sends "True" | | | | |
| 20 | **Window state** | Open<br>Closed | 1.019<br>1 bit | CWU |
| The thermostat is set to Economy mode if value “1” (open) is received. It switches back to the previous mode when the value is “0” (closed).<br>"Window state" is sent e.g by a KNX switch or a KNX presence detector. It has the same effect as the local operating mode switchover contact X1, X2 (parameter P38, P40).<br>*Only one input source must be used, either local input X1/X2 or KNX bus.* | | | | |
| 21 | **Room temperature** | Temp. value | 9.001<br>2 Bytes | CRT |
| The value of the room temperature measured via built-in or external sensor is available via this communication object. | | | | |
| 22 | **Room temperature: Comfort basic setpoint** | Temp. value | 9.001<br>2 Bytes | CWU |
| If function "Temporary setpoint" is enabled via parameter P69, then after an operating mode change, the setpoint adjustments made by the user and via communication object 23 will be dismissed and the thermostat will be reset to the Comfort basic setpoint.<br>Note: Setpoints that have been changed via the local HMI may be overwritten during a system startup from a central master controller, e.g.RMB795.<br>*The Comfort basic setpoint is stored in EEPROM (see section 3.3.2). → The service life of the EEPROM depends on the number of write cycles. Never write this communication object cyclically!* | | | | |
| 23 | **Room temperature: Comfort setpoint** | Temp. value | 9.001<br>2 Bytes | CWTU |
| Communication object used to shift the setpoint used by the thermostat (see section 3.3.2). Same priority as local setpoint shift on the thermostat. The last intervention wins.<br>Note: The Comfort basic setpoint (object 22) will not be changed. | | | | |
| 24 | **Current setpoint** | Temp. value | 9.001<br>2 Bytes | CRT |
| Current setpoint, including shift, compensation, etc., used by the thermostat for temperature control | | | | |
| 25 | **Heating output primary** | 0…100 % | 5.001<br>8 bit | CRT |
| Indicates the position of the heating actuator of first stage.<br>E.g. 2-pipe with electric heater application: Output of heating coil. | | | | |
| 26 | **Heating output secondary** | 0…100% | 5.001<br>8 bit | CRT |
| Indicates the position of the heating actuator of the second stage.<br>E.g. 2-pipe with electric heater application: Output of the electric heater. | | | | |

<table>
<tr><th>Obj</th><th>Object name</th><th>Function</th><th>Type/ length</th><th>Flags</th></tr>
<tr><td>27</td><td><b>Cooling output primary</b></td><td>0…100%</td><td>5.001<br>8 bit</td><td>CRT</td></tr>
<tr><td colspan="5">Indicates the position of the cooling actuator of the first stage.<br>E.g. 2-pipe with electric heater application: Output of the cooling coil</td></tr>
<tr><td>29</td><td><b>Enable electric heating</b></td><td>Enable / disable</td><td>1.003<br>1 bit</td><td>CWU</td></tr>
<tr><td colspan="5">An electric heater can be disabled with this communication object (e.g. to meet tariff regulations).<br>The same function is also available via local multifunctional input X1/X2 (parameter P38, P40).<br><i>Only one input source must be used, either local input X1/X2 or KNX bus.</i></td></tr>
<tr><td>30</td><td><b>Heating / cooling changeover</b></td><td>Heat / Cool</td><td>1.100<br>1 bit</td><td>CWU</td></tr>
<tr><td colspan="5">Changeover information transmitted via bus.<br>Default: Current mode before power down.<br>The same function is also available via local multifunctional input X1/X2 (parameter P38, P40).<br><i>Only one input source must be used, either local input X1/X2 or KNX bus..</i></td></tr>
<tr><td>31</td><td><b>Application mode</b></td><td>HVAC control mode</td><td>20.105<br>8 bit</td><td>CWU</td></tr>
<tr><td colspan="5"><table>
<tr><td>0</td><td>Auto (default)</td><td>Heating and/or cooling</td></tr>
<tr><td>1</td><td>Heat</td><td>Heating only</td></tr>
<tr><td>2</td><td>Morning warmup*</td><td>Heating only</td></tr>
<tr><td>3</td><td>Cool</td><td>Cooling only</td></tr>
<tr><td>5</td><td>Precool*</td><td>Cooling only</td></tr>
<tr><td>6</td><td>OFF</td><td>Neither heating nor cooling</td></tr>
<tr><td>8</td><td>Emergency heat*</td><td>Heating only</td></tr>
<tr><td>9</td><td>Fan only</td><td>Fan runs at high speed</td></tr>
</table><i>* Function handled like Heat (1) or Cool (3)</i></td></tr>
<tr><td>32</td><td><b>Enable fan command value</b></td><td>Enable<br>Disable</td><td>1.003<br>1 bit</td><td>CWU</td></tr>
<tr><td colspan="5">Set fan mode to Auto (disable) or Manual (enable) by a KNX control unit. If Manual, the value received on <i>Fan command value (34)</i> will be used to command the fan speed.<br>Default: Enable<br>The last interaction wins – either from the local fan mode button or via bus.</td></tr>
<tr><td>33</td><td><b>Fan operation</b></td><td>Auto<br>Manual</td><td>1.001<br>1 bit</td><td>CRT</td></tr>
<tr><td colspan="5">Indicates the status of the fan mode: Auto (0) or Manual (1).</td></tr>
<tr><td>34</td><td><b>Fan command value</b></td><td>0…100%</td><td>5.001<br>8 bit</td><td>CWU</td></tr>
<tr><td colspan="5">The fan can be set to a specified speed by a KNX control unit when manual fan operation is enabled.<table>
<tr><th>Speed</th><th>Fan command value (physical KNX value)</th></tr>
<tr><td>1</td><td>1...33% (1…85)</td></tr>
<tr><td>2</td><td>34…67% (86...170)</td></tr>
<tr><td>3</td><td>68…100% (171…255)</td></tr>
</table>Fan speed “0” is not supported by the thermostat and the fan speed will remain unchanged.</td></tr>
<tr><td>35</td><td><b>Fan output</b></td><td>0…100%</td><td>5.001<br>8 bit</td><td>CRT</td></tr>
<tr><td colspan="5">Indicates the current fan speed as a value 0...100%<table>
<tr><th>Speed</th><th>Fan output (physical KNX value)</th></tr>
<tr><td>OFF</td><td>0% (0)</td></tr>
<tr><td>1</td><td>33% (84 )</td></tr>
<tr><td>2</td><td>66% (186)</td></tr>
<tr><td>3</td><td>100% (255)</td></tr>
</table></td></tr>
<tr><td>36<br>37<br>38</td><td><b>Fan speed 1</b><br><b>Fan speed 2</b><br><b>Fan speed 3</b></td><td>ON<br>OFF</td><td>1.001<br>1 bit</td><td>CRT</td></tr>
<tr><td colspan="5">Indicate the state of the relay outputs</td></tr>
</table>

<table>
<tr><th>Obj</th><th>Object name</th><th>Function</th><th>Type/ length</th><th>Flags</th></tr>
<tr><td>39<br>40</td><td><b>X1: Temperature</b><br><b>X2: Temperature</b></td><td>Temp. value</td><td>9.001<br>2 Byte</td><td>CRT</td></tr>
<tr><td colspan="5">Indicate the values of the temperature sensors connected to the local inputs X1 / X2</td></tr>
<tr><td>41<br>42</td><td><b>X1: Digital</b><br><b>X2: Digital</b></td><td>ON<br>OFF</td><td>1.001<br>1 bit</td><td>CRT</td></tr>
<tr><td colspan="5">Indicate the status of the digital inputs (adjusted by parameters P39/P41) including considering of operating action</td></tr>
<tr><td>44</td><td><b>Outside temperature</b></td><td>Temp. value</td><td>9.001<br>2 Byte</td><td>CWU</td></tr>
<tr><td colspan="5">The outside temperature measured by a KNX sensor can be displayed on the thermostat, if parameter P07 "Additional user information” is set = 2 (outside temperature).</td></tr>
<tr><td>45</td><td><b>Buttons left ON/OFF</b></td><td rowspan="2">ON<br>OFF</td><td rowspan="2">1.001<br>1 bit</td><td rowspan="2">CT</td></tr>
<tr><td>51</td><td><b>Buttons right ON/OFF</b></td></tr>
<tr><td colspan="5">Switch control: Parameter ON/OFF functions = Top: ON; Bottom: OFF<br>When pressing the button, the corresponding switching telegram is sent immediately.</td></tr>
<tr><td>45</td><td><b>Button top left: ON/OFF</b></td><td rowspan="4">ON<br>OFF</td><td rowspan="4">1.001<br>1 bit</td><td rowspan="4">CT<br>CWTU 1)</td></tr>
<tr><td>46</td><td><b>Button bottom left: ON/OFF</b></td></tr>
<tr><td>51</td><td><b>Button top right: ON/OFF</b></td></tr>
<tr><td>52</td><td><b>Button bottom: Right ON/OFF</b></td></tr>
<tr><td colspan="5">Switch control: Parameter ON/OFF functions = 2 “ON/OFF” functions.<br>When pressing the button, the corresponding switching telegram is sent immediately: ON, OFF or Toggle.<br>1) If “Toggle” is selected, the communication object becomes output and synchronization input</td></tr>
<tr><td>45<br><br>51</td><td><b>Buttons left: ON/OFF</b><br><b>Buttons right: ON/OFF</b></td><td>ON<br>OFF</td><td>1.001<br>1 bit</td><td>CT</td></tr>
<tr><td>47<br><br>53</td><td><b>Buttons left: Dim up/down</b><br><b>Buttons right: Dim up/down</b></td><td>Darker / Brighter</td><td>1.001<br>4 bit</td><td>CT</td></tr>
<tr><td colspan="5">On a short operation of the button, a switching telegram is sent, e.g. press left top button: “On” is sent, press left bottom button: “OFF” is sent.<br>When pressing the buttons longer, a dimming telegram is sent, e.g. press left top button: “Brighter” is sent, press left bottom button: “Darker” is sent.<br>On releasing the button, a “Stop” telegram is sent.</td></tr>
<tr><td>48<br><br>54</td><td><b>Buttons left: Blind step/stop</b><br><b>Buttons right: Blind step/stop</b></td><td>Step / Stop</td><td>1.001<br>1 bit</td><td>CT</td></tr>
<tr><td>49<br><br>55</td><td><b>Buttons left: Blind up/down</b><br><b>Buttons right: Blind up/down</b></td><td>Up / Down</td><td>1.001<br>1 bit</td><td>CT</td></tr>
<tr><td colspan="5">On a short operation of the button, a telegram is sent to adjust the louvers or stop the blinds if moving up or down.<br>On a long operation of the button, a telegram is sent to raise or lower the blinds (up or down)</td></tr>
</table>

<table>
<tr><th>Obj</th><th>Object name</th><th>Function</th><th>Type/ length</th><th>Flags</th></tr>
<tr><td>50<br>56</td><td><b>Buttons left: Scene</b><br><b>Buttons right: Scene</b></td><td>Scene control</td><td>18.001<br>8 bit</td><td>CT</td></tr>
<tr><td colspan="5">The “Scene (8-bit)” function is used to change the characteristics of a preset scene, i.e. brightness levels and switching states of a group within a scene, without using the ETS.<br>For scene control, short and long (<1 s / > 3 s) pressing on the buttons are distinguished.<br>On a short press, a telegram is sent to recall the corresponding scene. On a long press, a telegram is sent to save the corresponding scene.<br>For each button a different scene number can be configured in ETS.</td></tr>
</table>

## 3.13 Control parameters

A number of control parameters can be readjusted to optimize control performance. This can be done on the thermostat via HMI or via commissioning / operating tool. These parameters can also be set during operation without opening the unit.
In the event of a power failure, all control parameter settings are retained, see page 45.

The control parameters are assigned to 2 levels:
- “Service level”, and
- “Expert level” including communications, diagnostics and test

The “Service level” contains a small set of parameters to set up the thermostat for the HVAC system and to adjust the user interface. These parameters can be adjusted any time.
Change parameters at the “Expert level” carefully, as they impact the thermostat’s control performance and functionality.

### 3.13.1 Parameter setting via local HMI

**Enter only “Service” level**

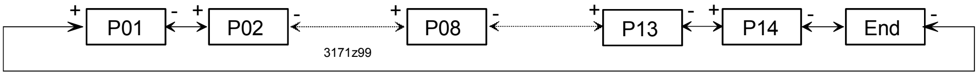
1. Press buttons + and – simultaneously for 4 seconds.
   Release and press **button +** again within 2 seconds until the display shows “P01”.
   Continue with step 2.

**Enter “Service” and “Expert” level.**

1. Press buttons + and – simultaneously for 4 seconds.
   Release and press **button –** again within 2 seconds until the display shows “P01”.

**Adjust parameters**

2. Repeatedly press the **+** or **–** button to select the required parameter.



3. Press **+** and **–** simultaneously. The current value of the selected parameter begins to flash, allowing you to change the value by repeatedly pressing **+** or **–**.
4. The next parameter is displayed when you press **+** and **–** again simultaneously.
5. Repeat steps 2 to 4 to display and change additional parameters.
6. Press + or – until “End” is displayed, and then press + and – simultaneously to save the change and exit parameter entry mode.

**Reset parameters**

The factory setting for the control parameters can be reloaded via parameter P71, by changing the value to “ON”, and confirming by pressing buttons **+** and **–** simultaneously. The display shows “8888” during reload.

### 3.13.2 Parameter setting / download via tool

Control parameters can be adjusted via bus either by parameter download during commissioning or during normal operation with a tool like ACS.

**ACS**

With the ACS tool, the parameters can be changed…

- during commissioning via parameter download (all parameters)
- during normal operation via Popcard (most of the parameters)

**OZW772 Web server, RMZ792 bus operator unit**

Most parameters can be changed during normal operation using the OZW772 web server or the RMZ792 bus operator unit.

**ETS**

ETS is an engineering tool and can be used for the full commissioning of the RDF KNX thermostats.  Device address, application, control parameters and parameters for the switching groups can be defined and downloaded via ETS

Notes

- Setting RDF KNX parameters is only supported by ETS4 or higher / ACS version 5.11 or higher.
- The RDF KNX thermostats (without ETS parameter download) require version ETS3f or higher

**Connecting a KNX tool**

Connecting a KNX commissioning / operating tool to the RDF is described in section 4.2.

### 3.13.3 Parameters of the "Service level"

| Parameter | Name | Factory setting | Range |
|---|---|---|---|
| | **Service level** | | |
| P01 | Control sequence | 2-pipe:<br>1 = Cooling only<br>4-pipe:<br>4 = Heating and Cooling | 0 = Heating only<br>1 = Cooling only<br>2 = H/C changeover manual<br>3 = H/C changeover auto<br>4 = Heating and Cooling |
| P02 | Operation via room op selector | 1 | 1 = Auto – Protection<br>2 = Auto - Comfort - Economy - Protection |
| P04 | Unit | C (0) | C = ° Celsius<br>F = ° Fahrenheit |
| P05 | Measured value correction | 0 K | – 3 ... 3 K |
| P06 | Standard display | 0 | 0 = Room temperature<br>1 = Setpoint |
| P07 | Additional display information | 0 | 0 = --- (No display)<br>1 = °C and °F<br>2 = Outside temperature (via bus)<br>3 = Time of day (12h) (via bus)<br>4 = Time of day (24h) (via bus) |
| P08 | Comfort basic setpoint | 21 °C | 5 ... 40 °C |
| P09 | Comfort setpoint minimum | 5 °C | 5 ... 40 °C |
| P10 | Comfort setpoint maximum | 35 °C | 5 ... 40 °C |
| P11 | Economy heating setpoint | 15 °C | OFF, 5 ... WCoolEco;<br>WCoolEco = 40 °C max |
| P12 | Economy cooling setpoint | 30 °C | OFF, WHeatEco ... 40 °C;<br>WHeatEco = 5C min |
| P13 | Electric heater when cooling | ON | ON: Enabled<br>OFF: Disabled |
| P14 | Button lock | 0 | 0 = Unlocked<br>1 = Auto lock<br>2 = Manual lock |

Note: Parameter display depends on selected application and function.

### 3.13.4 Parameters of the "Expert level with diagnostics and test"

| Parameter | Name | Factory setting | Range |
|---|---|---|---|
| | **Expert level** | | |
| P30 | Heat P-band Xp / switching diff | 2 K | 0.5 … 6 K |
| P31 | Cool P-band Xp / switching diff | 1 K | 0.5 … 6 K |
| P33 | Dead zone Comfort mode | 2 K | 0.5 … 5 K |
| P34 | Setpoint differential | 2 K | 0.5 … 5 K |
| P35 | Integral action time Tn RDF301... /<br>RDF600KN | 5 min<br>45 min | 0…10 min<br>0...120 min |
| P36 | H/C ch'over swi point cooling | 16 °C | 10…25 °C |
| P37 | H/C ch'over swi point heating | 28 °C | 27…40 °C |
| P38 | Input X1 | 3 = Op mode c/o | 0 = --- (no function)<br>1 = Room temp ext. sensor / Return air temp (AI)<br>2 = H/C changeover (AI/DI)<br>3 = Operating mode contact (DI)<br>4 = Dew point sensor (DI)<br>5 = Enable electric heater (DI)<br>6 = Fault input (DI)<br>7 = Monitor input (Digital)<br>8 = Monitor input (Temp) |
| P39 | Normal position input X1 | 0 (N.O.) | 0 = Normally open / Open<br>1 = Normally closed / Close |
| P40 | Input X2 | 1 = Ext. sensor | 0 = --- (no function)<br>1 = Room temp ext. sensor / Return temp (AI)<br>2 = H/C changeover (AI/DI)<br>3 = Operating mode contact (DI)<br>4 = Dew point sensor (DI)<br>5 = Enable electric heater (DI)<br>6 = Fault input (DI)<br>7 = Monitor input (Digital)<br>8 = Monitor input (Temp) |
| P41 | Normal position input X2 | 0 (N.O.) | 0 = Normally open / Open<br>1 = Normally closed / Close |
| P44 | Actuator running time Y11/Y21 | 150 s | 20…300 sec |
| P45 | RDF600KN:<br>Power of electric heater on Y21 (for adaptive temperature compensation | 0.0 kW | 0.0...1.2 kW |
| P46 | Output Y11/Y21 | ON/OFF (1) | 0 = 3-position<br>1 = 2-position |
| P48 | On time minimum 2-pos output | 1 min. | 1...20 min |
| P49 | Off time minimum 2-pos output | 1 min. | 1...20 min |
| P50 | Purge time | OFF | OFF: Not active<br>1…5 min: Active with selected duration |
| P51 | Flow temp limit floor heating | OFF | OFF, 10...50 °C |
| P52 | Fan control | 1 | 0 = Disabled<br>1 = Enabled<br>2 = Heating only<br>3 = Cooling only |
| P53 | Fan speeds | 3-speed | 1 = 1-speed<br>2 = 3-speed |
| P54 | Fan overrun time | 60 sec | 0...360 sec |
| P55 | Fan speed switching point high | 100% | 80...100% |
| P56 | Fan speed switching point med | 65% | 30..75% |
| P57 | Fan speed switching point low | 10% | 1...15% |
| P58 | Fan start kick | ON | ON: Enabled<br>OFF: Disabled |
| P59 | On time minimum fan | 2 min | 1...6 min |
| P60 | Periodic fan kick Comfort RDF301...<br>RDF600KN | 0<br>OFF | 0…89 min, OFF(90) |

| Parameter | Name | Factory setting | Range |
|---|---|---|---|
| | **Expert level** | | |
| P61 | Periodic fan kick Eco | OFF | 0…359 min, OFF(360) |
| P62 | Service filter | Off (0) | Off, 100…9900 h |
| P65 | Protection heating setpoint | 8 °C | OFF, 5…WCoolProt;<br>WCoolProt = 40 °C max |
| P66 | Protection cooling setpoint | OFF | OFF, WHeatProt… 40;<br>WHeatProt = 5°C min |
| P68 | Temporary Comfort mode | 0 (= OFF) | 0...360 min |
| P69 | Temporary Comfort setpoint | OFF | OFF = Disabled<br>ON = Enabled |
| P71 | Restore factory setting | OFF | OFF = Disabled<br>ON = Reload start<br>“8888” is displayed for 3s during reload process |

| Parameter | Name | Factory setting | Range |
|---|---|---|---|
| | **Communications** | | |
| P81 | Device address | 255 | 1…255 |
| P82 | Geographical zone (apartment) | --- | ---, 1...126 |
| P83 | Geographical zone (room) | 1 | ---, 1...63 |
| P84 | Heat distr zone heating coil | --- | ---, 1...31 |
| P85 | Refrig distr zone cooling coil | --- | ---, 1...31 |
| P88 | Transformation Precomfort | 0 | 0 = Economy<br>1 = Comfort |

1) Physical address = Area.Line.DeviceAddress. Factory setting for Area = 0, Line = 2.
Can be changed by special management service e.g. from line coupler or via ACS commissioning tool.

2) Type = geographical zone A.R.S. In RDF sub zone = fixed value 1

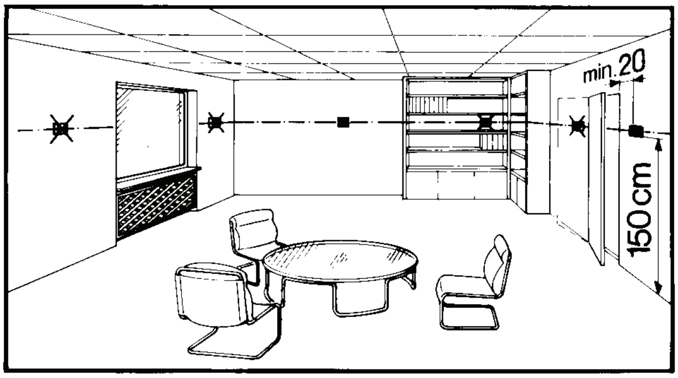
| Parameter | Name | Range |
|---|---|---|
| | **Diagnostics & test** | |
| d01 | Application number | NONE = (No application)<br>2P = 2-pipe<br>2P3P = 2-pipe 3-position<br>2PEH = 2-pipe with electric heater<br>4P = 4-pipe |
| d02 | X1 state | 0 = Not activated (for DI)<br>1 = Activated (DI)<br>0…49 °C = Current temp. value (for AI)<br>00 ❄ = H/C Input shorted<br>100 ♨ = H/C Input open |
| d03 | X2 state | 0 = Not activated (for DI)<br>1 = Activated (DI)<br>0…49 °C = Current temp. value (for AI)<br>00 ❄ = H/C Input shorted<br>100 ♨ = H/C Input open |
| d05 | Test mode for checking the Y11/Y21 actuator's running direction 3) | "---" = no signal on outputs Y11 and Y21<br>OPE = output Y11 forced opening<br>CLO = output Y21 forced closing |

3) This parameter can only be quit when the setting is back at “---”.
Press buttons + and – simultaneously to escape.

# 4. Handling

## 4.1 Mounting and installation

Mount the room thermostat on the conduit box. Do not mount on a wall in niches or bookshelves, behind curtains, above or near heat sources, or exposed to direct solar radiation. Mount about 1.5 m above the floor.



**Mounting / dismounting** ⚠

- Mount the room thermostat in a clean, dry indoor place without direct airflow from a heating / cooling device, and not exposed to dripping or splash water
- RDF301... :In case of limited space in the conduit box, use mounting bracket ARG70.3 to increase the headroom by 10 mm
- Before removing the front cover, disconnect the power supply.

**Wiring**

See Mounting Instructions enclosed with the thermostat.
M3171... [3], M3076.1 [3a]

- ⚠ Comply with local regulations to wire, fuse and earth the thermostat
- ⚠ Properly size the cables to the thermostat, fan and valve actuators for AC 230 V mains voltage
- ⚠ Use only valve actuators rated for AC 230 V
- ⚠ The AC 230 V mains supply line must have an external fuse or circuit breaker with a rated current of no more than 10 A
- ⚠ Cables of SELV inputs X1-M/X2-M: Use cables with 230 V insulation, as the conduit box carries AC 230 V mains voltage.
- Inputs X1-M or X2-M: Several switches (e.g. summer / winter switch) may be connected in parallel. Consider overall maximum contact sensing current for switch rating
- ⚠ KNX communication cables (input CE+ / CE-): Use cables with 230 V insulation, as the conduit box carries AC 230 V mains voltage
- No metal conduits
- No cables provided with a metal sheath
- Disconnect from supply before opening the cover

## 4.2 Commissioning

**Applications**

The room thermostats are delivered with a fixed set of applications.

Select and activate the relevant application during commissioning using one of the following tools:

- Local DIP switch and HMI
- Synco ACS
- ETS

**DIP switches**

Set the DIP switches before snapping the front panel to the mounting plate, if you want to select an application via **DIP switches**.

All DIP switches need to be set to “OFF” (remote configuration), if you want to select an application via **commissioning tool**.

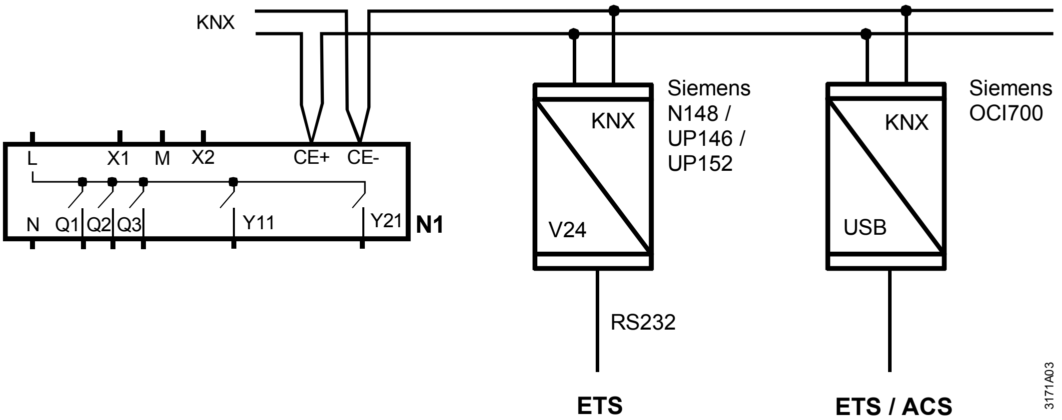
After power is applied, the thermostat resets and all LCD segments flash, indicating that the reset was correct. After the reset, which takes about 3 seconds, the thermostat is ready for commissioning by qualified HVAC staff.

If all DIP switches are OFF, the display reads "NONE" to indicate that application commissioning via a tool is required.

Note: Each time the application is changed, the thermostat reloads the factory setting for all control parameters, except for KNX device and zone addresses!

**Connect tool**

Connect the Synco ACS or ETS tools to the KNX bus cable at any point for commissioning:



ACS and ETS require an interface:

- RS232 KNX interface (e.g. Siemens N148 / UP146 / UP152)
- OCI700.1 USB-KNX interface

Note: An external KNX bus power supply is required if an RDF is connected directly to a tool (ACS or ETS) via KNX interface.

**Control parameters**

The thermostat's control parameters can be set to ensure optimum performance of the entire system.
The parameters can be adjusted using
– Local HMI
– Synco ACS
– ETS
*Commissioning* of switching groups for RDF301.50 is only possible with ETS).

The control parameters of the thermostat can be set to ensure optimum performance of the entire system (see section 3.13, control parameters).

Control sequence

- The control sequence may need to be set via parameter P01 depending on the application. The factory setting is as follows:

| Application | Factory setting P01 |
|---|---|
| 2-pipe and chilled / heated ceiling | 1 = cooling only |
| 4-pipe, chilled ceiling and radiator | 4 = heating and cooling |

Compressor-based applications ⚠

- When the thermostat is used with a compressor, adjust the minimum output on-time (parameter P48) and OFF-time (parameter P49) for Y11/Y21 to avoid damaging the compressor or shortening its life due to frequent switching

Calibrate sensor

- Recalibrate the temperature sensor if the room temperature displayed on the thermostat does not match the room temperature measured (after min. 1 hour of operation). To do this, change parameter P05

Setpoint and range limitation

- We recommend to review the setpoints and setpoint ranges (parameters P08…P12) and change them as needed to achieve maximum comfort and save energy

**Programming mode**

The programming mode helps identify the thermostat in the KNX network during commissioning.
Press buttons “operating mode” ⏻ and “+” simultaneously for 6 sec to activate programming mode, which is indicated on the display with "PrO9".
Programming mode remains active until thermostat identification is complete.

**Assign KNX group addresses**

Use ETS to assign the KNX group addresses of the thermostat's communication objects.

**Switching groups**
RDF301.50 only

RDF301.50 has 2 switching groups with a pair of buttons each, which must be configured via ETS. The switching groups only work in S-mode.

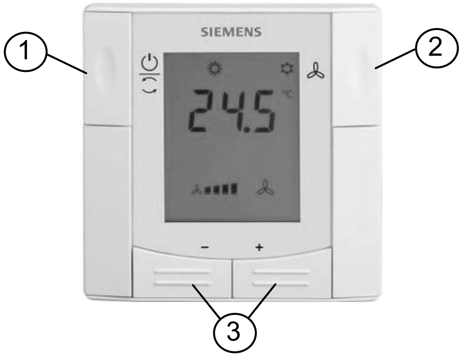
**KNX serial number**

Each device has a unique KNX serial number inside the front panel. An additional sticker with the same KNX serial number is enclosed in the packaging box. This sticker is intended for installers for documentation purposes.

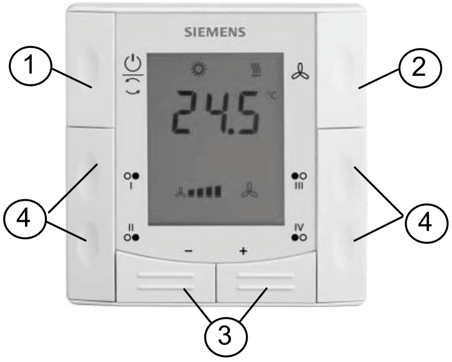
## 4.3 Operation

See also Operating Instructions B3171 [2] enclosed with the thermostat.

**Layout**



RDF301, RDF600KN



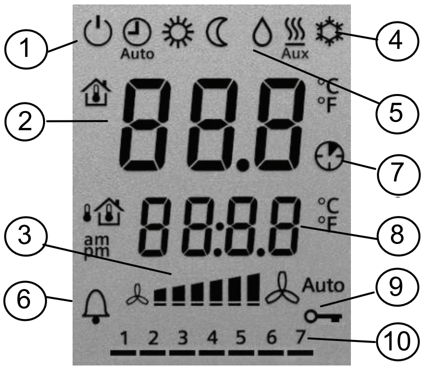
RDF301.50

1 Operating mode selector
2 Button to change fan operation
3 Buttons to adjust setpoints and control parameters
4 Four buttons to control KNX actuators via KNX S-mode
(functions: switching, dimming, blind control, 8-bit scene)

**Button operation**

| User action | Effect, description |
|---|---|
| Normal operation | Actual operating mode and state are indicated by symbols |
| Press any button<br>(thermostat in normal operation) | Backlit LCD turns on and… (see below for further action)<br>After the last operation and a timeout of 10 seconds, the LCD backlight turns off |
| Press left button (operating mode) | Change operating mode |
| Press left button (P01 = 2) | Toggle between heating and cooling |
| Press left button while "Operating mode switchover" via bus is activated | Activate "Extend Comfort mode"<br>(for details, see page 16) |
| Press left button >5 / >3 seconds (RDF301... / RDF600KN) | Activate / deactivate button lock |
| Press right button | Change fan mode |
| Press + or – | Adjusts the Comfort room temperature setpoint .<br>Thermostat changes to Comfort mode |
| Press + and – >3 seconds, release, then press + again >3 seconds | Go to parameter setting mode “Service level” |
| Press + and – >3 seconds, release, then press – again >3 seconds | Go to parameter setting mode “Expert level”, diagnostics and test |
| Press operating mode button and “+” simultaneously for 6 seconds | Enter (KNX) programming mode |

**Display**



1 Operating mode
⏻ Protection
☼ Comfort
☾ Economy
🕘 Auto Timer according to schedule (via bus)

2 Displays room temperature, setpoints and control parameters.
⌂ Symbol indicates current room temperature

3 Fan mode

| | |
|---|---|
| Auto | Auto fan active |
| ▮▮▮▮▮▮ | Fan speed<br>low, medium, high |

4 Heating / cooling mode
❄ Cooling
♨ Heating
♨ Aux Electric heater active

5 💧 Condensation in room (dew point sensor active)

6 🔔 Indicates fault or reminder

7 🕘 Temporary Comfort mode extension active

8 Additional user information, like outside temperature 🌡⌂ or time of day from KNX bus. Selectable via parameters

9 🔑 Button lock active

10 1 2 3 4 5 6 7
Weekday 1…7 from KNX bus (1 = Monday / 7 = Sunday)

## 4.4 Remote operation

The RDF KNX thermostats can be operated from a remote location using a OZW772 / OZW775 web server, a RMZ792 bus operating unit or the ACS tool.

## 4.5 Disposal

The device is classified as waste electronic equipment in terms of the European Directive 2002/96/EC (WEEE) and should not be disposed of as unsorted municipal waste.

The relevant national legal rules must be adhered to.
Regarding disposal, use the systems setup for collecting electronic waste.

Observe all local and applicable laws.

# 5. Supported KNX tools

## 5.1 ETS

**ETS**

ETS is an engineering tool. It can be used for the full commissioning of the RDF KNX thermostats.

The following functions can be realized with ETS4:

- Define and download the physical address
- Define and download the application (plant type, control sequence)
- Set up and download the thermostat's control parameters
- Download the switching group parameters (RDF301.50)
- Set up and download group addresses

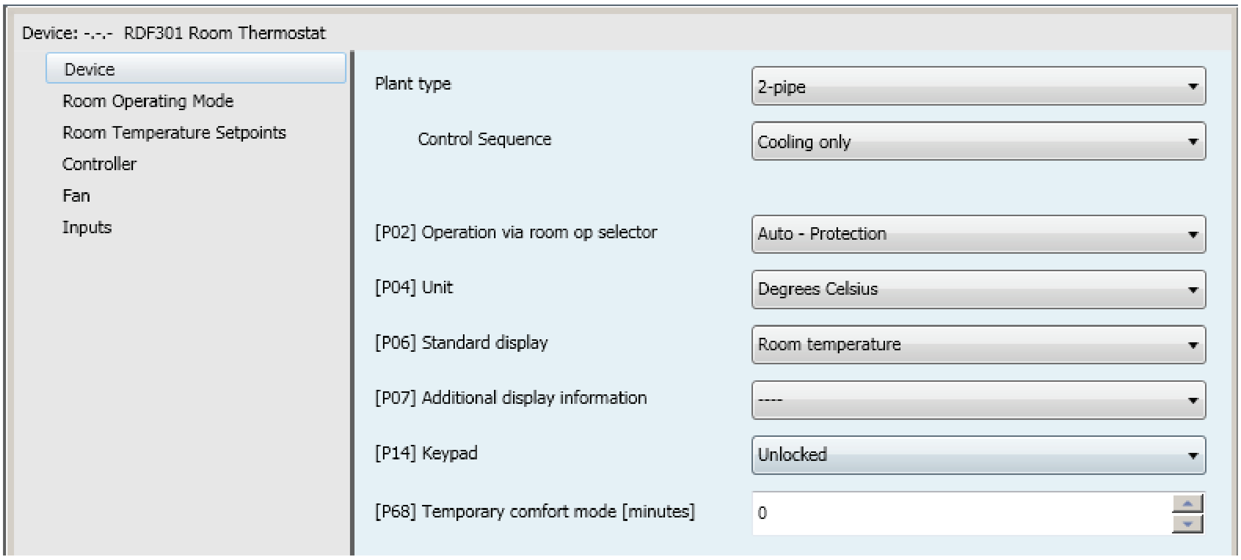
This basic documentation does not describe how to operate ETS and commission a device. Refer to the KNX Manual for more details.

**Note!**

**Setting RDF KNX parameters is only supported by ETS4 or higher.**
**ETS4 can be updated online.**

### 5.1.1 Parameter settings in ETS

For setting the parameters, open the project and select a device.
To start the parameter settings, select **Edit,** then **Edit parameters**.



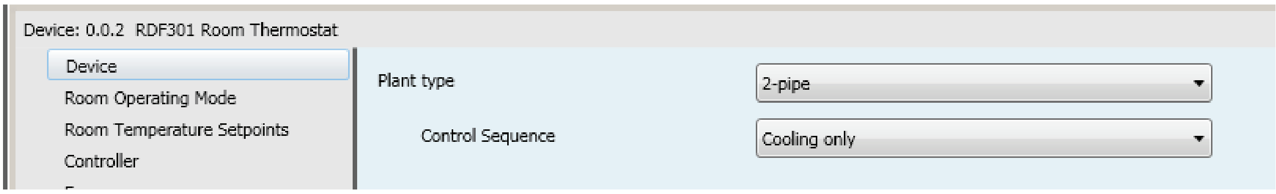
Device: -.-.- RDF301 Room Thermostat

| | |
|---|---|
| Plant type | 2-pipe |
| Control Sequence | Cooling only |
| [P02] Operation via room op selector | Auto - Protection |
| [P04] Unit | Degrees Celsius |
| [P06] Standard display | Room temperature |
| [P07] Additional display information | ---- |
| [P14] Keypad | Unlocked |
| [P68] Temporary comfort mode [minutes] | 0 |

Notes

- The ETS version 3f or higher can be used to assign the communication objects to group addresses (S-mode)
- The ETS4 or higher can be used to download the application and parameters

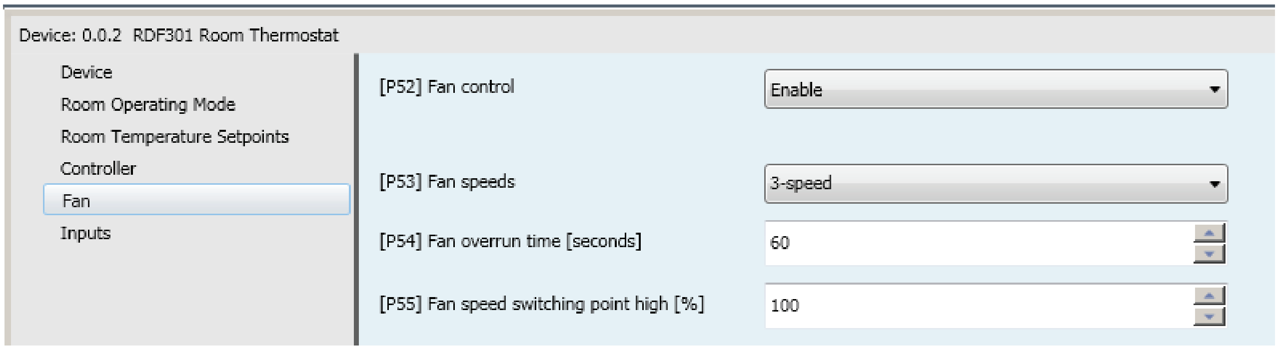
The **application** (plant type) and **Control Sequence** can be adjusted and downloaded.


Device: 0.0.2 RDF301 Room Thermostat

Plant type: 2-pipe

Control Sequence: Cooling only

The **control parameters**, ([Pxx] description) can also be adjusted and downloaded. Refer to section 3.13.


Device: 0.0.2 RDF301 Room Thermostat

[P52] Fan control: Enable

[P53] Fan speeds: 3-speed

[P54] Fan overrun time [seconds]: 60

[P55] Fan speed switching point high [%]: 100

## 5.2 ACS Service and Operating tool

**ACS**

With the ACS tool, the RDF KNX thermostats can be commissioned (physical address, application, parameters). They can be operated or monitored via bus during normal operation.

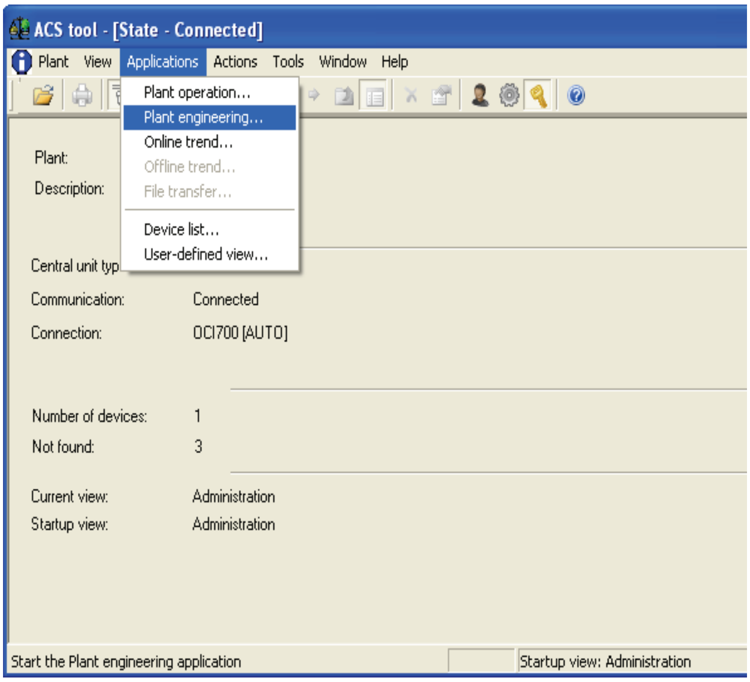
This Manual does not describe how the physical address is defined. Also, it only gives a brief overview of the main functionality of ACS.
For more information, refer to the ACS online help.

**Note!**

**Setting RDF KNX parameters is only supported by ACS Version 5.11 or higher.**

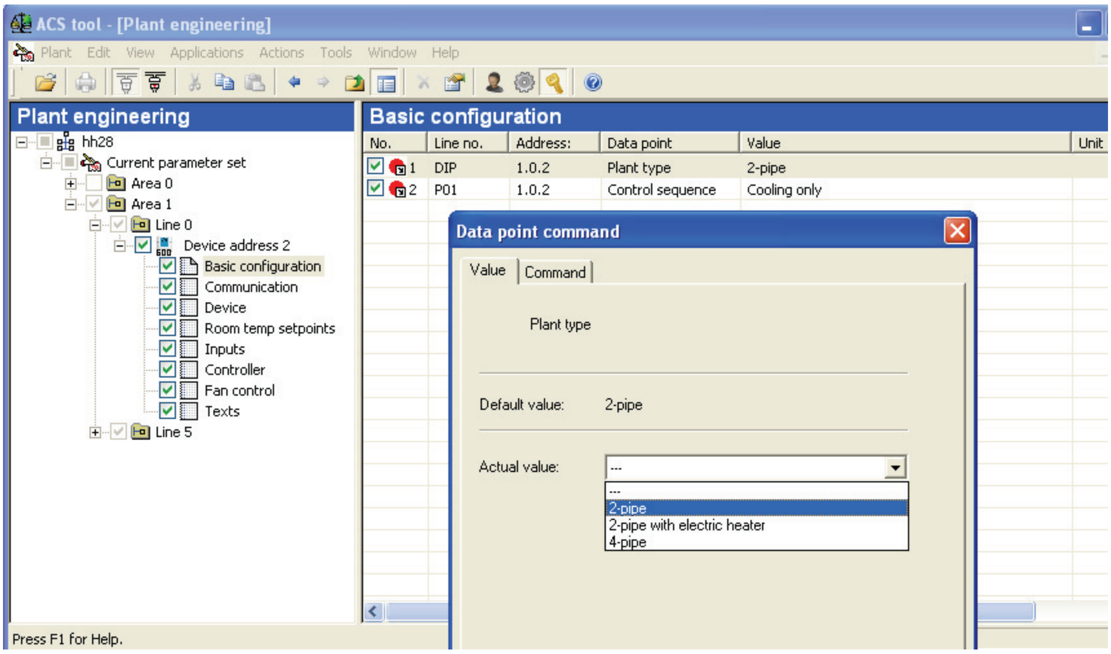
### 5.2.1 Parameter settings in ACS

In the **ACS** program, select **Plant,** then **Open** to open the plant.
To start the parameter settings, select **Applications,** then **Plant engineering…**:



Plant:
Description:
Central unit typ
Communication: Connected
Connection: OCI700 [AUTO]
Number of devices: 1
Not found: 3
Current view: Administration
Startup view: Administration
Start the Plant engineering application
Startup view: Administration

The **application** and **control parameters** can be adjusted and downloaded.
Column *Line no.* contains the parameter number as shown in the parameter table.
Refer to section 3.13, control parameters.



Basic configuration

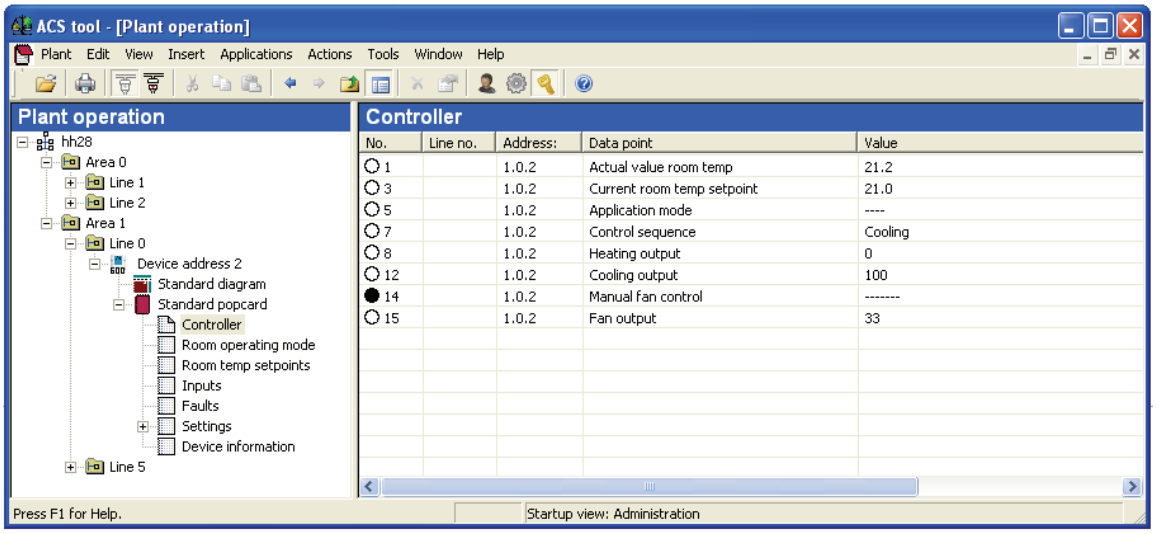
| No. | Line no. | Address: | Data point | Value | Unit |
|---|---|---|---|---|---|
| 1 | DIP | 1.0.2 | Plant type | 2-pipe | |
| 2 | P01 | 1.0.2 | Control sequence | Cooling only | |

Plant type
Default value: 2-pipe
Actual value: ---

### 5.2.2 Operation and monitoring with ACS

**ACS**

In the **ACS** program, select **Plant,** then **Open** to open the plant.
To start monitoring and operation, select **Applications,** then **Plant operation**



| No. | Line no. | Address: | Data point | Value |
|---|---|---|---|---|
| ○ 1 | | 1.0.2 | Actual value room temp | 21.2 |
| ○ 3 | | 1.0.2 | Current room temp setpoint | 21.0 |
| ○ 5 | | 1.0.2 | Application mode | ---- |
| ○ 7 | | 1.0.2 | Control sequence | Cooling |
| ○ 8 | | 1.0.2 | Heating output | 0 |
| ○ 12 | | 1.0.2 | Cooling output | 100 |
| ● 14 | | 1.0.2 | Manual fan control | ------- |
| ○ 15 | | 1.0.2 | Fan output | 33 |

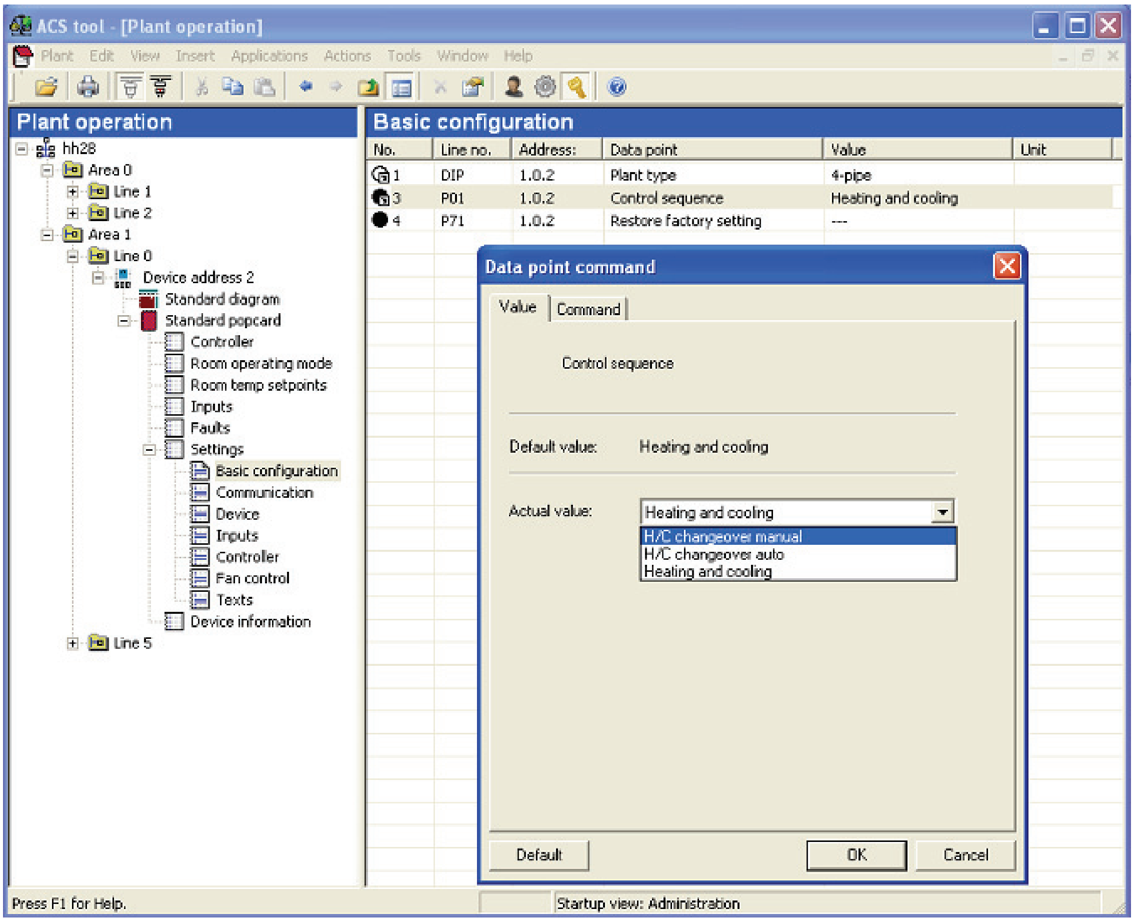
Parameter settings in ACS

ACS supports parameter settings even during normal operation.

To change a control parameter, select **Popcard,** then **Settings**.

Notes:

- Make sure you have logged on with sufficient access right
- Only control parameter can be changed, no application!



| No. | Line no. | Address: | Data point | Value | Unit |
|---|---|---|---|---|---|
| 1 | DIP | 1.0.2 | Plant type | 4-pipe | |
| 3 | P01 | 1.0.2 | Control sequence | Heating and cooling | |
| ● 4 | P71 | 1.0.2 | Restore factory setting | --- | |

Control sequence

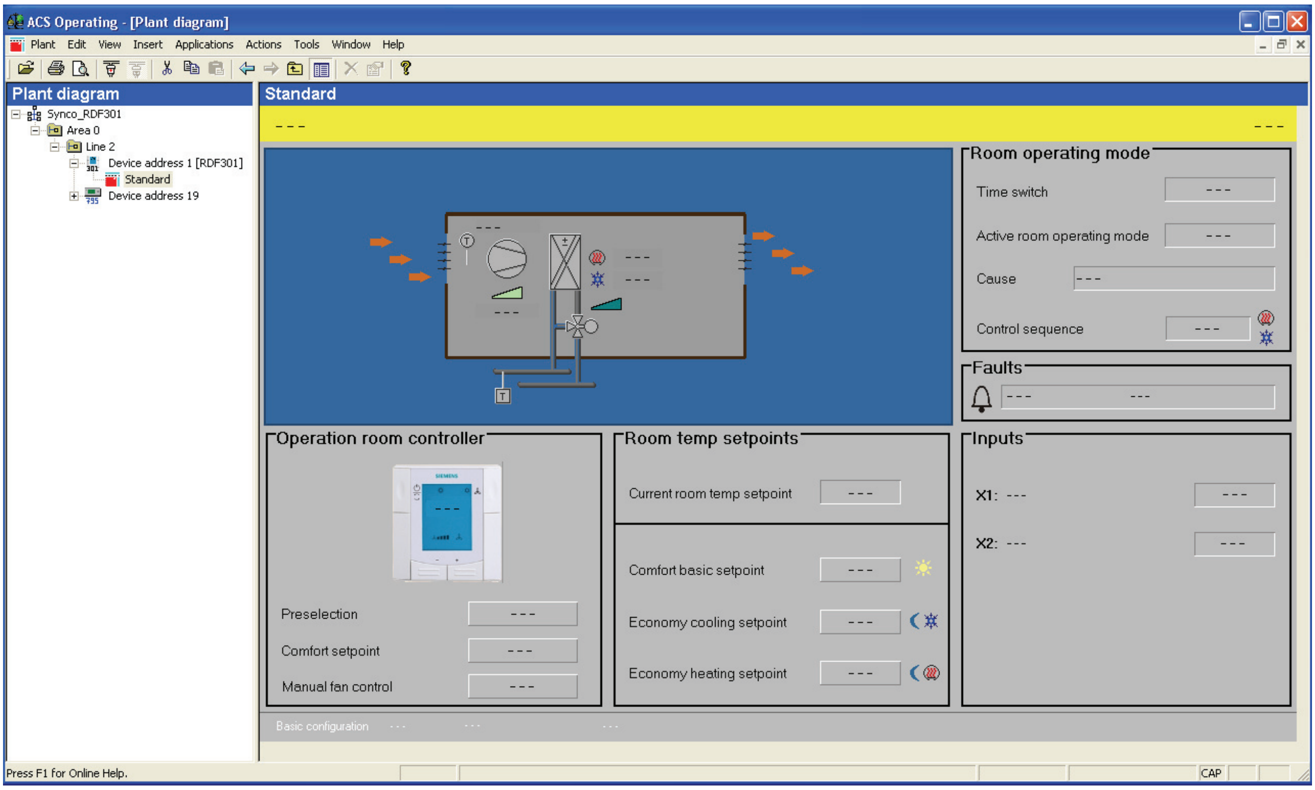
Default value: Heating and cooling

Actual value: Heating and cooling

H/C changeover manual
H/C changeover auto
Heating and cooling

Plant diagram in ACS

**ACS** offers plant diagrams for easy monitoring and operation of the thermostat. To start this application, select **Applications,** then **Pant diagram**



Time switch ---

Active room operating mode ---

Cause ---

Control sequence ---

Faults --- ---

Preselection ---

Comfort setpoint ---

Manual fan control ---

Current room temp setpoint ---

Comfort basic setpoint ---

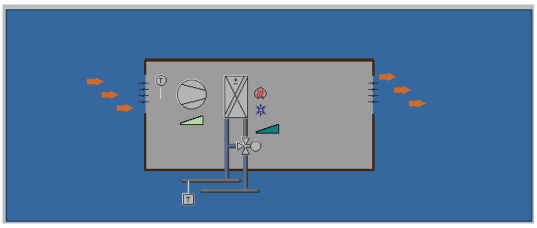
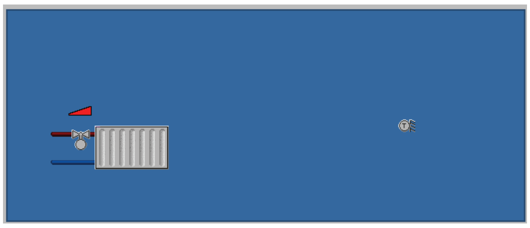
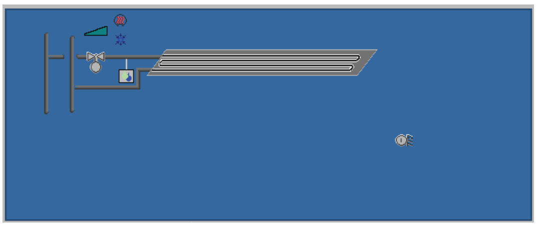
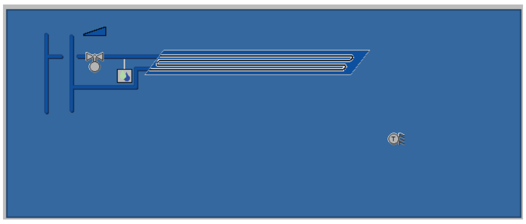
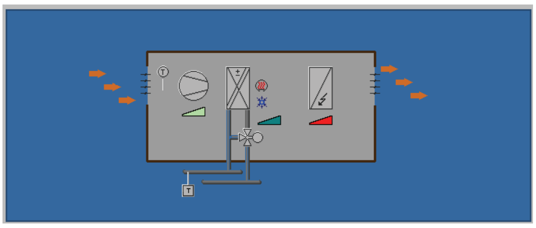
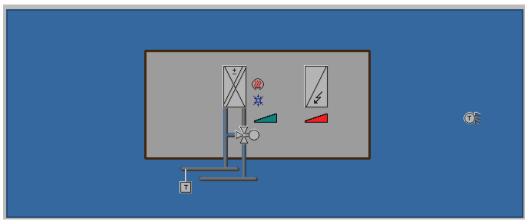
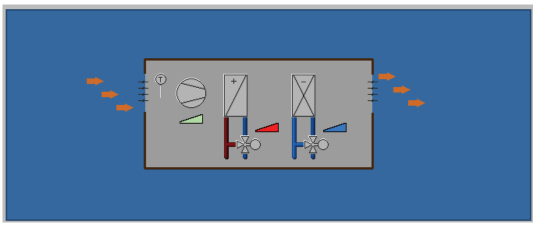
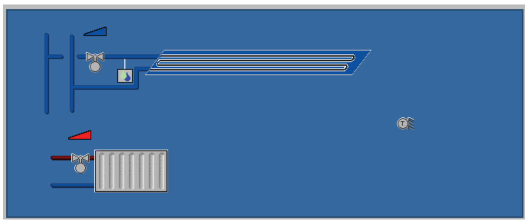
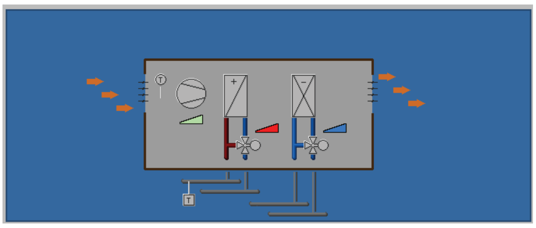
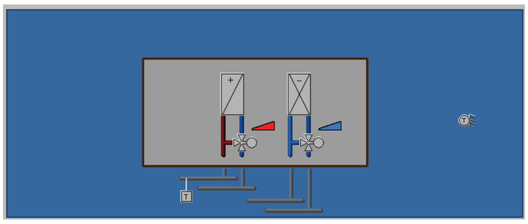
Economy cooling setpoint ---

Economy heating setpoint ---

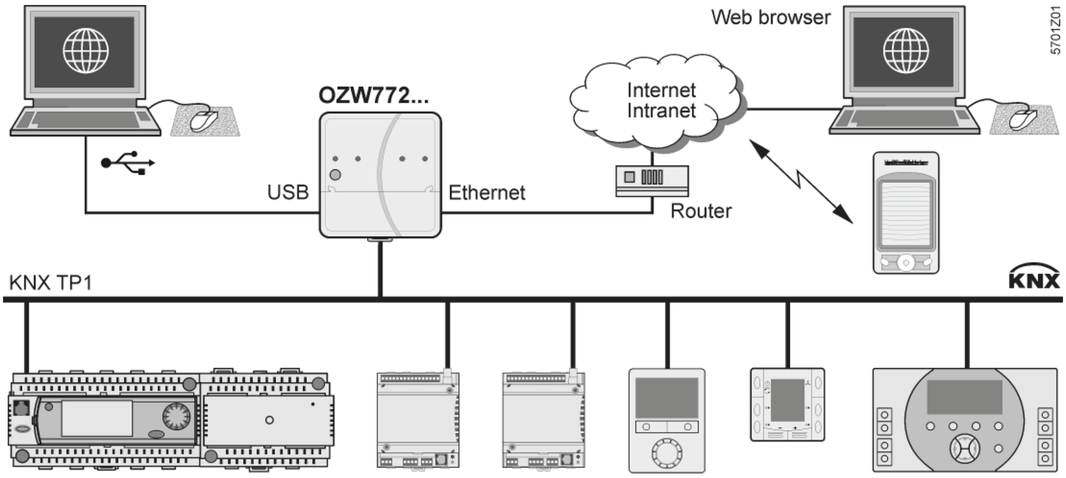
X1: --- ---

X2: --- ---

ACS provides standard plant diagrams for RDF KNX thermostats, which depend on the configuration as follows:

| **Plant type** | **Application**<br>*Configuration* | **Application**<br>*Configuration* |
|---|---|---|
| 2-pipe | **2-pipe fan coil unit**<br>*– Control sequence: No impact (P01 = any)*<br>*– Fan operation: Not disabled (P52 <> 0)*<br> | **Radiator**<br>*– Control sequence: Heating only (P01 = 0)*<br>*– Fan operation: Disabled (P52 = 0)*<br> |
| | **Chilled / heated ceiling**<br>*– Control sequence: Changeover (P01 = 2,3)*<br>*– Fan operation: Disabled (P52 = 0)*<br> | **Chilled ceiling**<br>*– Control sequence: Cooling only (P01 = 1)*<br>*– Fan operation: Disabled (P52 = 0)*<br> |
| 2-pipe and electric heater | **2-pipe fan coil unit with electric heater**<br>*– Control sequence: No impact (P01 = any)*<br>*– Fan operation: Not disabled (P52 <> 0)*<br> | **Single stage with electric heater**<br>*– Control sequence: No impact (P01 =any)*<br>*– Fan operation: Disabled (P52 = 0)*<br> |
| 4-pipe | **4-pipe fan coil unit**<br>*– Control sequence: Not auto c/o (P01 <> 3)*<br>*– Fan operation: Not disabled (P52 <> 0)*<br> | **Chilled ceiling with radiator**<br>*– Control sequence: No impact (P01 =any)*<br>*– Fan operation: Disabled (P52 = 0)*<br> |
| | **Fan coil unit main / secondary**<br>*– Control sequence: Auto c/o (P01 = 3)*<br>*– Fan operation: Not disabled (P52 <> 0)*<br> | **Main / secondary**<br>*– Control sequence: Auto c/o (P01 = 3)*<br>*– Fan operation: Disabled (P52 = 0)*<br> |

### 5.2.3 Operation and monitoring with OZW772



**HomeControl app for plant control**

The OZW772 web server enables users to operate a Synco HVAC system from a remote location – via PC, or from a smart phone – using the HomeControl app. A start page shows the most important data points. A combination of menu / path navigation enables users to access all data points quickly and straightforwardly. The entire installation can be visualized in the form of plant diagrams. Alarm and state messages can be forwarded to different message receivers, such as e-mail, SMS, etc.

For details, see Commissioning Instructions CE1C5701.

### 5.2.4 Operation and monitoring with RMZ972

The RMZ792 is a communicating operator unit designed for operating Synco™ 700 and RDF KNX devices in a KNX network.
The operator unit is suited both for fixed installation and mobile use (e.g. for use by the service engineer).
Third-party devices cannot be operated with it.

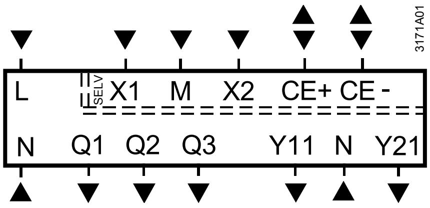
For details, see Basic Documentation CE1P3113.

Note: The application cannot be displayed in the form of text, instead a number is used: (Parameter **Plant type** on menu **Basic setting)**:

0 = no application
1 = 2-pipe
2 = 2-pipe and electric heater
4 = 4-pipe

# 6. Connection

## 6.1 Connection terminals

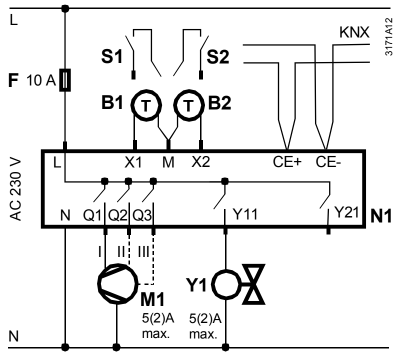


| | |
|---|---|
| L, N | Operating voltage AC 230 V |
| Q1 | Control output “Fan speed 1 AC 230 V” |
| Q2 | Control output “Fan speed 2 AC 230 V” |
| Q3 | Control output “Fan speed 3 AC 230 V” |
| Y11,Y21 | Control output “Valve” AC 230 V (NO, for normally closed valves), output for compressor or output for electric heater |
| X1, X2 | Multifunctional inputs for temperature sensor (e.g. QAH11.1) or potential-free switch<br>Factory setting:<br>– X1 = Operating mode switchover contact<br>– X2 = External sensor<br>(function can be selected via parameters P38 / P40). |
| M | Measuring neutral for sensor and switch |
| CE+ | KNX data + |
| CE- | KNX data - |

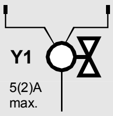
## 6.2 Connection diagrams

**Application**

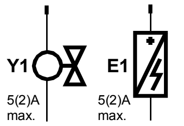
2-pipe, 2-position



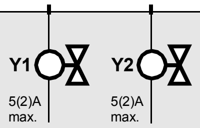
2-pipe, 3-position
– Y11 = Up
– Y21 = Down



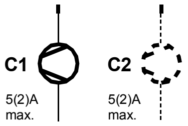
2-pipe and electric heater



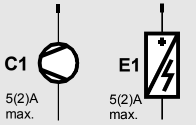
4-pipe
– Y1 = Heating
– Y2 = Cooling



1-stage compressor
– C1 = Heating
and / or
– C2 = Cooling)



1-stage compressor and electric heater



| | |
|---|---|
| N1 | Room thermostat<br>RDF301... , RDF600KN |
| M1 | 1- or 3-speed fan |
| Y1 | Valve actuator, 2- or 3-position |
| Y1, Y2 | Valve actuator, 2-position |
| E1 | Electric heater |
| C1, C2 | 1-stage compressor |
| F | External fuse |
| S1, S2 | Switch (keycard, window contact, presence detector, etc.) |
| B1, B2 | Temperature sensor (return air temperature, external room temperature, changeover sensor, etc.) |
| CE+ | KNX data + |
| CE- | KNX data – |

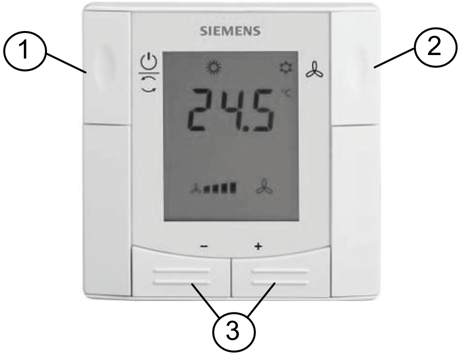
# 7. Mechanical design

## 7.1 General

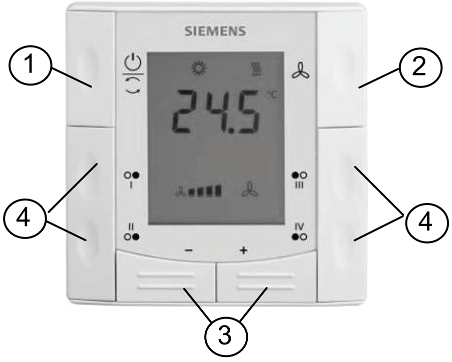
The thermostats consist of 2 parts:

- Front panel with electronics, operating elements and built-in room temperature sensor
- Mounting base with power electronics

The rear of the mounting base carries the screw terminals.
Slide the front panel in the mounting base and snap on.



RDF301, RDF600KN



RDF301.50

1 Operating mode selector

2 Button for fan operation

3 Buttons to adjust setpoints and control parameters

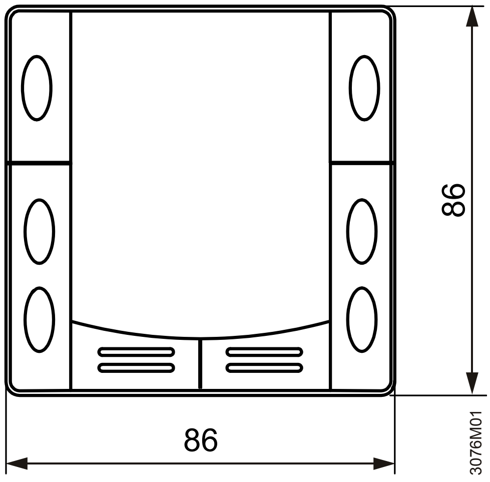
4 Four buttons to control KNX actuators via KNX S-mode
(functions: switching, dimming, blind control, 8-bit scene)

For operation, refer to section 4.3.

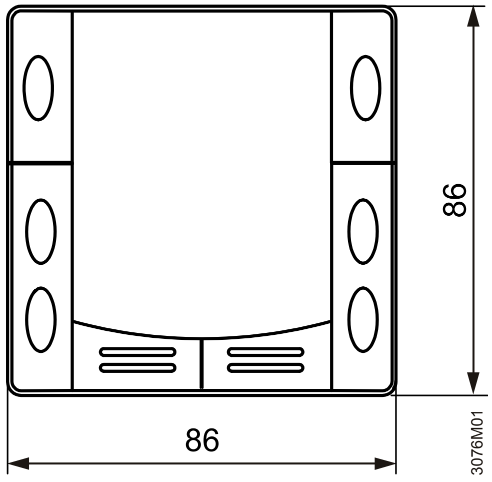
## 7.2 Dimensions

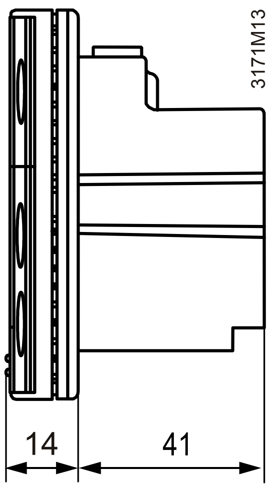
Dimensions in mm

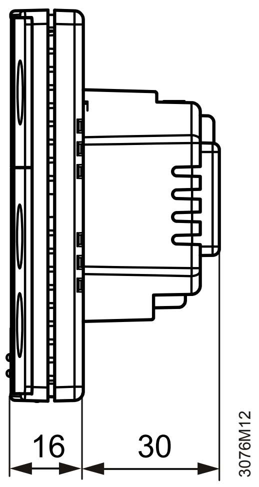
RDF301...

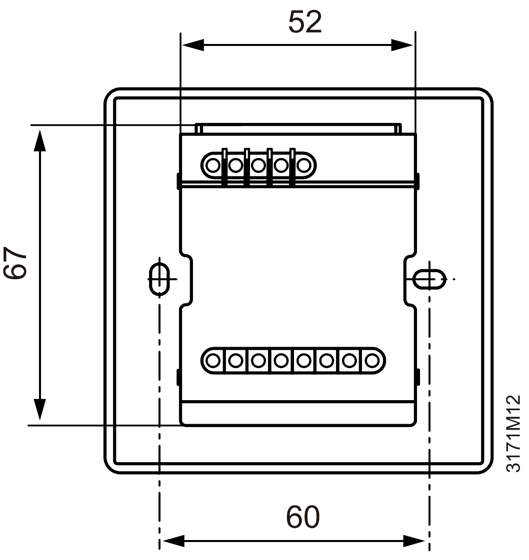


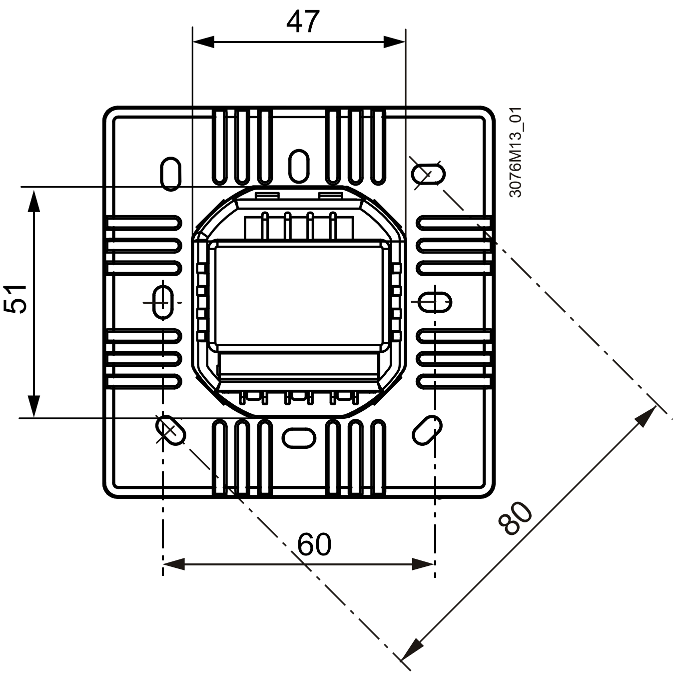
RDF600KN











# 8. Technical data

| | | | |
|---|---|---|---|
| ⚠ Power supply | Rated voltage | | AC 230 V |
| | Frequency | | 50/60 Hz |
| | Power consumption | | |
| | RDF301... | | Max. 4 VA / 3.0 W |
| | RDF600KN | | Max 1.2 VA / 3.5 W |
| Outputs | Fan control Q1, Q2, Q3-N | | AC 230 V |
| | Rating | | Min. 5 mA, Max. 5(2) A |
| | Control output Y11-N / Y21-N (NO) | | AC 230 V |
| | Rating | | Min. 5 mA, Max. 5(2) A |
| | Max. total load current through terminal “L” (Qx+Yxx) | | Max. 7A |
| Inputs | Multifunctional input X1-M/X2-M | | |
| | Temperature sensor input: | | |
| | Type | | QAH11.1 (NTC) |
| | Temperature range | | 0...49 °C |
| | Cable length | | Max. 80 m |
| | Digital input: | | |
| | Operating action | | Selectable (NO/NC) |
| | Contact sensing | | SELV DC 0...5 V/max. 5 mA |
| | Parallel connection of several thermostats for one switch | | Max. 20 thermostats per switch |
| | Insulation against mains voltage (SELV) | | 4 kV, reinforced insulation |
| | Function of inputs: | | Selectable |
| | External temperature sensor, heating / cooling changeover sensor, operating mode switchover contact, dew point monitor contact, enable electric heater contact, fault contact, monitoring input | | X1: P38<br>X2: P40 |
| KNX bus | Interface type | | KNX, TP1-64 (electrically isolated) |
| | Bus current RDF301... | | 20 mA |
| | RDF600KN | | 5 mA |
| | Bus topology: See KNX Manual (see 1.2 “Reference documents”) | | |
| Operational data | Switching differential (adjustable) | | |
| | Heating mode | (P30) | 2 K (0.5...6 K) |
| | Cooling mode | (P31) | 1 K (0.5...6 K) |
| | Setpoint setting and range | | |
| | ☼ Comfort | (P08) | 21°C (5...40 °C) |
| | ☾ Economy | (P11-P12) | 15°C/30 °C (OFF, 5...40 °C) |
| | ⏻ Protection | (P65-P66) | 8°C/OFF (OFF, 5...40 °C) |
| | Multifunctional input X1/X2 | | Selectable 0...8 |
| | Input X1 default value | (P38) | 3 (operating mode switchover) |
| | Input X2 default value | (P40) | 1 (external temperature sensor) |
| | Built-in room temperature sensor | | |
| | Measuring range | | 0…49 °C |
| | Accuracy at 25 °C | | < ± 0.5 K |
| | Temperature calibration range | | ± 3.0 K |
| | Settings and display resolution | | |
| | Setpoints | | 0.5 °C |
| | Current temperature value displayed | | 0.5 °C |

| | | | |
|---|---|---|---|
| Environmental conditions | Operation | | IEC 721-3-3 |
| | Climatic conditions | | Class 3K5 |
| | Temperature | | 0...50 °C |
| | Humidity | | <95% r.h. |
| | Transport | | IEC 721-3-2 |
| | Climatic conditions | | Class 2K3 |
| | Temperature | | -25...60 °C |
| | Humidity | | <95% r.h. |
| | Mechanical conditions | | Class 2M2 |
| | Storage | | IEC 721-3-1 |
| | Climatic conditions | | Class 1K3 |
| | Temperature | | -25...60 °C |
| | Humidity | | <95% r.h. |
| Standards and directives | CE conformity | | |
| | EMC directive | | 2004/108/EC |
| | Low-voltage directive | | 2006/95/EC |
| | C-tick conformity to EMC emission standard | | AS/NZS 61000.6.3: 2007 |
| | RoHS ☑ 2002/95/EC Reduction of hazardous substances | | 2002/95/EC |
| | Product standards | | |
| | Automatic electric controls for household and similar use | | EN 60730–1 |
| | Special requirements for temperature-dependent controls | | EN 60730–2-9 |
| | Electronic control type | | 2.B (micro-disconnection on operation) |
| | Home and Building Electronic Systems | | EN 50090-2-2 |
| | Electromagnetic compatibility | | |
| | Emissions | | IEC/EN 61000-6-3 |
| | Immunity | | IEC/EN 61000-6-2 |
| | Safety class | | II as per EN 60730 |
| | Pollution class | | Normal |
| | Degree of protection of housing | | IP30 as per EN 60529 |
| General | Connection terminals | | Solid wires or prepared stranded wires<br>1 x 0.4…1.5 mm2 |
| | Housing front color | | RAL 9003 white |
| | Weight without / with packaging | RDF301... | 0.240 kg / 0.320 kg |
| | | RDF600KN | 0.150 kg / 0.220 kg |

# Index

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Fax +41 41-724 35 22
www.buildingtechnologies.siemens.com

# CERTIFICADO DE EFICIENCIA ENERGÉTICA DE EDIFICIOS EXISTENTES

## IDENTIFICACIÓN DEL EDIFICIO O DE LA PARTE QUE SE CERTIFICA:

| | | | |
|---|---|---|---|
| **Nombre del edificio** | Leon van Gelder School | | |
| **Dirección** | Diamantlaan 27 | | |
| **Municipio** | Burgos | **Código Postal** | 9743 BA GRONINGA |
| **Provincia** | Burgos | **Comunidad Autónoma** | Castilla y León |
| **Zona climática** | E1 | **Año construcción** | 2007 |
| **Normativa vigente (construcción / rehabilitación)** | C.T.E. | | |
| **Referencia/s catastral/es** | .. | | |

**Tipo de edificio o parte del edificio que se certifica:**

- ○ Vivienda
    - ○ Unifamiliar
    - ○ Bloque
        - ○ Bloque completo
        - ○ Vivienda individual

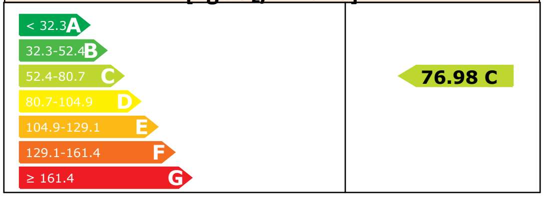
- ● Terciario
    - ● Edificio completo
    - ○ Local

## DATOS DEL TÉCNICO CERTIFICADOR:

| | | | |
|---|---|---|---|
| **Nombre y Apellidos** | MªAmparo Martínez Comes | **NIF** | 53608517 W |
| **Razón social** | Graduate thesis | **CIF** | - |
| **Domicilio** | .. | | |
| **Municipio** | .. | **Código Postal** | .. |
| **Provincia** | Valencia | **Comunidad Autónoma** | Comunidad Valenciana |
| **e-mail** | m.amparo.mc@gmail.com | | |
| **Titulación habilitante según normativa vigente** | Ingeniero de Edificación | | |
| **Procedimiento reconocido de calificación energética utilizado y versión:** | CE³X v1.1 | | |

## CALIFICACIÓN ENERGÉTICA OBTENIDA:

**CALIFICACIÓN ENERGÉTICA GLOBAL**
**EMISIONES DE DIÓXIDO DE CARBONO**
**[$kgCO_2/m^2$ año]**



El técnico certificador abajo firmante certifica que ha realizado la calificación energética del edificio o de la parte que se certifica de acuerdo con el procedimiento establecido por la normativa vigente y que son ciertos los datos que figuran en el presente documento, y sus anexos:

Fecha: 20/8/2014

Firma del técnico certificador

***Anexo I.*** *Descripción de las características energéticas del edificio.*
***Anexo II.*** *Calificación energética del edificio.*
***Anexo III.*** *Recomendaciones para la mejora de la eficiencia energética.*
***Anexo IV.*** *Pruebas, comprobaciones e inspecciones realizadas por el técnico certificador.*

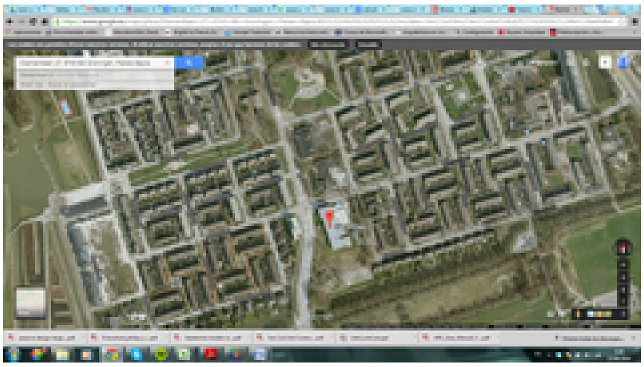
Registro del Órgano Territorial Competente:

# ANEXO I
# DESCRIPCIÓN DE LAS CARACTERÍSTICAS ENERGÉTICAS DEL EDIFICIO

En este apartado se describen las características energéticas del edificio, envolvente térmica, instalaciones, condiciones de funcionamiento y ocupación y demás datos utilizados para obtener la calificación energética del edificio.

## 1. SUPERFICIE, IMAGEN Y SITUACIÓN

| | |
|---|---|
| **Superficie habitable [$m^2$]** | 5300 |

| Imagen del edificio | Plano de situación |
|---|---|
|  |  |

## 2. ENVOLVENTE TÉRMICA

### Cerramientos opacos

| Nombre | Tipo | Superficie [$m^2$] | Transmitancia [$W/m^2\cdot K$] | Modo de obtención |
|---|---|---|---|---|
| Cubierta Panel Sandwich | Cubierta | 1681.17 | 0.23 | Estimado |
| Fachada Este | Fachada | 724.7 | 0.14 | Conocido |
| Fachada acristalada Este | Fachada | 208.4 | 0.19 | Conocido |
| Fachada sandwich oeste | Fachada | 607.54 | 0.14 | Conocido |
| Fachada acristalada oeste | Fachada | 128.7 | 0.19 | Conocido |
| Fachada acristalada sur | Fachada | 347.8 | 0.19 | Conocido |
| Fachada acristalada norte | Fachada | 304.15 | 0.19 | Conocido |
| Suelo con terreno | Suelo | 1681.17 | 0.48 | Por defecto |

### Huecos y lucernarios

| Nombre | Tipo | Superficie [$m^2$] | Transmitancia [$W/m^2\cdot K$] | Factor solar | Modo de obtención. Transmitancia | Modo de obtención. Factor solar |
|---|---|---|---|---|---|---|
| lucernario 1 | Lucernario | 5.75 | 3.30 | 0.75 | Estimado | Estimado |
| lucernario 2 | Lucernario | 3.9 | 3.30 | 0.75 | Estimado | Estimado |
| Hueco | Hueco | 27 | 1.82 | 0.53 | Estimado | Estimado |
| Hueco 2 | Hueco | 58.82 | 1.82 | 0.53 | Estimado | Estimado |
| Hueco 3 | Hueco | 121.25 | 1.82 | 0.53 | Estimado | Estimado |
| Hueco 1 | Hueco | 53.15 | 1.82 | 0.53 | Estimado | Estimado |
| Hueco acristalado | Hueco | 280 | 1.82 | 0.53 | Estimado | Estimado |
| Hueco fn | Hueco | 280 | 1.82 | 0.53 | Estimado | Estimado |
| Hueco fo | Hueco | 75 | 1.82 | 0.53 | Estimado | Estimado |

## 3. INSTALACIONES TÉRMICAS

### Generadores de calefacción

| Nombre | Tipo | Potencia nominal [kW] | Rendimiento [%] | Tipo de Energía | Modo de obtención |
|---|---|---|---|---|---|
| Calefacción y refrigeración | Bomba de Calor - Caudal Ref. Variable | | 124.20 | Electricidad | Estimado |

### Generadores de refrigeración

| Nombre | Tipo | Potencia nominal [kW] | Rendimiento [%] | Tipo de Energía | Modo de obtención |
|---|---|---|---|---|---|
| Sólo refrigeración | Máquina frigorífica - Caudal Ref. Variable | | 164.50 | Electricidad | Estimado |
| Calefacción y refrigeración | Bomba de Calor - Caudal Ref. Variable | | 198.00 | Electricidad | Estimado |

### Instalaciones de Agua Caliente Sanitaria

| Nombre | Tipo | Potencia nominal [kW] | Rendimiento [%] | Tipo de Energía | Modo de obtención |
|---|---|---|---|---|---|
| Equipo ACS | Caldera Estándar | | 95.0 | Electricidad | Estimado |

## 4. INSTALACIÓN DE ILUMINACIÓN (sólo edificios terciarios)

| Espacio | Potencia instalada [W/m²] | VEEI [W/m²·100lux] | Iluminación media [lux] | Modo de obtención |
|---|---|---|---|---|
| Edificio Objeto | 10.42 | 2.08 | 500.00 | Estimado |
| Edificio Objeto | 27.78 | 5.56 | 500.00 | Estimado |

## 5. CONDICIONES DE FUNCIONAMIENTO Y OCUPACIÓN (sólo edificios terciarios)

| Espacio | Superficie [m²] | Perfil de uso |
|---|---|---|
| Edificio | 5300 | Intensidad Media - 8h |

# ANEXO II
# CALIFICACIÓN ENERGÉTICA DEL EDIFICIO

| | | | |
|---|---|---|---|
| **Zona climática** | E1 | **Uso** | Intensidad Media - 8h |

## 1. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO

| | | | | | |
|---|---|---|---|---|---|
| **INDICADOR GLOBAL** | | **INDICADORES PARCIALES** | | | |
| < 32.3 A<br>32.3-52.4 B<br>52.4-80.7 C<br>80.7-104.9 D<br>104.9-129.1 E<br>129.1-161.4 F<br>≥ 161.4 G | **76.98 C** | **CALEFACCIÓN** | | **ACS** | |
| | | | C | | E |
| | | *Emisiones calefacción [kgCO$_2$/m$^2$ año]* | | *Emisiones ACS [kgCO$_2$/m$^2$ año]* | |
| | | 11.34 | | 0.02 | |
| | | **REFRIGERACIÓN** | | **ILUMINACIÓN** | |
| | | | E | | C |
| *Emisiones globales [kgCO$_2$/m$^2$ año]* | | *Emisiones refrigeración [kgCO$_2$/m$^2$ año]* | | *Emisiones iluminación [kgCO$_2$/m$^2$ año]* | |
| 76.98 | | 3.55 | | 62.1 | |

La calificación global del edificio se expresa en términos de dióxido de carbono liberado a la atmósfera como consecuencia del consumo energético del mismo.

## 2. CALIFICACIÓN PARCIAL DE LA DEMANDA ENERGÉTICA DE CALEFACCIÓN Y REFRIGERACIÓN

La demanda energética de calefacción y refrigeración es la energía necesaria para mantener las condiciones internas de confort del edificio.

| | | | |
|---|---|---|---|
| **DEMANDA DE CALEFACCIÓN** | | **DEMANDA DE REFRIGERACIÓN** | |
| < 10.2 A<br>10.2-18.7 B<br>18.7-30.6 C<br>30.6-40.8 D<br>40.8-51.1 E<br>51.1-64.7 F<br>≥ 64.7 G | **21.71 C** | < 1.8 A<br>1.8-3.5 B<br>3.5-5.9 C<br>5.9-8.0 D<br>8.0-10.1 E<br>10.1-12.8 F<br>≥ 12.8 G | **9.83 E** |
| ***Demanda global de calefacción [kWh/m$^2$ año]*** | | ***Demanda global de refrigeración [kWh/m$^2$ año]*** | |
| 21.71 | | 9.83 | |

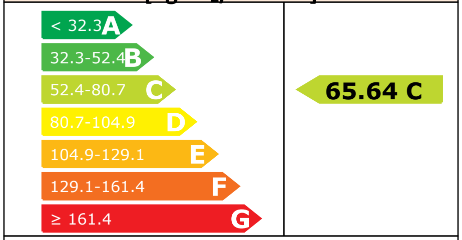
## 3. CALIFICACIÓN PARCIAL DEL CONSUMO DE ENERGÍA PRIMARIA

Por energía primaria se entiende la energía consumida por el edificio procedente de fuentes renovables y no renovables que no ha sufrido ningún proceso de conversión o transformación.

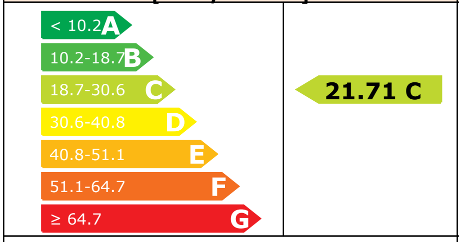
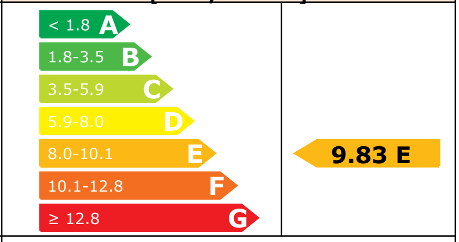
| | | | | | |
|---|---|---|---|---|---|
| **INDICADOR GLOBAL** | | **INDICADORES PARCIALES** | | | |
| < 128.4 A<br>128.4-208.7 B<br>208.7-321.1 C<br>321.1-417.4 D<br>417.4-513.7 E<br>513.7-642.2 F<br>≥ 642.2 G | **309.57 C** | **CALEFACCIÓN** | | **ACS** | |
| | | 0.93 | C | 1.5 | E |
| | | *Energía primaria calefacción [kWh/m$^2$ año]* | | *Energía primaria ACS [kWh/m$^2$ año]* | |
| | | 45.61 | | 0.06 | |
| | | **REFRIGERACIÓN** | | **ILUMINACIÓN** | |
| | | 1.35 | E | 0.95 | C |
| *Consumo global de energía primaria [kWh/m$^2$ año]* | | *Energía primaria refrigeración [kWh/m$^2$ año]* | | *Energía primaria iluminación [kWh/m$^2$ año]* | |
| 309.57 | | 14.28 | | 249.62 | |

# ANEXO III
# RECOMENDACIONES PARA LA MEJORA DE LA EFICIENCIA ENERGÉTICA

**EMISIONES DE DIÓXIDO DE CARBONO [$kgCO_2/m^2$ año]**



| *Emisiones globales [$kgCO_2/m^2$ año]* |
|---|
| 65.64 |

| **DEMANDA DE CALEFACCIÓN [kWh/m² año]** | **DEMANDA DE REFRIGERACIÓN [kWh/m² año]** |
|---|---|
|  |  |
| *Demanda global de calefacción [kWh/m² año]* | *Demanda global de refrigeración [kWh/m² año]* |
| *21.71* | *9.83* |

**ANÁLISIS TÉCNICO**

| **Indicador** | **Calefacción** | | **Refrigeración** | | **ACS** | | **Iluminación** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Demanda [kWh/m² año] | 21.71 | C | 9.83 | E | | | | | | |
| Diferencia con situación inicial | 0.0 (0.0%) | | 0.0 (0.0%) | | | | | | | |
| Energía primaria [kWh/m² año] | 27.13 | B | 14.28 | E | 0.06 | E | 249.62 | C | 291.09 | C |
| Diferencia con situación inicial | 18.5 (40.5%) | | 0.0 (0.0%) | | 0.0 (0.0%) | | 0.0 (0.0%) | | 18.5 (6.0%) | |
| Emisiones de $CO_2$ [$kgCO_2/m^2$ año] | 0.00 | A | 3.55 | E | 0.02 | E | 62.07 | C | 65.64 | C |
| Diferencia con situación inicial | 11.3 (100.0%) | | 0.0 (0.0%) | | -0.0 (-23.9%) | | 0.0 (0.0%) | | 11.3 (14.7%) | |

Nota: Los indicadores energéticos anteriores están calculados en base a coeficientes estándar de operación y funcionamiento del edificio, por lo que solo son válidos a efectos de su calificación energética. Para el análisis económico de las medidas de ahorro y eficiencia energética, el técnico certificador deberá utilizar las condiciones reales y datos históricos de consumo del edificio.

**DESCRIPCIÓN DE MEDIDA DE MEJORA**

**Conjunto de medidas de mejora: heating**

Listado de medidas de mejora que forman parte del conjunto:

- Mejora de las instalaciones

# ANEXO IV
# PRUEBAS, COMPROBACIONES E INSPECCIONES REALIZADAS POR EL TÉCNICO CERTIFICADOR

Se describen a continuación las pruebas, comprobaciones e inspecciones llevadas a cabo por el técnico certificador durante el proceso de toma de datos y de calificación de la eficiencia energética del edificio, con la finalidad de establecer la conformidad de la información de partida contenida en el certificado de eficiencia energética.

COMENTARIOS DEL TÉCNICO CERTIFICADOR

Inspecciones en el sistema de calefacción del edificio, donde se compueba que la calefacción esta intalada por el techo, con lo cual no funciona como toca.
Se han realizado pruebas termicas de las fachadas
Se han realizado comprobaciones y calculos de la temperatura de cada local en el edificio, al igual que la humedad relativa y ventilación.

DOCUMENTACION ADJUNTA

La documentación está perteneciente esta situada en los anexos del documento de investigación

All the documents that explain the certificate are in the attachments of the Literature Research, in the report for the energy efficient building.

# Energy Performance Certificate in Existing Buildings.

## Leon van Gelder School

At the report of energy performance certification in buildings we can see that the calculations carried out to know the emissions of carbon dioxide emitted by the building. This certificate is made by CE3X program, as we can see the certificate is entirely in Spanish, because the program could not change the language, but here I will explain and gives the certificate results.

Firstly, I put all the building data needed, and as the program only could put data location and climate zone of Spain, I looked for a similar climate zone, even though we are talking about Spain, the city of Burgos, which is selected has some similar characteristics.

These climatic conditions are variables that are determined by calculating the temperature, humidity, light, sunshine, wind speed, etc.

Besides the location of the building keep in mind the orientation of this, the year of construction, construction features, surfaces and headroom, space, facilities

With this we can determine the condition of the building for heating purposes, cooling, degrees of temperature, radiation, ventilation, etc.

For the certification, we calculate the thermal envelope of the building, firstly with the transmittance and thermal resistance of all opaque building envelopes is calculated. We measure the surface of these enclosures and the transmittance by the materials making up the enclosure. Removing the windows, doors and skylights calculated in the same way as we said above. For the calculation of the holes, has kept in mind that the windows are double glazed with air chamber there between that with low emission characteristics. In addition I calculated the factor affecting the framework of these windows and the thermal bridge that can produce.

Later were calculated the efficiency and the influence of the facilities in the building. The heating of the building is currently calculated as the building and adding the current problems that we have analyzed in the research. The calculations are estimates, as we could not get enough information. Regarding the building cooling is calculated for use with heat pump, but as there are other systems in the building for cooling during the summer have been installed, these have been considered.

It has also keeping in mind the estimated building lighting by estimate way, the power used that the average lighting.

As seen in the certification has been reached reality the rate C, with 76,98kgCO2 / m2 per year.

Heating system demand is 21,71kW/m2

Cooling demand is 9,83kw/m2

Heating system emission 11,34 83kwCO2/m2

Cooling Emission 3,55 kwCO2/m2

Heat water emission 0,02 kwCO2/m2

Lighting emission 62,07 kwCO2/m2

**Calificación energética de edificios**

**Indicador kgCO2/m2**

**Edificio objeto**

| | | |
|---|---|---|
| Demanda de calefacción (kWh/m2) | 21.71 | C |
| Demanda de refrigeración (kWh/m2) | 9.83 | E |
| Emisiones de calefacción (kg CO2/m2) | 11.34 | C |
| Emisiones de refrigeración (kg CO2/m2) | 3.55 | E |
| Emisiones de ACS (kg CO2/m2) | 0.02 | E |
| Emisiones de iluminación (kg CO2/m2) | 62.07 | C |

At the end of the Energy certificate there are com improvements in the heating system for improve the energy performance of it, but it is not specific, because for have a good improvements in that we should do a specific research for it. And this is not the objective of our research. For improve the energy performance of this building it should reach at least the A level, as the goal it was built.