

Carlos Vaño Navarro

409731

Thesis Supervisor: Vincent Inja
Hanze University Groningen



Reader:
Gerrit Ribberink
Hanze University Groningen



Client:
Marteen Vieveen
Hanze University Groningen,
Research Centre, Area development



Foreword

As part of the graduation at the Hanze University Groningen, in the Architecture of the School of Architecture, Architecture and Civil Engineering has launched an investigation in February with the aim of reducing the energy consumption of monumental buildings in the city of Franeker. This research I have conducted as junior staff of Office North Area. In the preparation of this study, I have had the pleasure to have been able to access. Several parties from the field, lecturers and researchers from North Office Space and teachers of the Hanze University Groningen All have an important contribution to the realization of this thesis report. Therefore, we would especially like to thank the following people:

wERF

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Hanze University Groningen

Mr. G. Ribberink

Building physics teacher/ Reader

Mr. V. Inja

Graduation supervisor

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1. Introduction

The reason for the study was obtained from the initiative launched by a number of residents from the town of Franeker. The initiative, which operates under the name "workgroup energetic restoration Franeker" hereinafter wERF, has set a goal to give Franeker sustainable appearance.

The main purpose of the group is to look for the many monumental buildings in the downtown area and the problem that these premises entail regarding the maintenance and management of properties a solution. Many of the old historic buildings lose a lot of heat generated in the air, making homes spend much fossil fuel. This creates high costs for users and a high load on the environment. This problem calls for an adjustment of these homes in order to achieve an improvement of the energy performance. The working group is looking for ways to restore these historic buildings in a responsible manner without the loss of historic value and thereby reduce energy consumption. In this context wERF works with Office North Area. Front wERF has prepared a study by North Area Office.

Since February 2014, I have worked at my final thesis at Hanzehogeschool Groningen University of Applied Sciences. The major topic of my work is Energy Efficiency of a Historical building from Franeker.

Since 1988, the city of Franeker has many historic and listed buildings. The law guarantees maintained all these monuments. These buildings often do not meet the comfort requirements demanded by the user and also with the current standards. Current users are now facing the problem of using a lot of energy to acclimate their homes, which results from high costs on their bills.

My idea is to resolve this problem, through energetic measures and to reduce consumption. In this study, it is illustrated all the possible variants and the best

option for each case. Moreover, it has explanations and a clear view that the used solution respects the historical values. The problem described above leads us to ask the following research question:

“How can we update the energy efficiency of an historical building without compromising the architectural value?” (In the house in Eise Eisingastraak 10)

The thesis is a closer look at the various studies, analyzes and reports that are designed to answer the main and sub-questions during the graduation period. The research is roughly divided into three phases. These are the theoretical stage, the problem and the design phase. The theoretical phase of this study contains mainly for research. During this research, there is essentially a literature research has been done with the aim of obtaining of the problem and the related factors, a better understanding. Based on these factors, the research looked at the monumental regulation, energy metabolism, thermography, comfort, comfort, Enorm element program and the use of the EPC. In addition, I looked at the influence of architectural backgrounds such as moisture and ventilation. After analyzing the information obtained, it is used for filling of the steps in the next phase, the phase problem.

The phase problem has started with a thermographic survey. After this has occurred, there is an analysis of the energy transmission. This has happened with Enorm program. Also, this model is verified with the theory. In addition, the program is also used to calculate the EPC value. I also used a Multi-criteria Analysis to

find the best measures for the house.

With this obtained information, I proceed to formulate the solution phase.

From the recording and analysis, the following adjustments are considered: with Internal insulation we will decrease the R value of the wall, respecting the historical value of the facade. Last decision in the roof is the insulation of the attic floor, because it is the most effective with respect to the isolation of the entire roof surface. The investment for double-glazing is sometimes non-viable for the owner. Only addressing tochtstrips in the opening part, we will have good results, investing little money. My expensive recommendation for heat system is the biomass (Pellets), my cheap recommendation is easier: by moving the central heating boiler, the distance is decreased to the taps. As a result, less energy is lost. Additionally, you can choose to use thinner lines to go to the taps. Again, it is energy saving. And the best option for renewable energy sources is thermal tile. It is the only option compatible with the historic roof. The problem is that today, this option is not very developed. But in a few years it is a serious option to consider.

3. Building analysis

2.1 The monuments in Holland

It is called a monument in the Netherlands, a building or object, or the remainder thereof, when is of general interest because of the beauty , the significance of the scientific or cultural value. A more accurate formal designation is "protected monument" as defined in the 1988 book.

Until 2012, a monument that was built 50 years ago, it was able to be eligible for protection. On January 1, 2012, this criterion expired.

Municipalities and provinces often protect monuments (which we refer to as municipal and provincial monuments).

Netherlands has about 61,000 entries (52,000 objects) with monument status, of which approximately 1,500 archaeological national monuments are .

The building located in Eise Eisingastraet 10 has historical elements like: the façade, roof and also we can see interesting parts as decorative element found above the main door.

2.2 History existing building

Introduction

The Street building Eise Eisingastraet number 10 is a very old building, built in the year 1617. During that time there have been major developments and the house has many different uses. The most important are the reforms in 1985 and 2000. Is also important the prior use of the house, who was a police station, and therefore was remodeled and adapted to their new roles. After all this history the building has undergone and is worn, and now the most important to be preserved include roof and facade, because the originals are kept and therefore has

great significance.

The style and some ornaments located in the cornice of the gutter triglyphs (squares in which three vertical grooves) and artfully carved gutter brackets are all imitations of the Greek Doric style. From this we can conclude that this front has been established at the beginning of the 18th century.



Another important value to preserve is in the door. It was introduced during the 18th century practice. It was with the objective to decorate the house. The ornament is an Igdrasil. Normally, we can see it above the front door of a house. The belief is that Igdrasil branches have the power to connect the world with the heaven.

2.3 Research on the current state of the existing building

Description

The monument consists of a spacious house with an alley next to the “girl’s home”, which is suitable as a workshop or guesthouse. The house has a deep, sunny garden (40 meters deep) with beautifully decorated borders and terraces. With wood and stone floors, the fireplace, the spacious living room and cozy kitchen of the house exudes comfort and atmosphere. Now, this empire includes many original parts and has a rich history with distinguished residents, including a mayor and notary.

Ground floor:

There is a big living room and kitchen overlooking the garden. Through the vestibule you enter a long corridor with stone floor, which also has a toilet and a fine staircase. On the front you will find the spacious, cozy living room (approx. 55 sqm) with beamed ceiling, fireplace and wooden floor .

Through the living room you walk into the middle room, which is furnished as a library and music room. The middle room is also equipped with a wooden floor.

At the rear of the ground floor is the spacious kitchen with wood floors, beamed ceilings and modern kitchen including a kitchen island, From the kitchen overlooks the beautiful, spacious garden with, terraces and wooden barn (2001).

1st floor:

Five bedrooms and a comfortable bathroom.

This home offers all the space on the first floor to the residents. So you

will find the spacious landing with wooden floors and exposed beams a wet cell. In front of the house is the master bedroom, a spacious bedroom with an adjacent bathroom. The bathroom (2003) offers all the comforts: bath, under floor heating and shower.



Historic facade



Facade Anchors



Wood beam determining degrees of

This building is classified as a living monument and important people lived such as: the mayor or the notary. It has a unique past and it is also considered a national monument.

4. Regulation Monument protection

4.1 In what ways is the building legally protected?

The Franeker city hall is a nationally designated monument, a rijksmonument. This legal status exists to protect privately-owned buildings and structures of significant cultural and historical value, by restricting the ways in which they can be altered. Hence, we found necessarily to research what kind of changes of the city hall would or would not be allowed. After all, an environmentally friendly idea isn't very useful if it can't legally be put into practice.

4.2 Monument protection laws

4.2.1 Dutch law

Unlike many Dutch laws, laws concerning protection of monuments are not overly complex. The relevant law states that "It is forbidden to damage or destroy a protected monument." Permission is required to "demolish, disrupt or in any aspect alter" a monument (Rijksoverheid sd).

This limits many major renovation options, which means it is not possible to bring the building up to modern standards, but such ideas are not possible without significantly damaging the building's historical character, anyway. Replacing the glass of the windows is one measure we examined, and which would likely require permission. This permission has to be given by the College van B&W of the municipality; because the glass in the windows is not original (it is about a century old). It is required for permission for the glass which we propose to replace.

About laws for historic buildings in the Netherlands: these in general only effect listed buildings. The basis of Dutch heritage preservation, including buildings (and objects such as: fences, infrastructural works and memorial statues), is found in the Dutch heritage Act. which states that listed buildings should be preserved and that damaging the building can have consequences in court. So the owner is legally responsible for preserving the listed building. Damage is demolishing (building parts) on purpose or by modifying the building in a wrong way.

There are not specific rules for modifying listed buildings, but there are some basis design ideas which in general in the Netherlands are more or less accepted:

- the historic qualities are most important, so modifications must be designed refined and not ask to much attention in the overall image of the building. So, replacing a detailed historic window for a new window is, in most cases, unacceptable; or changed detailing of the roof (at the gutters) because of high quality (thicker) insulation.
- to prevent noise in what is old and what is new, it is suggested to design new building components in a contemporary style instead of building it in the historic style. For example: a new door entry can be accepted when designed in a contra story style, and not in a historic style.
- preserve as much old material as possible, reversible modifications are preferred in most municipalities. For example: when insulation, do not use materials that damage historic material (when removing the new material in the future). To know when the building was constructed and modified can help in determine what building components may be modified more or less, or in a different way. For this you can make an inventory the historic qualities and

building/modification periods comparing plans in the archive,
searching for old pictures, talk to owners and (local) historic experts)

5. Energy efficient

To explain when a building is energy efficient, I will describe the Bouwbesluit 2012.

2. Notwithstanding the first paragraph, if there has a building or part thereof that is no more than one plot with several functions, it is applicable an energy performance coefficient. This coefficient is total characteristic of energy, determined by NEN 7120, that does not exceed the total energy, according to NEN 7120 certain allowable energy. The allowable energy use is a used function based on the value specified in Table 5.1.

3. If through the application of NEN 7120 using NVN 7125, we found that the coefficient of performance of energy is not enough, then use a maximum of 1.33 times the figures shown in Table 5.1.

Use function	Members of application			limit
	energieprestatiecoëfficiënt			energieprestatiecoëfficiënt
article member	5.2			5.2
	1	2	3	1, 2 and 3 [-]
1 Living Function				
a caravan	1	-	3	1.3
b other residential function	1	2	3	0.6
2 Meeting Function	1	2	3	2
3 Cell function	1	2	3	1.8
4 Health Function				
a with bedgebied	1	2	3	2.6
b other health care function	1	2	3	1
5 Industrial function	-	-	-	-
6 Office Function	1	2	3	1.1
7 Guest Feature				
a in an accommodation building	1	2	3	1.8
b Other accommodation function	1	2	3	1.4
8 Education Function	1	2	3	1.3
9 Sports Feature	1	2	3	1.8
10 Shop Function	1	2	3	2.6
11 Other functional	-	-	-	-
12 Building no building being	-	-	-	-

Table 5.1

Article 5.2 Energy Performance Coefficient

In Building

The EPC requirement is expressed as a limit on the energy performance coefficient and indicates the degree of energy efficiency of a building. This determination method gives much design freedom and it is an incentive for the integrated design of airframe and systems and the generation of energy-efficient building concepts. It follows from Section 5.5 that this article does not apply to use functions that are not intended to be heated for the purpose of

use by people.

The limits for the EPC differ per user function. The first paragraph above refers to Table 5.1. The calculated EPC must be lower than the value defined in the table. It is noted that since January 1, 2011 a coefficient for the caravan apply (1.3). At that time also the EPC for the "other residential function» tightened to 0.6.

So after all this information, we arrived to the conclusion that a house is called energy efficient when the EPC is less than 0.6.

6 . How to calculate Energy efficient

The ENORM program is very user-friendly layout. The input data is always checked for accuracy, and to assist in entering data, the user is included specific help information in several places. The EPC is immediately recalculated after each change in the input data and displayed (live). Both residential and commercial buildings and are seamlessly integrated into one program.

After all this information we arrive to the conclusion that to know the amount of energy, we need calculate the EPC, and we can do this with a software, for example "Enorm". I will calculate the EPC for my historical building, and then I will make some improvements for see the benefits.

7. Architectural value criteria

Valuation criteria

It is virtually impossible to objectively establish standards for the preservation of monuments and other, for their historic or architectural significance of buildings deemed value. Almost all the criteria that can be measured for boil down to an opinion, a view with which one can agree or not.

However, criterion can be derived from the value which attach to people with buildings.

The State Service for Cultural Heritage has developed a standard for valuing architecture. Thus the monumental value of a building can be clearly and unambiguously identified. The valuation plays a leading role in the identification of a building as a monument, and when changing the protected building.

The valuation is based on five main criteria, which are divided into sub-criteria. The fields of art and history form the basis of the valuation of the built heritage. But also spiritual, geographical, socio-economic, administrative and technical developments play a role in the valuation, in addition to integrity and rarity. Each building has its own range of values.

I . Cultural and historical values

1. Importance of the property / complex as a particular expression of (a) cultural, socio-economic and / or administrative / policy and / or mental development (s);
2. Importance of the property / complex as a particular expression of (a) geographic, scenic and / or historical-spatial development; **(In this point I want to explain the importance of the scenic. In Eise Eisingastraet we can see different kind of houses, and some are similar. This is a important value to preserve, and our house is similar than other historical buildings in this street, for example to the house on Eise Eisingastratt 17)**
3. Importance of the property / complex as a particular expression of (a) technical and / or typological development (s);
4. Importance of the property / complex due to innovative or pioneering nature value;
5. Importance of the property / complex due to special recall value.

II Architecture and art historical values

1. special interest of the property / complex for the history of architecture and / or engineering;
2. special interest of the property / complex for the work of a master builder, architect, engineer or artist;
3. importance of the property / complex because of the aesthetic qualities of the design;
4. importance of the property / complex due to the special materials, the

ornamentation and / or monumental art; ***(Another important value to preserve is in the door. It was introduced during the 18th century practice, with the objective to decorate the house. The ornament is an Igdrasil. Normally we can see it above the front door of a house. The belief is that Igdrasil branches have the power to connect the world with the heaven.)***

5. importance of the property / complex because of the special relationship between exterior and interior (parts).

III Situational and ensemble values

1. meaning of the object as essential (cultural-historical, functional and / or architectural history and visual) part of a complex;
2.
 - a) special, iconic significance of the property for the appearance of its surroundings;
 - b) special significance of the complex for the prestige of his surroundings, neighborhood, city or region;
3.
 - a) special significance of the complex due to the high quality of the building in relation to the mutual historical and spatial context and in relation to the associated landscaping, roads, water, soil and / or archeology;
 - b) special significance of the object because of the way allotment / decor / amenities.

IV Integrity and recognizability

1. Importance of the property / complex because of the architectural integrity and / or recognition of former and / or interior;

2. Importance of the property / complex because of the material, technical and / or structural integrity; ***(Another important element to consider is the distance between the inside window frame and the facing wall. If we are going to modify the interior or exterior adding wall insulation, we must take into account that we are going to update this important value.)***
3. Importance of the property / complex if still well recognizable expression of the original or an important historical function;
4. Importance of the complex due to the accumulation of valuable interesting historical construction and / or use phases;
5. Importance of the complex due to the damage and recognizability of the entire ensemble of the constituent parts (head and outbuildings, fences, landscaping, etc.);
6. Importance of the property / complex in relation to the structural and / or visual integrity of the urban, village or rural environment.

V Rarity

1. Importance of the property / complex because absolute rarity in historic architecture, building technology, typological or functionally;
2. Exceptional importance of the property / complex due to relative rarity.

8- Thermal Study

8.1 Why a Thermo graphic Study?

I made a thermo graphic study because it is essential to know the current state of the house. With the pass of time some materials start to lose her properties. This is a good way to know the specific points where we should focus our restoration.

Without a thermal imaging survey it would not have been possible to identify the issues exposed in this report with a large amount of invasive work such as removing ceilings to identify where insulation is missing or using smoke bombs to show where windows and doors are leaking air. This also means that only the affected areas of ceilings need to be removed to rectify these issues dramatically cutting down the expense and disruption of any remedial works.

8.2 How It works

For a thermal imaging survey it is more effective when outside is colder and inside the property is. The images in this report were taken with an ambient air

temperature of around 1 degree centigrade, and the heating was turned up in the property to ensure good results.

It should be noted that when images are taken from the outside of the property then areas where heat is leaking out show as orange and red, while well insulated areas show as blue. The opposite is true for images taken from inside the property where blue areas show where heat is leaking out of the property. The thermal imaging camera incorporates a digital still image camera to allow the various thermal images to be easily identified. Not every color corresponds to the same temperature all the time. It depends on the heat difference that we have in the image.

8.3 Results

Air leakages

Typical air leakage places were around and through windows and doors, in the junction of ceiling/floor with the external wall, penetrations through the air barrier systems, and walls and floors between apartments.

The main typical air leakage place was in detached houses in the junction of the roof and the external wall. In apartments most typical air leakage was around the doors and windows.

In our building, the main air leakage is placed in the windows, in the part where we can open it. If we change the entire window for a double glassed, we will spend a lot of money with poor results. I think that the smarter solution is address tochtstrips. We are not going to spend a lot of money, and we will lose less energy in those points.

Spalling

As we can see in some pictures of the thermal-study some interior and exterior walls suffer spalling. After an investigation, I arrived to the conclusion that the

water penetrates by capillarity. But, where is this water from? There was water flowing in parallel canal to Eise Eisingastraet. This canal was removed, but some years later, in a house in Eise Eisingastraet started to appear a big infiltration water. The owner had to use an extractor water pump, like a provisional solution. My conclusion is that when they removed the canal, some water started to flow under the Eise Eisingastraet street. And this is the water of the infiltration.

Insulation lack.

There isn't any area where there is a thermal bridge due to lack of insulation. But I can see that the isolation is not the best, and is possible a good improvement. So the conclusion is that is possible and highly recommended to increase the insulation thickness.

9-Energy efficiency calculation

Energy Label Introduction.

The energy label is a label according to various European directives (92/75/CEE, 94/2/CE, 95/12/CE, 96/89/CE, 2003/66/CE) should be included in the sale, among other car 's electrical appliances, lighting and buildings.

This label is a measure of the consumer to see how efficient, environmentally friendly and / or energy saving the purchased product. Also there is often information about the performance of the product and the materials used in the production.

In the Netherlands, the Directive is implemented as the Decree of 25 February 2012 laying down rules on the energy labeling of energy-related products (Decree energy labeling of energy-related products) . Pursuant to Directive

2010/30/EU, the Commission shall adopt delegated regulations (also called delegated acts) fixed. Those delegated acts have direct effect and therefore do not require implementation by ministerial regulation. For the product categories for which there is no regulation, the ministerial order remains in force provisionally.

Buildings

A ++	Less than 0.5
A +	Less than 0.7
A	Less than 1.05
B	Less than 1.3
C	Less than 1.6
D	Less than 2.0
E	Less than 2.4
F	Less than 2.9

In 2002, the European Parliament adopted the EPBD directive. This Directive aims at reducing the energy consumption of buildings , with a view to reducing emissions include CO₂ and to reduce dependence on fossil fuels. On the basis of this European Directive is mandatory since January 1, 2008 in the Netherlands that energy should be handed over to the new user on any transaction of a dwelling or non-residential building over 10 years. Housing associations have to comply with this obligation, provided they or their entire building stock suddenly with an energy until January 1, 2009

G	More than 2.9
---	---------------

The rules for granting greatly simplified since 2010: It is estimated how many giga joules of energy the home used each year per square meter for heating, hot water and lighting. These will be deducted the estimated heat from sewage and ventilation, and the estimated energy via solar collectors (both electrical and hot water). It is assumed average occupancy, average outdoor climate and an average combustion behavior.

A property with an A + + label fired in theory, four times less energy than a house with a D-tag. That saves a house of 100 square meters each year roughly 3,000 euros on energy bills. Incidentally, anyone who uses the energy during the night and working hours, the heating layer always move, usually much less than the label suggests.

The obligation of the energy also applies to the sale or lease of a different building than a home. The energy label is required for construction, sale or rental of residential and non-residential buildings, which are: offices, schools, factories, barracks, hospitals and others. The requirement also applies to new leases of non-independent units, such as student rooms and also for some holiday. In buildings larger than 1000 m² in which public authorities or public institutions are located and accessible to the public, is from 1 January 2009 a permanent energy to be present. This label must be visible to the public.

In the Netherlands, there are approximately 350 certified companies that can provide an energy end of 2008. Since November 1, 2008 we must have a certificate issued by CITO. It states that every energy sensor and / or a property consultant can adopt it. Without this degree, one is no longer authorized to provide energy labels for homes.

ENORM

introduction

Since July 1, 2012, the new energy performance standard BS 7120 EPG forces and makes architects, engineering consultants and municipalities to use the new energy software HUGE. This package is the logical sequel to the successful software EPU NPR NPR EPW 2917 and 5129, as developed in recent years.

DGMR through in collaboration with NEN

ENORM allows you to perform, for example, the energy building from a calculation in a simple way. These modern techniques can be measured to achieve EPC requirement. The results of a calculation are always clearly presented. In the context of the review of the planning application the HUGE program connects seamlessly with the new EPC program of the municipalities. The use of the ENORM program fits in well with the NEN NPR software as it was used. Till July 1, 2012 this allows you to get started quickly with the new HUGE software.

Possibilities of the program

The ENORM program is very user-friendly layout. The input data is always

checked for accuracy. To assist in entering data, the user is included specific help information in several places (i). The EPC is immediately recalculated after each change in the input data and displayed (live). Both residential and commercial buildings are seamlessly integrated into one program.

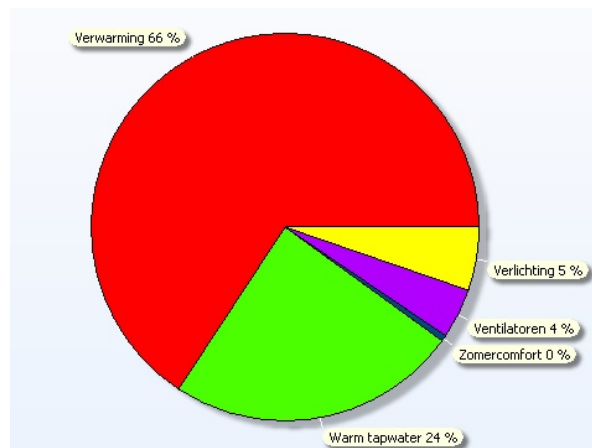
Enforcement

Existing situation

The calculation of the EPC with the ENORM program, with the existing situation, give the result of 2,08. As we can see in the table above, we are in the D energy label.

A new building has to respect the current rules and should have the EPC below 0.6. But this case is not a new building, so we don't have to be under 0.6.

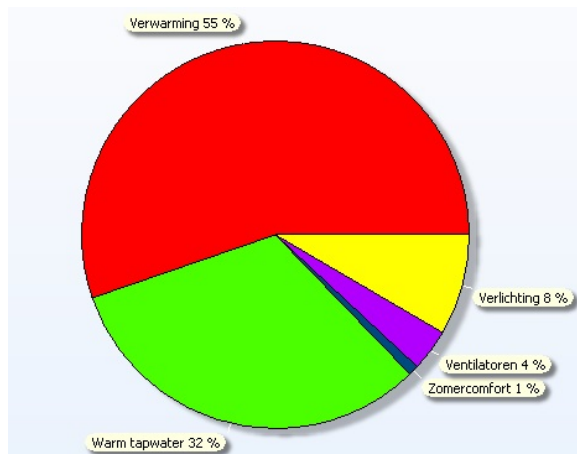
Anyway, I'm going to implement some improvements to reduce our EPC.



New situation

I have introduced in the program the next list of improvements. The initial value

of EPC is 2.08 and after the improvements is 1, 19. We've gone to a D energy level to a B energy level. In this point we arrive to ALARA. I mean, we can not improve more the energy efficient. If the owner wants to invest more money is



not profitable.

Improvement	EPC decrease	%	EPC total
Existing	2,08		2,08
HR-107 boiler	0,31	34,8314606	1,77
Tappaint warm water: u-6mm ; pipe diameter: 8mm	0,08	8,98876404	1,69
Pilot light	0,02	2,24719101	1,67
Wall insulation Rc=2,5	0,02	2,24719101	1,65
Windows U= 5,7 --- 2,8	0,22	24,7191011	1,43
Roof R c= 1,1--- 2,5	0,14	15,7303370	1,29
DC fans	0,03	3,37078651	1,26
Solar panel 10m2 east Roof	0,07	7,86516853	1,19

		9	
	0,89	100	

11- Construction procedures

10.1 Introduction

We have two big groups of measures.

Firstly, passive measures which improve casing. They help to reduce the demand for great heating and/or the cooling demand ideal.

Secondly, the measures which improve air conditioning systems. They can be divided into two blocks: those which contribute for reducing consumption due to an increase of Seasonal Performance systems; and those which lower the consumption following a reduction ratio demands.

1. Measures which improve performance enhancing: replacement of boilers, chillers and autonomous teams, division of power and incorporating evaporation air condensers.
2. Improvement measures which decrease the ratio of demands: reduction of distribution losses and accumulation, free cooling and recovery energy from the exhaust air.
3. Measures which improve transport systems: they contribute to a reduction in transport factor.
4. Improvement measures through the contribution of renewable energies such as: solar thermal use of production.
5. Measures which improve lighting systems: contribute for improving lighting consumption by reducing the installed capacity while maintaining or improving the level of luminance.

10.1. Passive measures

10.1.1 Introduction

Passive measures are those that impact by reducing energy demand of existing buildings. They affect the thermal envelope of the building and its infiltration and air changes.

a) It is important to place the building in its general context in order to assess their inputs and losses, especially in the oldest buildings in hydrothermal behavior, which directly depends on this:

- Geographic location, climate zone and local microclimate, temperatures, sunlight, rainfall, altitude, mountain area, interior or coast, winds dominant.

The immediate environment can generate constraints that require rehabilitation focus on a certain way:

- Vegetation, vegetation type, height, foliage expiration.

- Building orientation, sunlight, weathering...

- The year of construction. It provides the information about period which was built (inertia, airflow, etc.).

- Classification of the building. Existing buildings can be cataloged and protected by heritage laws affecting rehabilitation.

b) According to the analysis of the context, it is necessary to scrutinize the architectural conditions which influence the energy for rehabilitating the building, include:

- Compactness of the building.

- Thermal envelope (insulation level, thermal bridges, thermal mass).

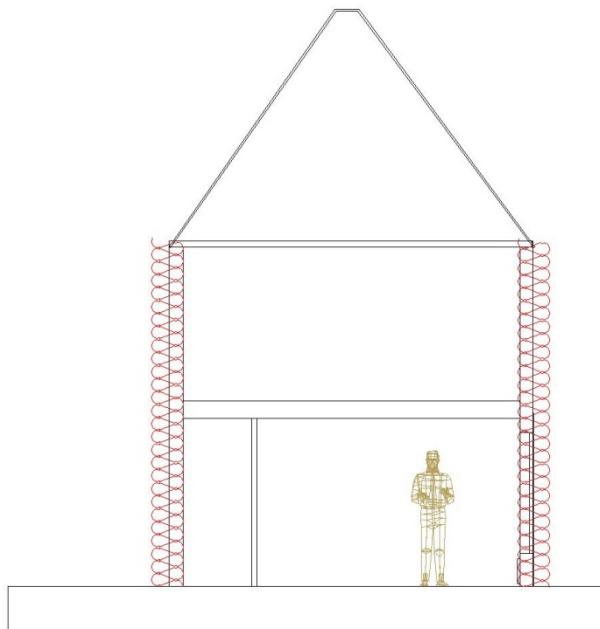
- Holes in walls and cover (surface, orientation, permeability, level insulation).

- Presence of the unheated spaces (attics or attics uninhabitable, clotheslines, sanitary chambers or underground parking floors, commercial ground floor ...).

- Presence of greenhouses and/or space solar gain.

After all this analysis we start to talk about the different parts of the house, and the different solutions for each.

10.2.1 Walls



Introduction

The insulation in the facade walls in the rehabilitation projects consist of adding a layer of thermal insulation to walls and / or dividing existing accessible, in order to reduce the thermal transmittance.

a. Goal

Reduce the energy demand by reducing the overall mass transfer coefficient in external opaque enclosures, primarily vertical walls. Primarily, it is aimed to

reduce the energy losses in winter.

b. Degree of applicability

The energy measure is always interesting if the facade is not, or is insufficiently isolated. The effectiveness (energy savings from implementation) increases as the weather is cooler and the facade is less exposed to the sun, I mean, orientations north, east and west by the order and / or shaded facades during the winter and / or exposed to the prevailing wind. In generally, it is more effective for residential than non-residential buildings.

c. Influence on energy demand

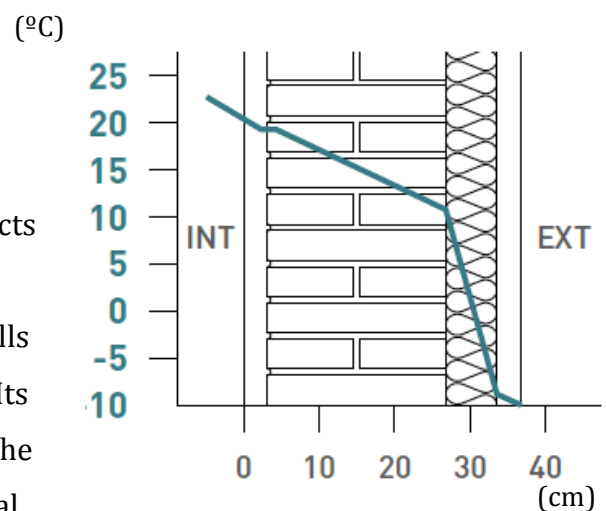
Energy demand for transmission through walls and roofs is reduced proportionally to the decrease in the overall coefficient of the same.

d. Technical Implementation

Implementations can undertake external, internal insulations and ventilated facade.

Exterior thermal insulation

The exterior insulation on rehabilitation projects consist in add a surface layer of insulation attached externally to the existing dividing walls and then protect it with a new exterior finish. Its application is especially recommended when the building facade, which aims to improve thermal

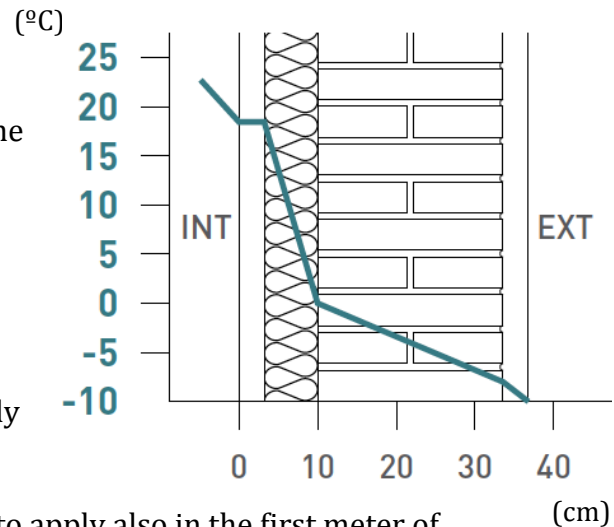


insulation, is substantially flat and vertical. The outer surface is reasonably easy placement in buildings 1 or 2 levels. For buildings, higher altitudes increase the difficulty of access and therefore the cost aids.

Interior thermal insulation

This system deployment insulation is a good choice, when there is an inability to act from the outside, as it is buildings whose facades are cataloged and protected. It is based on the placement of thermal insulation on the inner faces of the facades and then it covers with a new interior finish. The system generates easily numerous thermal bridges, especially on the edges of slabs.

To avoid isolation is necessary to apply also in the first meter of the top face of the slab. This system leaves out of the envelope thermal mass of the enclosure (if any), and thus allows rapid heating of the living space. In return the enclosures will not accrue or radiate heat into the interior.



Ventilated facade

The ventilate facade is a constructive exterior cladding system consisting of an inner leaf, an insulating layer, and an outer sheet unsealed. This type of facade usually allows durable and high quality of finishing works, and offers good thermal performance, although it has a high price. It is a common solution and representative institutional buildings.

Now we compare the different options that I explained with a Multi-criteria analysis. The score that I give depends on the quality or how the advantage/disadvantage fit in the option.

The best solution is the internal solution, because we have a protected facade, and with this solution we can work from the interior.

The system is based on the placement of thermal insulation on the sides domestic needs of the facades and then cover it with a new finished interior.

The fact that an option also uses to isolate acoustically is very important, because it gives a second application to the solution used.

The fact that you can work from outside or inside the building is not very important, because the discomfort is only during the period of work.

Thermal insulation

The insulation is well positioned on metal wall guides or in the support.

Dimensioning the correct size for the climate zone and the existing enclosure type. This technique increases the risk of moisture condensation in cold areas (thermal bridges), especially in wet rooms (kitchens, toilets...) so it is essential to use closed cell insulation, or apply a moisture vapor barrier primer on the warm side of the insulation.

Vapor barrier

When you install the interior insulation, we have the possibility of occurrence of interstitial moisture due to condensation.

One of the problems is the connection with the wrought, because it can produce a thermal bridge.

Energy effect

The actual R value in the walls of the house is $1,3 \text{ m}^2\text{xK} / \text{W}$, and with a better isolation will increase the R value to $2,5 \text{ m}^2\text{xK} / \text{W}$. We increase in $1,2 \text{ m}^2\text{xK} / \text{W}$ the R value of the house. With this insulation the EPC decreases 0.2 points.

How this measure affect the historical value.

Using the internal insulation we respect the facade, because the reformation is totally inside.

10.2.2 Roofs**Introduction**

Is to add a layer of thermal insulation to existing decks in order to reduce the thermal transmittance. Resolve adequately the roof of the buildings has a strong impact on the conditions of users comfort (from the thermal point of view) and hygiene spaces, since the presence of condensation causes a direct effect on the health of users: the deterioration of certain allergic reactions, bronchial asthma, asthmatic bronchitis.

a. Goal

Reduce energy demand by reducing the overall coefficient of transfer covered. The insulation helps reduce both losses in winter as in summer reduce contributions .

b. Degree of applicability

This measure is of great interest for buildings 1 or 2 levels. Should initially be excluded cover-high rise buildings and / or that have a thermal buffer cap space, such as storage or storage areas uninhabitable.

c. Influence on energy demand

Energy demand for transmission through walls and roofs is reduced proportionally to the decrease in the overall coefficient of the same.

d. Technical Implementation**Thermal insulation on the outside**

This measure is interesting when the current status of deck sets of outstanding repairs.

Thermal insulation on the inside covers

The insulation from the inside is achieved by isolating the roof of the upper housing. It is simple to implement and allows the use of thermal insulation materials of lower quality and lower cost than in the exterior insulation.

e. Measure used

Thermal insulation on the inside covers

In addition to the isolation of the surface may also be chosen for the insulation on the inside. It is important to add on the warm side of the structure a vapor control layer to prevent moisture.

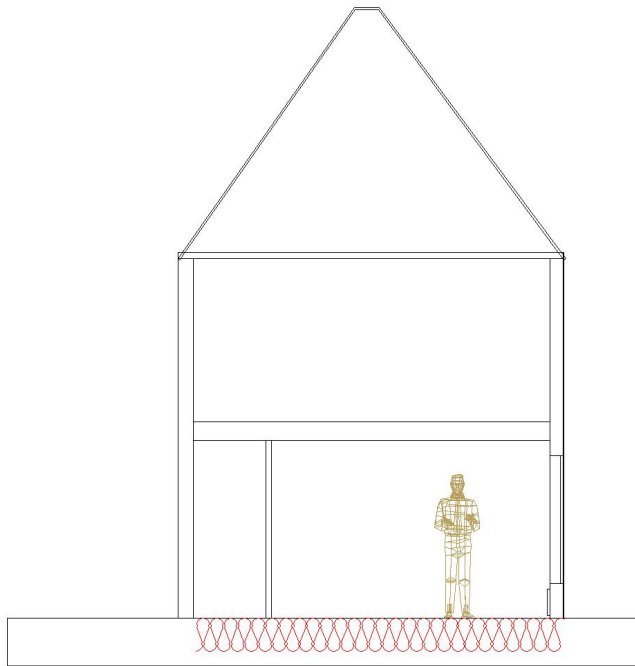
Energy effect

The actual R value in the roof of the house is 1,1 m²xK / W, and with a better isolation will increase the R value to 2,5 m²xK / W. With this insulation the EPC decreases 0.14 points.

How this measure affect the historical value.

Using the internal insulation we respect the roof, because the reformation is totally inside.

10.2.3 Floors



Increased levels of floors insulation

-Adding a layer of thermal insulation to existing soil in order to reduce the thermal transmittance.

a. Goal

Part of the energy losses that occur in a building happens through the soil, whether they are in contact with the ground (hearth) on ventilated chamber inaccessible (forged health) on unheated spaces (basements, garages) or outdoors (porches).

b. Degree of applicability

This upgrade is recommended for buildings with 1 or 2 levels.

c. Energy demand influence

Energy demand for transmission through walls and roofs is reduced proportionally to the decrease in the overall coefficient of the same.

d. Technical Implementation

Implementations can undertake insulation inside and outside.

External Thermal insulation

The external thermal insulation can be made only when there is a space high enough to work comfortably to install insulation system. Using closed pore insulation thermal performance is not lost even if the insulation is wet.

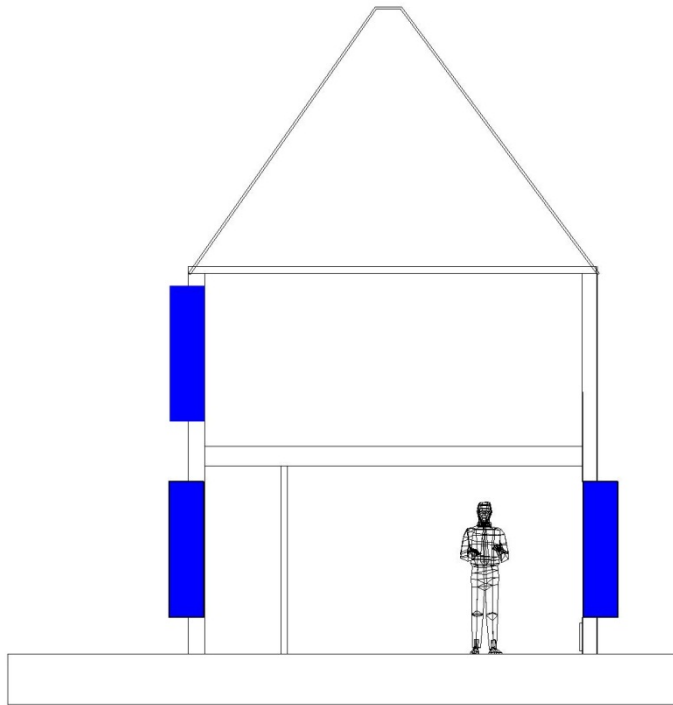
Internal thermal insulation

The insulation from the inside is achieved by isolating the lower housing floor. This simple implementation is necessary in order to replace the floor of the living downstairs. The insulation inside necessarily produce an elevation of the level of the ground in about 7 to 10 cm, which should be taken into account especially for housing affordability.

Measure used

Finally, I decided to don't use any measure in the floor. The house just has a good insulation, and any measure will be very expensive and not too useful.

10.2.4 Windows

**a. Goal**

-Is to reduce energy demand by replacing, conversion of glazing, joinery and / or installation of double glazed windows. On one hand, it should limit the energy losses through the windows (one square meter of space loses the order of five times more energy than the same area of enclosure). Moreover, it may be beneficial to introduce sunlight into the inner space through the holes in front and skylights and skylights for a passive heating in winter.

b. Degree of applicability

The interest of this measure should be carefully contrasted on an annual basis, as the positive effects of a performance regime for winter are usually opposite effect for summer regime. In the towns of warm areas, the summer regimen is usually dominant, so the best performance in summer will be the best option on an annual basis. Consequently, the interest of this measure, keeping to the heating season, increases in buildings with a significant percentage of single glazing on facades facing north or shaded facades. In summer conditions, the actions proposed in this section are primarily intended to reduce solar radiation entering the building facades mentioned and may represent the most important component of energy demand for cooling.

c. Influence on energy demand

The performances of glazing originate changes in gain Solar and heat transmission losses. The optimal regimen in winter: the first factor would increase while the second is reduced, which

It is not always possible. However, keep in mind those losses transmission glazing can represent a significant percentage global energy demand, so their reductions in these cases would priority over other considerations.

d. Technical Implementation

We considered three types of actions in hollow facade: the replacement of windows, replacement windows and trim and installing double-glazing

Replacement glass

Placement specific glasses with thermal insulation characteristics.

To prevent heat loss in winter, in the recesses oriented north and greater losses, the use of low-e insulating glass is recommended to reduce thermal loads and provide better comfort in the perimeter zones.

Replacement of timber and glass

This measure consists of raised the existing for replacement with new ones with specific characteristics of thermal insulation and sealing joinery. The change in carpentry can affect leaves, frames, or both parties.

Installing double glazing

It is a solution for cold areas, traditionally used in high mountain areas. You should verify that the front thickness is sufficient to support the installation of a second carpentry. An air chamber is created between the two windows, which provide the overall thermal resistance, reducing the transmittance. The most suitable for this installation is sliding windows because it is not encountered in their opening path. Sealing is important to prevent infiltration that can erase the thermal resistance of the

camera.

Measure used

Double glazing

“There is an epidemic spreading across the country: in the name of energy efficiency and environmental responsibility, replacement window manufacturers are convincing people to replace their historic wood windows. The result is the rapid erosion of a building's character, the waste of a historic resource, and a potential net loss in energy conservation. Typically replacement windows are vinyl, aluminum, or a composite with wood, and none will last as long as the original window. Repairing, rather than replacing, wood windows is most likely to be the “greener option” and a more sustainable building practice
“

With this introduction, I want to explain in what is based my opinion to decide the measure used. With the new law, we can put a double glass, and we will notice the decrease in heat loss. You should verify that the front thickness is sufficient to support the installation of a second carpentry. In addition, an air chamber is created between the two windows set provides thermal resistance, reducing the transmittance.

But, as we can see in the introduction, It isn't always the best option. The investment for double glazing is sometimes non-viable for the owner. Only addressing tochtstrips in the opening part, we will have good results, investing little money.

Energy effect

The actual U value in the windows of the house is $5,7 \text{ W/m}^2 \cdot \text{K}$, and with a double glass we decrease the U value to $2,8 \text{ W/m}^2 \cdot \text{K}$. We decrease in $2,9 \text{ W/m}^2 \cdot \text{K}$ the U value of the house. With this measure the EPC decrease 0.22 points.

Monumental influence legislation and historical value

The application of restoration glass creates an architectural intervention, but the characteristic appearance is guaranteed. Before applying restoration with glass rods of the frame, a permit must be applied for modified or replaced.

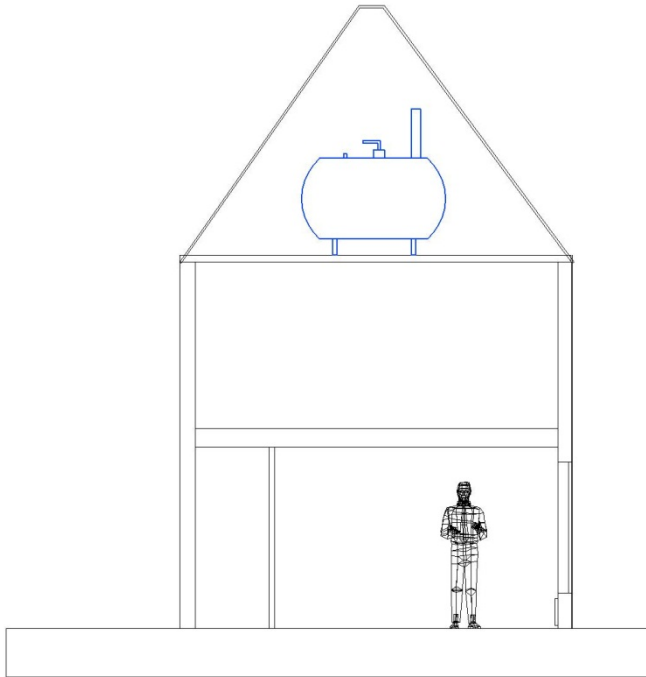
Cover glass can be placed on the outside or inside. When placed on the inside the view is hardly affected. When taking the rods of the frame, a custom permission must be sought.

To customize the frame a permit must be applied for.

10.3 .Active measures

Active measures are those that affect production systems of cold or heat in existing buildings. As we saw in the introduction, these improvement measures can be divided into two groups: those that contribute to lower consumption as a result of an increase in average seasonal performance of systems; and those for lowering consumption due to a reduction ratio demands.

10.3.1 Improved installation and equipment



a. Goal

The heat production systems in buildings are traditionally formed by fossil fuel boilers such as coal, oil or gas. The importance of reducing the consumption of these sources energy is because the polluting factor. Therefore it must be reduced to maximum use through efficient equipment and systems incorporating auxiliary from renewables.

b. Degree of applicability

The interest of this measure should be carefully contrasted on an annual basis, as the positive effects of a performance regime for winter are usually opposite effect for summer regime. In the towns of warm areas, the summer regimen is usually dominant, so the best performance in summer will be the best option on an annual basis. Consequently, the interest of this measure, keeping to the heating season, increases in buildings with a significant percentage of single glazing on facades facing north or shaded facades. In summer conditions, the

actions proposed in this section are primarily intended to reduce solar radiation entering the building facades mentioned and may represent the most important component of energy demand for cooling.

c. Influence on energy demand

The performances of glazing originate changes in gain Solar and heat transmission losses. The optimal regimen in winter the first factor would increase while the second is reduced, which

It is not always possible. However, keep in mind that losses transmission glazing can represent a significant percentage global energy demand, so their reduction in these cases would priority over other considerations.

d. Technical Implementation

There are two big groups for heat system: fossil fuel boilers and Biomass.

Fossil fuel boilers

Standard boilers operate at a constant temperature, approximately 80 ° C on average. There aren't allowed to adapt consumption to the different demands that occur depending on the time of year, time of day or outside temperature.

Biomass

Biomass is all organic matter, plant origin and also animal origin, where those materials are included from their natural or artificial transformation. Examples of biomass are wood products derived from farming, animal manure, shavings or pellet and others.

Measure used**Biomass (Pellets)**

Wood pellets are a refined and densified biomass fuel that is formed when wood residues are compressed into a uniform diameter under high pressure. Wood pellets have a uniform shape, size and density and are ideal for automatic combustion heating systems such as pellet stoves and boilers. By pelletizing wood residues from sustainably harvested biomass and quality waste wood, millions of tons of biomass can be put to work for the local economy while at the same time preserving the environment.

The main economic advantage of biomass on natural gas or diesel, and more respect to liquefied petroleum gas or electricity, lies in the lower fuel costs and greater price stability thereof, does not depend on oil prices. This advantage has to balance and prevail against representing initial install a biomass equivalent gas or oil.

Energy effect

Wood pellets are an efficient source of heat because they contain very low levels of moisture and ash, when compared to woodchips or cordwood.

Virtually all of the material is burned and converted to heat. Wood pellets are economically competitive with home fossil fuel options and electric heat.

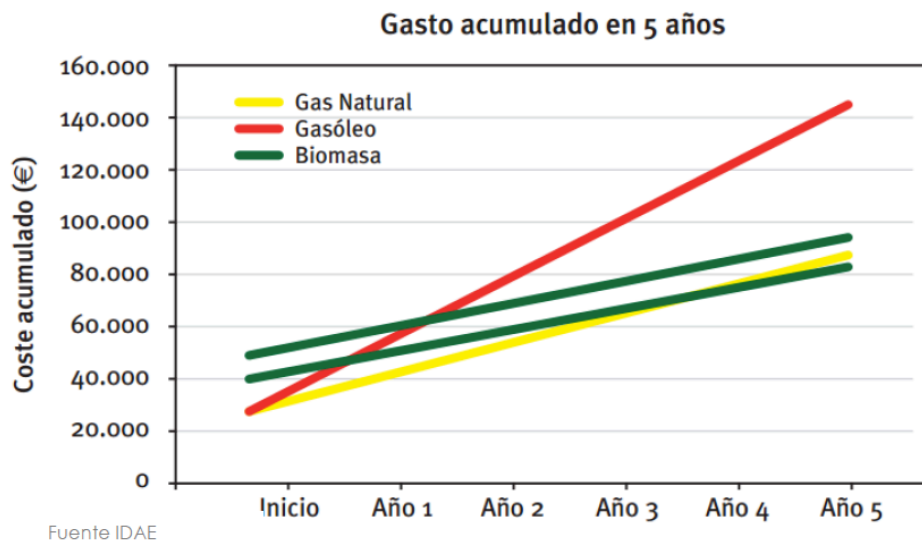
Relative to other home heating alternatives, pellet fuel prices are less volatile.

The first investment is expensive compared with other alternatives. However, in only 5 years we amortize the money invested. Sometimes the owner of the

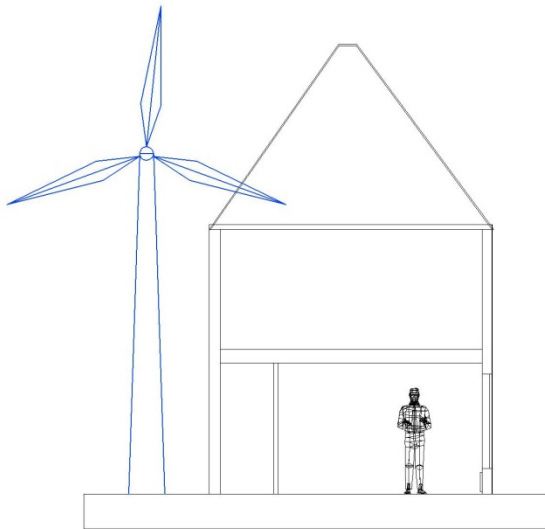
house don't decide this measure because the first big invest. So I decided to use in Enorm a better boiler. With a HR-107 boiler, the EPC decrease 0,31 points.

How this measure affect the historical value.

In the historical buildings, the stove or fireplace always played a central role in the living room. When the central heating had not appeared yet, the stove was the only way of heat. So, in my opinion, the pellets system is similar than the stove and fireplace, and not the boiler system. Of course, It does not affect any historical value like the facade or the roof, but looking the historical aspect, it is important to mention the measure.



10.3.2 Energy from renewable



Add systems with renewable energy

-Is to add a renewable energy system to existing heat system in order to reduce the consumption.

a. Goal

As support for the above named production systems, there may be included contribution systems with renewable energy.

b. Degree of applicability

In an installation of a biomass boiler, considering it as renewable energy, it is no more necessary to implement the system. In other cases it will be necessary to install a backup system for the production of sanitary hot water. The most common of these is

solar thermal.

c. Energy demand influence

Reduce energy costs in proportion to the contribution from renewable energy.

d. Technical Implementation

We have the next renewable energy systems: Solar Thermal Energy, Solar photovoltaic, Geothermal, Mini wind and Aero-thermal.

Solar Thermal Energy

Solar collection can reduce energy bills with minimal maintenance costs. The main application of these facilities is the hot water supply, usually in conjunction with other conventional systems that it helps.

Solar photovoltaics

The use of solar radiation is direct transformation into electricity by the photovoltaic effect. This process is achieved by materials that have the ability to absorb photons and emit electrons. When these free electrons are captured, the result is a stream power that can be used as electricity.

Mini wind

-Is when we use the wind resources using lower power turbines than 100 kW. According to international standards, the mills of this technology should have a swept area not exceeding the 200 m².

Aerothermal

Aerothermics is the harnessing of the energy contained in the air around us. This energy is constantly renewed from the solar energy received by the Earth's crust, making the air in a inexhaustible source of energy. With the aerothermal, can capture this energy and use it for free heat a home.

Geothermal

Geothermal energy is energy that can be obtained by taking advantage in the heat storage capacity that is in the earth. The earth has the property of maintaining a constant temperature in all the year seasons, due to the large mass and the materials that compose the earth.

Measure used

Solar tiles

Looking the MCA (Multi-criteria analysis in the Annex), we have in the first position, the mini-wind system. But we don't have enough space in the house to install it. So I focus in the second option, and second and third option has the same punctuation: Solar thermal energy and Geothermal. The geothermal is not for rehabilitations, and we are working in a rehabilitation, so our definitely system is Solar thermal energy.

We cannot forget that we are working in a historical building, and we cannot alter the facade and the roof. So a good solution is a solar tile. Solar tile links protection of historical buildings with power generation.

Energy effect

With the implementation of 10m² of solar panel in the east roof, the EPC decreases 0,07 points. The best position of solar panels is in the South, but in our house there isn't space in the south roofs.

How this measure affects the historical value.

The tiles' collector surfaces are much smaller than conventional solar panels, because the historical roofs can only be used to generate energy despite monument protection regulations if their optical impression is preserved. A roof oriented toward the south with a size of 18 square meters and an inclination of 30 degrees thus produces 1,650 kilowatt-hours per year (see table) under the Southern Italian sun. That is enough energy to cover five sixths of the annual power consumption of a one-person household in Netherlands.



11. Conclusions

Walls

Energy reduction

By isolating the party walls, the value of R increases. The energetic effect of this adjustment is tested in Enorm. The actual R value in the thermic insulation of the house is 1,3 m²xK / W, and with 100 mm of insulation will increase the R value to 2,5 m²xK / W. We increase in 1,2 m²xK / W the R-value of the house. With this insulation the EPC decreases 0.2 points.

Comfort

By isolating within the wall, residents no longer suffer from the cold radiation medians, so increases Comfort.

Regulation

License is required to implement this improvement

Historical value

There is a risk of damage at the end of wooden beams by the occurrence of condensation in the connections with the wall. To avoid this we should inject a chemical product in the connection between the wall and wooden beam.

Architectural intervention

When thermal insulation is used, care must be taken with the wooden beams. By isolating the wall in the area of the beam, vapor pressure

changes occur in the structure, which can cause wood rot. There should always be a vapor barrier on the warm side and /or use chemical product in the end part of the wooden beam.

In addition, the mortar of the wall, used in the beam part, should be water-repellent. In this way we prevent that the rainwater can contact with wooden beam.

Roofs

Energy reduction

By isolating the party walls, the value of R increases. The energetic effect of this adjustment is tested in Enorm. The actual R value in the roof of the house is $1,1 \text{ m}^2\text{xK} / \text{W}$, and with a better isolation will increase the R value to $2,5 \text{ m}^2\text{xK} / \text{W}$. With this insulation the EPC decreases 0.14 points.

Comfort

inside temperature remains constant, in the summer it remains cooler for longer and longer in the winter warmer.

Regulation

For remodeling, a license must be applied for.

Historical value

to insulate under the roof deck, the historical value is not adjusted. The insulation is made demountable.

Architectural intervention

isolating the inner side is the most suitable design. This is because the view is not affected and Rc can be extracted. 3.0 The construction is thereby faster and cheaper than in the isolation on the roof boarding

Windows

Energy reduction

By isolating the party walls, the value of R increases. The energetic effect of this adjustment is tested in Enorm. The actual R value in the thermic insulation of the house is 1,3 m²xK / W, and with 100 mm of insulation will increase the R value to 2,5 m²xK / W. We increase in 1,2 m²xK / W the R-value of the house. With this insulation the EPC decreases 0.2 points.

By double-glazing the windows, the value of U decreases. the actual U value is 5,7 W/m² ·K, and with a double glass we decrease the U value to 2,8 W/m² ·K. We decrease in 2,9 W/m² ·K the U value of the house. With this measure the EPC decrease 0.22 points.

Comfort

Comfort is increased by being drafts, condensation and cold radiation is reduced. In addition, the sound insulation is also greatly improved compared with single glazing.

Regulation

License is required to implement this improvement. Enough space in the windows frame is necessary. Sometimes this space is not enough.

Historical value

Double glazing a window not only results in the loss of its old glass, but also adds more weight. This can cause problems for small and often fragile timber sections, and is generally best avoided.

From the perspective of historic and aesthetic significance, secondary glazing solutions have the advantage over double-glazing systems that they are reversible: the window can be returned to its original condition in the future if required. Almost the only permanent alteration is the fixing holes where a frame is secured, and otherwise the original details remain undamaged.

Architectural intervention

In double-glazing restoration, the next steps should be done; glazing beads disassemble, pull out existing glass, frame rebate, places new glass and assemble it again. This is a procedure that must be carried out carefully.

Improved installation and equipment**Energy reduction**

By using a better heat system, HR-107 boiler, the EPC decrease 0,31 points. This is the 34,8 % of Total EPC.

Comfort

The use of a pellet stove will be seen as a comfort-enhancing solution. The heat radiation from a wood stove is better experience than the radiation from a radiator. In addition, with a pellet is easier to get a comfortable temperature in the living room.

Regulation

This needs to be a requested license.

Historical value

Placing a pellet stove has little effect on the historic value. Pellet stove is "similar" than the old chimney, so from the perspective of historic and aesthetic significance is better.

Architectural intervention

The installation of a pellet stove requires a small architectural intervention by the realization of the pipeline route.

Energy from renewable

Energy reduction

By the implementation of 10m² of solar panel in the east roof, the EPC decreases 0,07 points. This is the 7,86 % of Total EPC.

Comfort

Solar panel has no effect on comfort.

Regulation

An authorization must be requested.

Historical value

I decided tiles' collector ,because the historical roofs can only be used to generate energy despite monument protection regulations if their optical impression is preserved.

Architectural intervention

To install solar panels only a little work is needed

12. Recommendations

Walls

With Internal insulation we will decrease the R value of the wall, respecting the historical value of the facade.

Attic Floor

Last decision is the insulation of the attic floor, because it is the most effective with respect to the isolation of the entire roof surface.

Windows

The investment for double-glazing is sometimes non-viable for the owner. Only addressing tochtstrips in the opening part, we will have good results, investing little money.

Heat system

My expensive recommendation is the biomass (Pellets).

My cheap recommendation is easier:

By moving the central heating boiler, the distance is decreased to the taps. As a result, less energy is lost. Additionally, you can choose to use thinner lines to go to the taps. Again, it is energy saving.

Energy from renewable

The best option for renewable energy sources is thermal tile. It is the only option compatible with the historic roof. The problem is that today, this option is not very developed. But in a few years it is a serious option to consider.

13. Research continue.

Achieve target

In the first moment, my goal was answer correctly the main question:
“How can we update the energy efficiency of an historical building without compromising the architectural value?” (In the house in Eise Eisingastraat 10).
After all the work, I founded the best solution attending to all the factors. I arrived one point where I had a lot of information, but it was diversified. With patience and some teacher’s help, I fit all this information in the correct way.

Good points

A strong point in my research is that I obtained the exact EPC value. And with this I could use it to determine the best solution. It also helps to increase the energy efficient caring about the historical value.

Follow-up research

In the empirical research, I tried to reduce the EPC value. The maximum reduction of epc obtained is 1,19. I started with 2,08. A possible further research could be trying to get to 0.6.

A solar tile is a serious future option. The problem is that today, this option is not very developed. But in a few years it is a serious option to consider. However, this will need to be further investigated in a follow-up study

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