West Pomeranian Technical University of Szczecin
Faculty of Civil Engineering and Architecture
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Overhaul design and energy study of the library of the Faculty of Civil Engineering and Architecture building

BACHELOR THESIS

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Indications

Table 0.1. Symbols and Units.

Symbol	Quantity	Unit
A	area	m^2
c	specific heat capacity	J/(kg·K)
d	layer thickness	m
g	total solar energy transmittance of a building element	1
H	heat transfer coefficient	W/K
h	surface coefficient of heat transfer	$W/(m^2 \cdot K)$
I_{sol}	solar irradiance	W/m^2
L	length	M
N	number	1
q_v	(volumetric) airflow rate	m^3/s
R	thermal resistance	$m^2 \cdot K/W$
U	thermal transmittance	$W/(m^2 \cdot K)$
V	volume of air in a conditioned zone	m^3
Z	heat transfer parameter for solar walls	$W/(m^2 \cdot K)$
η	efficiency, utilization factor	1
θ	centigrade temperature	ºC
ρ	density	kg/m^3
τ	time constant	h
χ	point thermal transmittance	W/K
Ψ	linear thermal transmittance	W/(m·K)

1. INTRODUCTION

This project aims to improve energy efficiency and an overhaul design of a library in a building of the Faculty of Civil Engineering and Architecture of the West Pomeranian Technical University of Szczecin.
The building is located southwest of the city of Szczecin in Piastów Avenue 50.

First of all, there is a brief definition of some aspects that appears throughout the project of overhaul design and energy study of the library of the Faculty of Civil Engineering and Architecture building:

- a building is a completely enclosed construction made by man to people, animals, things or activities,
- there is a direct correlation between economic fluctuations (prosperity) and access to electricity (energy),
- sources of energy whose primary resources are only available for a finite period, cause severe environmental damage and leave residues,
- buildings are responsible for half of energy consumption and CO_2 emissions in the European Union.

The project was prepared by three persons:

Javier Cano Catalá (J.C.C.)
Mª Ángeles Ortega Martínez (M.A.O.M.)
Ricardo Frías Palenzuela (R.F.P.)

And is divided into parts that include:

- background (done by R.F.P.),
- main information about the West Pomeranian Technical University of Szczecin (done by R.F.P),
- description of the Civil Engineering and Architecture Faculty building (done by R.F.P),
- description of faculty's library (done by R.F.P.),

- estimation of current conditions of the library (done by J.C.C. and M.A.O.M.),
- taking data (done by M.A.O.M.),
- design proposals for the overhaul (done by J.C.C and R.F.P.),
- results, discussion and conclusion (done by done by J.C.C., M.A.O.M. and R.F.P.).

To calculate the energy performance of the library we go to use the monthly method in according to the European standard EN ISO 13790 [10].

This method includes the calculation of:

- the heat transfer by transmission and ventilation of the building zone,
- the contribution of internal and solar heat gain to the building heat balance,
- the annual energy needs for heating.

The building energy needs for heating of the building are calculated on the basis of the heat balance of the building.

These energy needs for heating are the input for the energy balance of the heating system and ventilation system.

There are two basic methods of thermal balance calculation:

- quasi-steady-state method, calculating the heat balance over a sufficiently long time (typically one month or a whole season), which enables one to take dynamic effects into account by an empirically determined gain and/or loss utilization factor,
- dynamic method, calculating the heat balance with short times steps (typically one hour) taking into account the heat stored in, and released from, the mass of the building,

In project of overhaul design an energy study of the library we go to use the monthly method, because even we want to know the energy that we need in all the year, we can repeat this method for all months and finally know the total energy.

About the proposal of design, we can say that we keep all the rooms of the library, giving a new use two of them and transforming them into a computer room and a room for group work. The tables and bookshelves of the main room we distribute differently to maximize space as much as possible.

With this project we try to improve the energy efficiency of the library, in order to reduce their energy consumption and therefore reduce the economic cost and pollutant emissions. So we propose the reform in which we will replace some elements of the current window by others made with materials more efficient energetic.

In order to check the validity of our proposal, as well as to quantify the benefits of the same, we will calculate the current energy costs and necessary if you undertake reform, using a calculation method called monthly method, extracted from the European standard EN ISO 13790 [10].

After making the calculations, we will carry out an assessment of the appropriateness of such reform, in view of the results that we obtain.

We have applied sustainable development through the use of low thermal conductivity materials to improve the energy efficiency of our library.

2. BACKGROUND

2.1. WHAT IS A BUILDING?

A building is a construction made by man. This is completely enclosed by an outer casing formed by the walls, ceiling and floor, creating a microclimate inside.

The buildings have a lot of forms and functions and have had to adapt to a number of factors throughout history, from the available building materials, climatic conditions, soil conditions, aesthetic reasons, and so on. Buildings covering some needs of society, especially acting as a shelter to weather conditions and as a place to live, enjoy privacy, keeping belongings and live and work comfortably. A building, understood as a shelter, represents a physical separation of the human habitat inside (a place of comfort and safety) to the outside (a place that can sometimes be harsh and harmful). The first shelter was built in history a relatively close ancestor of human, Homo erectus, and is thought dating back to 500,000 BC. The construction of a building and its use involve eating a lot of energy and has an enormous direct and indirect impact on the environment. Buildings not only use resources like energy and raw materials, but also generate hazardous waste and have associated a number of atmospheric emissions. Because the economy and population continue to rise, architects and builders face a unique challenge to meet the demand for new and renovated facilities that are accessible, safe, healthy and productive as to minimize its impact on the environment.

Recent answers to this challenge required an integrated and synergistic approach that considers all phases of the installation throughout the life cycle. This "sustainable" is based on a greater commitment to the care and conservation of the environment, results in an optimum balance of environmental costs, social, human and yet the benefits of the mission and function of the installation and infrastructure.

The main objectives of sustainable design are:

- avoid depletion of natural energy resources, water and raw materials,
- prevent environmental degradation caused by facilities and infrastructure throughout its life,
- create buildings that are habitable, comfortable, safe and productive.

Buildings are mainly classified according to function and use for which are built either for residential, educational and cultural, commercial, governmental, industrial, health, agricultural, military, parking and warehouse use [32].

2.2. ENERGY AND PROSPERITY

The International Monetary Fund (IMF) research shows that there is a direct correlation between economic fluctuations and access to electricity [1]. The energy consumption per head for selected countries is shown in relation to their gross domestic product (GOP). This clearly shows that as an agricultural economy changes into a consumer society through industrialization, energy consumption increases at the same time. During the process there seems to be a level at which a society "optimises”, that is to say GDP rises and energy consumption remains unchanged. I think however that it has been more a case of shifting energy consumption from one country to another, that is to say a state imports the majority of its goods from another. A classic example for this is the United States: part of its energy consumption is transferred as it were to China.

Two further aspects must be taken into consideration critically regarding the chart: the first being that the nation shown to have the highest energy consumption per head has at the same time used all its energy resources. The second point is that the two most populous countries in the world China and India have the lowest gross domestic product and the lowest energy conpsumption per head. Both of these highly populated countries are currently striving to climb up the ladder. If every Chinese person drives a car then the current known world oil reserves would be exhausted within six months.

Nowadays traffic jams occur in every town in every country. Clogged up main arterial roads, the real motors of economy, which pump development potential through every contemporary society, could drastically restrict our society´s performance-capability. At some stage this clogging, this blockade, will reach a critical point. Energy production for the society of today has got to change. Industry is moving – albeit involuntary – from the paradigm of the centralised Industrial Age towards a model which is divided and decentralised in a substantially more up-to-date way. This change is essential politically. If you look at the energy supply chain two thirds of the energy is lost during conversion and distribution. Electric energy remains a fundamental requirement of today's society. It is the basis of almost every-thing we do today. Historically electricity was produced to further growth in small and large industries which were situated in the vicinity of energy sources. Over time the thirst for energy exceeded the capacity of local sources. For this reason large power stations emerged which were closer to supplies of raw materials than to consumers' infrastructure. Due to the emissions from the power stations these were built at some distance from the cities and the resulting enormous transmission losses were simply accepted as part of the system. However nowadays there are more and more possibilities to decentralise the production of electricity. Instead of one large power station there should be many small ones, spread throughout a region. They would all be inter-connected with each other and would be powered by small wind turbines, fuel cells in buildings, solar cells or small gas turbines. This system-wide approach increases the reliability of supply on the one hand and reduces the vulnerability of the electric power supply on the other hand due to the fact that the producer is far nearer to the consumers and end-users. This method has the added advantage of being able to draw on the great store of renewable energy.

Fig. 2.1. View of a power station in the Soweto district, Johannesburg (ZA)[1].

In the figure 2.1. there is shown the sun rising over a power station in the Soweto district in Johannesburg. As it was built during the apartheid period it originally only provided energy for a small group of the population - excluding all those living directly in that quarter. The power station represented the centralisation of energy and power on many levels. Today, in a politically transformed and democratic South Africa, it produces energy for the whole of population. Moreover the picture shows – perhaps even more significantly – the most important source of energy is the sun. can we imagine the fact that all the energy the sun produces is renewable energy? What will happen when oil politics no longer determines the relationships between nations? Can we imagine no longer talking about shortages because produced renewable energies has become so efficient? Can we believe that every building produces so much energy that it repays the energy needed to build and keep up it?

Population shifts, increasing scarcity and the wanton consumption of fertile land and natural - renewable and non - renewable - resources could turn out to be a significant global problem, a dilemma of disastrous proportions. We can only hope that global awareness of the fragility of our planet will grow. We appear to have reached a critical and sobering point in history. Despite setbacks and mistakes all is not lost.

There is still time left for corrective steps. We as individuals in a "glocalised" society must heed the warning signs and we will thus be able to avoid falling into a downward spiral. How our future looks and in whichever built environment we and future generations experience it depends in many ways on our decisions. Ultimately it will not depend on technology and economics but on what we people decide. In the midst of uncertainty concerning the times which lie ahead of us one thing is sure: we are the ones who will determine the future that we bequeath to our descendants - whether or not we take up the challenge.

2.3. ENERGY CHANGE

The term energy change is being discussed controversially in public more and more often. The term is, however, somewhat ambiguous. Which elements of the energy supply should be changed and in which direction? Is it a question of new sources of energy or only of the sparing and efficient use of the sources of energy currently in use? Is it about more internationally uniform or decentralised energy structures, or about more competition or a more ecological or sustainable energy supply?

Usually, the term energy change is associated with sustainability, but that does not really make the term easier to understand. Meanwhile, even the use of nuclear power and fossil fuel is being labelled sustainable by the providers if those are a bit safer or more efficient than before. However, sources of energy whose primary resources are only available for a finite period - which applies to oil, natural gas, coal and ura-nium ore, and which, from their extraction right through to their conversion and use, cause severe environmental damage and leave residues - cannot justifiably be labelled sustainable. Energy change means energy changeover, that is to say, replacing nuclear and fossil fuel sources with renewable ones [1].

2.4. ENERGY USE IN BUILDINGS

Buildings are responsible for 40% of energy consumption and 36% of CO_2 emissions in the European Union. Improving the energy performance of buildings is therefore critical for achieving the EU's climate and energy objectives a reduction of 20% of greenhouse gases emissions, a share of 20% renewables and 20% energy savings, all to be achieved by 2020 [17].

Moreover, improving the energy performance of buildings is a cost-effective way of fighting against climate change and improving energy security, while also creating job opportunities, particularly in the building sector.

The main legislative instrument at EU-level to reduce the energy consumption of buildings is the Energy Performance of Buildings Directive [7] [17], which lays down a number of requirements that have to be implemented by the Member States. The implementation of the legislation is underpinned by standardization activities, financial programmes and other support initiatives.

2.4.1. Energy objectives

These are the steps to take:

- greenhouse gas emissions 20% (or even 30%, if the conditions are right) lower than 1990,
- 20% of energy from renewables,
- 20% increase in energy efficiency

Features of the targets

These objectives (tab. 2.1) must have the following characteristics [17]:

- they give an overall view of where the EU should be on key parameters by 2020,
- they are translated into national targets so that each Member State can check its own progress towards these goals,
- they do not imply burden-sharing – they are common goals, to be pursued through a mix of national and EU action,
- they are interrelated and mutually reinforcing:
    - educational improvements help employability and reduce poverty,
    - more R&D/innovation in the economy, combined with more efficient resources, makes us more competitive and creates jobs,
    - investing in cleaner technologies combats climate change while creating new business/job opportunities.

Table 2.1. Europe 2020 Targets[1] [17]

EU/Member States targets	Employment rate (in 1%)	R&D in % of GDP	CO2 emission reduction targets[2]	Renewable energy	Energy efficiency – reduction of energy consumption in Mtoe	Early school leaving in %	Tertiary education in %	Reduction of population at risk of poverty or social exclusion in number of person
EU headline target	75%	3%	-20% (compared to 1990 levels)	20%	20% increase in energy efficiency equalling 368 Mtoe	10%	40%	20.000.000
Estimated EU[3]	73,70-74%	2,65-2,72%	-20% (compared to 1990 levels)	20%	206,9 Mtoe	10,30-10,50%	37,50-38,0%	Result cannot be calculated because of differences in national methodology
AT	77-78%	3,76%	-16%	34%	7,16	9,50%	38%	235.000
BE	73,20%	3,00%	-15%	13%	9,80	9,50%	47%	380.000
BG	76%	1,50%	20%	16%	3,20	11%	36%	260.000
CY	75-77%	0,50%	-5%	13%	0,46	10%	46%	27.000

EU/Member States targets	Employment rate (in 1%)	R&D in % of GDP	CO2 emission reduction targets[2]	Renewable energy	Energy efficiency – reduction of energy consumption in Mtoe	Early school leaving in %	Tertiary education in %	Reduction of population at risk of poverty or social exclusion in number of person
CZ	75%	1% (public sector only)	9%	13%	n.a.	5,5%	32%	Maintaining the number of persons at risk of poverty or social exclusion at the level of 2008 (15.3% of total population) with efforts to reduce it by 30,000
DE	77%	3%	-14%	18%	38,30	<10%	42%	330.00 (long-term unemployed)
DK	80%	3%	-20%	30%	0,83	<10%	At least 40%	22.000 (household with low work intensity)
EE	76%	3%	11%	25%	0,71	9.5%	40%	Reduce the at risk of poverty rate (after social transfers) to 15% (from 17.5% in 2010)
EL	70%	to be revised	-4%	18%	2,70	9,7%	32%	450.000
ES	74%	3%	-10%	20%	25,20	15%	44%	1.400.000-1.500.000
FI	78%	4%	-16%	38%	4,21	8%	42% (narrow national definition)	150.000
FR	75%	3%	-14%	23%	34,00	9,50%	50%	Reduction of the anchored at risk of poverty rate by one third for the period 2007-2012 or by 1,600 000 people
HU	75%	1,80%	10%	14,65%	2,96	10%	30,3%	450.000

EU/Member States targets	Employment rate (in 1%)	R&D in % of GDP	CO2 emission reduction targets²	Renewable energy	Energy efficiency – reduction of energy consumption in Mtoe	Early school leaving in %	Tertiary education in %	Reduction of population at risk of poverty or social exclusion in number of person
IE	69-71%	approx. 2% (2,5% GNP)	-20%	16%	2,75	8%	60%	186.000 by 2006
IT	67-69%	1,53%	-13%	17%	27,9	15-16%	26-27%	2.200.000
LT	72,80%	1,90%	15%	23%	1,14	<9%	40%	170.000
LU	73%	2,3-2,6%	-20%	11%	0,20	<10%	40%	No target
LV	73%	1,50%	17%	40%	0,67	13,40%	34-36%	121.000
MT	62,90%	0,67%	5%	10%	0,24	29%	33%	6.560
NL	80%	2,50%	-16%	14%	n.a.	<8 %	>40% 45% expected in 2020	100.000
PL	71%	1,70%	14%	15,48%	14	4,50%	45%	1.500.000
PT	75%	2,7-3,3%	1%	31%	6,00	10%	40%	200.000
RO	70%	2%	19%	24%	10,00	11,30%	26,70%	580.000
SE	Well over 80%	4%	-17%	49%	12,8	<10%	40-45%	Reduction of the % of women and men who are not in the labour force (except full-time students), the long-term unemployed or those on long-term sick leave to well under 14% by 2020
SI	75%	3%	4%	25%	n.a.	5%	40%	40.000
SK	72%	1%	13%	14%	1,65	6%	40%	170.000
UK	No target in NRP	No target in NRP	-16%	15%	n.a.	No target in NRP	No target in NRP	Existing numerical targets of the 2010 Child Poverty Act

1 As set by Member States in their National Reform Programmes in April 2011

2 The national emissions reduction targets defined in Decision 2009/406/EC (or "Effort Sharing Decision") concerns the emissions not covered by the Emissions Trading System. The emissions covered by the Emissions Trading System will be reduced by 21% compared to 2005 levels. The corresponding overall emission reduction will be -20% compared to 1990 levels.

3 Addition of national targets

2.4.2. Legislation

Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council [5] seeks to achieve a high level of protection for the environment by reducing the potential environmental impact of Energy-using products (EuPs), which will ultimately be beneficial to consumers and other end-users. Sustainable development also requires proper consideration of the health, social and economic impact of the measures envisaged. Improving the energy efficiency of products contributes to the security of the energy supply, which is a precondition of sound economic activity and therefore of sustainable development.

In order to maximize the environmental benefits from improved design it may be necessary to inform consumers about the environmental characteristics and performance of EuPs and to advise them about how to use products in a manner which is environmentally friendly.

It may be necessary and justified to establish specific quantified ecodesign requirements for some products or environmental aspects thereof in order to ensure that their environmental impact is minimized. Given the urgent need to contribute to the achievement of the commitments in the framework of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), and without prejudice to the integrated approach promoted in this Directive, some priority should be given to those measures with a high potential for reducing greenhouse gas emissions at low cost. Such measures can also contribute to a sustainable use of resources and constitute a major contribution to the 10-year framework of programmes on sustainable production and consumption agreed at the World Summit on Sustainable Development in Johannesburg in September 2002.

The Kyoto Protocol on climate change is an international agreement which aims to reduce emissions of six gases that cause global warming: carbon dioxide (CO_2) gas methane (CH_4) and nitrous oxide (N_2O), plus three fluorinated industrial gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCS) and sulphur hexafluoride (SF_6), in an approximate percentage of at least one 5%, within the period running from 2008 to 2012, compared to the emissions of the year 1990. For example, if contamination of these gases in 1990 amounted to 100%, at the end of the year 2012 must be at least 95%. It should be noted that this does not mean that each country need to reduce their emissions of gases covered by 5% as a minimum, but this is a percentage at the global level and, instead, each country bound by Kyoto has their own percentages of emission that should decrease.

The World Summit on Sustainable Development that took place in Johannesburg in 2002, established as a goal reducing the shortage of fuel in half by 2015. Part of the proposed solution consists of the development of systems of solar energy in rural areas. Since the lack of fuel is more pressing in pretty sunny in developing countries, the potential of this type of energy is enormous. The UN development programme promotes a shift towards an energy system that does not produce CO2: solar energy in development, hydrogen in the already industrialised countries and greater use of biofuels in the transport world.

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance) [7] says that the control of European energy consumption and the increased use of energy from renewable sources, together with energy savings and increased energy efficiency, constitute important parts of the package of measures needed to reduce greenhouse gas emissions and comply with the Kyoto Protocol to the United Nations Framework Convention on Climate Change, and with further Community and international greenhouse gas emission reduction commitments beyond 2012.

When favouring the development of the market for renewable energy sources, it is necessary to take into account the positive impact on regional and local development opportunities, export prospects, social cohesion and employment opportunities, in particular as concerns SMEs and independent energy producers.

Directive 2010/31/EU of 19 May 2010 on the energy performance of buildings (recast) [8] [17] is the legislative instrument currently in force to improve the energy efficiency of buildings in the EU. Under this Directive, Member States must establish and apply minimum energy performance requirements for new and existing buildings, ensure the certification of building energy performance and require the regular inspection of boilers and air conditioning systems in buildings. Moreover, the Directive requires Member States to ensure that by 2021 all new buildings are so-called 'nearly zero-energy buildings'.

The Directive [8] [17] was adopted in 2010 after experience with the implementation of the first EPBD (Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings [4]) in the Member States and following a proposal from the Commission in 2008 [COM (2008) 780] which was based on a detailed impact assessment [SEC/2008/2865]. The main aim of this revision was to clarify and simplify certain provisions, extend its scope, strengthen some of its requirements to improve their effectiveness, and provide for the leading role of the public sector.

Law 8/20041 of Housing of the Valencian Community [26] pays special attention to measures of conservation, maintenance and rehabilitation of buildings housing in Title III.

In its development, 75/20072 Decree approved the regulation of Rehabilitation of Buildings and Houses [21], subsequently repealed by Decree 189/20093, which regulates the technical and regulatory framework relating to the rehabilitation of public housing buildings. Among its objectives, laying down the provide instruments to deal with the knowledge of the state of conservation of the housing buildings as a prerequisite for the rehabilitation activities protected, ensuring technical consistency between the condition of the building and derived actions, as well as encourage what concerted between municipalities and Regional Government established inspection plans to know the State of preservation of the buildings.

In this way the fulfillment of the requirement of the technical inspection and harmonization with the rehabilitation activities, in accordance with the provisions of Title III Chapter III of Act 8/2004 of Housing of the Valencian Community [26] and the requirements planning with respect to the duty of conservation and maintenance of buildings established by the articles 206 and 207 of the 16/20054 fits Valencia Planning Law requiring that has passed a roadworthiness attesting their status in buildings with more than 50 years in the form and time limits.

The Decree 66/2009, which approves the Regional Plan of housing in the Valencia Community 2009-20125 aims to support the activity of rehabilitation of buildings and promoting improvement in the quality of construction and the energy efficiency of homes. Chapter VI deals with the need for the Report on the state of Conservation of the Building (ICE), which adjusts the contents of the technical inspection of buildings, as a reference to know and to carry out a coherent policy of intervention on the residential park.

Law 16/2005 of 30 December, Valencia Town Planning, article 206 [28] establishes that the owners of buildings with more than 50 years old must promote an inspection (periodical inspection of buildings) at least every 5 years to prove the State of conservation of the same.

Law 8/2004, 20 October, which approves the law of the Housing of the Valencian Community. DOGV No. 4867, of 21 October 2004 Art. 34 [27], "The Generalitat Valenciana may establish the measures it considers appropriate to enable the technical inspections forced by urban development legislation..."

Decree 81/2006 of 9 June, of the Consell [25], "Report of the Building Conservation" requirement prior to the provisional rating of the rehabilitation activities.

Royal Decree 2066 / 2008 of 12 December, which regulates the state of Housing and Rehabilitation 2009-2012 Plan. (art. 59.4) [19], indicates that 25% budget, destined for renewable energy, energy efficiency, hygiene, health and protection of the environment, and accessibility in the building.

Decree 81/2006 of 9 June, of the Consell [25], of the development of measures and financial assistance for the rehabilitation of buildings and homes in the region of Valencia in the framework of the State Plan 2005-2008 and the restoration program of the Generalitat.

Decree 189/2009 of 23 October, of the Consell [24], approving the Regulation of Rehabilitation of Buildings and Houses.

Decree 66/2009 of 15 may [20], of the Consell, which approves the Regional Plan of Housing in the Valencian Community 2009-2012. DOCV nº. 6.016, May 19, 2009.

Decree 43/2011 April 29 [22], of the Consell, which amended the decrees 66/2009 of 15 may, and 189/2009 of 23 October, which were, respectively, the Regional Plan of Housing in the Valencian Community 2009-2012 and the Regulation of Rehabilitation of Buildings and Houses.

Decree 75/2007, of 18 may, of the Consell [23], which approves the Regulation for Protection of Public Housing. DOCV nº. 5.517, May 22, 2007.

Cost optimal methodology framework

Directive 2010/31/EU [8] [17] also requires the European Commission to establish, by means of a delegated act, a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements (article 5).

To obtain the input from experts into the development of this methodology framework, the Commission organized two expert meetings in March and May 2011:

- Expert Meeting on the Delegated Act on a Cost Optimal Framework Methodology 16 March 2011,
- second Workshop on Cost-Optimal Framework Methodology under the Energy Performance of Buildings Directive.

The Commission adopted this delegated act on 16 January 2012 and, after a two-month objection period by the European Parliament and Council, published the act in the Official Journal on 21 March 2012:

- Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements.

The Commission also elaborated guidelines accompanying the delegated act, which were published in the Official Journal on 19 April 2012.

Reporting requirements

Under article 10 (2) Directive 2010/31/EU [8] [17], Member States have to communicate to the Commission by 30 June 2011 a list of existing and, if appropriate, proposed measures and instruments including those of a financial nature, which promote the objectives of the Directive. So far the Commission has received the following information (next to the information received in the context of the National Energy Efficiency Action Plans referred to in Article 14 (2) of Directive 2006/32/EC [5].

Concerted Actions

Ever since the adoption of the first energy performance of buildings Directive [17], the Commission has supported its implementation in the Member States. The main tool for this purpose has been the so-called Concerted Action EPBD [4].

This forum was launched by the European Commission to promote dialogue and exchange of best practice between the Member States. It brings together the national authorities from 29 countries and focuses on finding common approaches to the most effective implementation of this legislation.

One of the key outputs of this Concerted Action is the Country Reports [17], which give an overview of the implementation of the Directive in all Member States, as well as in Norway and Croatia.

2.4.3. Standardization

The implementation of the EPBD [4] [17] is supported by a set of European standards, dealing with a wide range of relevant topics including calculation of delivered energy, energy needs and energy costs, inspections and definitions.

This set of standards was developed on the basis of a Commission mandate M/343. With the revision of the Directive in 2010, the Commission issued in December 2010 a new mandate (M/480) requesting CEN to update the existing standards, also based on the experience in the Member States with the use of those standards [17].

3. HISTORY OF THE UNIVERSITY

The Szczecin University of Technology, the oldest college in Western Pomerania, was established in January 1947 by a directive from the Ministry of Education which entered into force on 1st December 1946. By September 1955 had been elevated to the status of university. For over half a century, Szczecin University of Technology has made a considerable contribution to development of the city, region and country, being an inherent part of the development of science, technology and higher education in post-war Poland.

Prior to the Second World War there was no institute of higher education as such in Szczecin, although there was a technical vocational school. Fortunately, the buildings sustained little damage during the war, and this, along with the remaining academic teachers, led to the opening, in November 1945, of the City Technical High School, comprising the mechanical and building departments, and which became, in 1946, in the State Technical School. The city authorities and inhabitants of the time, who were keen to ensure Szczecin's political, economic and social success, they brought about the establishment, in 1946, of the School of Engineering.

The biggest hurdle to be overcome with regard to the organization of a technical institute was the lack of suitably qualified staff, attached to inattention by the failure of the Allies, along with extremely difficult living conditions, meant that specialists relocating to the Western Territories preferring other institutions. Also saw a serious crisis at the School of Engineering, caused by, among others, the forced resignations by the Stalinist authorities of some of the non-resident professors and lecturers, which led to radical changes in the management and organization of the school. As a result, several departments were closed. By its ninth year, the school had been elevated to the status of University of Technology.

The change in the political situation following the events of October 1956 allowed many of those professors removed during the Stalinist period to return to the university.

The period up to 1970 was characterized by intense activity and significant scientific and educational achievements, closely linked to the economy of the Western Pomeranian region, which allowed the University of Technology to consolidate its position both regionally and nationally. The role that the university played in the cultural life of the city during this period must not be forgotten. The university's fifth decade started with the deepening social crisis which would eventually lead to political breakthrough and to the complete transformation of the social and economic systems

During then 90´s, the university commenced direct collaborative projects with universities in Western Europe, in particular in Germany, Italy, France, Portugal, Ireland, and in the case of Spain, among others, with the Polytechnic University of Valencia, which allowed education and research of an international character. The university also worked with universities and institutes beyond Europe's borders: the Faculty of Civil Engineering and Architecture cooperated with, among others, the Hanoi Institute of Architecture in Vietnam, The Technical University in Jinan (China), and The Clemenson University (USA). Today, thanks to its many centres, both national and international, the university is carrying out both individual and team research projects, most of which are of practical application and are innovative in nature, which only serves to increase the prestige of the University of Technology.

The increase in the qualifications of the teaching staff has been accompanied by an expansion in the teaching operation. Through active participation in the EU-financed educational programme TEMPUS, modern programmes of study and specializations have been funded, along with well-equipped laboratories, lecture theatres and departmental libraries, and the chance for many academic teachers and students to take part in study programmes and placements with Western European universities. By joining the Socrates/Erasmus programme and applying a system of credits, students are better able to take advantage of exchange programmes with European institutions. The international collaborative projects also extend to scientific research, in which various organizational departments of the institution take part (for example under the 5th and 6th Framework Programme for European Research & Technological Development). Two administrative departments are responsible for such wide-ranging collaboration: The Research Department and the Office for International Programmes.

Finally, the institution's sixth decade has seen the further expansion of the teaching operation with the construction of new buildings or the adaptation of former barracks (one of which intended for the Faculty of Civil Engineering and Architecture). A series of major renovations and modernizations of other university buildings has also been undertaken. The present-day, Szczecin University of Technology is an energetic centre of scientific learning with six faculties, three interdepartmental institutes and four departmental academies. During its 60-year existence the Szczecin University of Technology has seen vice premiers, ministers, senators and members of parliament, town and county council leaders, or have held prominent positions in the largest companies in Western Pomerania. The University has attained a significant position not only within the city and the region, but also enjoys an increasingly good reputation amongst the technical institutions of Poland.

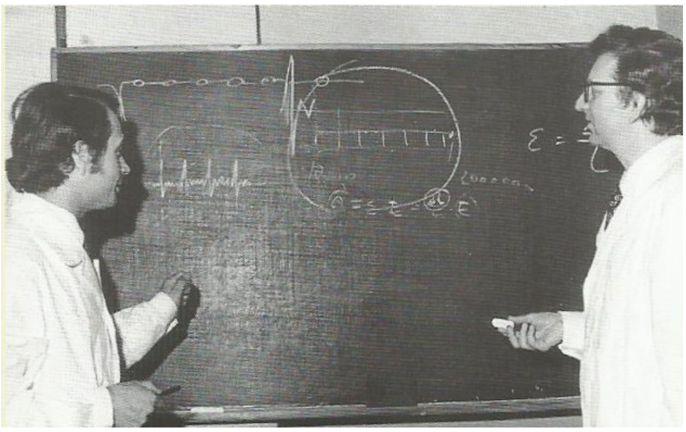


Fig. 3.1. Classes at the Faculty of Civil Engineering and Architecture [3]

Finally, there is a brief timeline of a Civil Engineering and Architecture Faculty:

- **1946 - October -** A Ministry of Education Commission inspects the site of the future School of Engineering.

  December - The School of Engineering comes into being on the basis of a decree from the Minister of Education of January 1947. The decision comes into force with a back date of December 1, 1946. The School commences work in December 1946, with entrance preparation courses for candidates.
- **1952 - December -** Due to the intensive restructuring of higher education, the following faculties are reorganized: Engineering, Mechanic and Electrical Engineering. The Faculty of Engineering is renamed the Faculty of Civil Engineering and undergoes several changes.

- **1956 - February** - Along with the change in status comes a change in name for the Faculty of Civil Engineering, which becomes the Faculty of Advanced Civil Engineering.
- **1959 - October** - A Szczecin University of Technology Consulting Point is opened in Koszalin, run initially by the Faculty of Engineering-Economics, and from 1963 also by the Faculty of Civil Engineering.
- **1962 - May** - the Faculty of Civil gains the right to award PhDs, which allows the speedier scientific development of the young scientists in the Faculty.
- **1969 - October -** The Architecture major is re-started, with the Faculty of Civil Engineering becoming the Faculty of Civil Engineering and Architecture.
- **1970 - January -**Construction work begins on an extension to the Faculty of Advanced Civil Engineering. The Ministry of Education brings in a new organizational structure to the institution, with the basic departments, up till now Chairs, becoming Institutes.

  September - The organizational structure of the Faculty of Civil Engineering and Architecture, until now comprised of three institutes, also changes.
- **1992 – October** - A new international major is offered, European Civil Engineering Management, which offers the option of studying at one of the partner universities abroad, allowing graduates to obtain not only Polish but al so German, Swedish or Dutch degrees [3].

Fig. 3.2. Faculty of Civil Engineering and Architecture building (1939) [2]

4. THE CIVIL ENGINEERING AND ARCHITECTURE FACULTY AND ITS LIBRARY

4.1. BUILDING DESCRIPTION

The Faculty of Civil Engineering and Arquitecture building was constructed in the 1930s as an L-shaped two-winged structure on Barnim Straβe and Burscher Straβe (Piastów Avenue and Łokietka Street nowadays). It is an interesting example of international architecture, in that the facade is inlaid with ceramic tiles which frame the windows. Following the war, the top storey of the wing was added (on Piastów Street), in keeping with the existing elevation.

During the 1960s the building was extended on the Jagiełly Street and Przybystawy Street side. Worth mentioning is the glass entrance on Przybystawy Street, which complements the modern character of the interior design, the lobby and stair case. The extension also houses modern lecture rooms, laboratories and administrative offices. With the extension, the building occupies a whole plot (actually a relatively small district in central Szczecin), with a central wing located in the interior. Housing a first- floor library and above, and audio-visual room. The interior courtyard was divided into two, with a fountain and green area which extends into the basement owing to the open work construction of the ground floor [3].

Fig. 4.1. Construction of the Faculty of Civil Engineering and Architecture (1965) [3]

Fig. 4.2. Faculty of Civil Engineering and Arquitecture nowadays. View from Jagiełly Street intersected to Przybystawy Street (done by R.F.P.)

Fig. 4.3. Faculty of Civil Engineering and Arquitecture nowadays. . View from Piastów Avenue intersected to Jagiełly Street (done by R.F.P.)

4.2. THE FACULTY LIBRARY

The Faculty Library is located on the mezzanine between the lobby floor and first floor, to +5,23 m above ground level. It has a total area of 438,24 m², divided into a own library area, two corridors, three magazines and books warehouses, an office, a staff area, a washbasin, and a toilet. It is seated on reinforced concrete columns and hollow-tiled floor and the partitions are made of brickwork covered with cement, plaster, paint and wood cladding. The floors are covered with tile and carpet and the external wall is made of facing bricks.

In the figures 4.4. and 4.5. there are shown the facades of the library from the courtyard.

Fig. 4.4. South view of the library from the courtyard (done by R.F.P.)

Fig. 4.5. North view of the library from the courtyard (done by R.F.P.)

In the figure 4.6. there is shown the entrance corridor to the library and in the figure 4.7. one of the warehouses for storing books.

Fig. 4.6. Corridor 1 (done by R.F.P.)

Fig. 4.7. Warehouse 1 (done by R.F.P.)

In the figures 4.8. and 4.9. there are shown the entrance of the reading area.

Fig. 4.8. Reading area (done by R.F.P.)

Fig. 4.9. Reading area (done by R.F.P.)

In the figures 4.10. and 4.11. there are shown the staff area and the entrance to a corridor, a wash basin and a toilet.

Fig. 4.10. Staff area (done by R.F.P.)

Fig. 4.11. Staff area (done by R.F.P.)

In the figures 4.12., 4.13. and 4.14. there are shown the main room. In this room we will change the distribution of the tables to save space as much as possible

Fig. 4.12. Main Room (done by R.F.P.)

Fig. 4.13. Main Room (done by R.F.P.)

Fig. 4.14. Main room (done by R.F.P.).

In the figure 4.15. there is shown a warehouse to stored magazines.

Fig. 4.15. Magazine warehouse (done by R.F.P.)

In the figures 4.16. and 4.17. there are shown the office that will be transformed into a groupwork room.

Fig. 4.16. Office (done by R.F.P.)

Fig. 4.17. Office (done by R.F.P.)

In the figure 4.18. there is show the reading area and the corridor to enter in a warehouse (figure 4.19.) that it will be transformed into a computers room.

Fig. 4.18. Corridor 2 and Reading Area (done by R.F.P.)

Fig. 4.19. Warehouse 2 (done by R.F.P.)

5. PRINCIPLES AND METHODOLOGY

5.1. Ventilation

The term *ventilation*, in its ampler sense, makes reference to the provision and/or extraction of the air of a zone, the premises or building, or of natural or mechanical form. Also of ample sense, the objectives of the ventilation consist of maintaining the oxygen levels in values that made the atmosphere of any breathable place and that this one outside perceived fresh and clean one.

We understand by ventilation the renovation of the air of a room by means of a connection with the outer surroundings. The ventilation needs an opening for the entrance and exit of the air, as well as a pressure differential.

We can tell apart two types of ventilation: natural ventilation and forced ventilation. The natural ventilation is created by the pressure differential caused by the wind drifts on the building and/or by the temperature differences between the air of the interior and the air of the outside. In the case of the forced ventilation, the fresh air is generated by means of a ventilator with motor.

In the case of our building, the ventilation is natural.

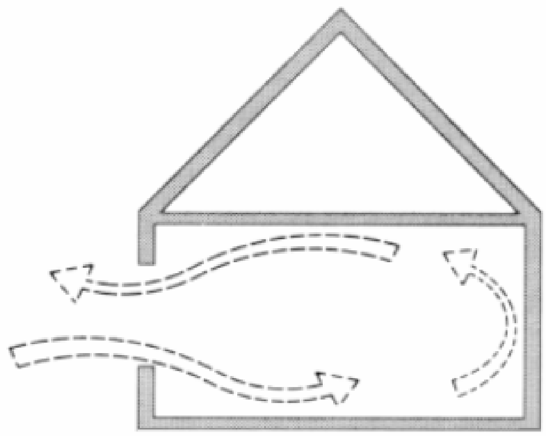


Fig. 5.1. Description of natural ventilation [19].

The ventilation takes to the humidity and the air contaminated to the outside, which reduces to the possibility of condensation and the growth of mould, besides to improve the quality of the air inside the room. The ventilation also generates sufficient and necessary oxygen for the users and the apparatuses of combustion.

The quality of the air in the interior gathers all the physical characteristics, chemical and biological of the air within building that they can affect to the health and comfort of the users.

In normal circumstances, the air is in favor compound mainly of nitrogen (78%), oxygen (21%) and carbon dioxide (0.03%). This air can be infected type of polluting agents yet.

The natural ventilation is a way to maintain an optimal quality of the air inside the house, since it provides oxygen, it dilutes or it eliminates the present polluting substances and it eliminates the excessive heat.

The windows can make the ventilation possible of the building of several ways: by means of small openings within the framework, opening totally to a window, using a folding window or using a special mechanism for ventilation. The difference in the pressure of necessary air for the natural ventilation one takes place by the temperature differences or the wind drifts. In our building we have the ventilation system inserted within the framework of the window as we see in the image [19].

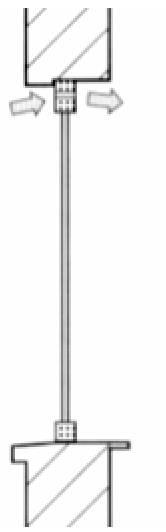


Fig. 5.2. Description system of ventilation in windows [19].

5.2. Thermography

The astronomer Sir Frederick William discovered the existence of the infrared radiation in 1800. Its curiosity by the thermal difference between the different colors from the light took to direct the solar light to him to traverse of a crystal prism to create a phantom and, next, it measured the temperature of each color. It discovered that these temperatures grew in progression from the part of the violet towards the one of the red one.

After observing this pattern, Herschel measured the temperature of the immediate point beyond the red portion of the phantom, in a region without visible solar light. And, for its surprise, it found that that region was the one that showed the highest temperature.

The infrared are halfway between the visible phantom and the microwaves of the electromagnetic spectrum. The main source of infrared radiation is the heat or the thermal radiation. Any object with a temperature superior to the zero absolute one (-273.15 ºC or 0 Kelvin) emits radiation in the infrared region.

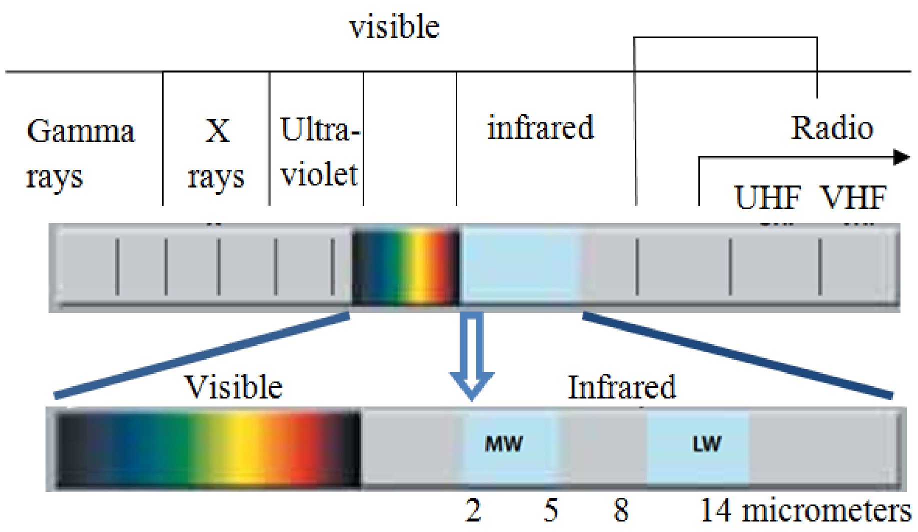


Fig. 5.3. The spectrum of radiation [36].

Our eyes are designed detectors to perceive the electromagnetic radiation in the phantom of visible light. Any other type of electromagnetic radiation, like the infrared one, is invisible for the human eye.

The energy losses are the result of anomalies in the construction and can be detected by infrared. In consequence, repairing these anomalies we will be able to save energy. Thanks to termographies, we can save in repairs, inasmuch as they provide the necessary information to us (Location of flights, detection of construction defects), in addition the thermal images to such anomalies serve the insuring or constructors as it undeniable evidences at the time of reaching an agreement in case of litigation and of plan the corresponding actions of repair.

The termographies locate with exactitude where losses of energy are detected, without need to make destructive test.

A thermal camera is the only tool able to represent the loss of energy of a building. The method is fast and the termographies that the camera produces are a precise and convincing argument. It is an instrument reliable able to visualize and analyze the temperature distribution of entire surfaces quickly and accurately. A thermal camera registers the intensity of the radiation in the infrared zone of the electromagnetic spectrum and it turns it a visible image.

The infrared energy (a) that radiates an object focuses with the optical system (b) on an infra-red seeker (c). The detector sends the data to the electronic sensor (d) to process the image. And the sensor translates the data in an image (e), compatible with the viewfinder and visible in a monitor of standard video or a screen LCD.

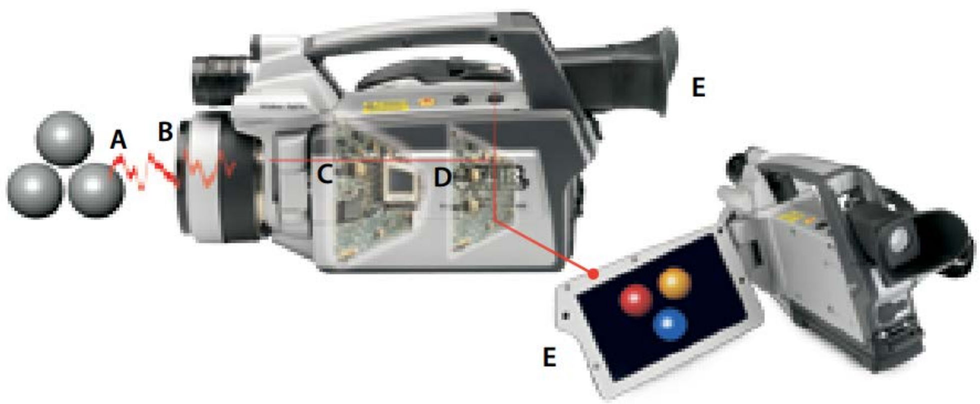


Fig. 5.4. The thermal camera [36]

A thermography that includes precise data of temperature provides to the experts of the construction important information on conditions of isolation, humidity entrances, electrical development of the mould, failures, the presence of thermal bridges and the conditions of the air conditioning systems. When using a thermal camera to locate to lack of isolation or losses of energy, the temperature difference between the interior and the outside of the building must be, preferably, of at least 20 ºC. In cold climates, the inspection of the buildings usually is carried out in winter. In warmer climates, in which it is important to see if the building is well isolated to maintain the air cold that they generate the air conditioning systems in his interior, the months of summer usually is ideal for this thermal type of inspection.

A thermal bridge is a zone in which the surrounding one of the building has a smaller thermal resistance. It is caused by limitations in the construction. The heat will follow the easiest route from the warmed up space the outside: the route with the smaller resistance. The habitual effects of the thermal bridges are the following ones:

- smaller temperatures of the inner surface; in worse of the cases the this it can give like result condensation problems, in particular in the corners,
- significantly greater losses of heat,
- cold areas in the buildings.

The most common thermal bridges in buildings are integrated into the walls, on pillars built into the facades or on the outlines of holes and skylights, and also formed by walls matches; on the front of slabs in facades, at the joints between roofs and facades, in the unions of facades with walls in contact with the ground and in the corners between walls [36].

5.3. Equipment used for the taking of data

For taking of data we have used the following equipment, all provided by Faculty of Civil Engineering and Architecture of the West Pomeranian Technical University of Szczecin.

Infrared thermometer TESTO 830

Infrared thermometer TESTO 830 (fig 5.5) is a thermometer that works by means of infrared. It serves in order to even measure the skin temperature in small objects to one distance safe. The diameter of the measurement mark is of 36 mm to one distance of 1m.

Fig. 5.5. Infrared thermometer "TESTO 830" (done by J.C.C. and R.F.P.)

Infrared thermometer TESTO 830 consist of:

- 30:1 optics for measurements of remote temperature, even in small objects,
- laser leader to indicate the measurement mark,
- visualization of the present value and the retained value,
- adjustment of the emissivity by means of sounding of temperature external,
- acoustic and optical alarm I spread exceed the values limit [38].

Multi-functional measuring TESTO 435

The multi-functional measuring instrument measures temperature, humidity, CO^2, CO, dew point, air velocity, differential pressure, lux, absolute pressure, surface temperature and u-values (R-values). Determining volume flow is easy using the pilot tubes, vane probes or thermoanemometer probes. TESTO 435 (fig 5.6) can measure differential pressure across filters, coils and pressurised rooms.

Fig. 5.6. Multi-functional measuring instrument "TESTO 435" (done by J.C.C and R.F.P)

Advantages of multi-functional measuring instrument:

- large clear display, with easy to follow menus,
- wireless temperature and humidity probes for remote monitoring,
- volume flow calculations 0 to 999,999 CFM,
- timed an multi-point mean calculations,
- 4-function IAQ probe for temperature % Rh, CO2 and absolute pressure,
- flow measurement using pilot tube, vane and thermal probes,
- light (Lux) probe for light surveys,
- optional built-in micro manometer for pressure,
- performs timed and multipoint averaging as well as CFM and total BTU calculations,
- PC software for analysis and documentation of measurement data [37].

Infrared camera FLIR B 335

Infrared camera FLIR B335(fig 5.7 and 5.8) is a small and light-weight infrared camera with excellent image quality and high sensitivity, ideal for building diagnostics and energy declaration surveys.

Fig. 5.7. Infrared camera "FLIR B 335" (done by J.C.C and R.F.P.)

Fig. 5.8. Infrared camera "FLIR B 335" (done by J.C.C and R.F.P.)

The camera has Picture in Picture, text/voice annotations and interchangeable lenses.

Advantages:

- 50mk thermal sensitivy,
- IR resolution 320x 240 pixels
- digital camera 3.1 Mp with LED lights,
- Picture in Picture
- text and voice annotations

The main features to Infrared camera FLIR B 335 are:

- high resolution IR images- 320x 240 pixels infrared resolution, NETD 50 mk,
- digital camera- 3.1 megapixels with built-in LED lights provides sharp images regardless of lighting conditions,
- wide temperature range- measures from -20°C to +120°C targeting building applications,
- insulation alarm- show the insulation performance of the building structure,
- dew point alarm- alerts you to the areas where there is a risk of condensation,
- zoom- 2x continuous digital zoom,
- laser pointer- pinpoints the hot spot on the IR image with the real physical target,
- annotations- add text and voice comments via touch screen or headset [30].

5.4. Taking of data

The taking of data was made at day 20 of March to 5:30 a.m. We make data collection at 5:30 a.m. because at this time the sun is not out, so that the difference in external and internal temperature is higher.

- outside temperature: 3.2°C (during this day the temperatures oscillated between 0.9°C and 11.2°C),
- average speed of the wind: 15 km/h
- relative humidity: 80%,
- solar Light: sunrise: 6:08 a.m., sunset: 18:11,
- cloudiness: high cloudiness, with precipitations [40].

This day and under the described environmental conditions we made the taking of data necessary to be able to make the calculations. For data collection we use the equipment described earlier

- infrared thermometer TESTO 830,
- multi-functional measuring instrument TESTO 435,
- infrared camera FLIR B 335.

During experiment there were measured following datas:

- temperature of the external surface of element of the facade,
- external air temperature,
- termographies of the facade.
- temperature of internal surface of the inner face of the facade,
- inner room temperature,
- speed of the air in ventilation channels.

All the taken data are enclosed in tables No 3 and 4

Table 5.1. Temperature of the outside facade elements.

EXTERIOR							
WALLS		GLASS OF WINDOWS		METAL OF WINDOWS		SLABS	
S (°C)	N (°C)	S (°C)	N (°C)	S (°C)	N (°C)	E (°C)	W (°C)
3,00	1,50	5	5	-1,00	3	7,5	8,5
3,00	3,00	4,5	1,5	-0,50	2	7	8,5
2,50	2,50	1	1,5	4,50	2,5	7,5	9
2,00	3,00	1	3,5	0,50	2	7,5	8
1,50	4,00	1	1,5	3,50	4,5	7	8,5
1,50	3,50	0,5	3				
2,50	4,00	0,5	3,5				
2,50	4,00	1	3				
		0,5	2				
		0,7	2,5				
		5,5	5,5				
2,31	**3,19**	**1,93**	**2,96**	**1,40**	**2,80**	**7,30**	**8,50**

Table 5.2. Temperature of the inside facade elements.

INTERIOR									
HIGHER PLYWOOD PANEL		GLASS OF WINDOWS		METAL OF WINDOWS		LOWER PLYWOOD PANEL		FLOOR	
22	20,5	12,5	15	11,5	12,5	22	15	20	17
21,5	21	15	15	11,5	11,5	20,5	20,5	19	18,5
22	20,5	14	14	10,5	13,5	18,5	22	19,5	18,5
22	21,5	13,5	17	9,5	11,5	16,5	21	19	19
22	21,5	15,5	15,5	13	13	19,5	20,5		
22	22	14,5	16	12,5	13	17,5	20,5		
		15,5	15	14	12				
		15	13,5	12,5	12,5				
		15	11,5	11	11				
				13	11				
				11,5	9				
21,92	**21,17**	**14,50**	**14,72**	**11,86**	**11,86**	**19,08**	**19,92**	**19,36**	**18,25**

At the time of data collection the outside temperature was 3.2°C and in the interior of the library 19.1°C.

Thermographies in our buildings

The night of data collection we make termographies of the library's façade. Below we show the termographies the north facade and south facade.

Fig. 5.9. Library north view (done by R.F.P)

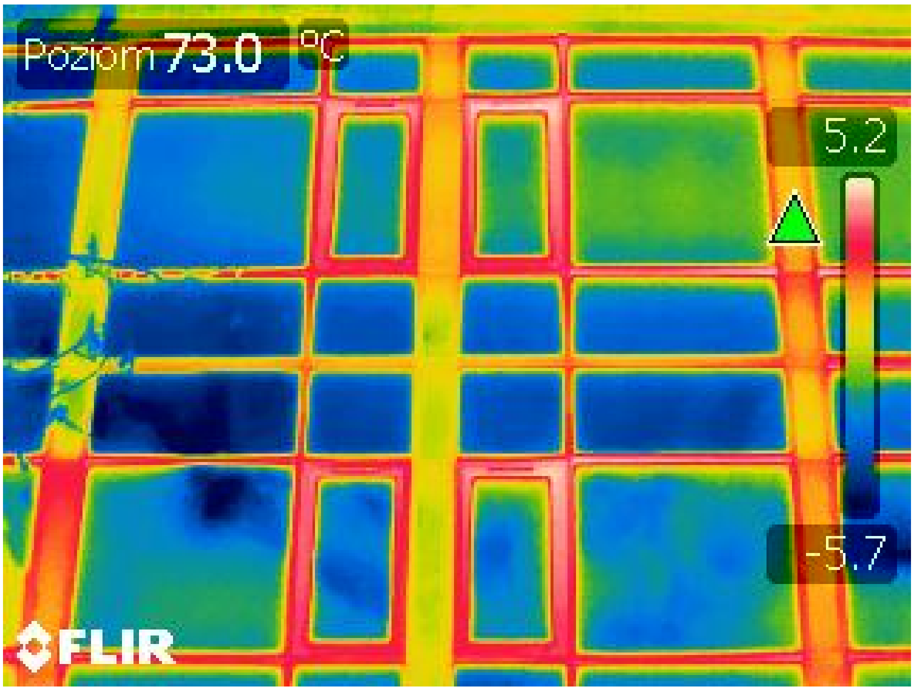


Fig. 5.10. Library north view, thermography 1 (done by R.F.P.)

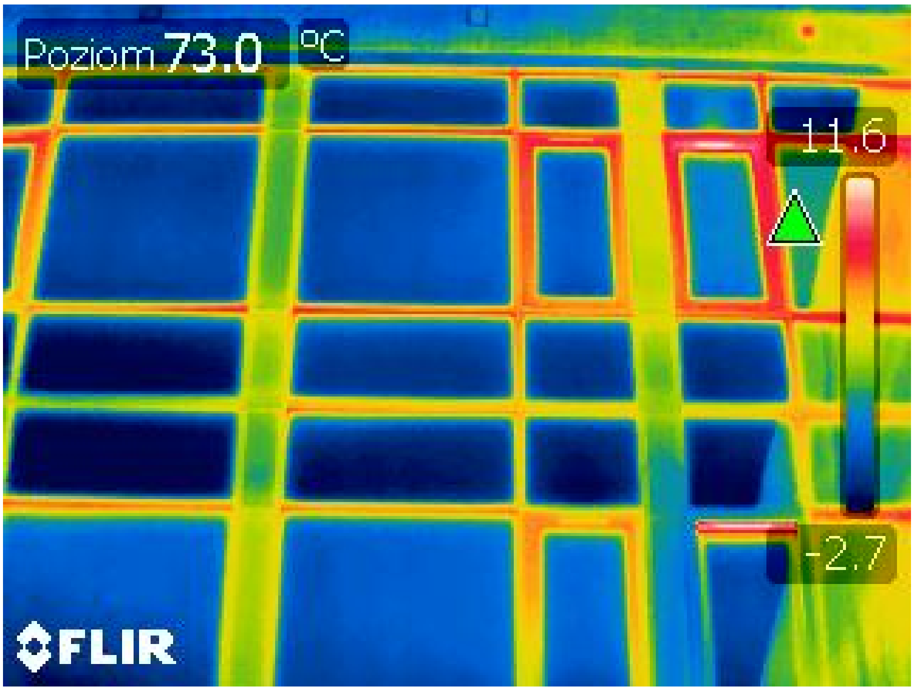


Fig. 5.11. Library north view, thermography 2 (done by R.F.P.)

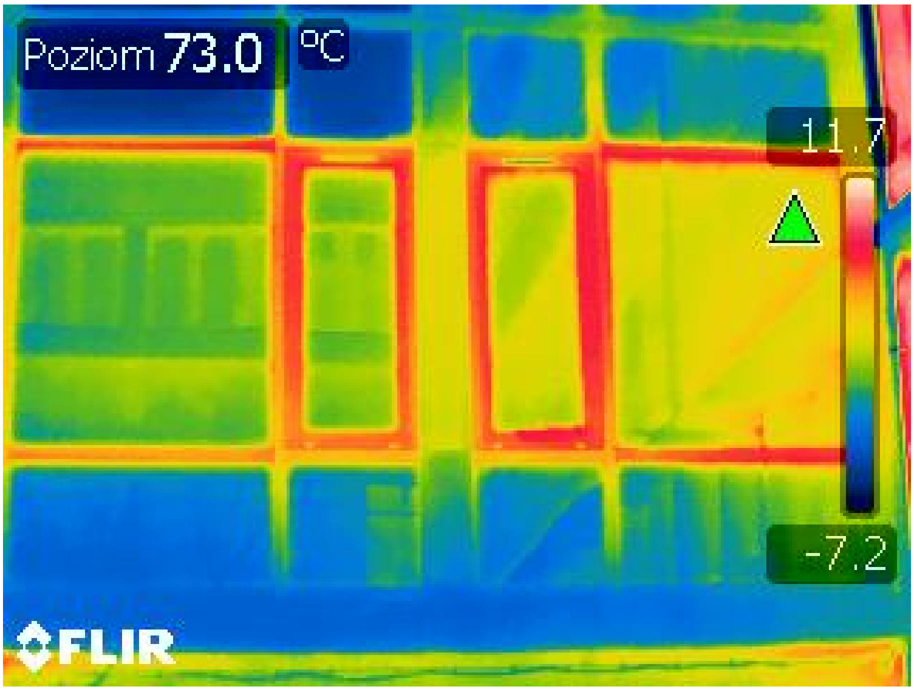


Fig. 5.12. Library north view, thermography 3 (done by R.F.P.)

Fig. 5.13. Library south view (made by R.F.P)

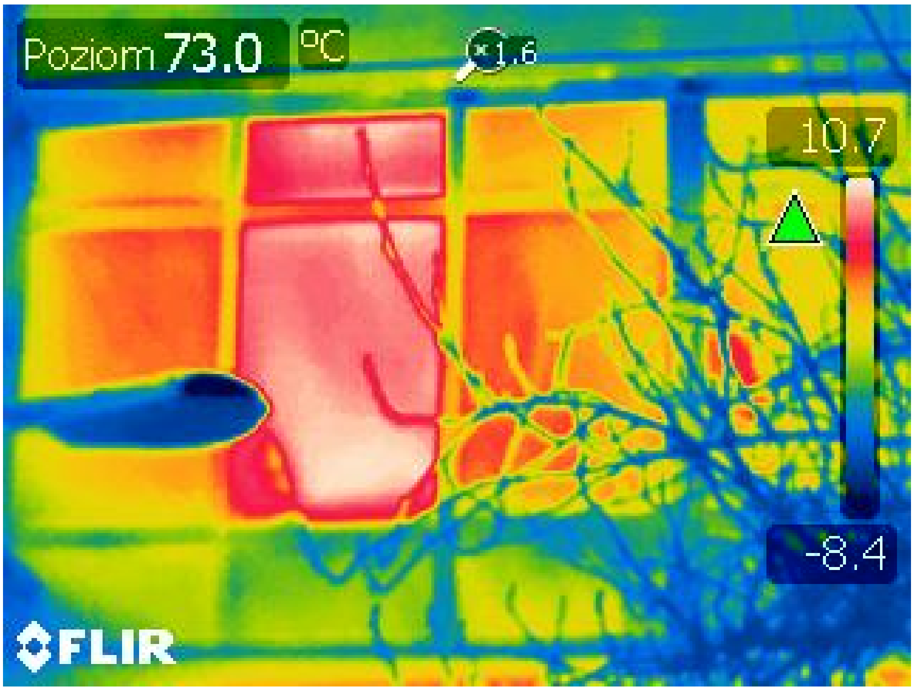


Fig. 5.14. Library south view, thermography 4 (done by R.F.P.)

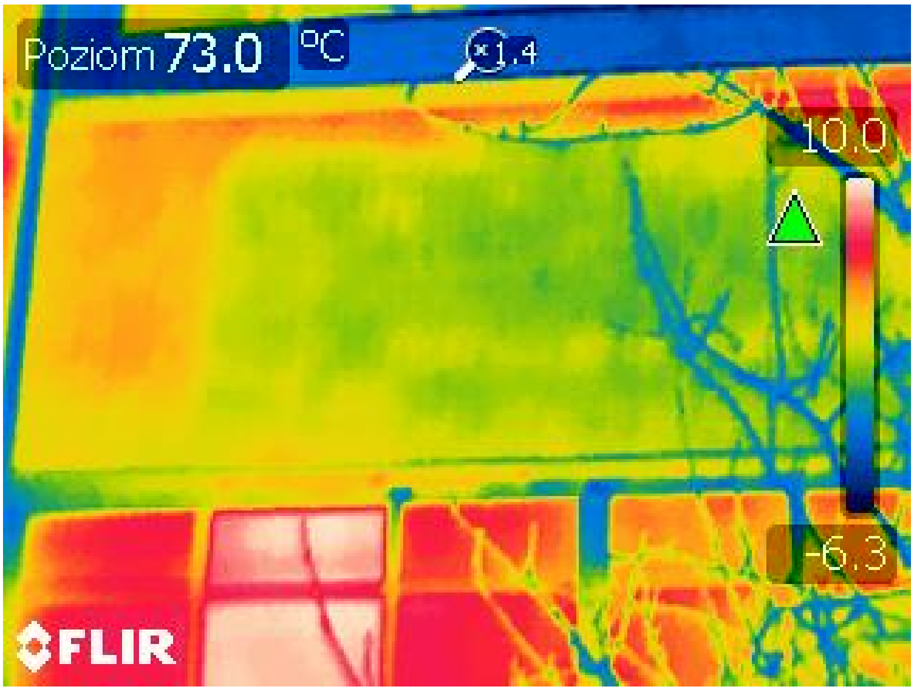


Fig. 5.15. Library south view, thermography 5 (done by R.F.P.)

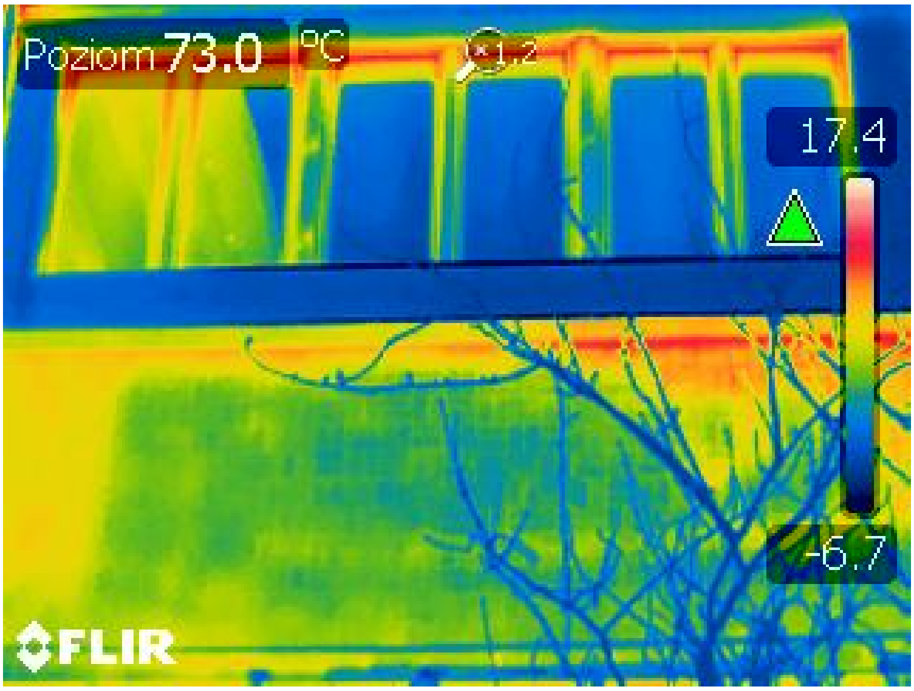


Fig. 5.16. Library south view, thermography 6 (done by R.F.P.)

As much in thermographies made in the North facade like in the South facade, we can observe that the thermal bridges always are in the zones where changes of materials take place, mainly in the encounter between the carpentry and the facade, and also in the slabs meetings.

All these data will be compared with the software ICEWIN2 [30].

6. CALCULATION METHOD

6.1. Calculation of U-Value for library partition

"U" Value is the coefficient of transmission, of heat through the materials, which compose the building's "envelope," or outer shell.

The U-value (or U-factor), more correctly called the overall heat transfer coefficient, describes how well a building element conducts heat. It measures the rate of heat transfer through a building element over a given area, under standardized conditions. The usual standard is at a temperature gradient of 24 °C, at 50% humidity with no wind (a smaller U-value is better at reducing heat transfer).

U is the inverse of R with SI units of $W/(m^2K)$

The R-value is a measure of thermal resistance used in the building and construction industry. Under uniform conditions it is the ratio of the temperature difference across an insulator and the heat flux (heat transfer per unit area, Q_A) through it:

$$R=\Delta_T/Q_A. \quad (6.1.1)$$

The thermal resistance is used for a unit value of any particular material. It is expressed as the thickness of the material divided by the thermal conductivity. For the thermal resistance of an entire section of material, instead of the unit resistance, divide the unit thermal resistance by the area of the material. For example, if you have the unit thermal resistance of a wall, divide by the cross-sectional area of the depth of the wall to compute the thermal resistance. The unit thermal conductance of a material is denoted as C and is the reciprocal of the unit thermal resistance. This can also be called the unit surface conductance and denoted by h. The higher the number, the better the building insulation's effectiveness.

Thermal resistance total RT of a component constituted by layers thermally homogenous it must calculate by means of the expression:

$$RT= Rsi + R1+ R2+\ldots+ Rn +Rse \quad (6.1.2)$$

In these equation, R1, R2, Rn are the thermal resistances of each layer and Rsi, Rse thermal resistances superficial, corresponding to theinner air and outside respectively, taken from the following table according to the position of the closing, direction of the heat flow and its situation in the building (m²K/W)

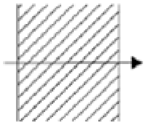
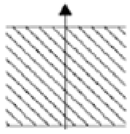
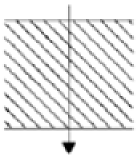
Position of the enclosure and heat flow direction		Rse	Rsi
Vertical enclousure or with a slope over the horizontal line >60° and horizontal flow		0.04	0.13
Horizontal enclousure or with slope over the horizontal line ≤60° and ascending flow.		0.04	0.10
Horizontal enclousure and downward flow		0.04	0.12

Fig. 6.1. Position of the enclosure and heat flow direction [0]

The thermal resistance of a thermally homogenous layer comes defined by the expression:

$$R = \frac{e}{\lambda} \qquad (6.1.3)$$

Being "e" the thickness of the layer (m) and "λ" the thermal conductivity of design of the material that composes the layer, calculated from values thermal declared according to the norm UNE EN ISO 10 456:2001

Calculation of U-Value:

We calculed U-Value with the following equation, and the results are shown in the tables 5 and 6.

Eq. inicial: $$\vartheta i = \theta i - U(\theta i - \theta e)Rsi \qquad (6.1.4)$$

$$\vartheta e = \theta i - U(\theta i - \theta e)\left(\frac{1}{\mu} - Rse\right) \qquad (6.1.5)$$

$$u_e = \frac{\vartheta e + \theta e}{Rse(\theta i - \theta e)} \qquad (6.1.6)$$

$$u_i = \frac{\theta i - \vartheta i}{Rsi(\theta i - \theta e)} \qquad (6.1.7)$$

U ext walls (S) $= \frac{2.2+3.2}{0.04(19.1-3.2)} = 6.18$ w/(m²*k)

Table 6.1. U-value external.

	WALLS		GLASS OF WINDOWS		METAL OF WINDOWS		SLABS	
	S (w/(m²*k))	N	S	N	S	N	E	W
U_e	6,18	7,16	5,75	6,90	5,16	6,73	11,77	13,12

U int. higher plywood panel (S) = $\frac{19.1-21.9}{0.13(19.1-3.2)} = -1.36$ w/(m²*k)

Table 6.2. U-value internal.

	HIGHER PLYWOOD PANEL		GLASS OF WINDOWS		METAL OF WINDOWS		LOWER PLYWOOD PANEL		FLOOR	
	S (w/(m²*k))	N	S	N	S	N	S	N	E	W
U_i	-1,36	-0,99	2,26	2,20	3,56	3,57	0,09	-0,24	-0,13	0,43

6.2. Calculate the flow of exhaust air volume.

In order to only obtain the maximum value of ventilation in winter if in the ventilated place we have a channel in ventilation vertical that ends up excelling over the cover, like a chimney, creating a proportional push to the height. The ventilated place is in zone of overpressure (effect chimney). If in the same time the size of opening settles down correctly and exists a great outer temperature difference and inner, the ventilation will be greater. The flow of volume of exit of air calculates with the following one formulates:

$$\tilde{V} = 3600 * \sqrt{(g \frac{\rho(ext)}{\rho(int)} * A^2 * H * \frac{\rho(ext)-\rho(int)}{\left(\frac{\rho(ext)}{\rho(int)}-1\right)+\frac{1}{2}}} \quad (6.2.1)$$

In order to calculate the flow of exhaust to air volume we know the following data:

g- it is the acceleration of the gravity, that we know that is 9.81 m/s^2

ρ- is the density of the air, this value varies depending on the temperature, reason why the density will be different in the interior and the outside of the building. The density of the air we calculated it with a simple equation:

$$\rho=\frac{351}{T°(K)} \quad (6.2.2)$$

As we indicated in the taking of data, the outer temperature is of 3,2°C (276,2K) and the inner temperature is of 19,1°C (292.1 K)

A It is the area of the section of the airway, to start off of the measurements of the planes we know that the radius of the ventilation conduit is of 5 cm.

H- It is the height of the airway, this data we obtain it from the planes, in which we observed that the ventilation conduit is to 7 meters of the ground.

Replacing all these values we obtain the following equation:

$$\tilde{V} = 3600 * \sqrt{(9.8 \frac{1.27}{1.2} * (\pi * 0.05^2)^2 * 7 * \frac{1.27-1.2}{(\frac{1.27}{1.2}-1)+\frac{1}{2}}} = 85.30 \text{ m}^3/\text{h}$$

The air flow in the library is 85.30 m^3/h.

With the following formula we are going to calculate the air flow that we needed, to see if the previous result is correct or is insufficient.

$$V_o= n *20(m^3/h)$$

n- it is the number of users of the library, we know that he is 55 since it is the number of chairs in the library.

$$V_o= 55*20(m^3/h)$$

$$V_o= 1100m^3/h$$

1100 > 85.30, reason why the air flow that circulates around the library is insufficient

6.3. Calculation of energy need for continuous heating

Heat lose through transmission and ventilation

$$\boldsymbol{H_{tr}} = \sum_i \left[\boldsymbol{b_{tr,i}} \cdot \left(\boldsymbol{A_i} \cdot \boldsymbol{U_i} + \sum_i \boldsymbol{l_i} \cdot \boldsymbol{\Psi_i}\right)\right], \qquad (6.3.1)$$

$$H_{tr,wall} = 1 \cdot (10{,}5 \cdot 6{,}18 - 14{,}85) = 50{,}04 \frac{W}{K}$$

In the table 7 we can see the calculation of the heat transfer coefficient by transmission.

Table 6.3. Heat transfer coefficient by transmission.

Nº	Partition		$A_{k,e}$ (m^2)	$U_{k,e}$ (W/m^2K)	$\Sigma\, l_{j,e}\Psi_{j,e}$ (W/K)	$b_{tr,k}$	H_{tr} (W/K)
1.	**wall**	*South*	10,50	6,18	-14,85	1,00	50,04
		North	10,50	7,16	-14,85	1,00	60,34
3.	**Windows**	*South*	33,98	5,75	0,00	1,00	195,33
		North	33,98	6,90	0,00	1,00	234,47
4.	**Metal estructural**	*South*	10,17	5,16	0,00	1,00	52,46
		North	10,17	6,73	0,00	1,00	68,43
5.	**Floor**	*East*	54,76	11,77	-0,01	0,70	451,24
		West	34,07	13,12	-0,01	0,70	312,83
						Sum	1425,15

To calculate the thermal bridges of the current state we use Therm [16], in which we can determinate the linear thermal transmittance. And with this, calculate the value of the thermal bridges, as we can see in table 8.

Table 6.4. Thermal bridges

Partition	Thermal bridge	Ψ_e [W/(m·K)]	l_e [m]	$\Psi_{ei} \cdot l_e$ [W/K]
Wall	Windows south	-0,847	17,53	-14,84791
	Windows north	-0,847	17,53	-14,84791
Floor	Floor east	-0,003	4,42	-0,01326
	Floor west	-0,003	2,75	-0,00825

To calculate the ventilation heat transfer coefficient we use the next equation:

$$H_{ve} = \rho_a \cdot c_a \cdot \sum_k (B_{ve,k} \cdot V_{ve,k,mn}) \qquad (6.3.2)$$

The building is without air tightness test, so the value of air infiltration flow is calculating by the equation:

$$V_{inf} = 0.2 \cdot \frac{(inner\ building\ volume)}{3600}$$

For our volumen (521.37 $m^{3)}$ is equal:

$$V_{inf} = \frac{0.2 \cdot 521.37}{3600} = 0.0289\, {m^3}/{s}$$

The design ventilation flow in accordance to polish standard [12] is of 20m^3/h for each person, and in the library there are 52 places and 3 workers, so:

$$V_0 = 55 \cdot 20 = 1100\, {m^3}/{h} = 0.305\, {m^3}/{s}$$

The natural ventilation

Flows share

$b_{ve,1} = 1$ for ventilation flow

$b_{v,2} = 1$ for infiltration flow

The ventilation heat transfer coefficient is equal:

$$H_{Ve} = 1200 \cdot (1 \cdot 0{,}0289 + 1 \cdot 0{,}305) = 400{,}68\, {W}/{K}$$

The heat losses through transmission and ventilation

To calculate the total heat losses we have to add Q_{tr} more Q_{ve}

$$Q_{H,ht} = Q_{tr} + Q_{ve}, {kWh}/{month}$$

$$Q_{tr} = H_{tr}(\theta_{int,H} - \theta_e)t_M \cdot 10^{-3}, {kWh}/{month}$$

$$Q_{ve} = H_{ve}(\theta_{int,H} - \theta_e)t_M \cdot 10^{-3}, {kWh}/{month}$$

The total heat transfer coefficient

$$H = H_{tr} + H_{ve} = 1425{,}15 + 400{,}68 = 1825.83\, {W}/{K}$$

The set point temperature for heating is 20℃, according toTable B.1. [39].

The external air temperature (average monthly value): www.mi.gov.pl

The average monthly external air temperature for March is 4℃

The number of hours in March is $t_M = 31 \cdot 24 = 744h$

The heat losses through transmission and ventilation in March are:

$$Q_{tr} = 1425{,}15 \cdot (20 - 4) \cdot 744 \cdot 10^{-3} = 16965 \frac{kWh}{m - c}$$

$$Q_{ve} = 400{,}68 \cdot (20 - 4) \cdot 744 \cdot 10^{-3} = 4769{,}69 \frac{kWh}{m - c}$$

The heat gains is defined by this equation

$$Q_{H,gn} = Q_{sol} + Q_{int}, \qquad (6.3.4)$$

where the **Solar heat gains** are obtained by

$$Q_{sol} = C_i \cdot A_i \cdot g \cdot Z \cdot k_{\propto}, \qquad (6.3.5)$$

for north orientation is

$$Q_{sol} = 33{,}98 \cdot 0{,}9 \cdot 0{,}85 \cdot 1 \cdot 1 = 26 \frac{kWh}{m - c}$$

The effective solar collecting area of glazed elements is given in Table 9.

Table 6.5. Solar Heat Gain

Orientation	N	S
A_i (m^2)	33,98	33,98
C_i	0,9	0,9
g	0,85	0,85
k_α	1	1
Z	1	0.9
$A_i \cdot C_i \cdot g \cdot k_\alpha \cdot Z$ (m^2)	26,00	23.39

Solar irradiance in March is defined in Table B.1. [39].

for north is I_N_90 **45,615**$\boldsymbol{{}^{kWh}/_{m^2 m - c}}$

for south is I_S_90 **62,658**$\boldsymbol{{}^{kWh}/_{m^2 m - c}}$

In consequence, the solar gains in March is:

$$Q_{sol} = (26 \cdot 45{,}615)_N + (23{,}39 \cdot 62{,}658)_S = 2651{,}56 \ {}^{kWh}/_{m - c}$$

The **internal heat gains** are defined by the equation:

$$Q_{int} = q_{int} \cdot A_f \cdot t_M \cdot 10^{-3}, \qquad (6.3.6)$$

$$q_{int} = 6 \, {}^{W}/_{m^2}$$

$$A_f = 219{,}27 \, m^2$$

In consequence, the internal heat gains in March:

$$Q_{int} = 6 \cdot 219{,}27 \cdot 744/1000 = 978{,}82\, {}^{kWh}/_{(m-c)}$$

Total heat gains in March:

$$Q_{H,gn} = Q_{sol} + Q_{int} = 2651{,}56 + 978{,}82 = 3630{,}38\, {}^{kWh}/_{(m-c)}$$

To calculate the monthly energy needs for heating space we use the next equation

$$Q_{H,nd,n} = Q_{H,ht} - \eta_{H,gn} Q_{H,gn}, \qquad (6.3.7)$$

To obtain the internal heat capacity of the building, the equal that have to use is:

$$C_m = \sum \chi_j A_j = \sum_j \sum_i (\rho_{ij} \cdot c_{ij} \cdot d_{ij} \cdot A_j), \qquad (6.3.8)$$

But we can use simplified method in accordance to the EN ISO 13790 [0]. We determinate that our structure is of medium class, because the weight of it is not so elevate and for this, we use the next equation:

$$C_m = 165000 \cdot A_f = 165000 \cdot 219.27 = 36179550\, {}^{J}/_{K}$$

To determinate the time constant of the building:

$$\tau = \frac{C_m}{3600 \cdot (H_{tr} + H_{ve})}, \qquad (6.3.9)$$

$$\tau = \frac{36.179.550}{3600 \cdot 1825{,}83} = 5{,}5h$$

The dimensionless numerical parameter is determined by

$$a_H = a_{H,0} + \frac{\tau}{\tau_{H,0}} \qquad (6.3.10)$$

In the standard EN ISO 13790:2008 [0] we obtain the value of parameters $a_{H,0} = 1$, and $\tau_{H,0} = 15h$.

then:

$$a_H = 1 + \frac{5{,}5}{15} = 1{,}36$$

the ratio of heat gains and losses

$$\gamma_H = \frac{Q_{H,gn}}{Q_{H,ht}} = \frac{Q_S + Q_{int}}{Q_{H,ht}}, \qquad (6.3.11)$$

in March

$$\gamma_H = \frac{3630,64}{21734,69} = 0.167$$

the dimensionless gain utilization factor

if $\gamma_H = \frac{Q_{H,gn}}{Q_{H,ht}} \neq 1$ $\eta_{H,gn} = \frac{1-\gamma_H^{a_H}}{1-\gamma_H^{a_H+1}}$

if $\gamma_H = \frac{Q_{H,gn}}{Q_{H,ht}} = 1$ $\eta_{H,gn} = \frac{a_H}{a_H+1}$

in our case, $\gamma_H \neq 1$, for this reason, we have to use the next factor

$$\eta_{H,gn} = \frac{1-0,167^{1,36}}{1-0,167^{2,36}} = 0,927$$

Now we have all data that we need to calculate the monthly energy needs for heating space in March, and for these, we use the equation 6.3.7:

$$Q_{H,nd,n} = 21734,69 - (0,927 \cdot 3630,64) = 18369,87\ kWh/month$$

With this method we can know the energy that we need to continuous heating for the library in March, but we need to know the energy for all year. For this reason, we use the same method in all months, and we can see the results in the tables 6.6 and 6.7.

Table 6.6. Monthly summary (October to March)

Month	October	November	December	January	February	March
H_{tr} (W/K)	1425,15	1425,15	1425,15	1425,15	1425,15	1425,15
H_{ve} (W/K)	400,68	400,68	400,68	400,68	400,68	400,68
t_M (h)	744	720	744	744	672	744
Q_{tr} (kWh/m)	12723,75	15494,24	19085,62	20039,90	19345,57	16965,00
Q_{ve} (kWh/m)	3577,27	4356,19	5365,91	5634,20	5438,99	4769,69
$Q_{H,ht}$ (kWh/m)	16301,02	19850,43	24451,53	25674,10	24784,56	21734,69
Q_{sol} (kWh/m)	2191,96	1222,75	994,31	1321,15	1731,27	2651,82
Q_{int} (kWh/m)	978,82	947,25	978,82	978,82	884,10	978,82
$Q_{H,gn}$ (kWh/m)	3170,78	2169,99	1973,13	2299,97	2615,37	3630,64
τ (h)	5,50	5,50	5,50	5,50	5,50	5,50
a_H	1,37	1,37	1,37	1,37	1,37	1,37
γ_H	0,195	0,109	0,081	0,090	0,106	0,167
$\eta_{H,gn}$	0,912	0,957	0,970	0,966	0,958	0,927
$Q_{H,nd,n}$ (kWh/m)	13408,44	17774,72	22536,67	23451,78	22277,88	18369,87

Table 6.7. Monthly summary (April to June)

Month	April	May	June
H_{tr} (W/K)	1425,15	1425,15	1425,15
H_{ve} (W/K)	400,68	400,68	400,68
t_M (h)	720	744	720
Q_{tr} (kWh/m)	12518,53	7740,28	4207,05
Q_{ve} (kWh/m)	3519,57	2176,17	1182,81
$Q_{H,ht}$ (kWh/m)	16038,10	9916,45	5389,85
Q_{sol} (kWh/m)	3686,14	4698,59	5024,13
Q_{int} (kWh/m)	947,25	978,82	947,25
$Q_{H,gn}$ (kWh/m)	4633,39	5677,42	5971,38
τ (h)	5,50	5,50	5,50
a_H	1,37	1,37	1,37
γ_H	0,289	0,573	1,108
$\eta_{H,gn}$	0,862	0,728	0,548
$Q_{H,nd,n}$ (kWh/m)	12041,96	5784,10	2118,85

Total annual energy needs for heating space:	137764,28 kWh/year
	629,58 kWh/m^2 year

As we can see, the amount of energy that we need actually is very high, and for this reason we think that is a good idea to make an overhaul.

7. OVERHAUL DESIGN

7.1. University library proposal

After analyzing energy library, our proposal is based on the change of windows and exterior insulation. With existing materials and windows, the library spends a lot of energy, which carries a high cost of it.

We have also made a new distribution of it, without modifying the existing rooms to be spending a minimum. In this design, we take the following rooms for reuse, where the old library area is distributed differently for the maximum use of space, the office becomes a groupwork room and warehouse becomes a computers room.

7.2. Constructive memory

The current conditions of the library are defined as follows:

- Slabs: one-way horizontal 25+5 cm edge executed with simple prestressed joist with distance between axis 70 cm and concrete jack-arch brick.

- Floor: carpet of synthetic fibres, taken in contact on layer with adhesive pavement.

- Interior partitions: factory lightweight 11.5 cm thick, made of hollow ceramic bricks of 24x11.5x11 cm, rigged to rope and received with cement mortar, with joints of 1 cm thick, coated on both sides with a plaster cast of 1.5 cm thick.

- Interior carpentry: joinery plywood with frames of same material.

- Exterior carpentry: in the main hall of the library carpentry is metal with a single sheet of 6 mm thick glass, stores joinery is PVC double sheet of glass 6-12-4 with ventilation slots on the top of the frame.

- Façade: Enclosure composed of main page of factory view ½ foot of thickness, made of ceramic bricks drilled with 1.5 waterproof mortar plastering cm. thick on its inner face, with ventilated air 5 cm. thick camera, non-hydrophilic insulation inside with

50 mm thick, inner sheet extruded polystyrene of factory hollow ceramic brick of 9 cm thick, trim and gypsum plaster.

Proposal conditions:

- Slab: maintained, still with an insulating layer of expanded polystyrene (EPS) Neopor, BASF company, 10 cm thick over the entire surface of the same, including the edge beams.

- Floor: is replaced by one with the same characteristics.

- Interior partitions: maintained.

- Interior carpentry: maintained.

- Exterior carpentry: maintained on the warehouses. In the main hall is replaced by carpentry company Schüco Corona SI 82, with a depth of profiles 82 mm, 6 cameras profiles system and double glazing.

- Façade: maintained.

Graphic details concerning this memory are at Appendix E.

7.3. Construction and materials

As noted in previously made calculations, the library requires a large amount of annual energy to maintain optimum temperature conditions that generate a degree of well-being and comfort requirements of the same. This fact is given due to the geographical position of the city in which we find ourselves, and the climatic conditions of the same, as there are few hours of light and very low temperatures during the winter months, in which is given to the library their greater use. This make us see the importance of a good practice constructive, as well as the choice of building materials tailored to each situation specific.

In the case that concerns us, not knowing beforehand the characteristics of the current construction, we have the need to resort to a gathering of data about the elements already executed, in order to determine the quality of the implementation, as well as isolation, to check in that measure may improve the isolation to ensure desired conditions reducing the energy consumption in large part.

In the above-mentioned data we realize, through thermography, the low insulating capacity of the building, both in the windows as in the rest of the enclosure elements.

Faced with this prospect we are presented two possible solutions; the first would consist of the demolition of the elements of enclosure to replace them by others of greater insulating capacity and control execution to achieve ultimately a better quality constructive, with what would improve energy efficiency of building. The other option we value would be the keep the executed enclosure but improving isolation through the implementation of a new external insulation layer, and the window replacement existing for a few with better insulating characteristics. This second option is that finally we decided, that can achieve similar results, presents a number of advantages that make it more attractive for the client, as it is primarily economic and time savings.

Once determined action to carry out, only have to select material appropriate for needs to cover. In our case, we chose to coat the enclosure existing with an insulator that has ideal characteristics for our situation. The chosen insulation is Neopor [34], is an insulation from expanded polystyrene (EPS) of the BASF company, which has a low rate of thermal conductivity, which assures us of a lower heat transfer between the interior and exterior of our building. In addition to this, the Neopor system occurs in rigid panels manageable by a single operator, and measures standard, which allows a fast performance at reduced cost. This isolation, to run on the outer face, it would be coat with a plaster of gypsum, on which the desired finish can be applied.

With regard to the characteristics of the material, include a thermal conductivity of 0,037 W/mK, which generates us, for 100 mm insulation thickness, a 0.29 W/m^2K heat transmission coefficient, i.e., a high thermal insulation.

With the same idea of improving insulation, seek to replace the old current Windows for a better quality, and materials more according to the thermal conditions of the place, so propose the use of PVC frames instead of metal frames, whose heat transmission is high. In addition, we improve also the quality of the glass, including double glazing integrated within that framework. The commercial choice is a few windows of the Schüco Company [35]. Due to the difference of insolation of the different walls, not put the same solution on both sides of the library, whether that adapt the solution most appropriate for each one of them, choosing for the north face the Corona SI 82 framework, and on the South side of increased insolation, marco Corona CT 70, whose values of U are 1.1 and 1.3, respectively.

Once elected the final materials, and knowing their technical characteristics, perform calculations, in order to verify the validity of our proposal. To perform calculations, we use the method already described above, the monthly method, with the results shown in tables 7.1 and 7.2.

Table 7.1. Monthly summary (October to March)

Month	October	November	December	January	February	March
H_{tr} (W/K)	94,58	94,58	94,58	94,58	94,58	94,58
H_{ve} (W/K)	400,68	400,68	400,68	400,68	400,68	400,68
t_M (h)	744	720	744	744	672	744
Q_{tr} (kWh/m)	844,40	1028,26	1266,60	1329,93	1283,85	1125,87
Q_{ve} (kWh/m)	3577,27	4356,19	5365,91	5634,20	5438,99	4769,69
$\mathbf{Q_{H,ht}}$ (kWh/m)	4421,67	5384,45	6632,51	6964,13	6722,84	5895,56
Q_{sol} (kWh/m)	2191,96	1222,75	994,31	1321,15	1731,27	2651,82
Q_{int} (kWh/m)	978,82	947,25	978,82	978,82	884,10	978,82
$\mathbf{Q_{H,gn}}$ (kWh/m)	3170,78	2169,99	1973,13	2299,97	2615,37	3630,64
τ (h)	20,29	20,29	20,29	20,29	20,29	20,29
a_H	2,35	2,35	2,35	2,35	2,35	2,35
γ_H	0,717	0,403	0,297	0,330	0,389	0,616
$\eta_{H,gn}$	0,808	0,926	0,959	0,949	0,931	0,847
$\mathbf{Q_{H,nd,n}}$ (kWh/m)	1861,26	3374,76	4740,76	4780,65	4288,43	2819,98

Table 7.2. Monthly summary (April to June)

Month	April	May	June
H_{tr} (W/K)	94,58	94,58	94,58
H_{ve} (W/K)	400,68	400,68	400,68
t_M (h)	720	744	720
Q_{tr} (kWh/m)	830,78	513,68	279,20
Q_{ve} (kWh/m)	3519,57	2176,17	1182,81
$Q_{H,ht}$ (kWh/m)	4350,35	2689,85	1462,00
Q_{sol} (kWh/m)	3686,14	4698,59	5024,13
Q_{int} (kWh/m)	947,25	978,82	947,25
$Q_{H,gn}$ (kWh/m)	4633,39	5677,42	5971,38
τ (h)	20,29	20,29	20,29
a_H	2,35	2,35	2,35
γ_H	1,065	2,111	4,084
$\eta_{H,gn}$	0,679	0,427	0,238
$Q_{H,nd,n}$ (kWh/m)	1202,75	265,83	40,65

Total annual energy needs for heating space:	23375,08 kWh/year
	106,82 kWh/m^2 year

In the light of the results obtained, we realize not only of the validity of the proposal, but also of the great importance of a good choice of materials and a good implementation. Now live an energy crisis, which in the coming years will do more than increase, and to which we all have responsibilities that we must address and trying to solve, and improve the insulation of our buildings is a good start to reduce in good measure the energy consumption, and with this the pollution of the environment.

8. RESULTS AND DISCUSSION

Comparing the results of the calculations made in paragraph 6 with those made subsequently in the situation of the reform, we note a notable decrease of the energy required to heat the library annually. Quantifying these savings, we went from an annual consumption of 137.764,08 kW to reduced consumption of 23.375,08 kW, an annual savings of more than 80% of the energy currently consumed. This means, as shown in chart 1, which could heat the library during 5 years in case of reform with the current annual spending.

This is why we think, that although reform is a costly and annoying process generates very good benefits that they do very interesting, as it is the rapid amortization of the work, as well as the future cost savings.

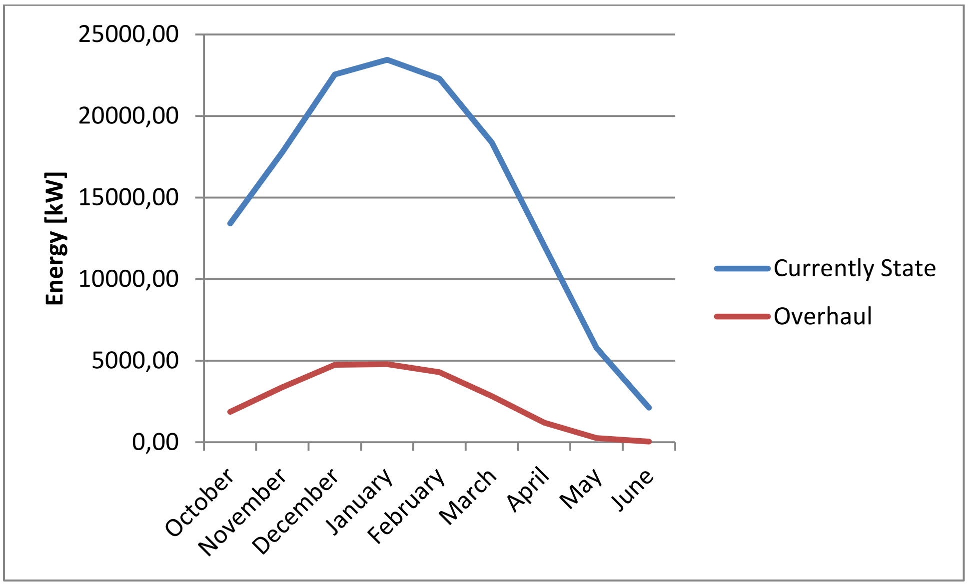


Fig. 8.1

Calculations quantify us exceptional results, so there is no place to doubt about the advantages and the convenience to undertake such reform. In addition to the calculations already shown, we can observe how work thermal bridges currently and how it will do so in the future, in the following simulations made with Therm software.

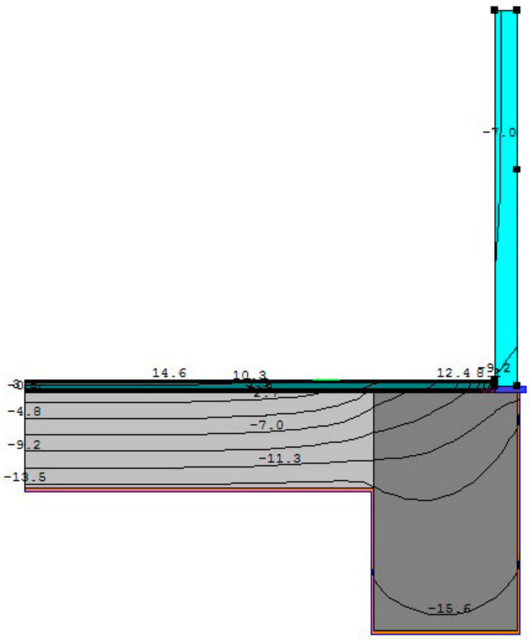


Fig. 8.2. Isotherm of current situation

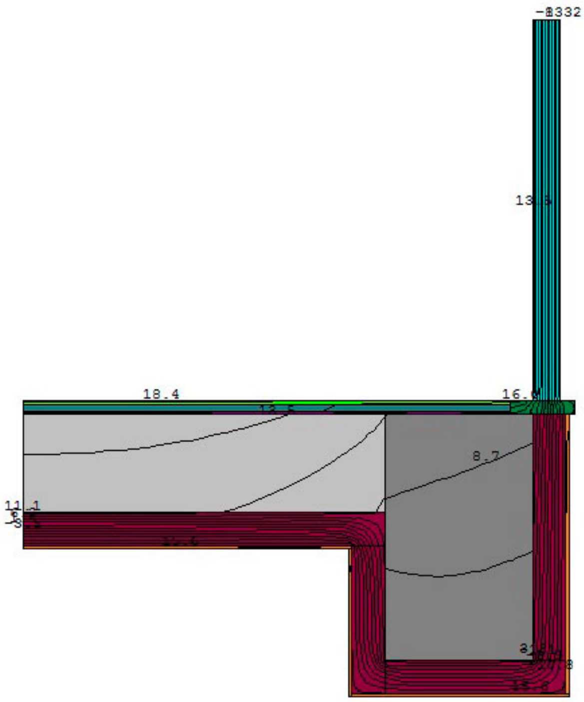


Fig. 8.3. Isotherm of overhaul design situation

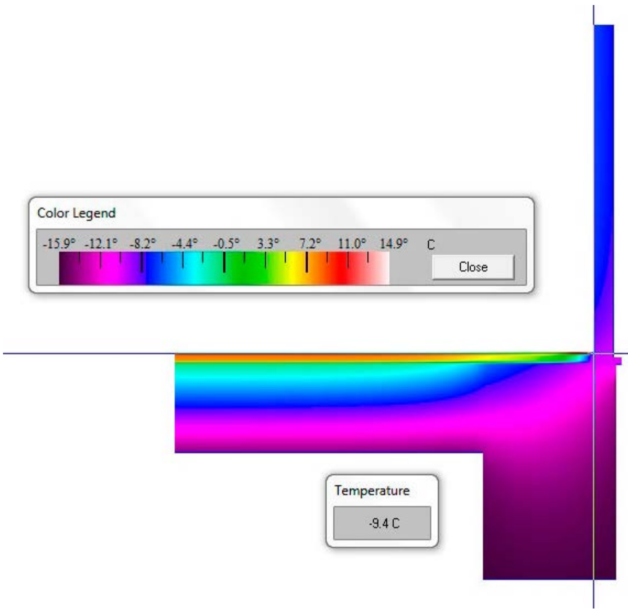


Fig. 8.4. Infrared of current situation

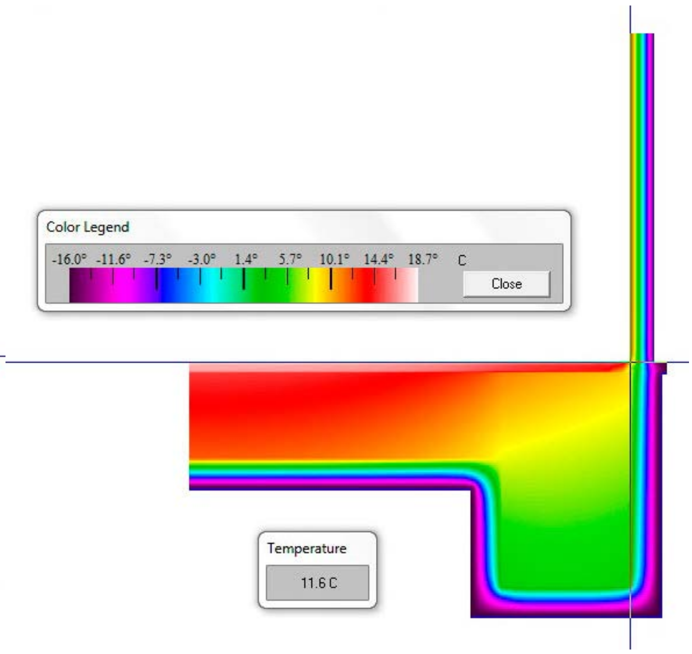


Fig. 8.5. Infrared of overhaul design situation

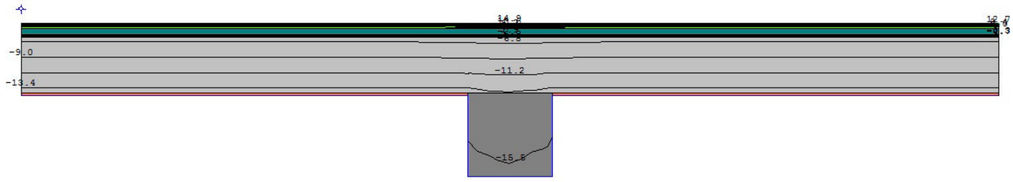


Fig. 8.6. Isotherm of current situation

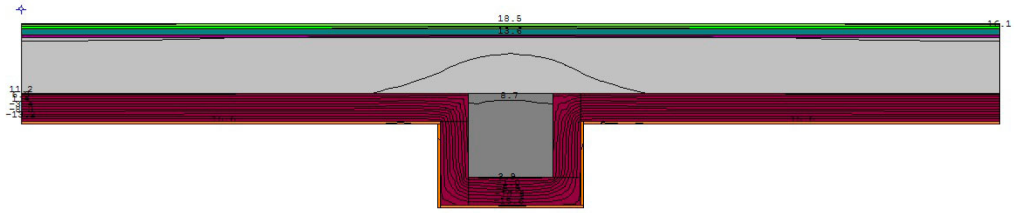


Fig. 8.7. Isotherm of overhaul design situation

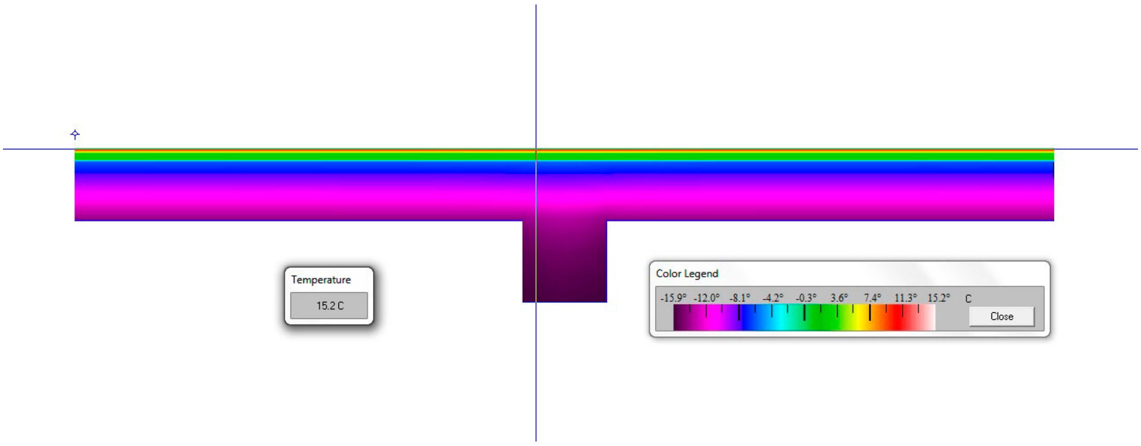


Fig. 8.8. Infrared of current situation

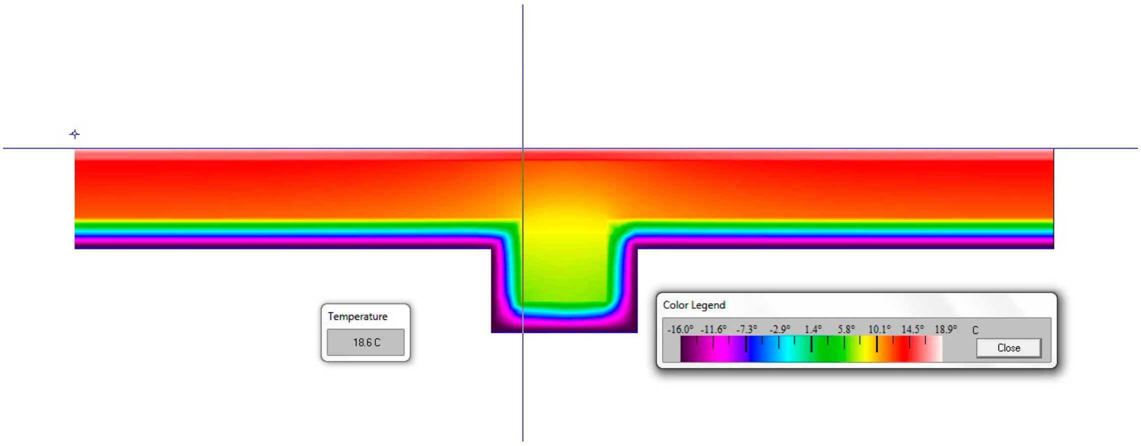


Fig. 8.9. Infrared of overhaul design situation

In these pictures we can see a comparative on the insulating capacity of the paraments between the current state and the State of reform. Is apparent the improvement of thermal bridges, since in the current state the indoor temperature is much lower than desired, due to the low insulating capacity of the materials used, while in the situation of the reform the difference between the temperature outside and inside is clearly greater, therefore getting a minor loss of heat, and thus a considerable decrease of the amount of energy needed to maintain the internal temperature.

Finally the software to analysed the building is ICEWIN2 [30], that generate reports to us for the conservation of the building and energy evaluation (ICE) with which we value other possible solutions.

ICE is a technical basis document which contains information concerning the State of conservation of the building in their common elements, as well as the energy performance of your thermal envelope (roofs, facades). The inspection allows us to verify possible injury or damage to the building at the time that analyzes the energy demand of the same in order to establish criteria to prioritize subsequent rehabilitation interventions. All this is directed to the measures of aid to be established within the framework of rehabilitation.

As objective must have qualitative information about the State of the residential park, in regard to fundamental aspects such as security, functionality and habitability, with special emphasis in regards to the energy needs of the thermal envelope of the building (roofs, facades) to ensure the optimum comfort situation, the reduction of energy consumption and CO_2 emissions in buildings.

Reports concerning this memory are in Appendix D.

9. CONCLUSIONS

We are experiencing a hard energy stage, in which we see how the demand is growing and becoming increasingly scarce as energy sources. The world must make an effort to limit their energy spending, reducing the demand to the extent possible, and replacing existing sources of energy by other renewable and environmentally friendly with the environment. Each year there are thousands of deaths related to pollution, climate change, in short, with the impact of man on the planet. This is something we must change from all areas of society, each one being aware of the responsibility we have as a society, from an individual point of view.

The construction sector is a highly polluting industry, both in the actual construction processes and in the manufacture of materials and consumption that generate the already executed buildings. Therefore believe that we must put great attention to good practice constructive, trying to make the buildings more sealed, and more efficient energy, thus reducing the impact of our profession in nature as far as possible.

With this project it gets highlighted the need for the proper execution of the construction, which can greatly reduce the energy demand of our cities.

As well as other sectors are already looking for solutions to this major problem, such as the automotive sector, the energy sector, etc. We also must do what this in our hand to make more habitable that nature has given to us and we have contaminated.

As seen in the results obtained with the ICEWIN2 software [30], the current state of the building is energetically costly, as we conclude upon completion of the consumer calculations. In the ICE report shows that the main energetic deficit is due to the current window, both for its state of repair and maintenance, and the quality of glazing.

Besides this, also proposed as a solution to increase the thickness of the enclosures of the building thermal envelope, which we improve with the use of an insulating layer.

In short, the results obtained with the ICE software are fully compatible with the solutions we provide, as can be seen with the calculations made one-off reform conditions.

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13. APPENDIXES

APPENDIX A - Wind studies

The wind rose is the time honoured method of graphically presenting the wind conditions, direction and speed, over a period of time at a specific location. To create a wind rose, average wind direction and wind speed values are logged at a site, at short intervals, over a period of time, for example 1 week, 1 month, or longer. The collected wind data is then sorted by wind direction so that the percentage of time that the wind was blowing from each direction can be determined. Typically the wind direction data is sorted into twelve equal arc segments, 30° each segment, in preparation for plotting a circular graph in which the radius of each of the twelve segments represents the percentage of time that the wind blew from each of the twelve 30° direction segments. Wind speed data can be superimposed on each direction segment to indicate, for example, the average wind speed when the wind was blowing from that segment's direction and the maximum wind speed during the logging period [33]. Data have been obtained through Autodesk® Green Building Studio® [18].

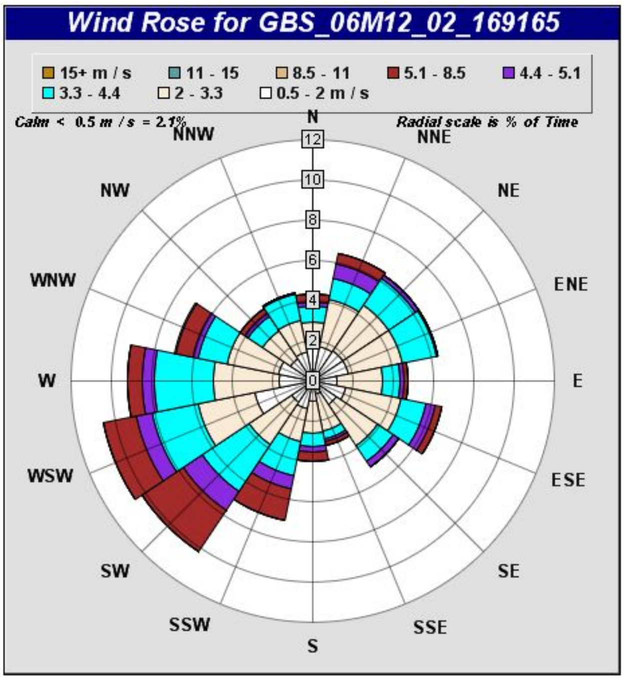


Fig. A. 1. Szczecin Wind Rose – Spring [14].

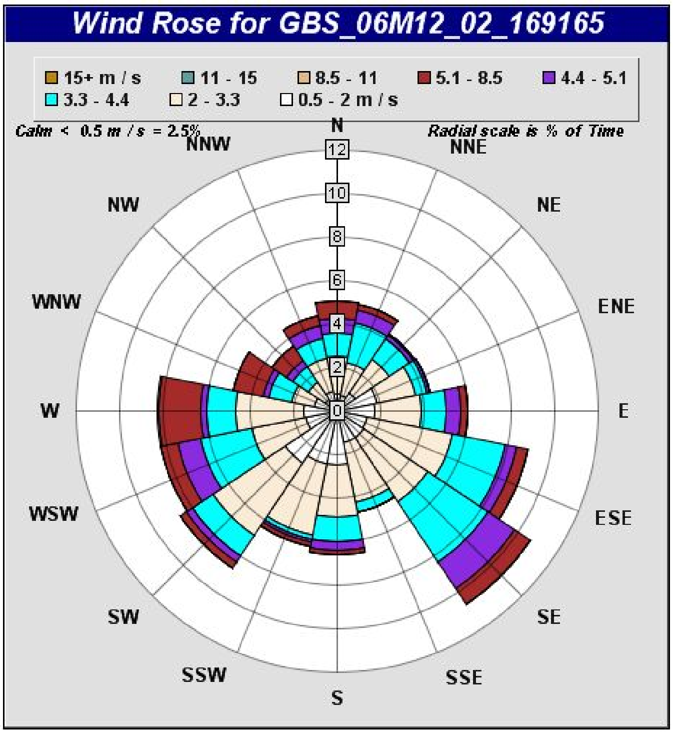


Fig. A. 2. Szczecin Wind Rose – Summer [14].

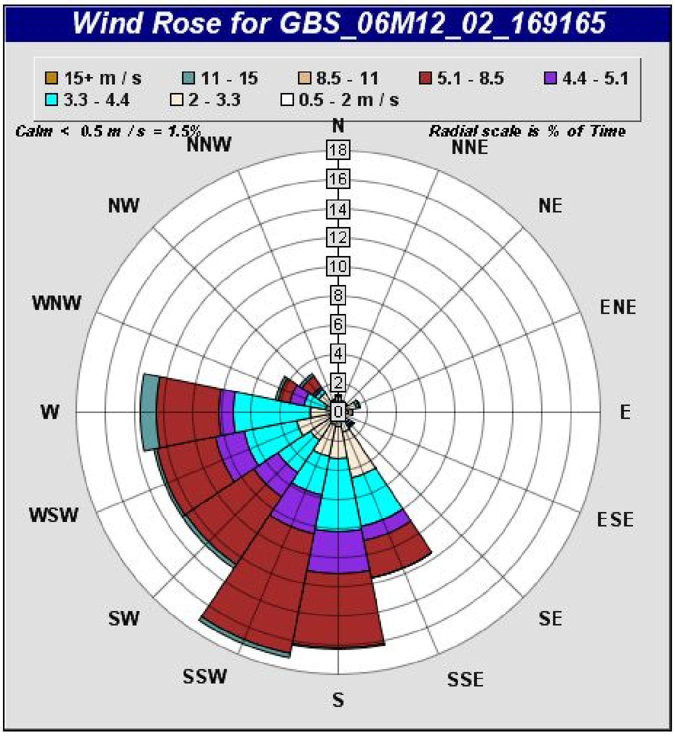


Fig. A. 3. Szczecin Wind Rose – Autumn [14].

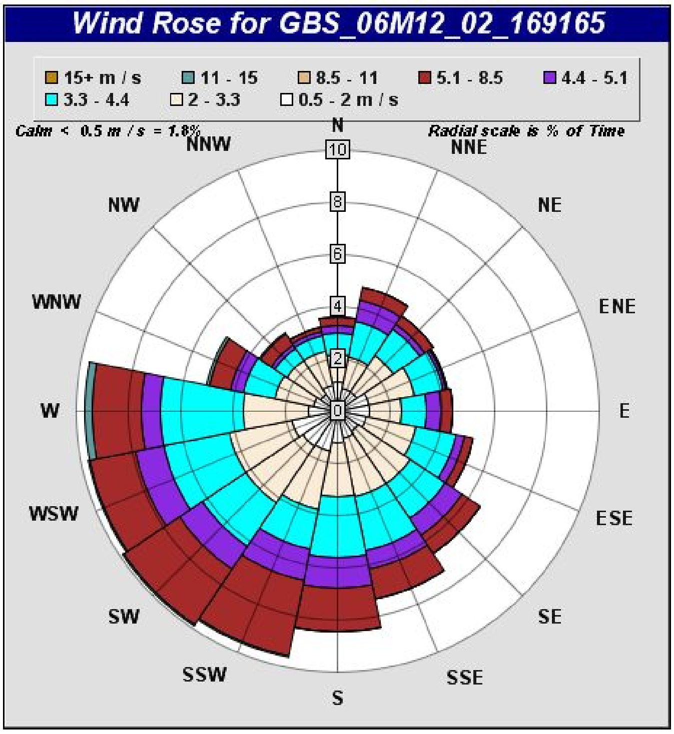


Fig. A. 4. Szczecin Wind Rose – Winter [14].

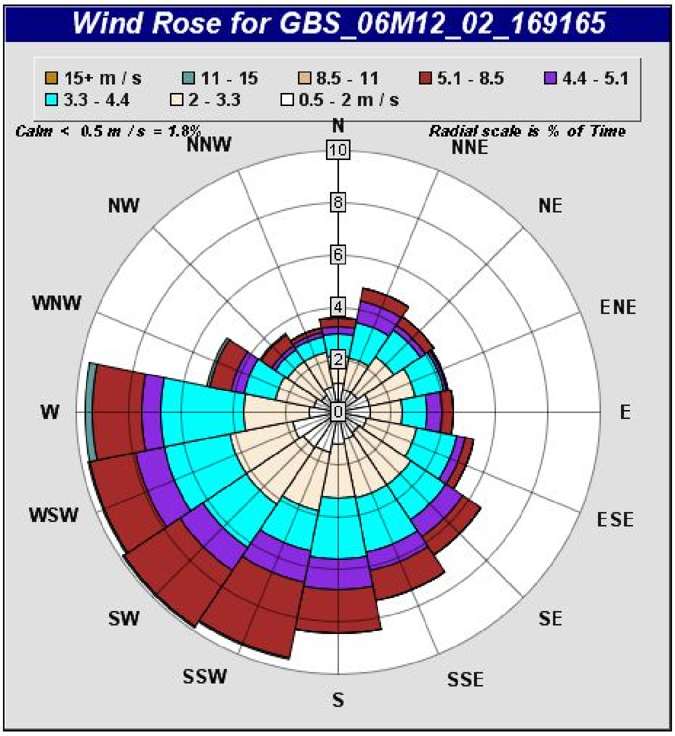


Fig. A. 5. Szczecin Wind Rose – Annual [14].

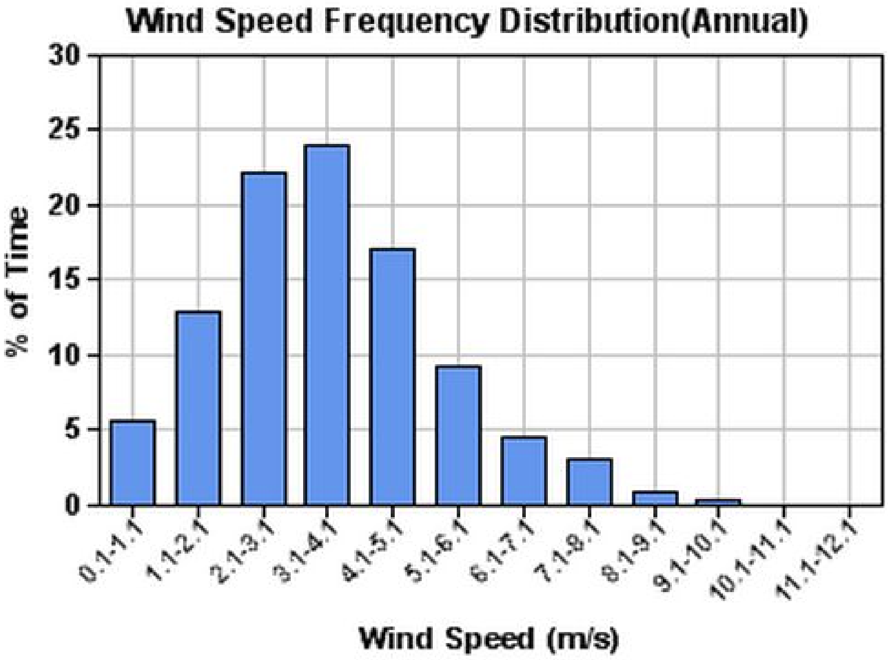


Fig. A. 6. Szczecin Wind Speed Frequency Distribution (Annual) [14].

APPENDIX B - Temperature Studies

Data have been obtained through the web page http://www.transport.gov.pl/2-48203f1e24e2f-1787735-p_1.htm [39] and the software Autodesk® Green Building Studio® [14].

Table B. 1. Typical meteorological year in Szczecin [39].

Month		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
I_N__0	$Wh/(m^2m\text{-}c)$												
I_N__90		19146	21630	45615	64219	83822	94990	97622	83993	54912	34942	19426	19041
I_NE_90		19146	21631	46273	68353	92763	100950	104079	87169	56226	34963	19426	19041
I_E__90		20900	28597	51594	76523	106130	108987	111332	95622	61415	38946	20642	19041
I_SE_90		31019	43522	59342	82867	111790	111737	113359	104197	67381	48765	27142	20632
I_S__90		35194	49963	62658	86195	107687	109192	110249	108201	69993	54862	30677	21341
I_SW_90		29968	39808	57018	86658	104468	110447	109796	104847	66136	49432	27622	20703
I_W__90		20157	25971	49746	80434	98819	108217	106791	96416	60350	39487	20981	19092
I_NW_90		19146	21630	45984	70093	89746	101150	101219	87642	55965	35062	19426	19041
Θ_e	^oC	1,1	-0,2	4	7,8	12,7	15,9	17,6	17,5	13,9	8	4,9	2
Θ_{SKY}	^oC	-8,6	-10,2	-4,9	-1,5	4,0	8,1	10,7	9,9	6,1	-1,0	-3,6	-7,0

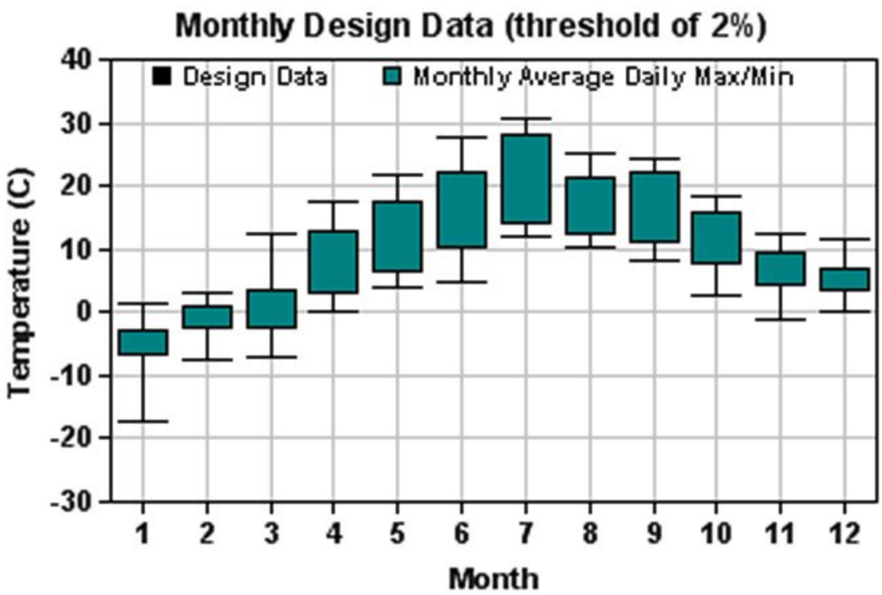


Fig. B. 1. Szczecin Monthly Design Data (threshold of 2%) [14].

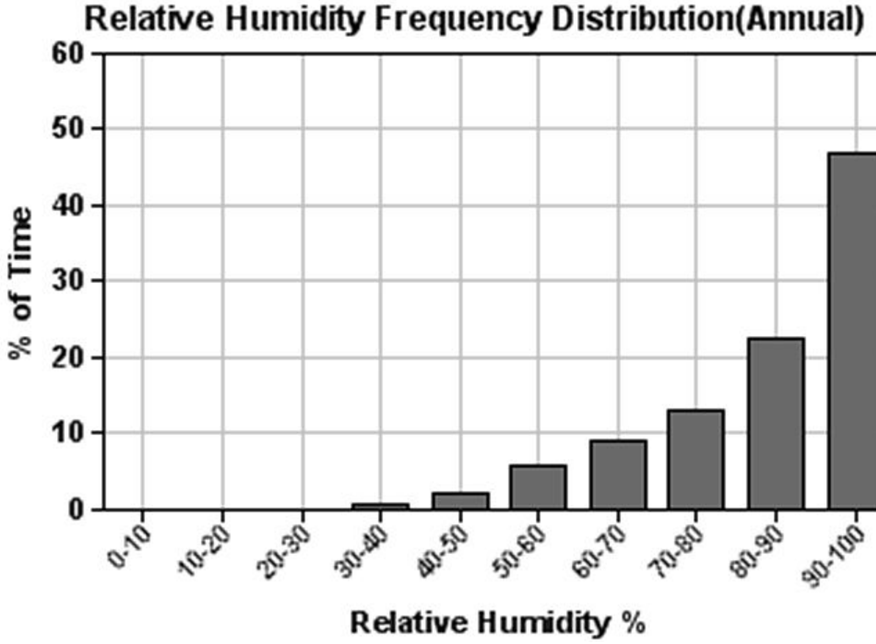


Fig. B. 2. Szczecin Monthly Design Data (threshold of 2%) [14]

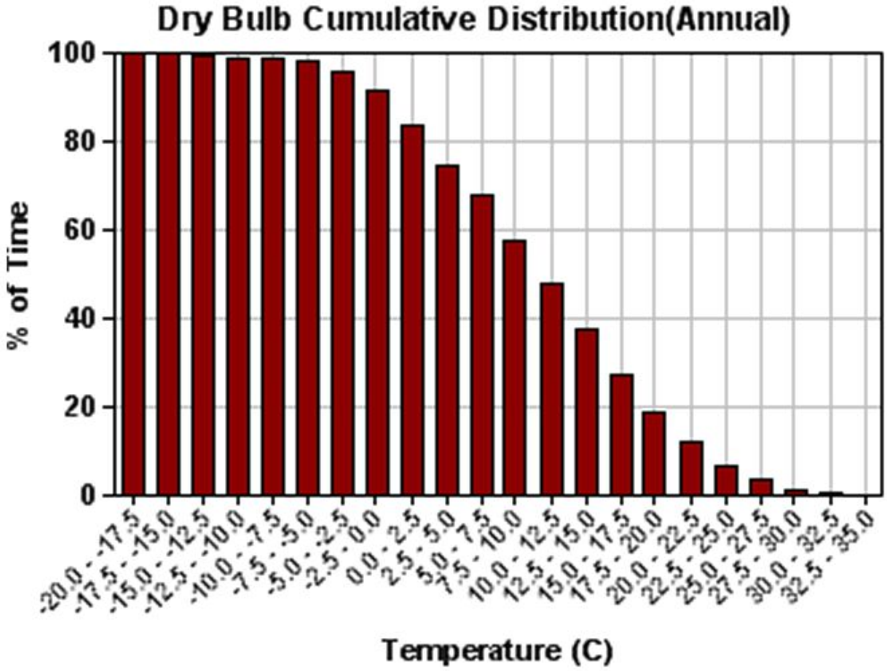


Fig. B. 3. Szczecin Dry Bulb Distribution (Annual) [14].

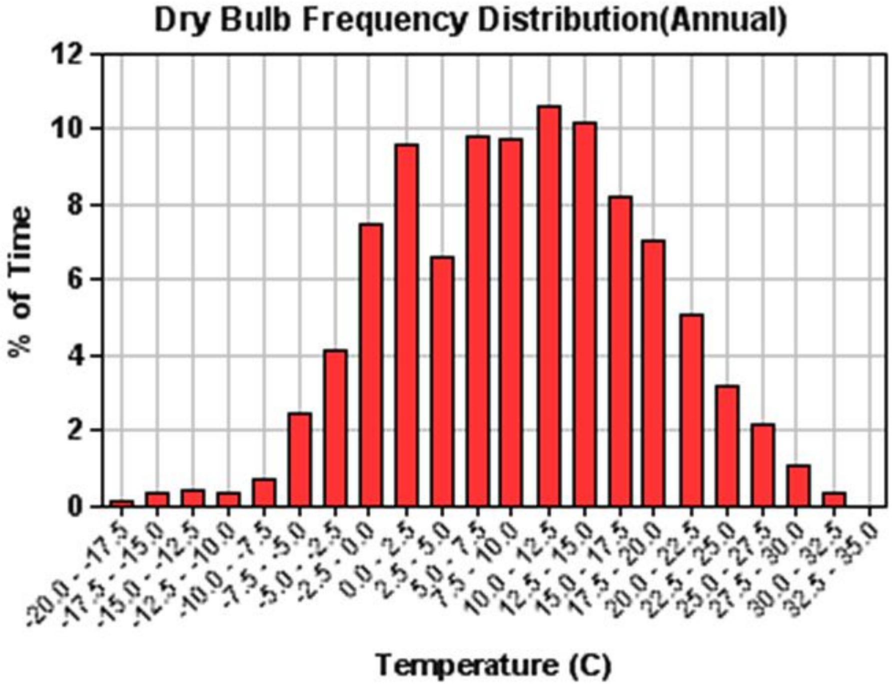


Fig. B. 4. . Szczecin Dry Bulb Frequency Distribution (Annual) [14].

APENDIX C – Solar study

Data have been obtained through Autodesk® Green Building Studio® [14].

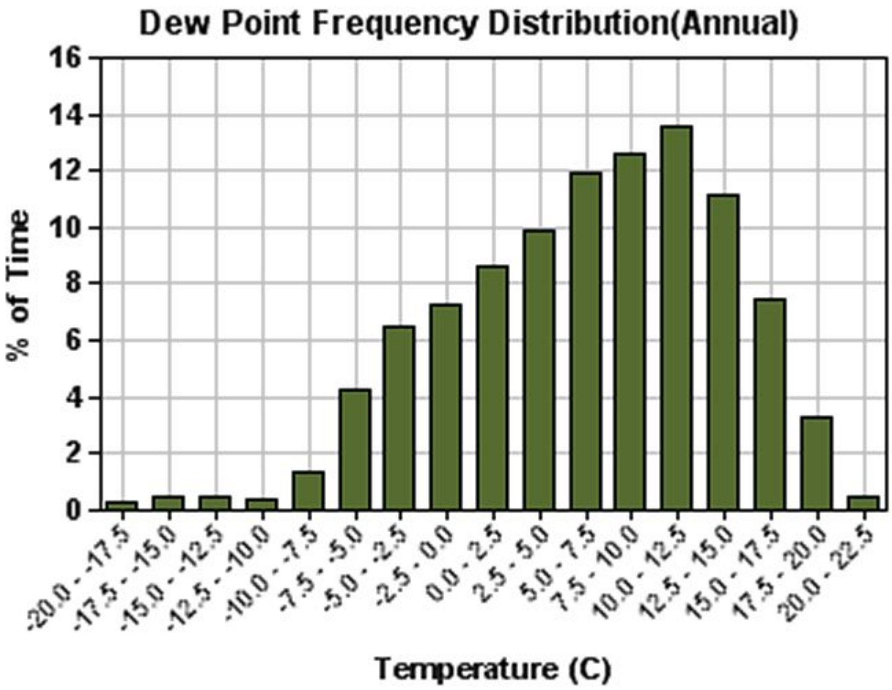


Fig. C. 1. Szczecin Dew Point Frequency Distribution (Annual) [14].

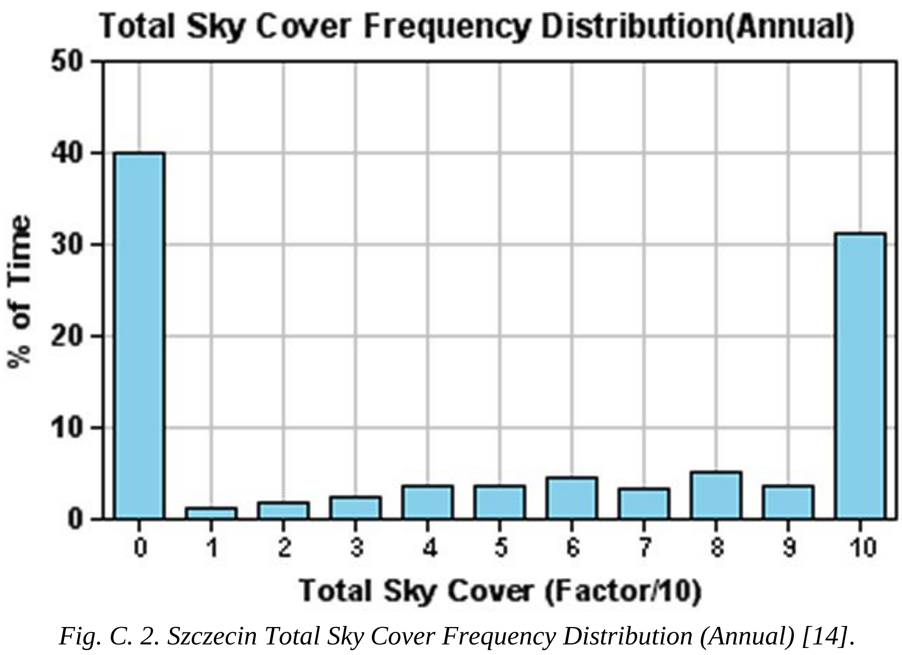


Fig. C. 2. Szczecin Total Sky Cover Frequency Distribution (Annual) [14].

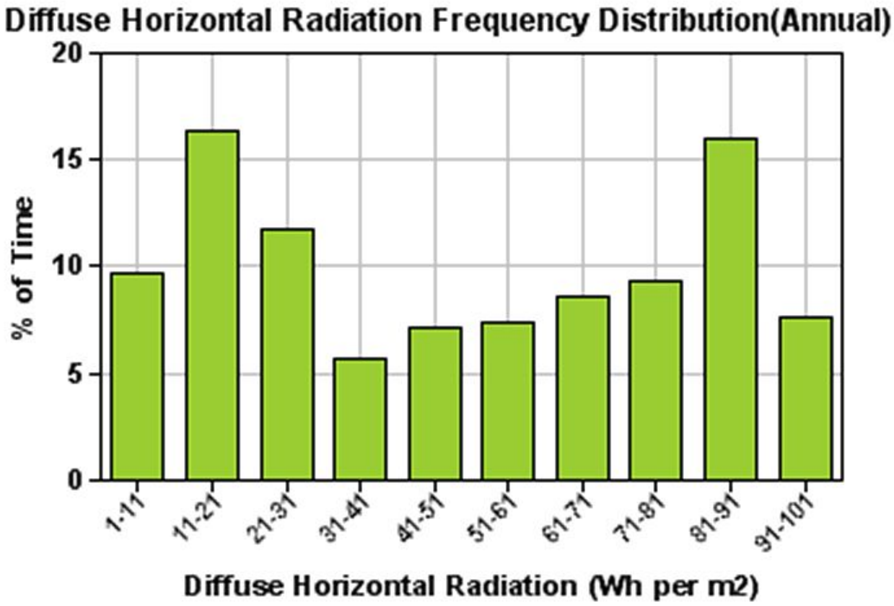


Fig. C. 3. Szczecin Diffuse Horizontal Radiation Frequency Distribution (Annual) [14].

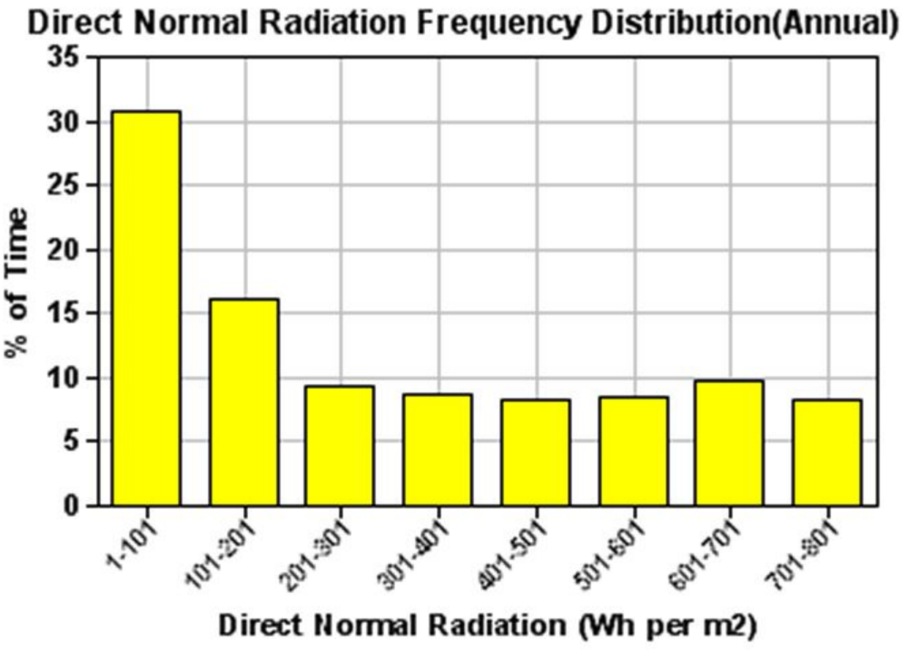


Fig. C. 4. Szczecin Direct Normal Radiation Frequency Distribution (Annual) [14].

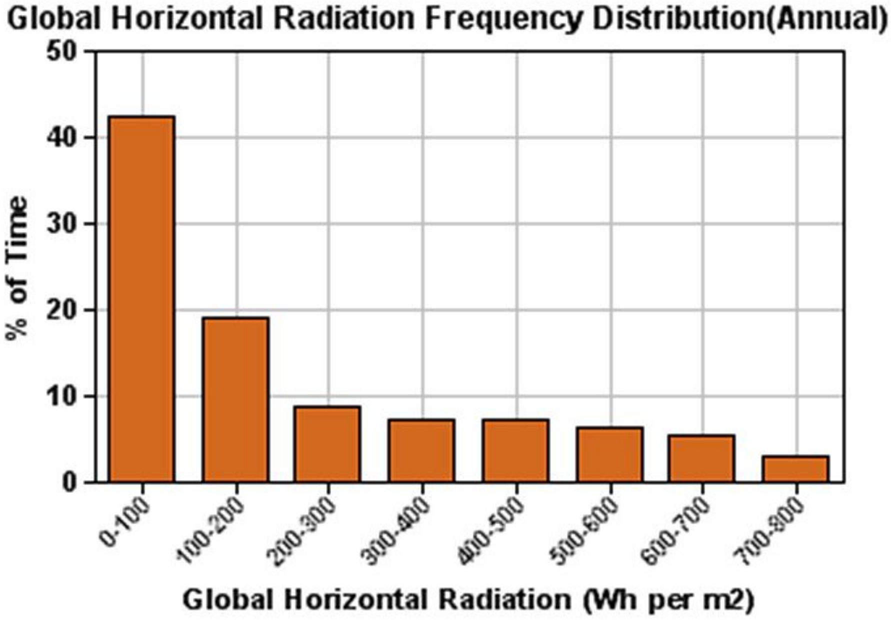


Fig. C. 5. Szczecin Global Horizontal Radiation Frequency Distribution (Annual) [14].

Autodesk® Green Building Studio® web-based energy analysis software can help architects and designers perform whole building analysis, optimize energy efficiency, and work toward carbon neutrality earlier in the design process. With faster, more accurate energy analysis of building design proposals, architects and designers can work with sustainability in mind earlier in the process, plan proactively, and build better [18].

APENDIX D – Reports of building conservation and energy assessment. ICE.

0.A. General information. Graphic Documentation
0.B. General information. Administrative Data
0.C. General information Building Description
1.A. Constructive elements. Facades
1.B. Constructive elements. Holes
1.C. Constructive elements. Other Walls
1.D. Constructive elements. Roofs
1.E. Constructive elements. Ceilings
1.F. Constructive elements. Floors
1.G. Constructive elements. Foundation and Structure
1.H. Installations
1.I. Common Areas. Accessibility
2.A. Building Inspection Final Act
2.B. Building Energy Assessment Act

FICHA NºO.B: DATOS GENERALES. DATOS ADMINISTRATIVOS.

Datos del promotor	
Nombre y Apellidos:	MªÁngeles Ortega Martínez
NIF/CIF:	48473794
Dirección:	C/ Guardia Civil Nº 21
Municipio:	VALENCIA
Código Postal:	46022
Provincia:	VALENCIA
Teléfono:	
En su condición de:	

Datos del representante	
Nombre y Apellidos:	Ricardo Frias Palenzuela
NIF/CIF:	877846558
Dirección:	C/ Larga Nº 89
Municipio:	VILLENA
Código Postal:	03639
Provincia:	ALICANTE
Teléfono:	695855585
En su condición de:	

Información administrativa del edificio	
Dirección:	aleja Piastow
Municipio:	VILLENA
Código Postal:	03639
Provincia:	ALICANTE
Tipo de promoción:	
Edificio catalogado:	N
Nivel de protección:	
Año de construcción:	1939
Número de plantas:	1
Número de viviendas:	1
Número de locales:	0
Ref. Catastral:	

Datos del inspector	
Nombre y Apellidos:	Javier Cano Catalá
Titulación:	arquitecto técnico
Nº de colegiado:	5496
Colegio profesional:	COLEGIO DE APAREJADORES DE VALENCIA
Teléfono fijo:	966666666
Teléfono móvil:	666196886
Correo:	jcanocatala@hotmail.com

FICHA Nº0.C: DATOS GENERALES. DESCRIPCIÓN DEL EDIFICIO.

Fecha de inspección:	20/03/2012

Localización		Zona climática	
Provincia	ALICANTE	Temperatura	C1
Municipio	VILLENA	Radiación	

Tipología edificatoria			
Unifamiliar	Aislada	Hasta planta baja+2	o
		A partir de planta baja+3	o
	En hilera o adosada	Hasta planta baja+2	o
		A partir de planta baja+3	o
Plurifamiliar	En bloque	Hasta planta baja+2	o
		A partir de planta baja+3	o
	Entre medianeras	Hasta planta baja+2	þ
		A partir de planta baja+3	o

Características de los tipos de viviendas y elementos comunes

Vivienda	Tipo A	Tipo B	Tipo C	Tipo D	Tipo E	Tipo F	Elementos Comunes
Número	1	0	0	0	0	0	
Superficie útil (m²)	438.24	0.0	0.0	0.0	0.0	0.0	0.0

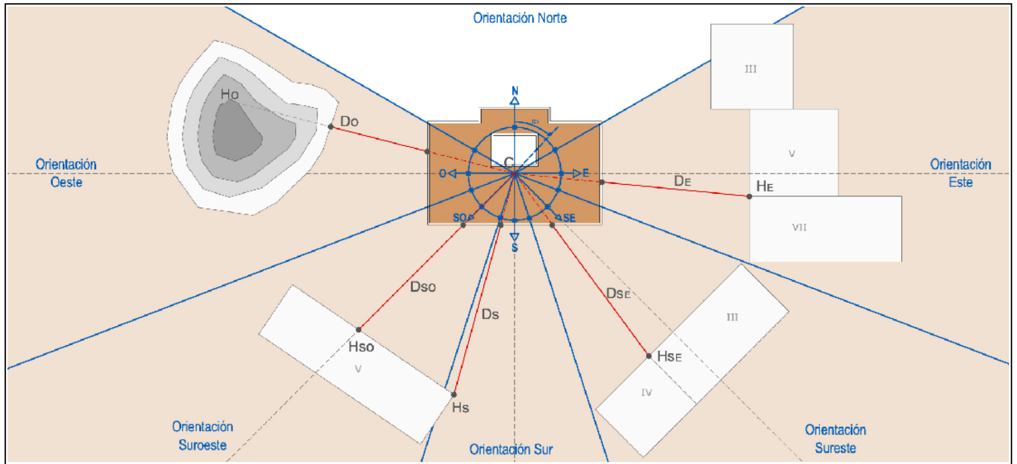
Características dimensionales del edificio	
Altura entre forjados de la planta tipo (m)	3,10
Superficie útil habitable (m²)	438,24
Volumen habitable (m³)	1358,54

Información Descriptiva del edificio

Es un edificio situado entre medioneras, se usa como biblioteca.

Características de los obstáculos del entorno

Oeste		Suroeste		Sur		Sureste		Este	
Do (m)	Ho (m)	Dso (m)	Hso (m)	Ds (m)	Hs (m)	Dse (m)	Hse (m)	De (m)	He (m)
0	0	0	0	0	0	20	24	12	15



Características de los elementos constructivos del edificio

Nº		Ubicación	Descripción/Tipo	Envolvente térmica
fachada	1	Fachada norte del edificio	IDFC03	þ
fachada	2	Fachada sur del edificio	IDFC03	þ
muro	1	muro perimetral en contacto con el terreno	IDPV03	þ
cubierta	1	En contacto con el ambiente exterior plana	IDQB09	þ
techo	1	techo de la biblioteca	ID_PH01	þ
suelo	1	suelo de la biblioteca	IDPH03	þ

Puentes térmicos del edificio

þ Valores según características constructivas

Encuentro con frente de forjado
- þ Frente de forjado no aislado
- o Frente de forjado aislado
- o Aislamiento continuo

Encuentro con pilares
- þ Encuentro con pilar no aislado
- o Encuentro con pilar aislado por el exterior
- o Encuentro con pilar aislado por el interior
- o Sin pilares

o Valores por defecto del LIDER

Equipos de ACS en el edificio

þ Caldera convencional

o Carbón 

þ Biomasa 

o Gas natural 

o Gasóleo 

o GLP 

o Bomba de calor aire-agua 

o Térmo eléctrico 

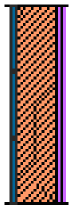
ESCALERA 1

Nº de viviendas y locales sobre rasante	1	Nº de plantas	1	Nº de unidades de inspección	1
Nº de viviendas	1	Nº de plantas sobre rasante	1	Nº de unidades Inspeccionadas	1
Nº de locales	0	Nº de plantas bajo rasante	0		

Identificación	biblioteca											
Planta	1											
Uso	Otros											

FICHA Nº1.A: ELEMENTOS CONSTRUCTIVOS. FACHADAS.

Nº	UBICACIÓN
1	Fachada norte del edificio
¿La fachada forma parte de la envolvente térmica del edificio?	SI þ NO o

Tipo	Elemento a inspeccionar	Orientación	Área de la fachada (m²)		Transmitancia U (W/m²K)			Indicadores		Actuaciones	Ref. fotográfica
			Área total sin huecos	Área fuera del primer plano sin huecos	Fachada	CTE-HE1 Máx.	CTE-HE1 Media	ID	EC	AP	
Ext  IDFC003	FACHADA/MEDIANERÍA	Norte	20,158		3,25	0,95	0,73				
	Soporte							2	0	MNT	
	Acabado exterior							2	1	INTm	FA001
	Elementos singulares O - Otros							1	0	MNT	
	Carpintería							3	2	INTu	FA002
Observaciones	La mayor parte de la fachada está formada por la carpintería, la cual esta en muy mal estado de conservación										

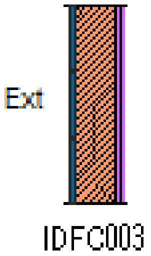
Elemento a inspeccionar	Lesiones y síntomas
Acabado exterior	mal estado del revestimiento
Carpintería	marcos y cristales rotos

Transmitancia	þ Valores estimados	þ Una hoja ligera	o Doble hoja	o Una hoja pesada

FICHA Nº1.A: ELEMENTOS CONSTRUCTIVOS. FACHADAS.

Nº	UBICACIÓN
2	Fachada sur del edificio

¿La fachada forma parte de la envolvente térmica del edificio? SI þ NO o

Tipo	Elemento a inspeccionar	Orientación	Área de la fachada (m²)		Transmitancia U (W/m²K)			Indicadores		Actuaciones	Ref. fotográfica
			Área total sin huecos	Área fuera del primer plano sin huecos	Fachada	CTE-HE1 Máx.	CTE-HE1 Media	ID	EC	AP	
	FACHADA/MEDIANERÍA	Sur	20,158	10,25	3,25	0,95	0,73				
	Soporte							1	0	MNT	
	Acabado exterior							2	1	INTm	FA003
	Elementos singulares O - Otros							1	0	MNT	
	Carpintería							3	2	INTu	
Observaciones											

Elemento a inspeccionar	Lesiones y síntomas
Acabado exterior	mal estado del revestimiento
Carpintería	marcos y cristales rotos

Transmitancia	þ Valores estimados	þ Una hoja ligera	o Doble hoja	o Una hoja pesada

FICHA Nº1.B: ELEMENTOS CONSTRUCTIVOS. HUECOS.

Identificación ventana/ puerta				Características			Transmitancia U (W/m²K)		Dimensiones	
Nº	Nº grupos iguales	Ubicación: Fachada	Ubicación: Orient.				Ventana/ puerta	CTE-HE1 Máxima		
1	18	1	N	Carpintería	Material	ML	5,70	4,40	Nº huecos grupo	18
					Permeabilidad	146,00			S(m)	2,20
					Fracción de marco (%)	10			Ancho(m)	0,87
				Vidrio	Tipo	MN	5,70	4,40	Alto(m)	2,53
					Espesor (mm)	6			Retranqueo(m)	0
					Factor solar	0,85			OD(m)	0
				Hueco			5,70		OB(m)	0

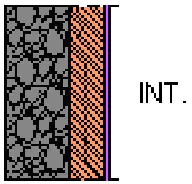
Factores modificadores						
Caja de persiana	Sombras eltos. fijos	Sombras por obstáculos remotos o del propio edificio				
SP - Sin caja de persiana	Sin elementos fijos	do	dso	ds	dse	de
		ho	hso	hs	hse	he
Ref. fotográfica						
FA001						

Identificación ventana/ puerta				Características			Transmitancia U (W/m²K)		Dimensiones	
Nº	Nº grupos iguales	Ubicación: Fachada	Ubicación: Orient.				Ventana/ puerta	CTE-HE1 Máxima		
2	18	2	S	Carpintería	Material	ML	5,70	4,40	Nº huecos grupo	18
					Permeabilidad	146,00			S(m)	2,2
					Fracción de marco (%)	10			Ancho(m)	0,87
				Vidrio	Tipo	MN	5,70	4,40	Alto(m)	2,2
					Espesor (mm)	6			Retranqueo(m)	0
					Factor solar	0,85			OD(m)	0
				Hueco			5,70		OB(m)	0

Factores modificadores						
Caja de persiana	Sombras eltos. fijos	Sombras por obstáculos remotos o del propio edificio				
SP - Sin caja de persiana	Sin elementos fijos	do	dso	ds	dse	de
		ho	hso	hs	hse	he
Ref. fotográfica						
FA003						

FICHA Nº1.C: ELEMENTOS CONSTRUCTIVOS. OTROS MUROS.

Nº	UBICACIÓN
1	muro perimetral en contacto con el terreno

Tipo	Elemento a inspeccionar	Situación del muro		Área del muro (m²)	Transmitancia U (W/m²K)			Indicadores		Actuaciones	Ref. fotográfica
					Muro	CTE-HE1 Máx.	CTE-HE1 Media	ID	EC	AP	
 IDPV003	Muro	En contacto con el terreno		194,8	1,20	0,95	0,73	0	0	MNT	
		En contacto con espacios no habitables	habitable/ no habitable								
			no habitable/ exterior								
		Adiabático/ medianería									
Observaciones											
Sintomas y lesiones	no presenta lesiones										

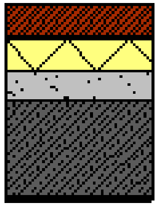
Dimensiones del muro en contacto con el terreno	
Profundidad Z (m)	4,87

Transmitancia	þ Valores estimados	þ En contacto con el terreno

FICHA Nº1.D: ELEMENTOS CONSTRUCTIVOS. CUBIERTAS.

Nº	UBICACIÓN
1	Cubierta del edificio (plana , transitable)

¿La cubierta forma parte de la envolvente térmica del edificio? SI þ NO o

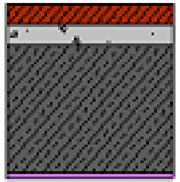
Tipo	Elemento a inspeccionar	Situación de la cubierta			Área de la cubierta (m²)		Transmitancia U (W/m²K)			Indicadores		Actuaciones	Ref. fotográfica
					Área total sin huecos	Área en sombra	Cubierta	CTE-HE1 Máx.	CTE-HE1 Media	ID	EC	AP	
ID QB09 	CUBIERTA	En contacto con el ambiente exterior	Plana		438,24	312,58	1,90	0,53	0,41				
			Inclinada	Norte									
				Oeste									
				Suroeste									
				Sur									
				Sureste									
				Este									
		En contacto con espacio no habitable		habitable/ no habitable									
				no habitable/ exterior									
	Soporte									0	0	MNT	
	Material de cubrimiento									1	1	INTm	
	Impermeabilización									0	0	MNT	
	Recogida de Aguas									0	0	MNT	
	Elementos Singulares												
Observaciones	La cubierta es plana, convencional y transitable. Se encuentra en buen estado de conservación												

Elemento a inspeccionar	Lesiones y síntomas
Soporte	buen estado
Material de cubrimiento	deterioro a causa de condiciones ambientales y uso
Impermeabilización	no presenta lesiones
Recogida de Aguas	se encuentra en buen estado

Transmitancia	þ Valores estimados	þ No ventilada	o Ventilada

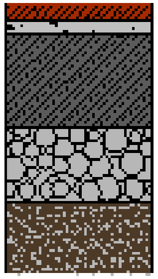
FICHA Nº1.E: ELEMENTOS CONSTRUCTIVOS. TECHOS.

Nº	UBICACIÓN
1	techo de la biblioteca

Tipo	Elemento a inspeccionar	Situación del techo	Área del techo (m²)	Lesiones y síntomas	Indicadores		Actuaciones	Ref. fotográfica
					ID	EC	AP	
ID_PH01 	Techo	Adiabático	438,24	despreciables	0	0	MNT	
Observaciones								

FICHA Nº1.F: ELEMENTOS CONSTRUCTIVOS. SUELOS.

Nº	UBICACIÓN
1	suelo de la biblioteca

Tipo	Elemento a inspeccionar	Situación del suelo		Área del suelo (m²)	Transmitancia U (W/m²K)			Indicadores		Actuaciones	Ref. fotográfica
					Suelo	CTE-HE1 Máx.	CTE-HE1 Media	ID	EC	AP	
ID_PH03 	Suelo	Apoyados sobre el terreno		438,24	0,85			1	2	INTm	
		En contacto con el ambiente exterior									
		En contacto con vacío sanitario									
		En contacto con espacios no habitables	habitable/ no habitable								
			no habitable/ exterior								
		Adiabático									
Observaciones	el pavimento de la biblioteca esta cubierto con moqueta, la cual se encuentra en mal estado por lo que es necesario sustituirla por otra										
Lesiones y síntomas	mal estado moqueta										

Dim. suelo apoyado sobre el terreno	
Profundidad (m)	438,24
Perímetro ext. (m)	40

Transmitancia	þ Valores estimados	þ Apoyados en el terreno

FICHA Nº 1.G: ELEMENTOS CONSTRUCTIVOS. CIMIENTOS Y ESTRUCTURA

¿Es necesario efectuar una inspección de profundización IPE por técnico especialista? SI o NO o

Elemento a inspeccionar				Ubicación	Material	Lesiones y síntomas	Indicadores ID	Indicadores EC	Actuaciones AP	Ref. fotográfica
En contacto con terreno	Cimientos	Superficial	Zapatas							
En contacto con terreno	Cimientos	Superficial	Losas		HA	no hay lesiones importantes	0	0	MNT	
En contacto con terreno	Cimientos	Semi-profunda	Pozos							
En contacto con terreno	Cimientos	Profunda	Pilotes							
En contacto con terreno	Cimientos	Muros			HA	no hay lesiones importantes	0	0	MNT	
En contacto con terreno	Solera				HA	no hay lesiones importantes	0	0	MNT	
En contacto con terreno	Forjado sanitario									
En contacto con terreno	Tierra apisonada									
Estructura	Vertical	Muro de carga¹								
Estructura	Vertical	Muro de carga²								
Estructura	Vertical	Pilares¹		norte	HA	no hay lesiones importantes	0	0	MNT	
Estructura	Vertical	Pilares²		sur	HA	no hay lesiones importantes	0	0	MNT	
Estructura	Vertical	Otros¹								
Estructura	Vertical	Otros²								
Estructura	Horizontal / inclinada	Vigas¹								
Estructura	Horizontal / inclinada	Vigas²								
Estructura	Horizontal / inclinada	Forjados	Unidireccional¹		HA	no hay lesiones importantes	0	0	MNT	
Estructura	Horizontal / inclinada	Forjados	Unidireccional²							
Estructura	Horizontal / inclinada	Forjados	Unidireccional³							
Estructura	Horizontal / inclinada	Forjados	Reticular							
Estructura	Horizontal / inclinada	Forjados	Losa¹							
Estructura	Horizontal / inclinada	Forjados	Losa²							
Estructura	Horizontal / inclinada	Otros¹								
Estructura	Horizontal / inclinada	Otros²								
Estructura	Escalera									
Estructura	Otros									
Observaciones										

FICHA Nº 1.H: INSTALACIONES.

SUMINISTRO DE AGUAS

¿Los contadores están centralizados? o SI o NO

Elemento a inspeccionar		Ubicación	Lesiones y síntomas	Indicadores ID	Indicadores EC	Actuaciones AP	Ref. fotográfica
Suministro de aguas	Contadores			0	0	MNT	
	Red						
	Otros						
Observaciones							

EVACUACIÓN DE AGUAS

Elemento a inspeccionar		Ubicación	Lesiones y síntomas	Indicadores ID	Indicadores EC	Actuaciones AP	Ref. fotográfica
Evacuación de aguas	Red	Baños	no hay lesiones importantes	0	0	MNT	
	Arquetas		no hay lesiones importantes	0	0	MNT	
	Sumideros		no hay lesiones importantes	0	0	MNT	
	Otros						
Observaciones							

SUMINISTRO ELÉCTRICO

¿Los contadores están centralizados? þ SI o NO

Elemento a inspeccionar		Ubicación	Lesiones y síntomas	Indicadores ID	Indicadores EC	Actuaciones AP	Ref. fotográfica
Suministro eléctrico	Contadores	cuarto de contadores		0	0	MNT	
	Red						
	Otros						
Observaciones							

FICHA Nº 1.I: ESPACIOS COMUNES. ACCESIBILIDAD.

A) CROQUIS / PLANO ACOTADO DE LAS CONDICIONES DE ACCESIBILIDAD. Desde la vía pública al acceso a las viviendas.

B) RECORRIDO EXISTENTE.

B.1. Desplazamientos verticales

Existencia de desnivel desde la calle hasta la cota de acceso al ascensor:	SI	Ref. fotográfica
En caso de existencia de desnivel, se salva con:	Hay escaleras pero no hay rampa	
Altura a salvar (m):	2	

Existencia de ascensor	SI	Ref. fotográfica
En caso de existencia de ascensor: Dimensión hueco de acceso (m):	1,2	
Dimensión ancho cabina (m):	1,5	
Dimensión profundidad cabina (m):	1,5	

Existencia de escalera	SI	Ref. fotográfica
Dimensiones: Ancho de escalera (m): (1)	1,5	
Dimensión de huella (m):	0,3	
Dimensión de contrahuella (m):	017	

B.2. Desplazamientos horizontales

Pasos y espacios de maniobra		Ref. fotográfica
Dimensiones diámetros inscribibles: Contiguo a puerta de acceso (m):	1,20	
Cambios de dirección (m): (2)	1,20	
Frente al hueco de ascensor (m):	1,50	
Anchos de pasos: Zaguán y pasillos (m): (3)	2	
Estrangulamientos (m):	1,50	

C) En caso de AUSENCIA DE ASCENSOR.

Posibilidad de instalación de ascensor		Ref. fotográfica
Ubicación posible: (4)		
En caso de posible ubicación en hueco de escalera: Ancho de hueco(m):		
Profundidad de hueco(m):		

D) INTERVENCIÓN NECESARIA PARA SALVAR LAS BARRERAS ARQUITECTÓNICAS. (5)

O Supresión de barreras

O Adecuación ascensor

O Colocación de ascensor

OBSERVACIONES

AYUDA

(1) El ancho útil del tramo se establecerá de acuerdo con las exigencias del CTE.
(2) En el supuesto de que hayan varios cambios de dirección se hará constar la situación más desfavorable.
(3) En el supuesto de que hayan varios anchos de paso se hará constar la situación más desfavorable.
(4) Ubicación posible:
- H: Hueco de escalera
- P: Patio de luces
- O: Ocupación espacio privativo
- F: Por fachada exterior

(5) Pueden marcarse una o dos intervenciones.

FICHA Nº 2.A: ACTA FINAL DE INSPECCIÓN DEL EDIFICIO

RESUMEN DE LAS ACTUACIONES Y PLAZOS PROPUESTOS EN CADA UNOS DE LOS ELEMENTOS CONSTRUCTIVOS E INSTALACIONES.

E.	Nº	Ubicación	Actuaciones y plazos-AP								Transmitancia U(W/m²K)			Observaciones
			Componentes del elemento constructivo						Por elemento construc. individual	Por elemento construc. global	Edificio	CT-HE1		
			Soporte	Acabado exterior	Elementos singulares	Carpintería	Imperm.	Recogida de aguas				media	máx.	
Fachadas	1	Fachada norte del edificio	MNT	INTm	MNT	INTu					3,25	0,73	0,95	
Fachadas	2	Fachada sur del edificio	MNT	INTm	MNT	INTu					3,25	0,73	0,95	
Otros muros	1	muro perimetral en contacto con el terreno	MNT								1,20	0,73	0,95	
Cubiertas	1	En contacto con el ambiente exterior plana	MNT	INTm			MNT	MNT			1,90	0,41	0,53	
Techos	1	techo de la biblioteca	MNT											
Suelos	1	suelo de la biblioteca	INTm								0,85			

Elementos constructivos					Actuaciones y plazos- AP
Componentes del elemento constructivo	En contacto con terreno	Cimientos	Superficial	Zapatas	
				Losas	MNT
			Semiprofunda	Pozos	
			Profunda	Pilotes	
			Muros		MNT
		Solera			MNT
		Forjado sanitario			
		Tierra apisonada			
	Estructura	Vertical	Muro carga 1		
			Muro carga 2		
			Pilares 1		MNT
			Pilares 2		MNT
			Otros 1		
			Otros 2		
		Horizontal	Vigas 1		
			Vigas 2		
			Forjado	Unidireccional 1	MNT
				Unidireccional 2	
				Unidireccional 3	
				Reticular	
				Losa 1	
				Losa 2	
			Otros 1		
			Otros 2		
		Escalera			
		Otros			
Por elemento constructivo global					
Observaciones					

Instalaciones	Actuaciones y plazos-AP		
	Suministro de aguas	Evacuación de aguas	Suministro eléctrico
Contadores	MNT		MNT
Red		MNT	
Arquetas		MNT	
Sumideros		MNT	
Otros			
Por instalación			
Observaciones de suministro de aguas			
Observaciones de evacuación de aguas			
Observaciones de suministro eléctrico			

ORDEN DE INTERVENCIÓN

Elementos		AP-Actuaciones y plazos	Orden de intervención
Elementos Constructivos	Fachadas		0
	Otros muros		0
	Cubiertas		0
	Techos		0
	Suelos		0
	Cimentos y estructura		0
Instala-ciones	Suministro de aguas		0
	Evacuación de aguas		0
	Suministro eléctrico		0
Espacios comunes. Accesibilidad			0

¿Se ha realizado alguna intervención o se está llevando a cabo algún tipo de obra de rehabilitación en los elementos comunes del edificio?

o SI

þ NO

En caso afirmativo, detallar cual:

Justificación de los criterios seguidos para establecer el orden de intervención

Tras haberse realizado la inspección ¿Presenta el edificio objeto, situación de riego inminente?

o SI

þ NO

En caso afirmativo, cumplimentar la COMUNICACIÓN DE ESTADO DE RIESGO INMINENTE TRAS LA INSPECCIÓN DEL INFORME DE CONSERVACIÓN DEL EDIFICIO (ICE)

En caso afirmativo, indicar debido a que:

FICHA Nº 2.B: ACTA EVALUACIÓN ENERGÉTICA DEL EDIFICIO

IDENTIFICACIÓN DEL EDIFICIO

Dirección	aleja Piastow
Localidad	VILLENA
Código Postal	03639

TIPOLOGÍA EDIFICATORIA

Plurifamiliar/Entre medianeras/Hasta PB+2

ZONA CLIMÁTICA

Temperatura	C1
Radiación	

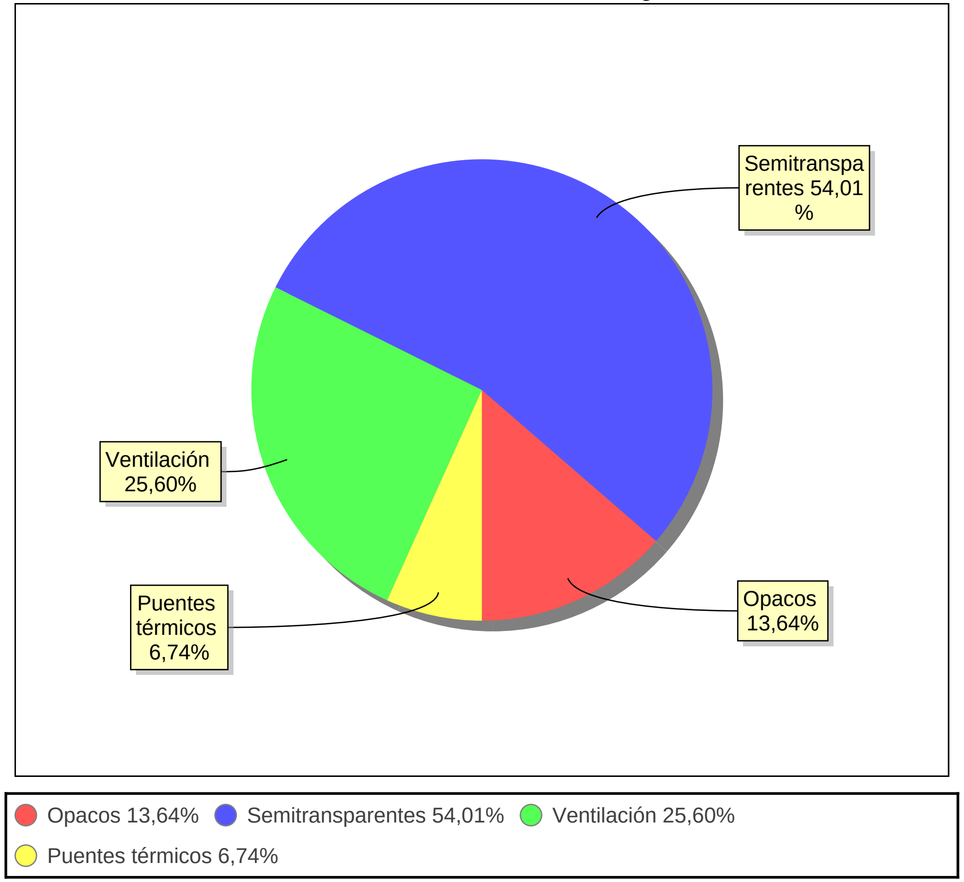
DEMANDA ENERGÉTICA Y EMISIONES CO_2

		kWh/m² año	kWh/año
Demanda	Calefacción	585,66	256.660,00
	Refrigeración	33,80	14.814,40
Consumo Energía final (*)	Calefacción	780,88	342.213,00
	Refrigeración	0,00	0,00
	ACS	17,58	7.703,34

		Kg CO_2/m² año	Kg CO_2/año
Emisiones CO_2	Calefacción	224,11	98.215,20
	Refrigeración	0,00	0,00
	ACS	0,00	0,00
	TOTALES	224,11	98.215,20

	Kg CO_2/m² año	Letra asignada (**)
CALIFICACIÓN	224,1	E

DETALLES DE EMISIONES TOTALES KgCO2/m²



OBSERVACIONES

(*) Consumo de energía final: Para calificar energéticamente el edificio se ha realizado una modelización teórica del consumo energético del edificio. En este sentido, el consumo de energía final debe considerarse en condiciones teóricas, ya que en el edificio habitado influyen los hábitos de cada usuario en el consumo energético real.

(**) La calificación de eficiencia energética del edificio que se muestra debe considerarse exclusivamente a título meramente orientativo, dado que no ha sido publicado por la Administración General del Estado un procedimiento oficial para la determinación de la calificación en edificios existentes, y la escala publicada no presenta ampliaciones por debajo de la letra E.
El procedimiento elegido para obtener la calificación de eficiencia energética ha sido la herramienta CERMA (Calificación Energética Residencial Procedimiento Abreviado),que es un Documento Reconocido para la certificación de eficiencia energética, según lo dispuesto en el artículo 3 del Real Decreto 47/2007, de 19 de enero, por el que se aprueba el Procedimiento básico para la certificación de eficiencia energética de edificios de nueva construcción Así mismo este software es documento reconocido para la calidad en la edificación por la CMAAUV de la GV según resolución de 7 de julio de 2010 del conseller de Medio Ambiente, Agua, Urbanismo y Vivienda publicada en el DOGV en fecha 20 de agosto de 2010.

Mejora de solución constructiva			AHORRO % en el consumo de energía respecto a el estado inicial	Equivalencia en el ahorro de emisiones CO_2 (árboles)	Equivalencia en el ahorro de emisiones CO_2 (coches)	Emisiones CO_2 Estado final: AHORRO Kg CO_2/m² año	Emisiones CO_2 Estado final: CALIFICACIÓN
	Fachadas y otros muros	+10mm	0,82%	0	0	222,2	E
		+20mm	1,18%	0	0	221,4	E
		+30mm	1,39%	0	0	220,9	E
		+40mm	1,53%	0	0	220,6	E
		+60mm	1,72%	0	1	220,2	E
		+80mm	1,84%	0	1	219,9	E
	Cubiertas	+10mm	3,29%	1	1	216,6	E
		+20mm	4,97%	2	2	212,7	E
		+30mm	6,00%	3	3	210,4	E
		+40mm	6,69%	3	3	208,8	E
		+60mm	7,55%	3	4	206,8	E
		+80mm	8,08%	4	4	205,6	E
	Suelos	+10mm	0,02%	0	0	224,2	E
		+20mm	0,05%	0	0	224,2	E
		+30mm	0,06%	0	0	224,3	E
		+40mm	0,08%	0	0	224,3	E
		+60mm	0,10%	0	0	224,3	E
		+80mm	0,12%	0	0	224,4	E
	Fachadas-Cubiertas-Suelos	+10mm	4,08%	2	2	214,8	E
		+20mm	6,10%	3	3	210,1	E
		+30mm	7,32%	3	4	207,3	E
		+40mm	8,13%	4	4	205,5	E
		+60mm	9,17%	4	5	203,1	E
		+80mm	9,79%	4	5	201,7	E
	Huecos	SOL1	37,31%	18	21	138,6	E
		SOL2	49,34%	24	29	111,1	E
		SOL3	59,55%	29	35	87,7	E
		SOL4	2,67%	1	1	218,0	E
		SOL5	5,50%	2	3	211,5	E
		SOL6	6,13%	3	3	210,1	E
		SOL7	39,92%	20	23	132,6	E
		SOL8	54,60%	27	32	99,0	E
		SOL9	65,21%	32	38	74,7	E

Una mejora de las fachadas y otros muros del edificio, con aislamiento térmico de +60mm y (lambda=0,004W/m²K), supondría un ahorro en el consumo de energía, respecto al estado inicial del edificio, del 1,72%. Además, las reducciones de emisiones de CO2 ,respecto al estado inicial, serían equivalentes a retirar de la circulación 1 coches al año, o a plantar 0 arboles al año.

Una mejora de las cubiertas del edificio, incorporando un aislamiento térmico de 60mm (en base a una conductividad de lambda=0,004W/m²K), supondría un ahorro en el consumo de energía, respecto al estado inicial del edificio, del 7,55%, de forma que sería más fácil y económico mantener unos niveles de confort térmico adecuados.Además, las reducciones de emisiones de CO2 ,respecto al estado inicial, serían equivalentes a retirar de la circulación 4 coches al año, o a plantar 3 arboles al año.

Una mejora de los suelos del edificio, incorporando un aislamiento térmico de 60mm (en base a una conductividad de lambda=0,004W/m²K), supondría un ahorro en el consumo de energía, respecto al estado inicial del edificio, del 0,10%, de forma que sería más fácil y económico mantener unos niveles de confort térmico adecuados.Además, las reducciones de emisiones de CO2 ,respecto al estado inicial, serían equivalentes a retirar de la circulación 0 coches al año, o a plantar 0 arboles al año.

Una mejora de las fachadas y otros muros, las cubiertas y los suelos del edificio, incorporando un aislamiento térmico de 60mm (en base a una conductividad de lambda=0,004W/m²K), supondría un ahorro en el consumo de energía, respecto al estado inicial del edificio, del 9,17%, de forma que sería más fácil y económico mantener unos niveles de confort térmico adecuados. Además, las reducciones de emisiones de CO2, respecto al estado inicial, serían equivalentes a retirar de la circulación 5 coches al año, o a plantar 4 arboles al año.

Una mejora en las calidades de vidrio y carpinterías de los huecos del edificio, utilizando vidrios dobles bajo emisivos (lambda=1,80W/m²K) y carpinterías de PVC-3 cámaras (lambda=1,80W/m²K), supondría un ahorro en el consumo de energía respecto al estado inicial del edificio del 65,21%. Además las reducciones de emisiones de CO2 respecto al estado inicial, serían equivalentes a retirar de la circulación 38 coches al año, o a plantar 32 arboles al año.

Mejora solución constructiva
"x"mm: Mejora de aislamiento térmico lambda=0,004W/m²K, respecto a la sol. inicial del edificio
SOL.1: 3,30 W/m²K- v.doble (mejora vidrio)
SOL.2: 2,50 W/m²K- v.doble bajo emisivo 0,03-0,01 (mejora vidrio)
SOL.3: 1,80 W/m²K- v.doble bajo emisivo <0,03 (mejora vidrio)
SOL.4: 4,00 W/m²K - metálico con rotura de p.térmico 4-12mm (mejora carpintería)
SOL.5: 2,20 W/m²K - madera densidad media/alta (mejora carpintería)
SOL.6: 1,80 W/m²K - PVC 3 cámaras (mejora carpintería)
SOL.7: SOL.1 +SOL.4 (mejora vidrio+carpintería)
SOL.8: SOL.2 +SOL.5 (mejora vidrio+carpintería)
SOL.9: SOL.3 +SOL.6 (mejora vidrio+carpintería)

La ejecución de esta intervención de mejora energética respecto al estado original, reduciría las emisiones de C02/año en un valor equivalente al CO2 absorbido por XX árboles durante su vida .

La ejecución de esta intervención de mejora energética respecto al estado original, reduciría las emisiones de CO2/año en un valor equivalente a retirar de circulación "X coches/año"

ANEXO FOTOGRÁFICO DE FACHADAS

Fachada 1. Acabado exterior [Ref. FA001]	Fachada 1. Carpintería [Ref. FA002]
	

Fachada 2. Acabado exterior [Ref. FA003]

ANEXO. LEYENDAS.

Todas. EC-Estado de conservación
0 - Bueno
1 - Deficiente
2 - Malo
3 - Sin poder determinar

Todas. ID-Importancia de daños
0 - Despreciable
1 - Bajo
2 - Moderado
3 - Alto
4 - Sin poder determinar

Todas. AP-Actuaciones y plazos
MNT - Mantenimiento(Estado de conservación bueno y/o daños despreciables)
INTm - Intervención a medio plazo(Estado de conservación deficiente o malo y/o daños bajos)
INTu - Intervención urgente(Daños moderados y/o altos)

Fachadas. Tipo de elementos singulares.
CL - Celosías
RB - Rejas y Barandillas
L - Lamas
O - Otros

Huecos. Material.
ML - Metálica aluminio sin rotura puente térmico
M4 - Metálica aluminio con rotura puente térmico 4-12mm
M12 - Metálica aluminio con rotura puente térmico >12mm
MA - Madera densidad media alta
MB - Madera densidad media baja
P2 - PVC con 2 cámaras
P3 - PVC con 3 cámaras
O - Otros

Huecos. Tipo de vidrio.
MN - Monolítico
DB - Doble
BE - Doble bajo
EP - Especiales

Huecos. Caja de persiana.
CP - Con caja de persiana
SP - Sin caja de persiana

Huecos. Permeabilidad.
Corredera, ajuste malo
Corredera, ajuste regular
Corredera, ajuste bueno
Corredera, ajuste bueno con burlete
Abatible, ajuste malo
Abatible, ajuste regular
Abatible, ajuste bueno
Abatible, ajuste bueno con burlete
Doble ventana

Cimentación y estructura. Permeabilidad.
FB - Fabrica de bloque
FC - Fábrica de ladrillo cerámico
H - Hormigón
HM - Hormigón en masa
HA - Hormigón armado
HP - Hormigón pretensado
PM - Perfil metálico
M - Madera
CA - Cerámica armada (viguetas)

APENDIX E – Architectural and Construction drawings

01. Situation

02. Location on the ground

03. Elevations

04. Floor Library – Measurements

05. Floor Library – Areas

06. Floor Library - Overhaul Design

07. Sections

08. Details

09. Details

10. 3D Views - Overhaul Design

11. 3D Views - Overhaul Design

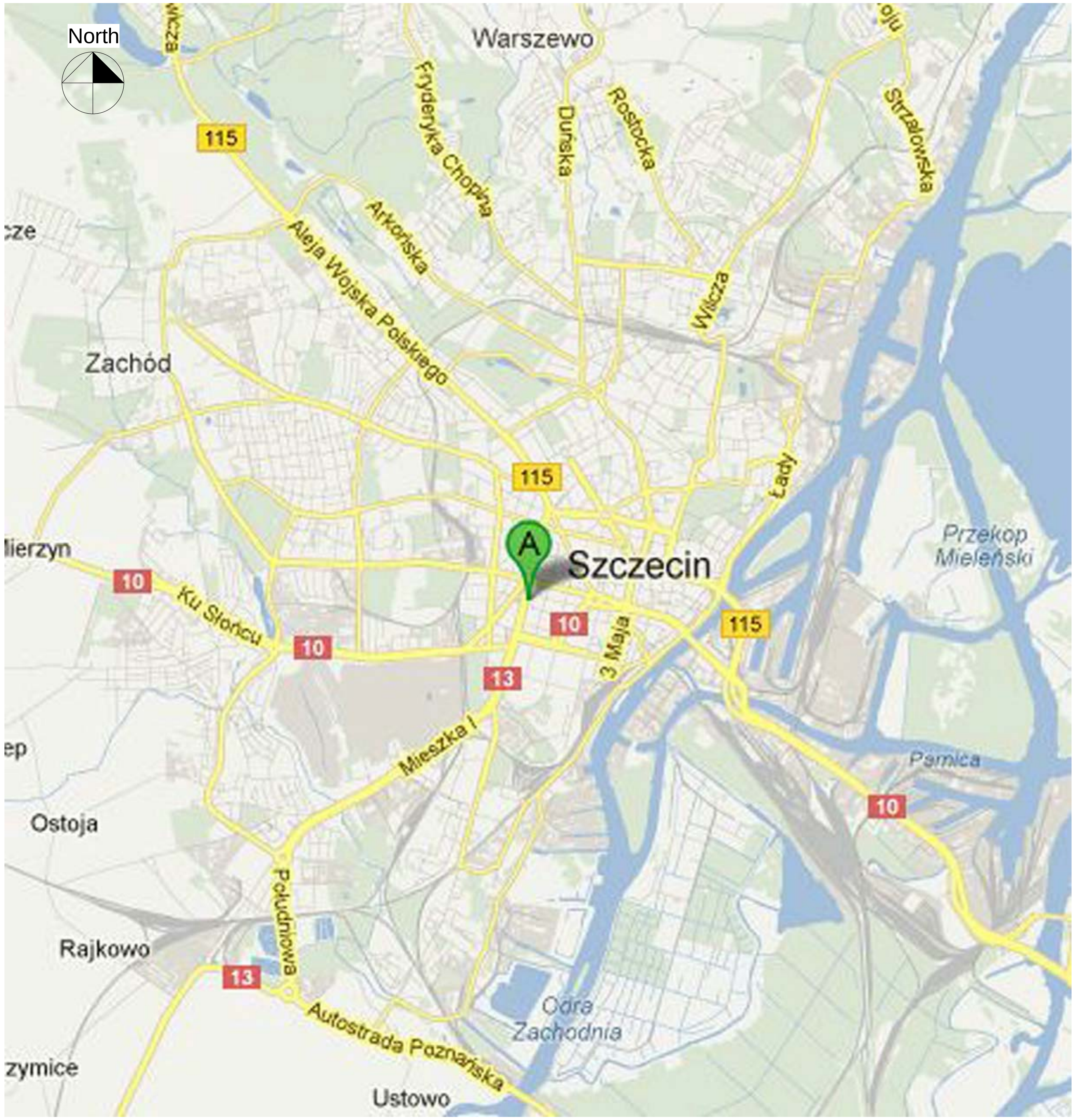
12. 3D Views - Overhaul Design

13. Sunpath case studies – SPRING

14. Sunpath case studies – SUMMER

15. Sunpath case studies – AUTUMN

16. Sunpath case studies - WINTER



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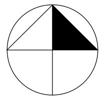
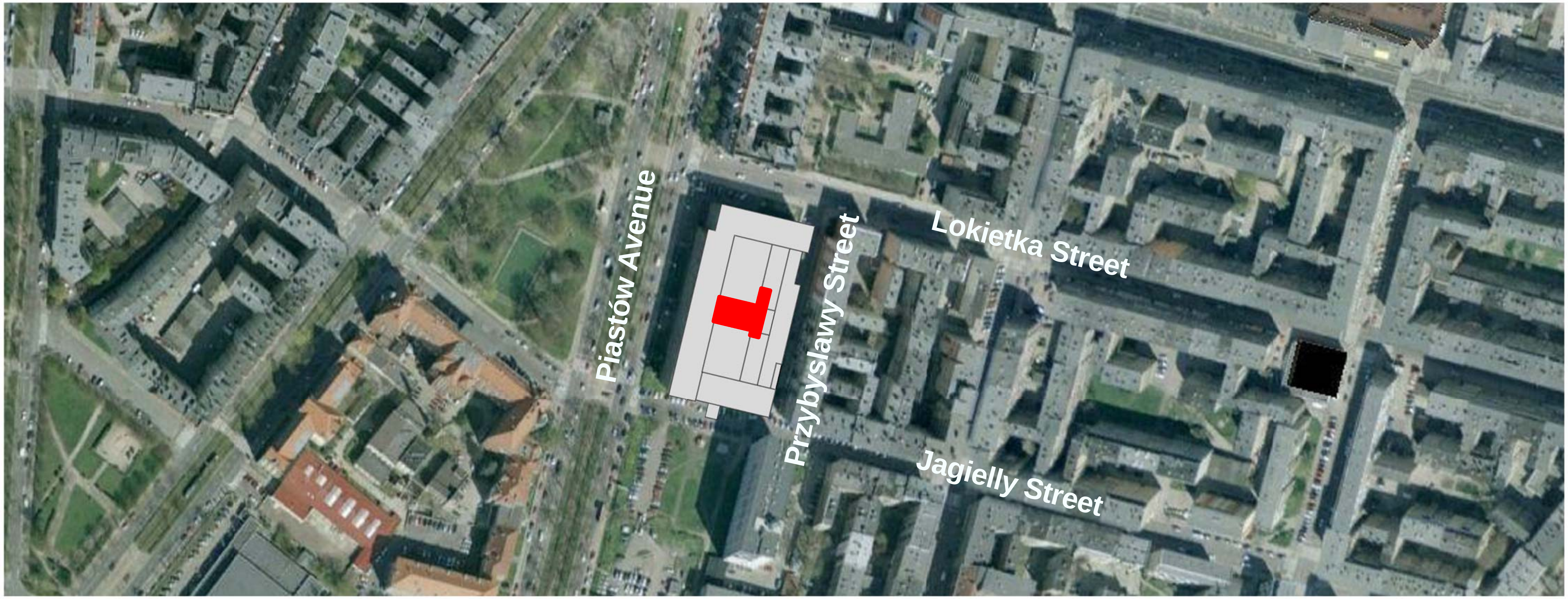
UNIVERSIDAD POLITECNICA DE VALENCIA	Plane Name: **Situation**	Date: 2012/05/25 Scale: No. Plane: 01





Faculty of Civil Engineering and Architecture

Lybrary

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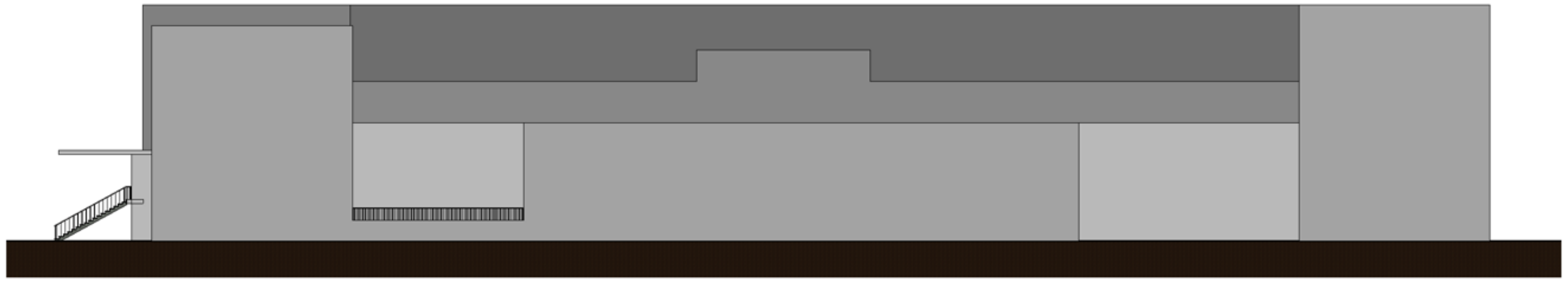
Plane Name **Location on the ground**

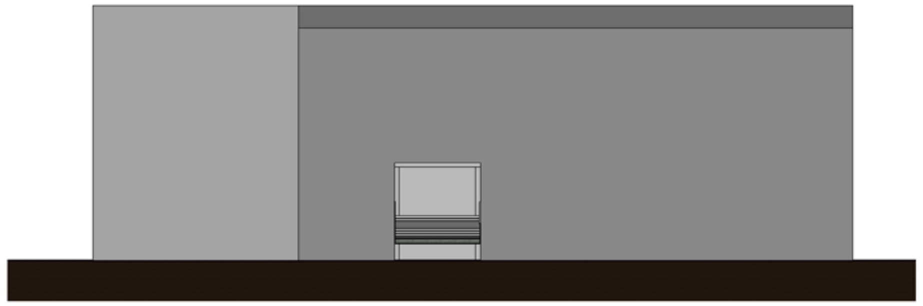
Date **2012/05/25**

Scale **1:2000**

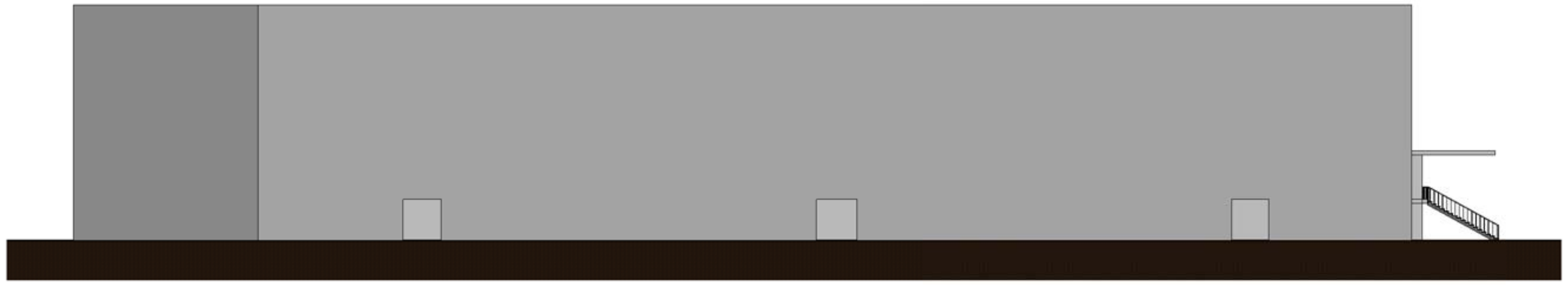
No. Plane 02



4 / 03 Przybyslawy Street
1 : 500



1 / 03 Jagielly Street
1 : 500



3 / 03 Piastów Avenue
1 : 500

2 / 03 Lokietka Street
1 : 500

Wydział Budownictwa i Architektury

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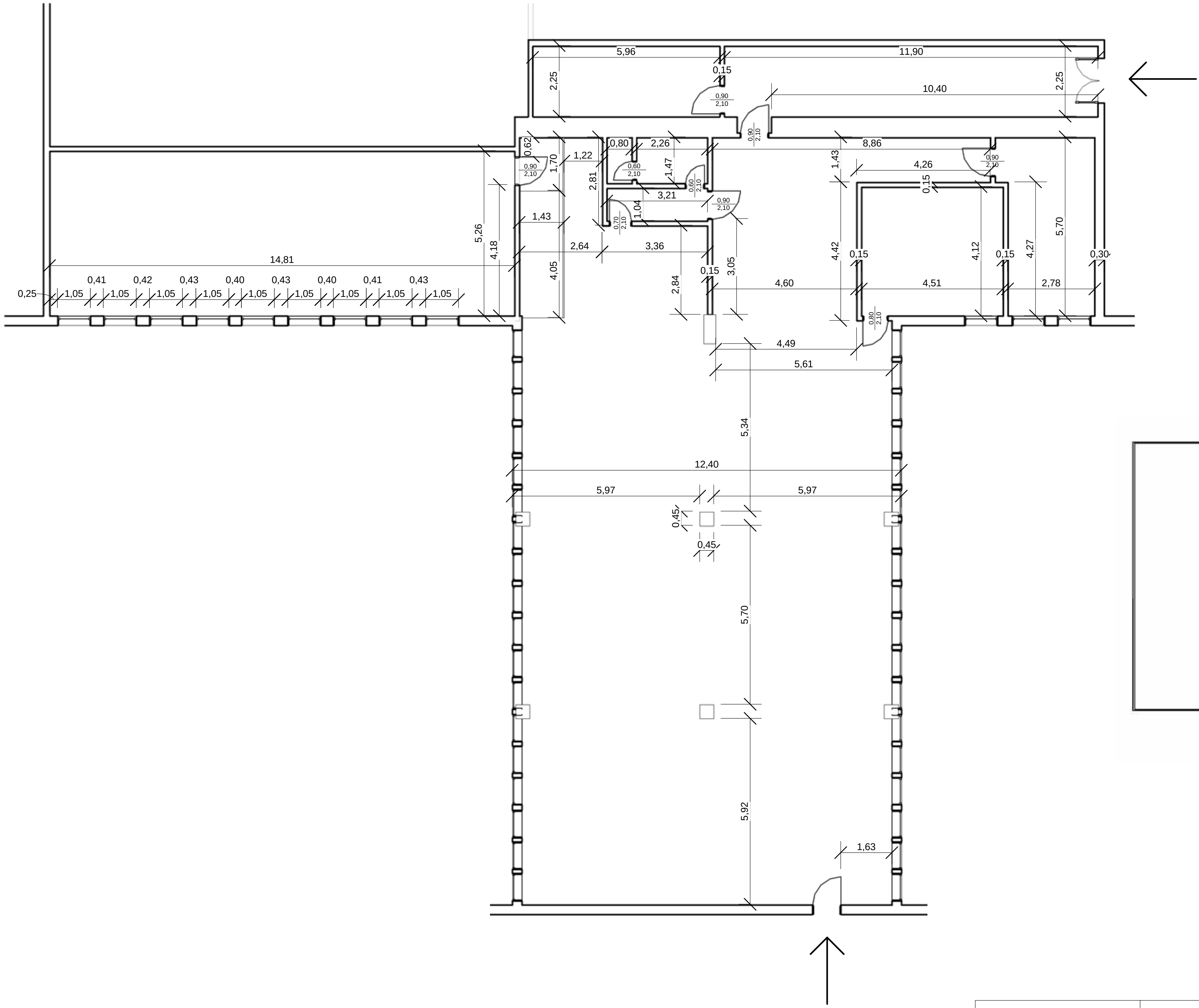
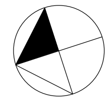
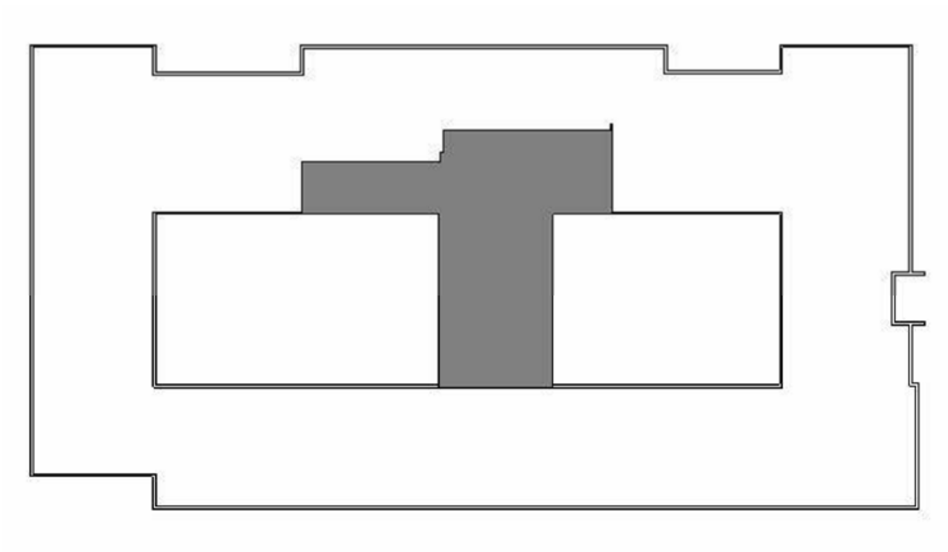
Project Title	**OVERHAUL DESIGN AND ENERGY STUDY OF THE LIBRARY OF THE FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE BUILDING**
Plane Name **Elevations**	Date **2012/05/25** Scale **1 : 500** No. Plane 03







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Plane Name

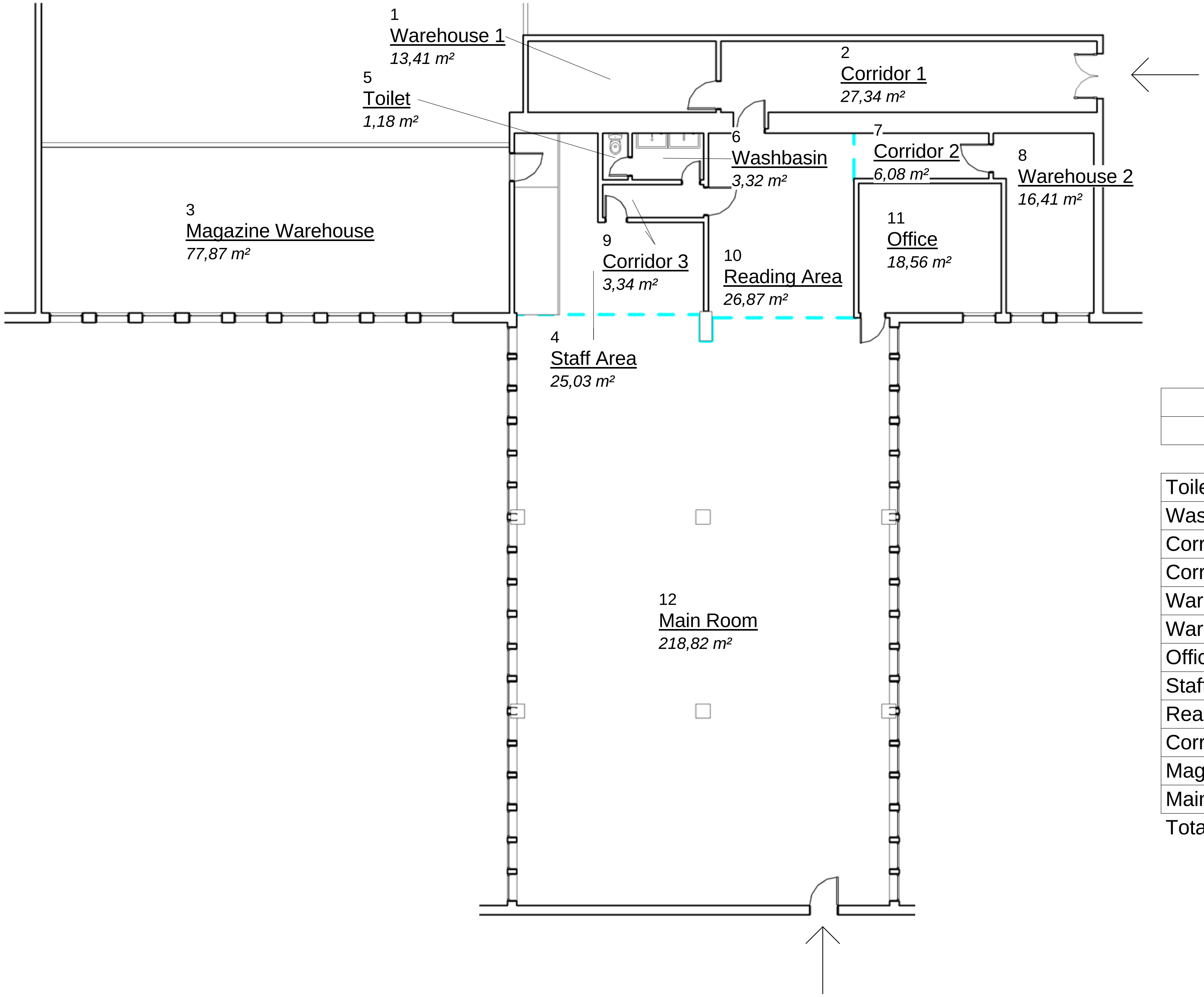
Floor Library - Measurements

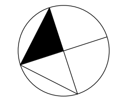
Date **2012/05/25**

Scale **1 : 150**

No. Plane

04





Room Schedule Chart		
Name	Area	Volume
Toilet	1,18 m²	4,22 m³
Washbasin	3,32 m²	11,93 m³
Corridor 3	3,34 m²	11,98 m³
Corridor 2	6,08 m²	21,84 m³
Warehouse 1	13,41 m²	32,46 m³
Warehouse 2	16,41 m²	58,92 m³
Office	18,56 m²	66,63 m³
Staff Area	25,03 m²	89,97 m³
Reading Area	26,87 m²	96,45 m³
Corridor 1	27,34 m²	66,48 m³
Magazine Warehouse	77,87 m²	218,18 m³
Main Room	218,82 m²	682,21 m³
Total general: 12	438,24 m²	1.361,28 m³

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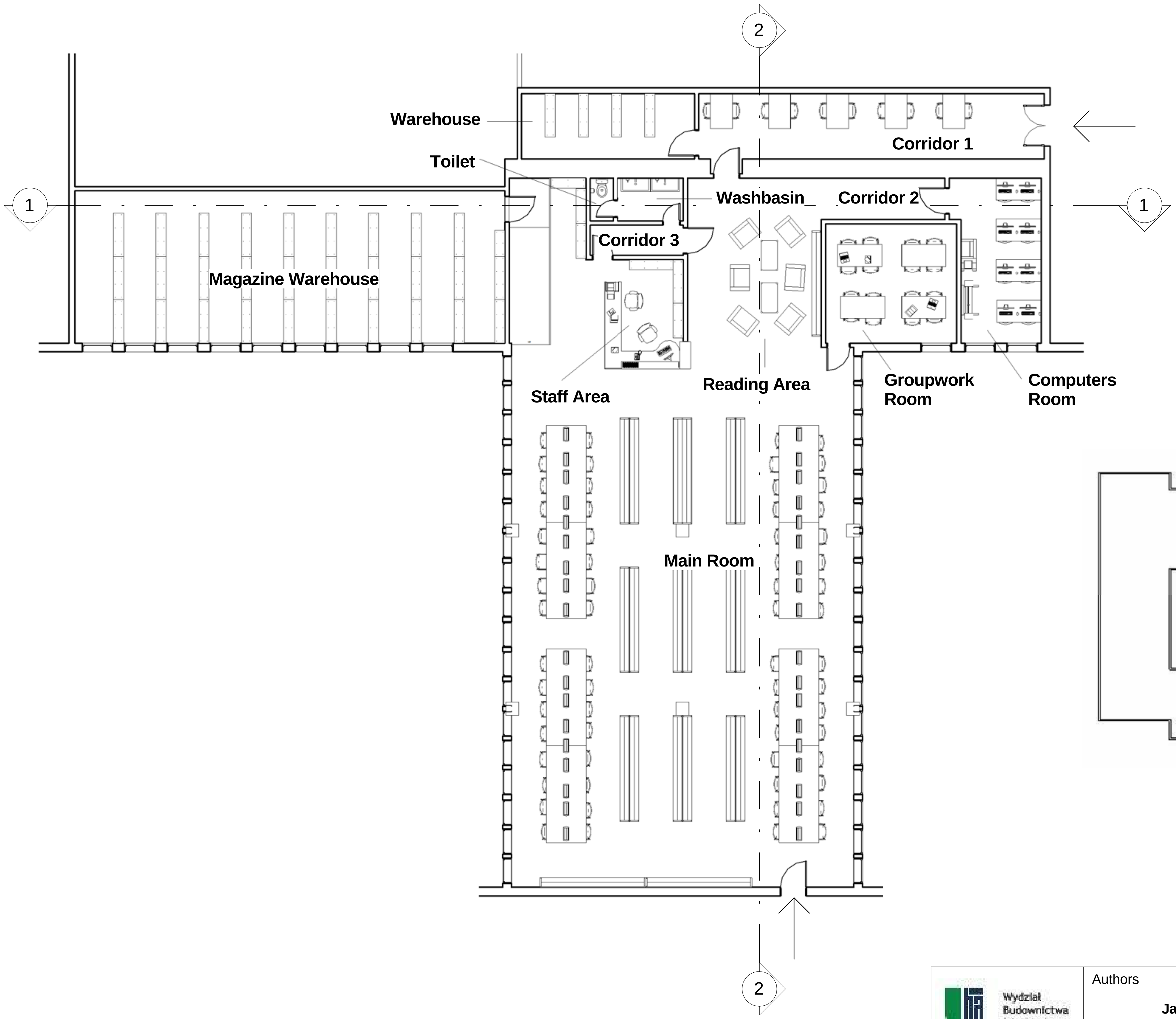
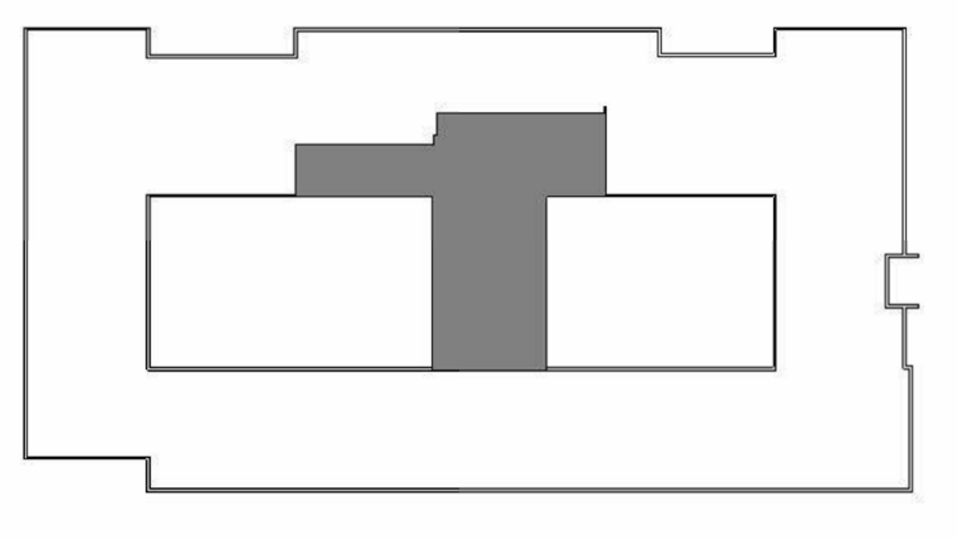
Plane Name
Floor Library - Areas

Date
2012/05/25

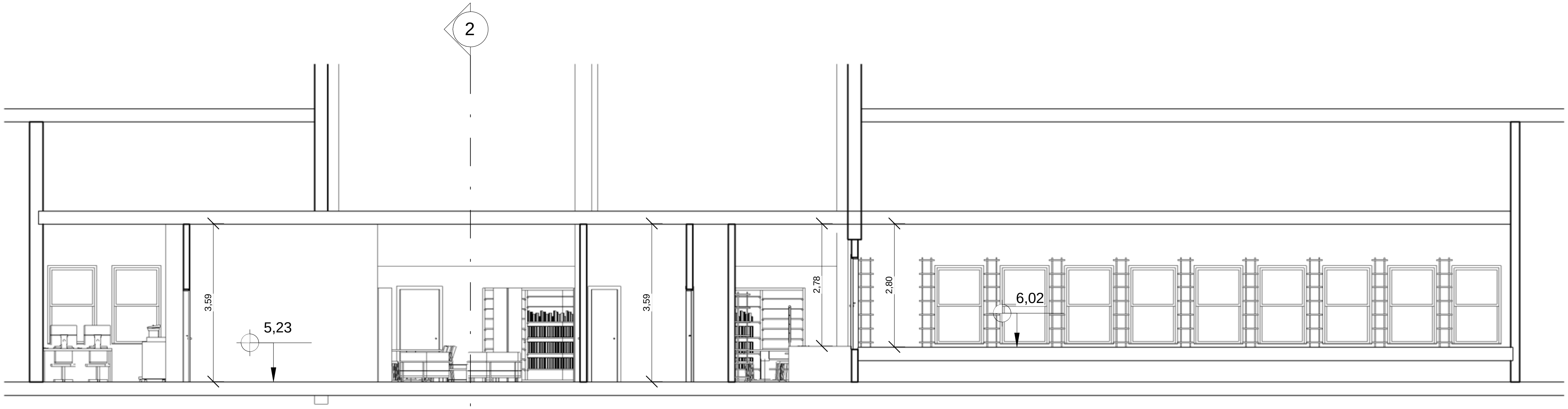
Scale
1 : 150

No. Plane
05

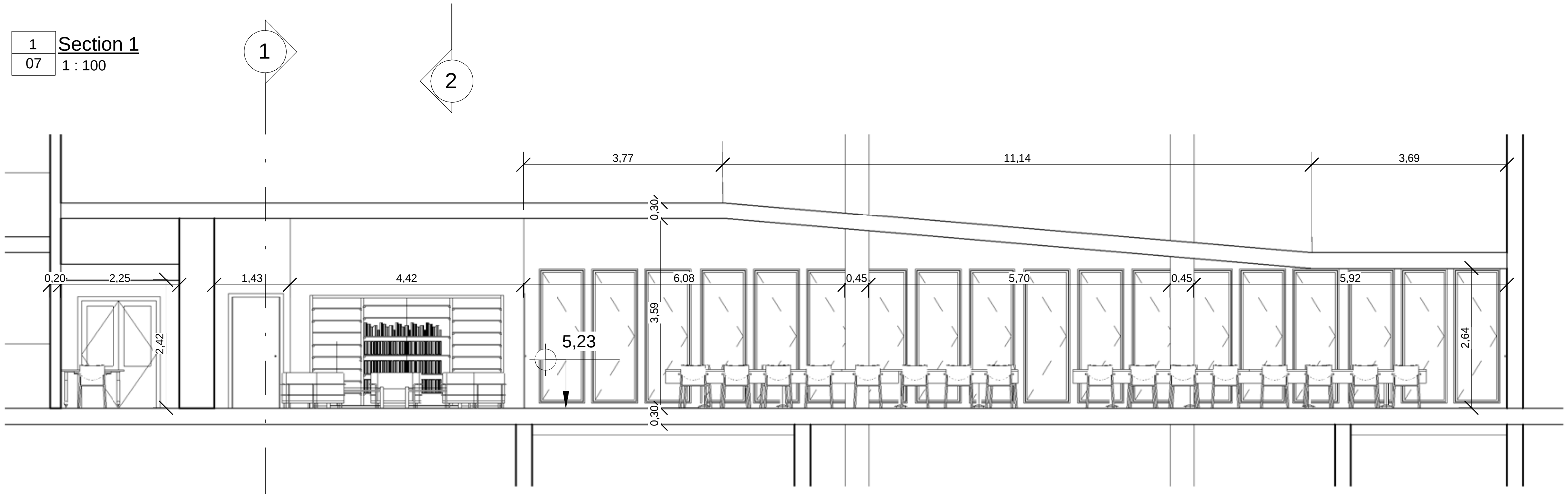




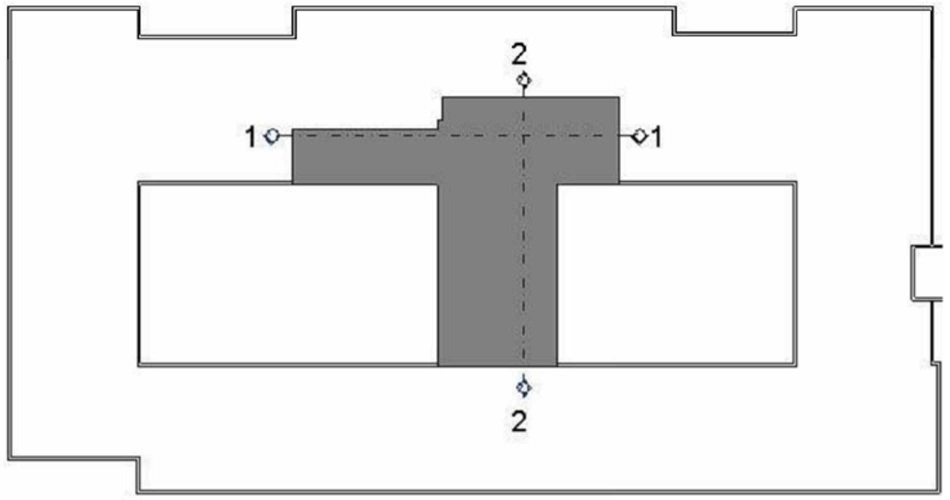
Wydział Budownictwa i Architektury Zachodniopomorski Uniwersytet Technologiczny w Szczecinie UNIVERSIDAD POLITECNICA DE VALENCIA	Authors Javier Cano Catalá Mª Ángeles Ortega Martínez Ricardo Frías Palenzuela	Tutoring Karolina Kurtz Esther Valiente Ochoa
	Project Title: OVERHAUL DESIGN AND ENERGY STUDY OF THE LIBRARY OF THE FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE BUILDING	
	Plane Name: Floor Library - Overhaul Design	Date: 2012/05/25 Scale: 1 : 150 No. Plane: 06



1 | 07 Section 1
1 : 100



2 | 07 Section 2
1 : 100



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Project Title **OVERHAUL DESIGN AND ENERGY STUDY OF THE LIBRARY OF THE FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE BUILDING**

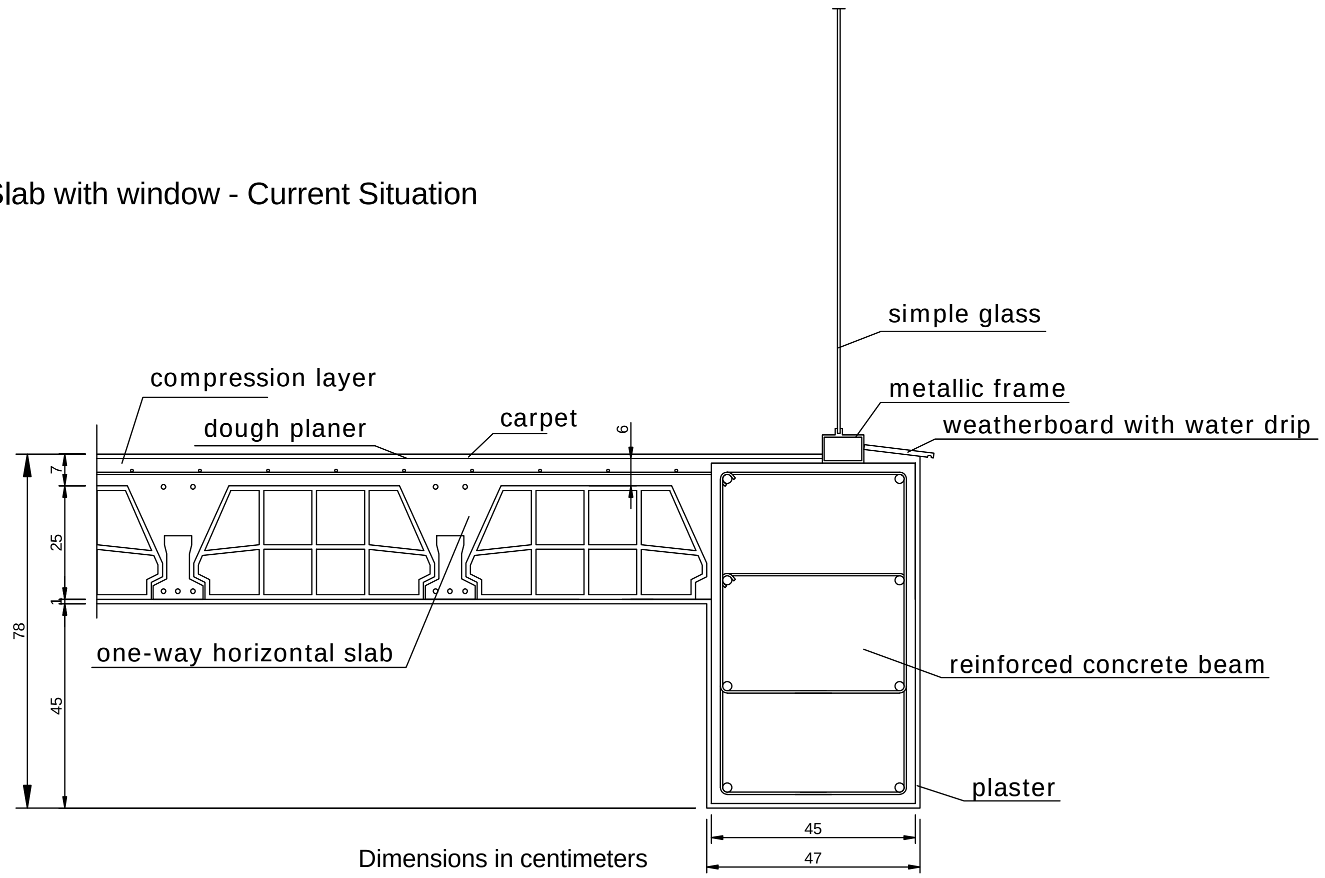
Plane Name **Sections**

Date **2012/05/25**

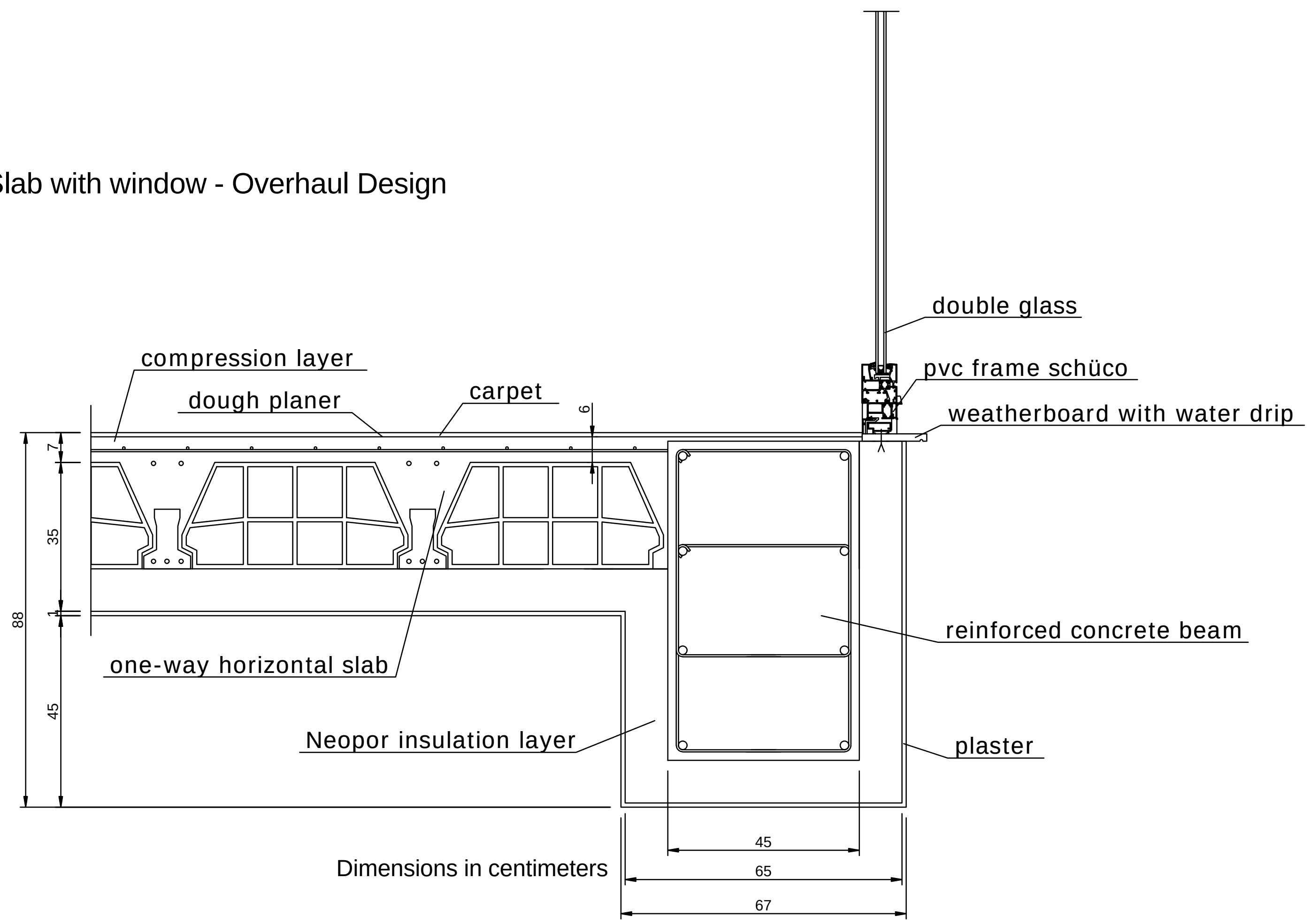
Scale **1 : 100**

No. Plane 07

Slab with window - Current Situation



Slab with window - Overhaul Design



Bottom view 1

Bottom view 2

Bottom view 3

Wydział Budownictwa i Architektury

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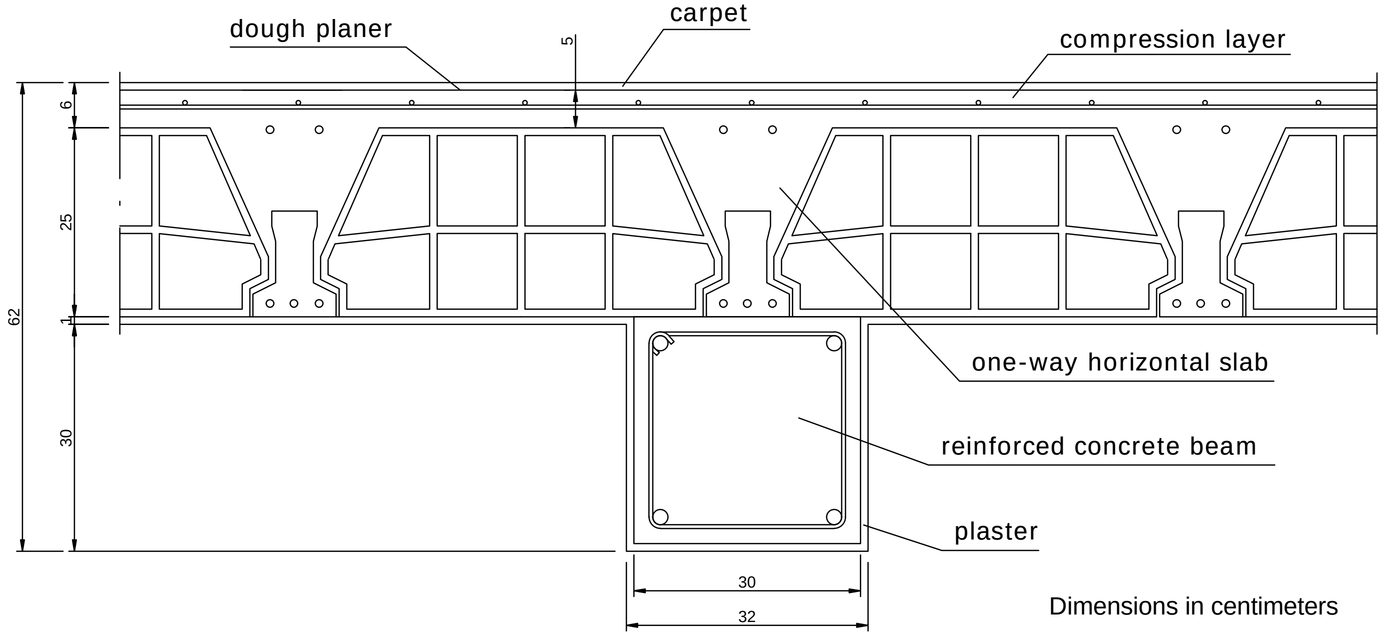
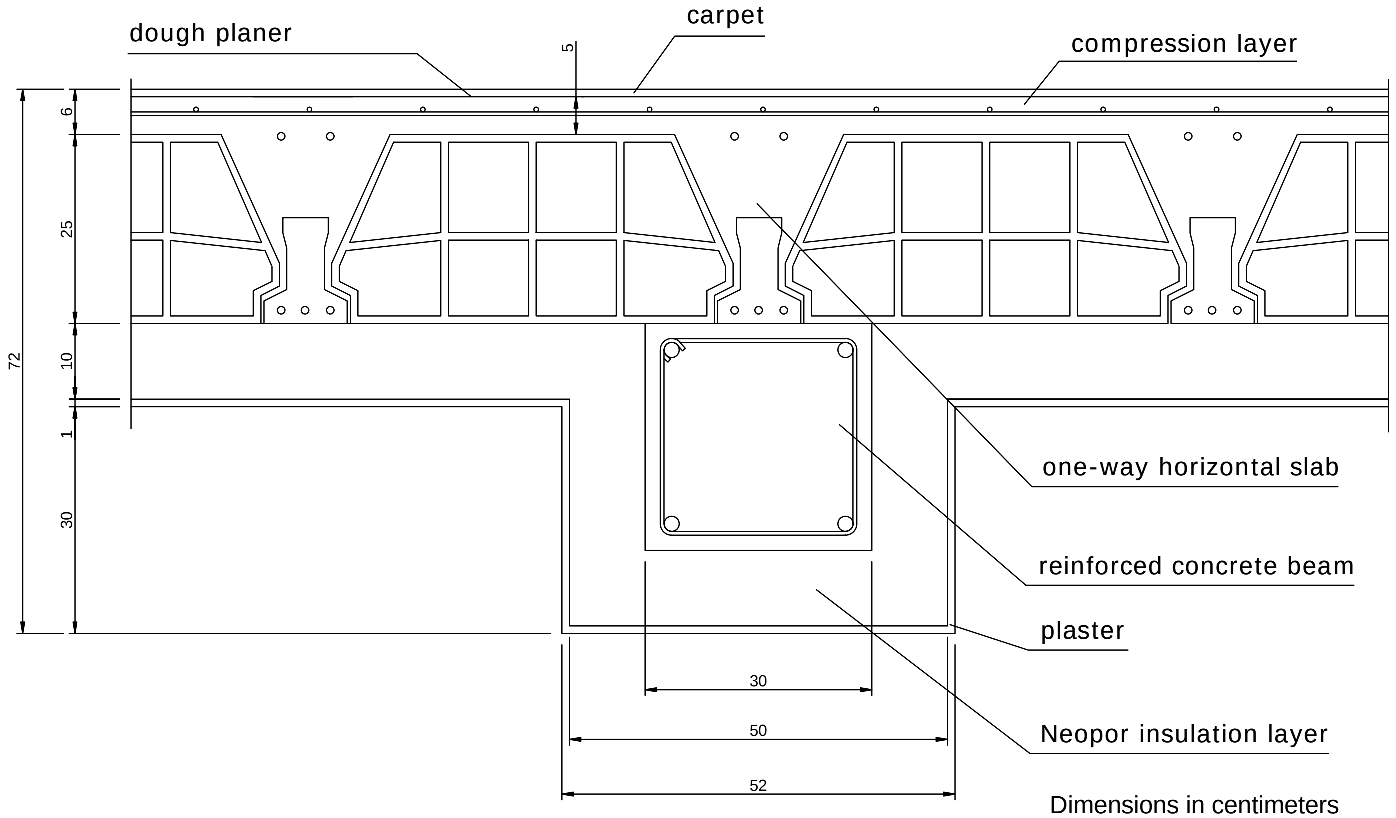
Plane Name	Date	No. Plane
Details	**2012/05/25**	08
	Scale	

Slab with beam - Current Situation



Dimensions in centimeters

Slab with beam - Overhaul Design



Dimensions in centimeters

Bottom view 1

Bottom view 2

Wydział Budownictwa i Architektury

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Project Title **OVERHAUL DESIGN AND ENERGY STUDY OF THE LIBRARY OF THE FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE BUILDING**

Plane Name **Details**

Date **2012/05/25**

Scale

No. Plane 09

Reading Area nowadays

Reading Area - Proposal Design

Office nowadays

Groupwork room - Proposal Design

Staff Area nowadays

Staff Area - Proposal Design

Wydział Budownictwa i Architektury

Zachodniopomorski Uniwersytet Technologiczny w Szczecinie

UNIVERSIDAD POLITECNICA DE VALENCIA

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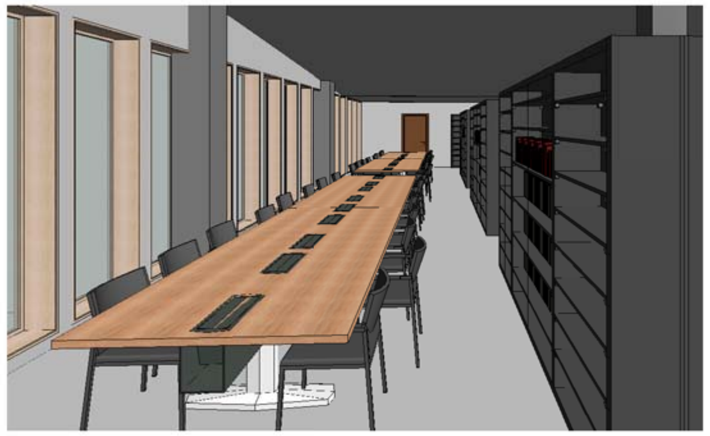
Project Title **OVERHAUL DESIGN AND ENERGY STUDY OF THE LIBRARY OF THE FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE BUILDING**

Plane Name	Date	No. Plane
3D Views - Proposal Design	**2012/05/25**	10
	Scale	



Main Room nowadays

Main Room - Proposal Design

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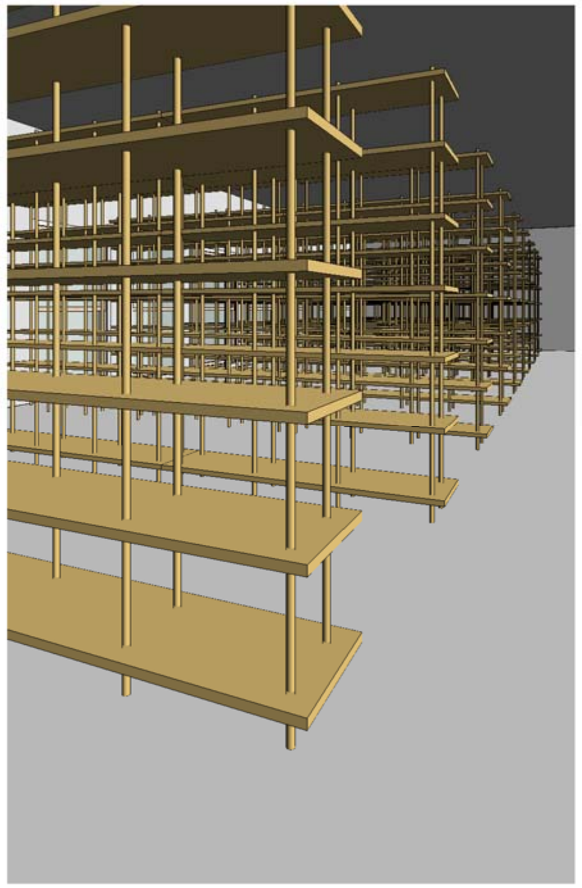
Plane Name **3D Views - Proposal Design**

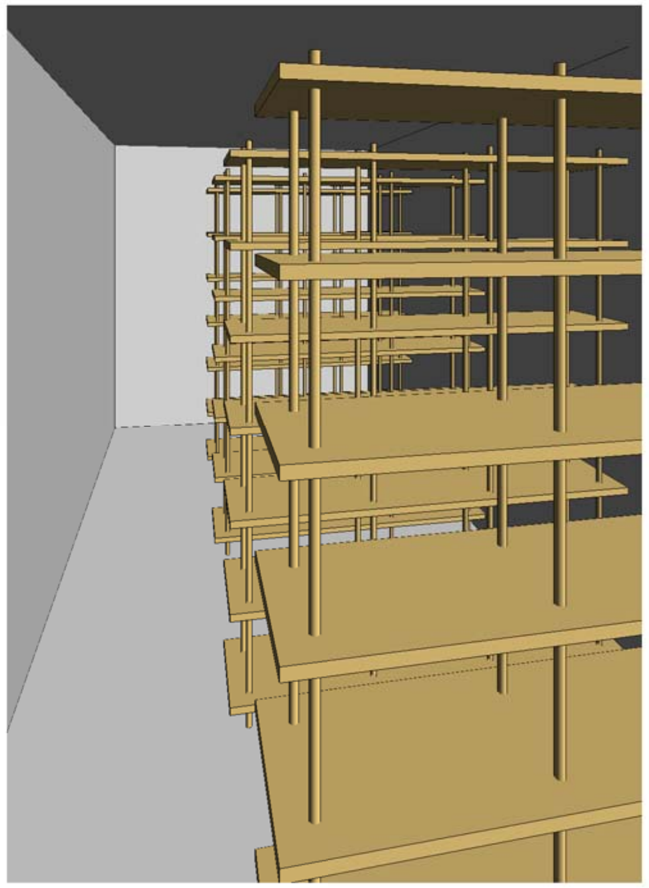
Date **2012/05/25**

Scale

No. Plane 11



Magazine Warehouse - Proposal Design



Warehouse 1 - Proposal Design

Corridor 1 - Proposal Design

Computers Room - Proposal Design

Magazine Warehouse nowadays

Warehouse 1 nowadays

Corridor 1 nowadays

Warehouse 2 nowadays

Wydział Budownictwa i Architektury

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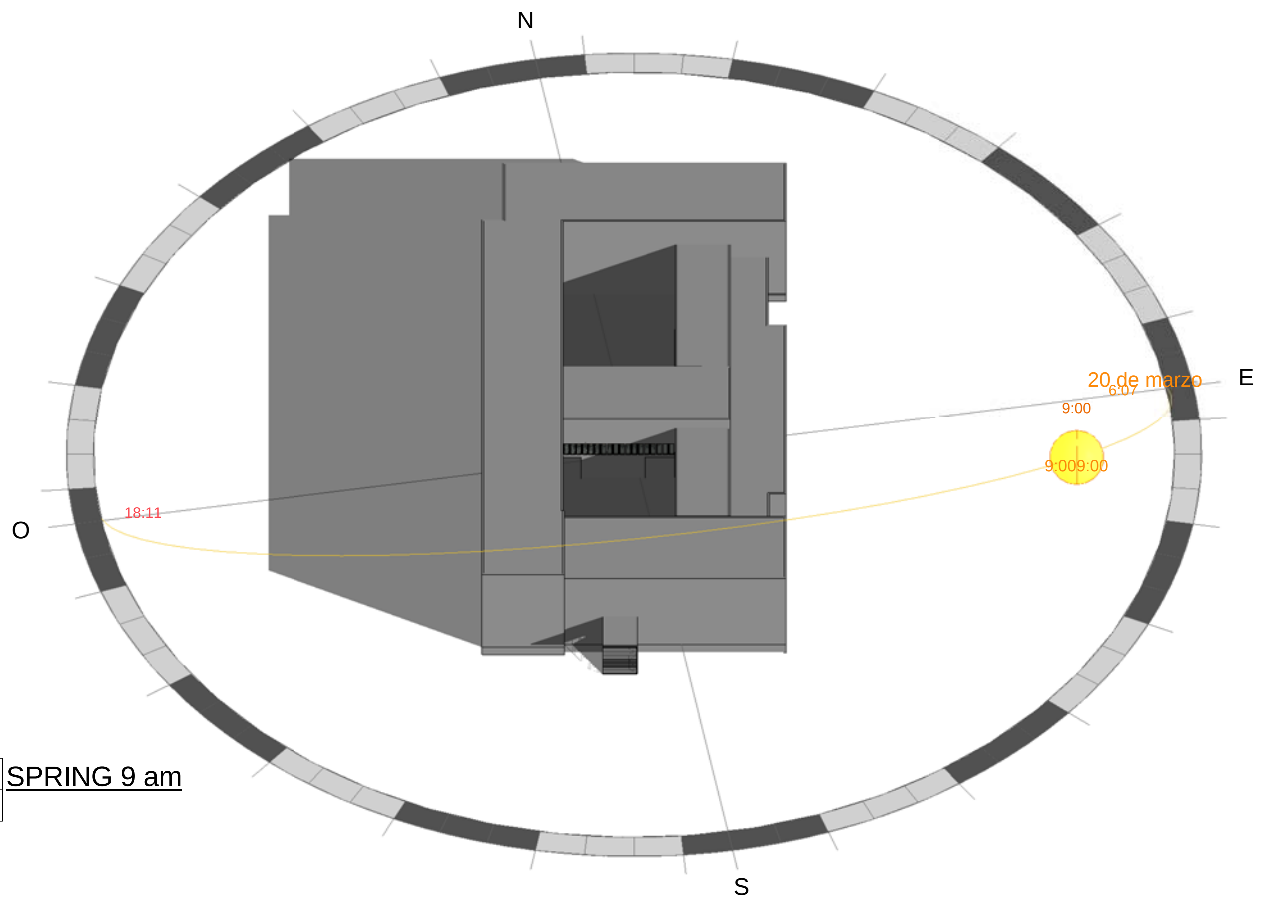
Plane Name **3D Views - Proposal Design**

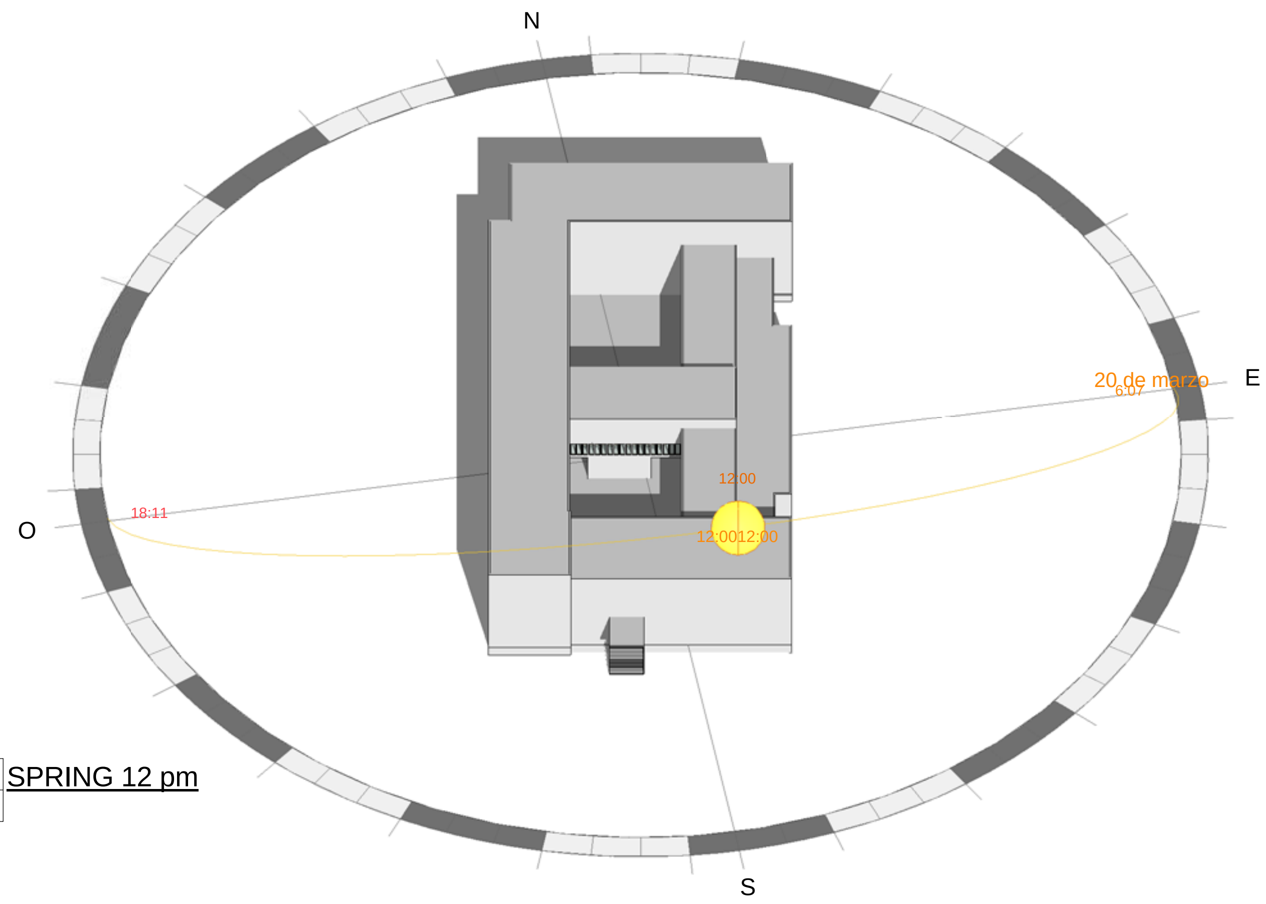
Date **2012/05/25**

Scale

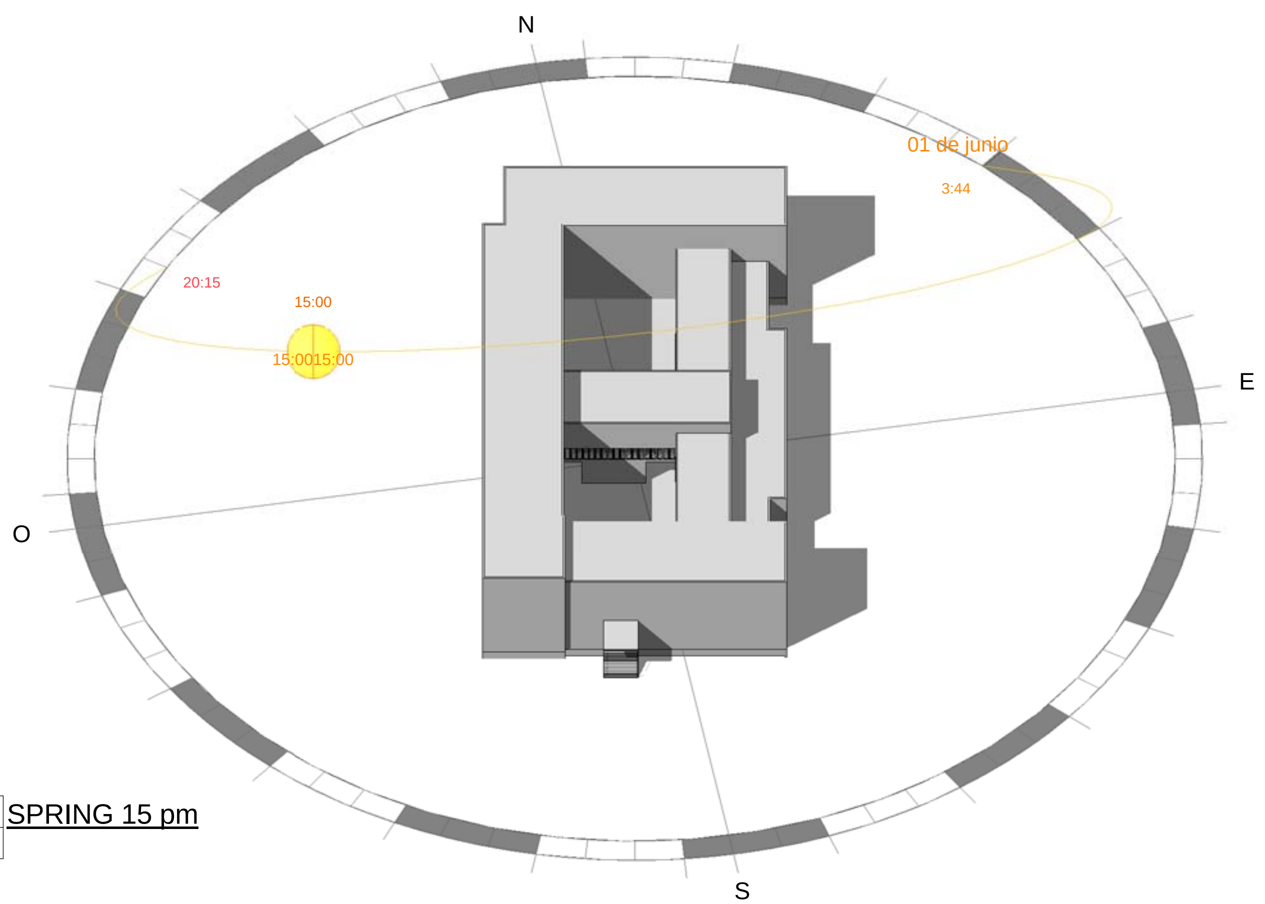
No. Plane 12



1
13
SPRING 9 am



2
13
SPRING 12 pm



3
13
SPRING 15 pm

Wydział Budownictwa i Architektury

Zachodniopomorski Uniwersytet Technologiczny w Szczecinie

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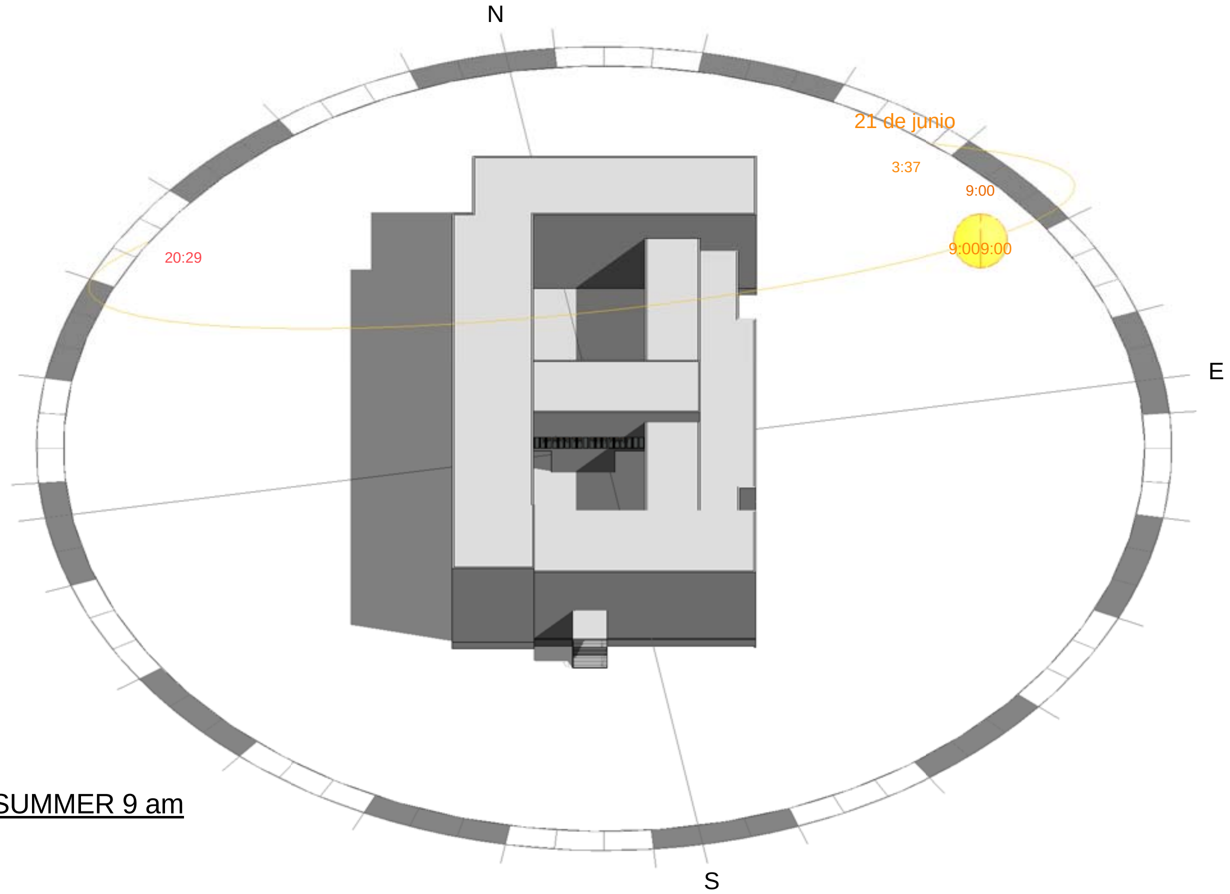
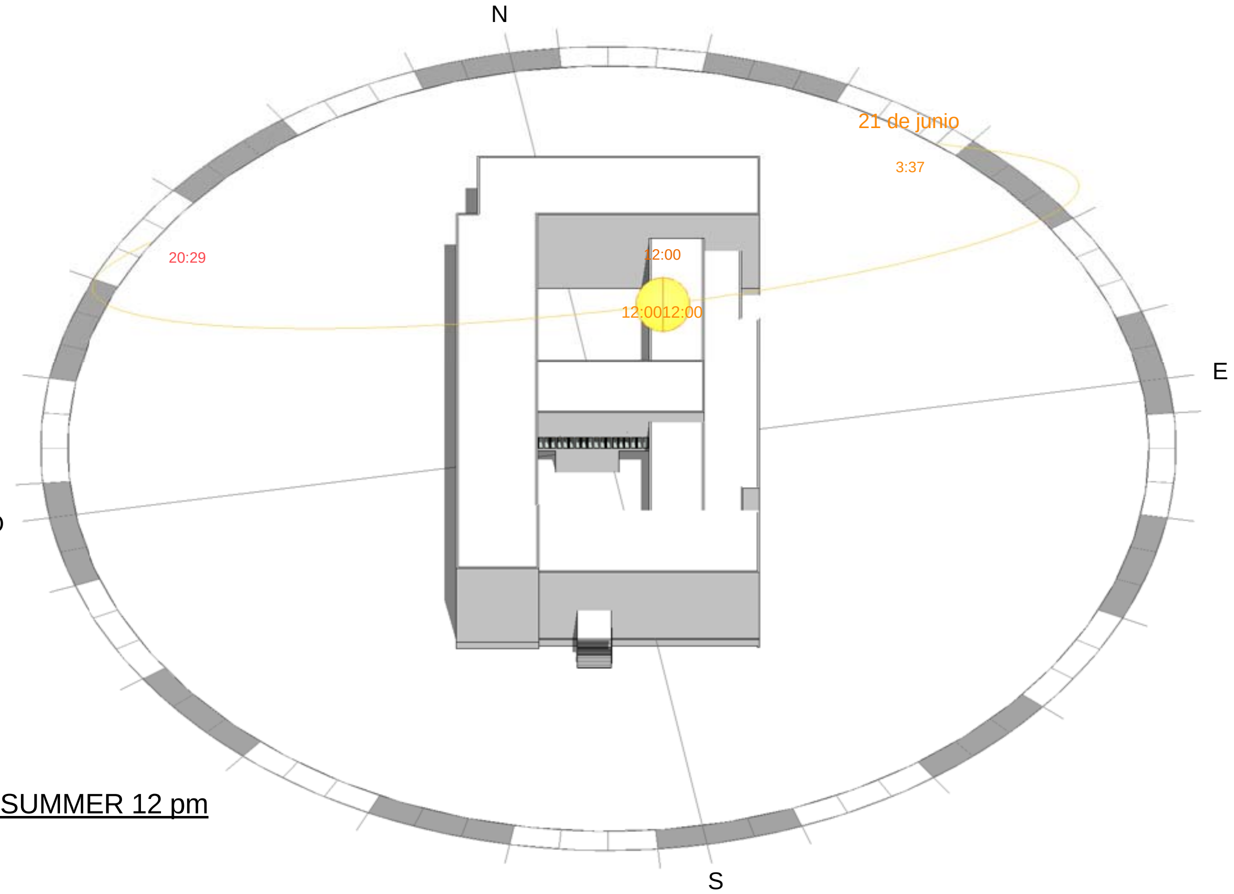
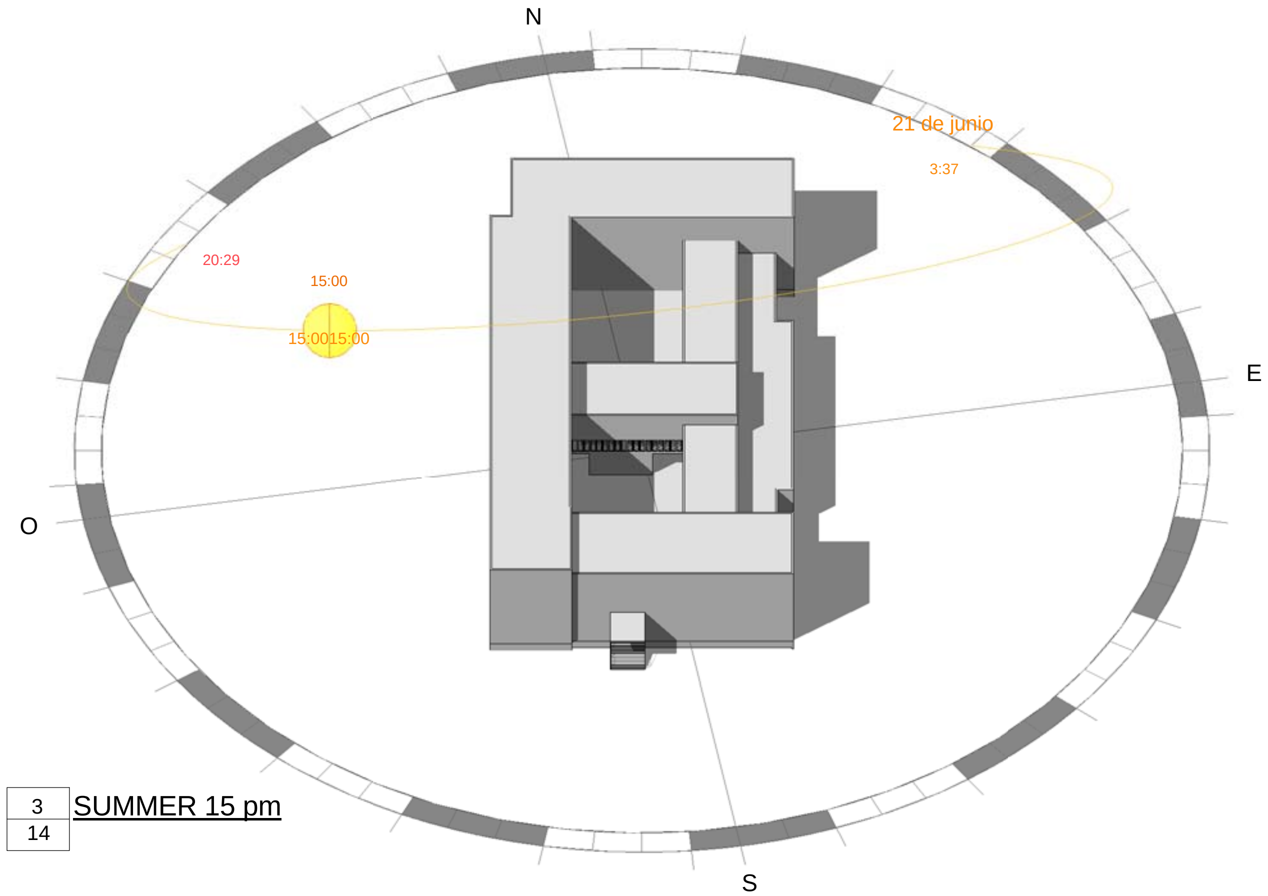
Project Title	**OVERHAUL DESIGN AND ENERGY STUDY OF THE LIBRARY OF THE FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE BUILDING**		
Plane Name **Sunpath case studies - SPRING**		Date **2012/05/25** Scale	No. Plane 13



1	SUMMER 9 am
14	



2	SUMMER 12 pm
14	



3	SUMMER 15 pm
14	

Wydział Budownictwa i Architektury

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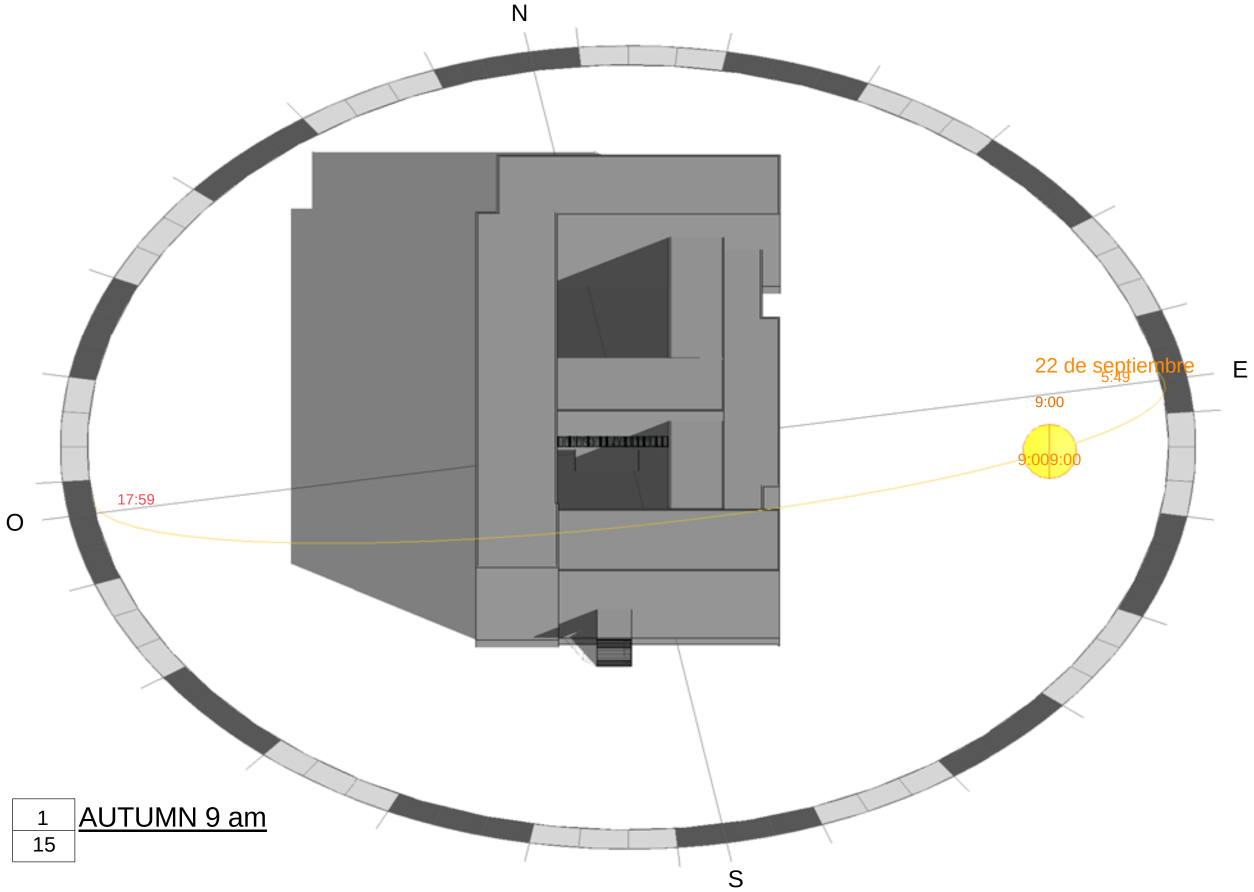
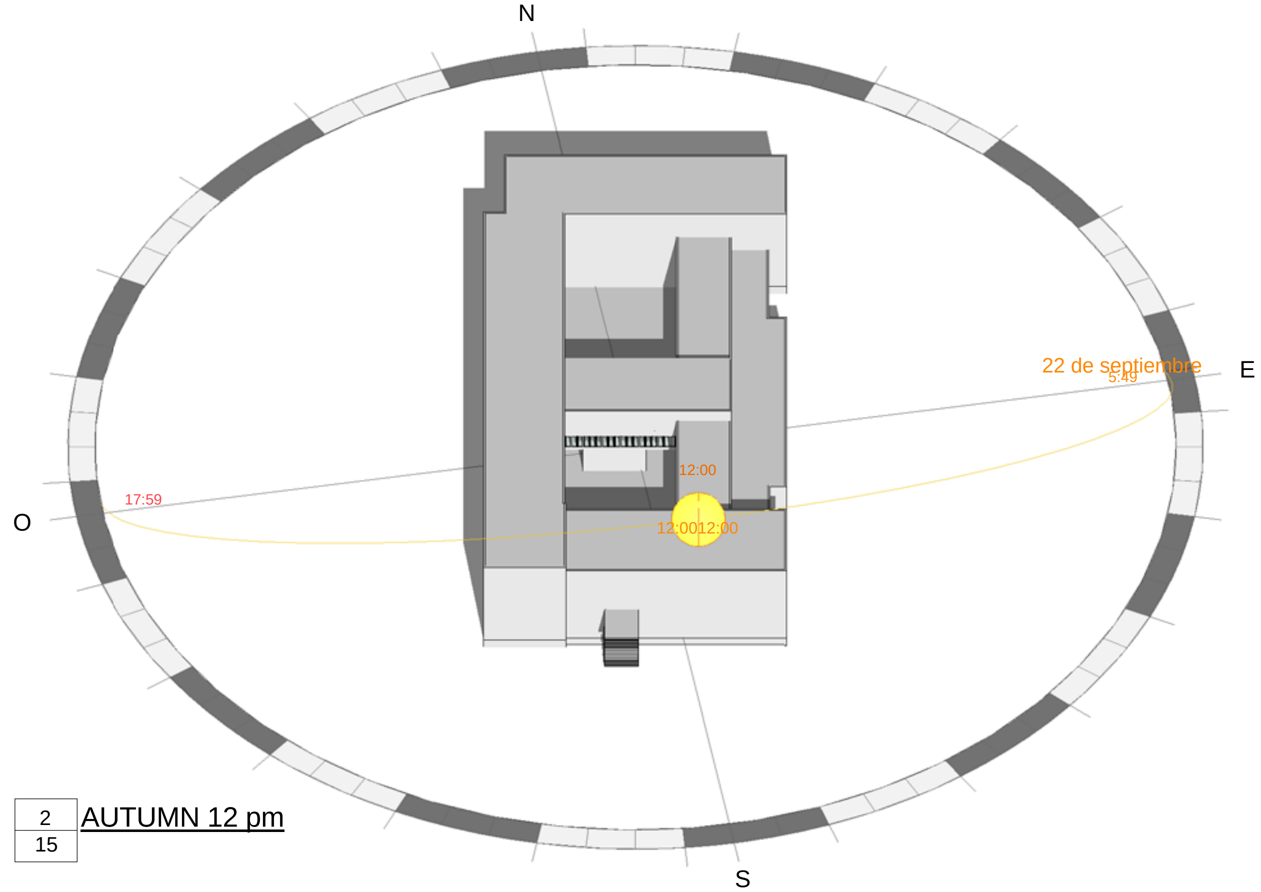
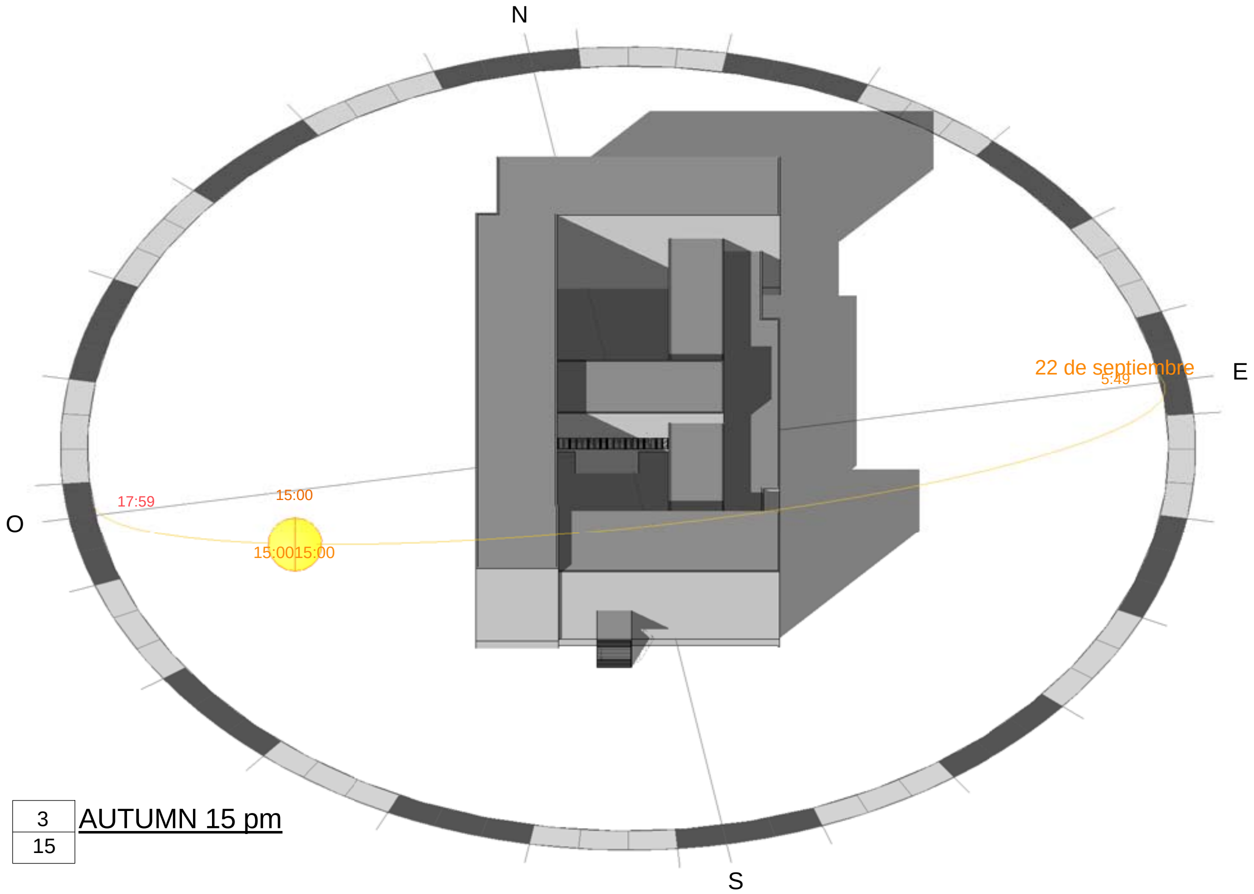
Plane Name	Date	No. Plane
Sunpath case studies - SUMMER	**2012/05/25**	14
	Scale	



1 | 15 AUTUMN 9 am



2 | 15 AUTUMN 12 pm



3 | 15 AUTUMN 15 pm

Wydział Budownictwa i Architektury
Zachodniopomorski Uniwersytet Technologiczny w Szczecinie
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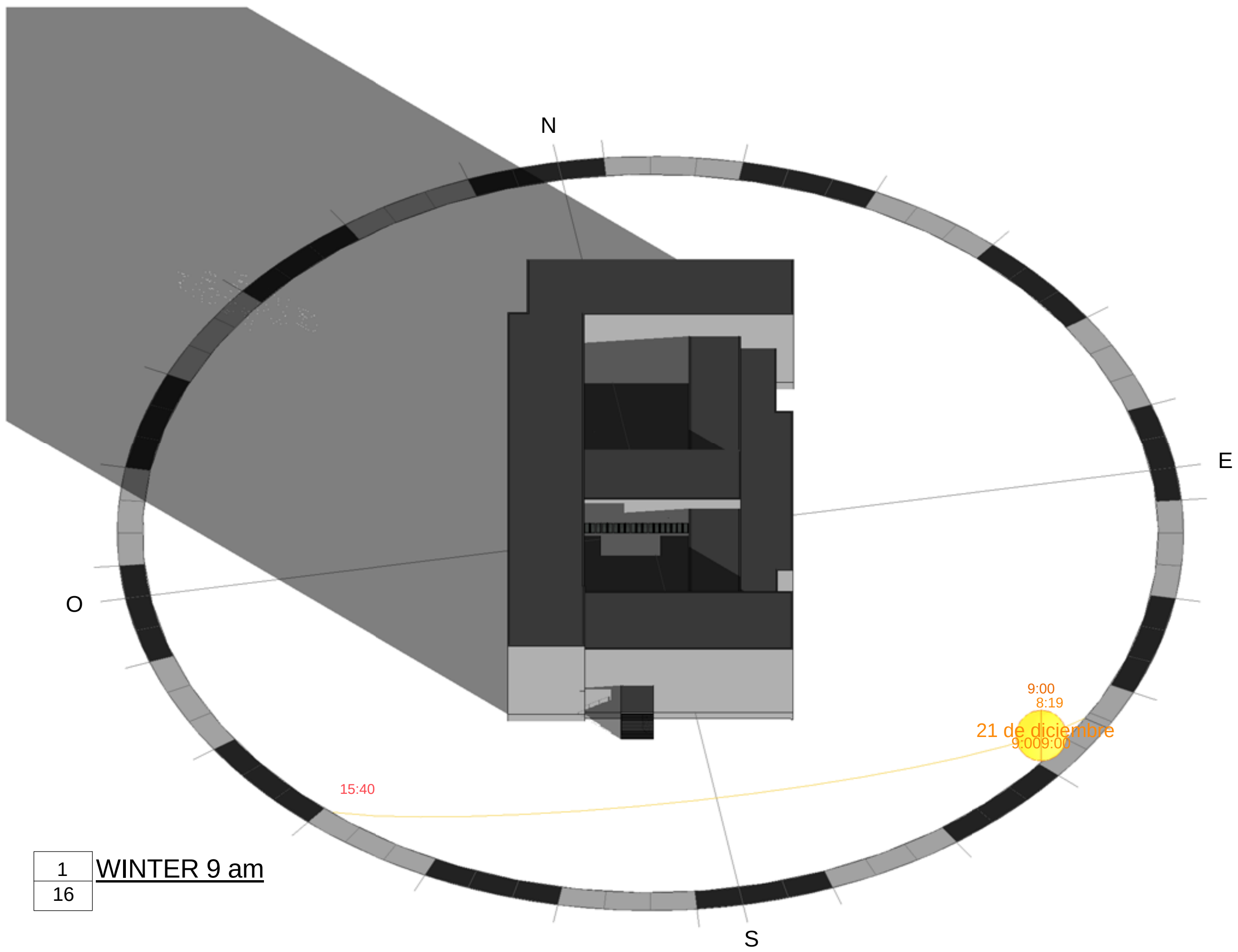
Plane Name **Sunpath case studies - AUTUMN**

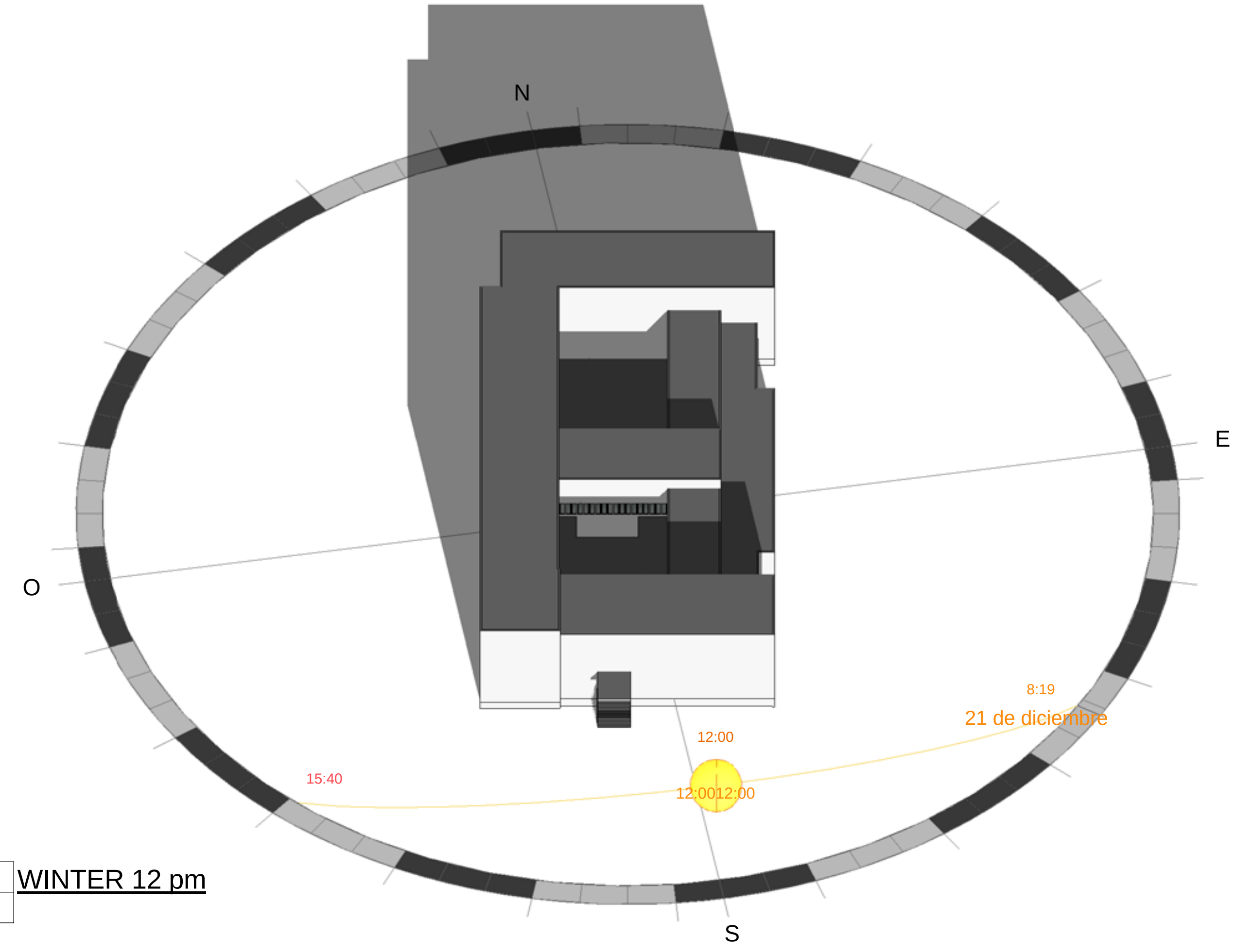
Date **2012/05/25**

Scale

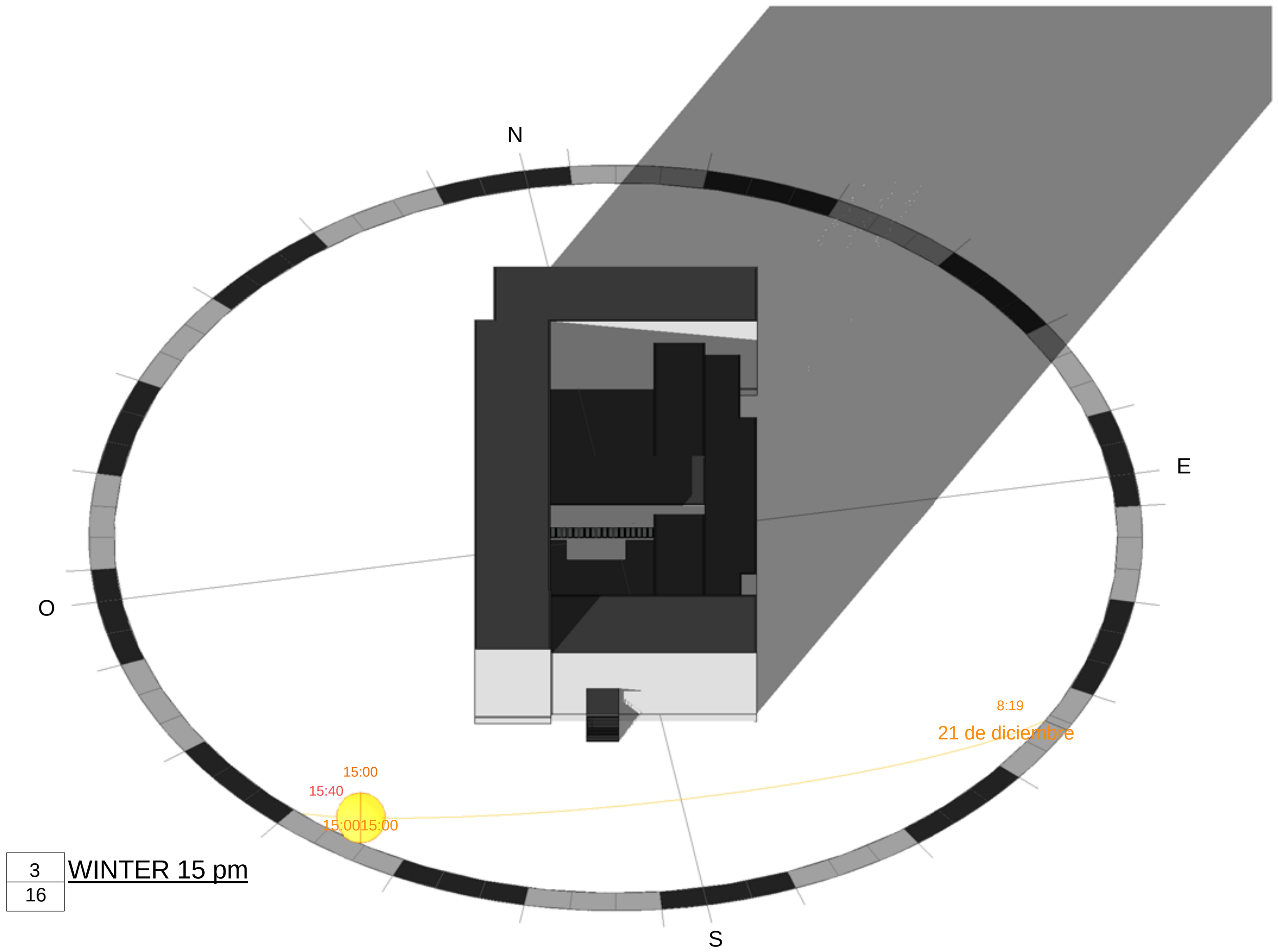
No. Plane **15**



1 / 16 WINTER 9 am



2 / 16 WINTER 12 pm



3 / 16 WINTER 15 pm

Wydział Budownictwa i Architektury Zachodniopomorski Uniwersytet Technologiczny w Szczecinie UNIVERSIDAD POLITECNICA DE VALENCIA	Authors **Javier Cano Catalá** **Mª Ángeles Ortega Martínez** **Ricardo Frías Palenzuela**	Tutoring **Karolina Kurtz** **Esther Valiente Ochoa**
	Project Title	**OVERHAUL DESIGN AND ENERGY STUDY OF THE LIBRARY OF THE FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE BUILDING**
	Plane Name **Sunpath case studies - WINTER**	Date **2012/05/25** Scale No. Plane 16