Final Report

RENOVATION PLATFORM

EPS project spring 2017
Vaasa, Finland

Team Members:	Supervisor:	Date:
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I. Abstract

The existence of refurbishment case studies is the mainstay for those who are interested in reconditioning a building through the employment of a specific renovation method. Lots of companies, after having carried out a building remodeling, provide information such as the method used, costs, energy calculation and images on the Internet. As a result, people that are interested in refurbishing a building in the same way gain knowledge about this online material. However, most of the cases supply this online material in a complex manner. Therefore, a customer that has just been concerned about the field might find it difficult to understand and then use for their own purpose. The range of search can be reduced to a unique efficient source of information by means of publishing case studies on the Internet, having asked for the corresponding owners consent, in a simple manner and answering the questions every customer would wonder before carrying out a refurbishment.

First of all, the team decided to do a research about the renovation methods to identify the most useful case studies: refurbishment viability depends on, among other factors, the suitability of the method according to the country climate. The method used must respond, in our case, to the Nordic countries weather. After the most appropriate case studies were studied and selected, the team presented them at a Renovation Center appointment to be evaluated. Afterwards, the four best cases were sent to the webpage designer according to the format agreed at the meeting with him. Finally, they were published on the webpage.

II. Thanks

A project is a work that is not only the result of personal effort of the team members. It also needs the help of many people, both professionally and personally. With these lines, the team would like to thank all of them.

To the supervisor, Niklas Frände, for the support, patience and all the help provided.

To Roger Nylund, the coordinator of EPS, to take care of the whole EPS and for everything that has taught us in the different courses.

To Annika Glader, Tommi Kilpio and the whole Renovation Center for giving us the opportunity to be a part of a European project.

To all the people who provided us information, replied our emails and answered all our questions. Also those people who have given us permission to use their case in our project.

III. General Information

1. European Project Semester

European Project Semester (EPS) is a programme offered by 18 European universities in 12 countries throughout Europe to students who have completed at least two years of study.[1] The project is basically directed to students from engineering fields but this factor is not pivotal one.

The goal of the European Project Semester is both to prepare engineering students with all the necessary skills to face the challenges of today's world economy and to address the design requirements of the degree. EPS is a mixture of "Project Related Courses" and project organized/problem based learning. Students work in international and usually interdisciplinary teams of 3–6 students on their projects, and most of the projects are interdisciplinary. [1]

The topics and the fields of working in the projects may vary. One can be mostly theoretical others are done in cooperation with commercial businesses and industries. The aim of EPS is mostly focused on improving students' communication and interpersonal skills. It is team work so the crucial asset is taking the responsibility for ones actions. It also increases in intercultural competences thanks to the opportunity to work in the multicultural surrounding as well as improving the ability to learn not only practical things but also those connected with leading the group, managing the work on short and long distance, planning the process of acting and eventually making the vital decisions under the time pressure so to achieve the goal. The key factor that the European Project Semester try to teach is that irrespective of the communication problems, failures, taking wrong paths during the project, argues within the members, unequal involvement in the project, lack of managing or leadership skills, the point is to reach the goal. All of the problems and failures people are facing or lack of the natural skills can only make them stronger. During the project students have great opportunity to get to know. There is no better lesson than that one learned on the failures or by taking the wrong way. There is no better opportunity to increase interpersonal skills than being forced to use them on a daily basis even without noticing of doing it. That is the point of EPS. Teaching students invaluable skills without strict and boring lessons but by practical usage and natural pressure of discovering them in themselves so to reach the stated goal.

According to the assumption of European Project Semester the fields that the programme involves are presented below.

Figure 1 EPS projects cover a wide range of topics

2. EPS team – Renovation Platform

During the spring semester 2017 at Novia University of Applied Sciences in Vaasa, Finland, several students from different countries were introduced to the programme of European Project Semester as their Erasmus exchange programme.

Students were given the basis of working characteristics during the EPS project, the marking system, the rules, the guidelines as well as some warnings. At the beginning of the semester, few topics were presented in front of the students. Presenters introduced each topic of the project and roughly described the field of each project. Students' task was to choose three topics according to their preferences from the most wanted one. Then, they were given the topic of the project based on their preferences, field of study and nationality. Naturally, they were formed in teams according to the given project. The presenters became their supervisors.

Thanks to such a combination one of EPS teams - a Renovation Platform group - has formed with Niklas Frände as a supervisor.

IV. Project Definition

1. General concept

Nowadays, the financial growth and sustainable development is based on the concept of deliberate and efficient usage of the resources. According to the flagship initiatives of the Europe 2020 strategy, both a Resource Efficient Europe as well as Baltic Sea Region support the resource efficiency policy and came to the same conclusion that it is the energy efficiency of the buildings that stops the climate change on the significant degree.

Energy consumption in residential and commercial buildings represents around 40 % of total final energy use. As a matter of that neglecting the maintenance of unkempt buildings play a major role in getting the country into debts. For instance, the preservation of such the buildings in Finland is currently estimated to cost 30-50 billion euros. Furthermore, postponing the repairs leads to aggravated user health problems and at the end makes the repairs more complex and even more expensive. Therefore, the need to take the problem of renovation the buildings in time is so severe. Moreover, the costs for increasing the energy efficiency in buildings are significantly lower if coordinated with necessary renovations. [4]

Unfortunately, the environment of the methods, materials, their applicability according to the climate and other factors connected to the modern renovation, especially that conducted in energy-efficient way, is not actually understandable among the society. Also the need for not postponing the maintenance both in the private and the public buildings is not so common in public opinion. It has to be claimed that the barrier for creating the energy-efficient and sustainable buildings is the problem of insufficient expertise on how to design and renovate buildings. To be able to meet the new demands there is an urgent need for competence development and better training in the building sector. With help to that goes the Renovation Center that is the Nordic center for energy efficient renovations. The main goal of their project is to increase the number of skilled professionals needed to perform resource and energy efficient renovations within the Bothnia Atlantica area. The aim of the project is also based on the common need for the knowledge network for sharing best practices and supporting regional stakeholders with information, education and new pedagogical tools on how to perform sustainable renovations. [4]

The EPS team was supposed to explore the used renovation methods applicable in Nordic countries. Students were to make the investigation into the location of the used method, documentation of the case and evaluation of the several quality parameters. A successful renovation should result in a building with a healthy and comfortable indoor climate, safe moisture performance of structures, improved energy efficiency and improved resource efficiency in the form of recyclable materials and elements (Hradil & al. 2014; SITRA 2014).

Students from the EPS project had to compare the different approaches to renovation, develop comparable data and tools, investigate the present state of the building in comparison to the state before the renovation and on basis of such factors analyse the found cases. The research process was mainly based on the online investigation. The students aim is to present the evaluated cases in an easy-to-understand way. As there exists the need to popularise the importance of the renovation process, the most suitable way to get to the majority is to share best practices in the understandable formula.

The concept of students field will be to publicise the found cases by creating the webpage for Nordic Countries citizens (with the help of Webpage Designer) interested in making their houses energy-efficient ones. Exemplary renovation cases will be sought for and studied in order to gather information and innovations. In order to meet future needs, new research topics will be identified and formulated on a practical level to relevant stakeholders.

The last version of the Renovation Platform's Definition of a Project is stated below.

Students have to search in online resources for the renovation methods, make the ideas in clear format for Web Designer and so popularise them by creating the webpage for Nordic Countries citizens interested in making their houses efficient.

2. Root problem

A root problem analysis is a project management methodology that attempts to get to the bottom of a problem. To start properly the project one should always ask oneself the question why there is a need of me working on that. The question of what has procured that the necessity for changing or improving something has occurred. It is actually not that easy to answer that it seems at the first glance. To analyse the root problem person should get as deep to the topic as possible and break the topic down.

Students from Renovation Platform has come to a conclusion that as far as the field of their project is concerned, the root problem is that:

People could face excessive costs unless renovations are carried out in an optimal way, and internet may provide technical renovation processes in a complicated way.

3. Mission Statement

The project mission statement, if formulated correctly, has a great ability to give project members a focus for working towards a common goal as well as increase both the quality and the project working experience. Unfortunately, wrongly or poorly formulated project mission statements can have the opposite effect. It may then confuse workers or the public as to the project's goals and methods for achieving them. The point of creating the mission statement is to form it unambiguously and understandable for others. [2]

The mission is a statement about what problem should be addressed. It answers two questions:

1) What are we going to do/provide/produce?

2) For whom are we going to do it?

Renovation Platform's first idea of naming their mission is pictured at the graph below.

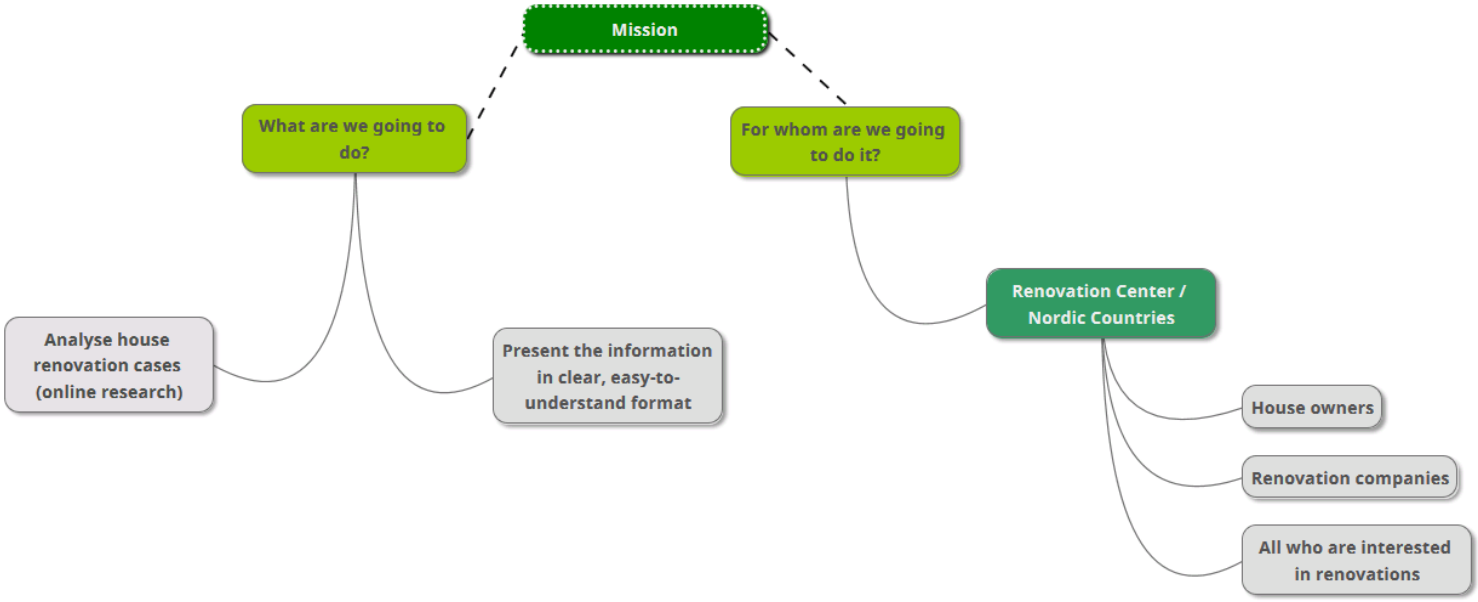

Figure 2 Students' first idea of their mission

After some conclusions and transforming the idea of the graph into the words, the final mission of Renovation Platform team sounds:

Popularization of modern renovation methods, for Nordic countries citizens who are interested in renovating houses, basing on energy efficient examples.

4. Vision

Nowadays, to make the project successful, creating a vision that communicates effectively to all is a necessity not an officiousness. It is caused by the fact that no project can make a serious progress without a clear understanding of where it is going and what it is trying to accomplish. Ironically, it is too easy to start developing the solution unless one fully understand the problem.

Basically, the vision statement is the brief summary of what the project team members and their stakeholders expect to achieve. It is a description of the desired state or ultimate condition that should exist after the project has been completed. Defining a vision enables the team to discuss and agree on the broad purpose of their project. [3]

A good vision is to describe the desired state and as well as reference stakeholder interests and providing relevant background. According to that thinking Renovation Platform team has got through some ideas of their vision. Starting from "People will live in an efficient way, based on our methods popularisation.", through "Improve the life quality of Nordic Countries citizens thanks to the popularisation of our renovation methods, living in an efficient way." the team has stated their vision as:

Improvement of both life quality and efficiency towards Nordic Countries citizens thanks to the popularisation of our renovation methods.

5. Scope

The scope was a project management tool used by the team in order to determine the most important aspects of the project. The team wanted to describe every factor that may have influenced their work and plan the procedures. Scope was one of the first elements produced by Renovation Platform before they have started the main investigation.

a) Objectives

According to the Midterm Report:

The main goal is to make useful information more easily available to the public as modern renovation methods are not popularized. The EPS team is going to achieve the goal by creating online learning about modern renovation methods. The delivery date of the final product is 15/05/2017 and the finish date (the release – final presentation of the project) is 18/05/2017.

After the whole semester of work, the team accomplished the main objectives. They have created the webpage layout for the information they wanted to present. Also, they have found interesting cases presenting modern renovation methods and they have processed those information in order to make them interesting and easy-to-understand. The delivery of the final product, however, changed to 12/05/2017 and the final presentation to 16/05/2017. Nevertheless, by now, the team is not sure about the date of publishing the cases on the Renovation Centre webpage. This part is independent of them.

b) Clients and Stakeholders

Neither clients nor stakeholders involved in the project has changed during the project work. The level of knowledge about the team's work increased. This report is supposed to be a collection of all information needed by the stakeholders. Clients satisfaction will be assured as soon as the cases are uploaded on the Renovation Centre webpage.

c) Main deliverables

According to the Midterm Report:

The main deliverables are a study report, communication data (web page of the project and classification of renovation methods for the Renovation Centre Web Designer) and EPS and Management documents. The main goal is to make useful information about the renovation methods easier to understand for the public.

All management documents were stored before the midterm presentation. The team was updating the Gantt's Chart and Daily Work until the very end of the project work. Also the EPS documents were delivered before deadlines. Study report and communication data are available in this report, however, those documents are not available for the public yet.

d) Milestones and their schedule

There were two milestones distinguished by the Renovation Platform team. The first one, which was choosing the part of the building that the team will focus on, was achieved before the Midterm Presentation. The second one was making decisions about the cases. The team was supposed to research for online cases presenting good examples of renovation applicable in Nordic countries. The deadline was estimated at 10/04/2017. However, the team realised that there is a number of cases available online. They have found a lot of them, however they had problems with deciding about the best. They were narrowing the number of cases for a long time. The team had many discussions until they made a decision. Nevertheless, the Renovation Platform team was able to provide all the requirements before the Final Presentation.

e) Technical Requirement

As stated in the Midterm Report, no technical equipment was required to achieve the goal.

6. Process of the project

The very first look at the topic of the project resulted in a very general description of the process of the project. Analysing the deliverables and tasks led the team to the idea of presenting the way of thinking in a perspicuous graph visible below.

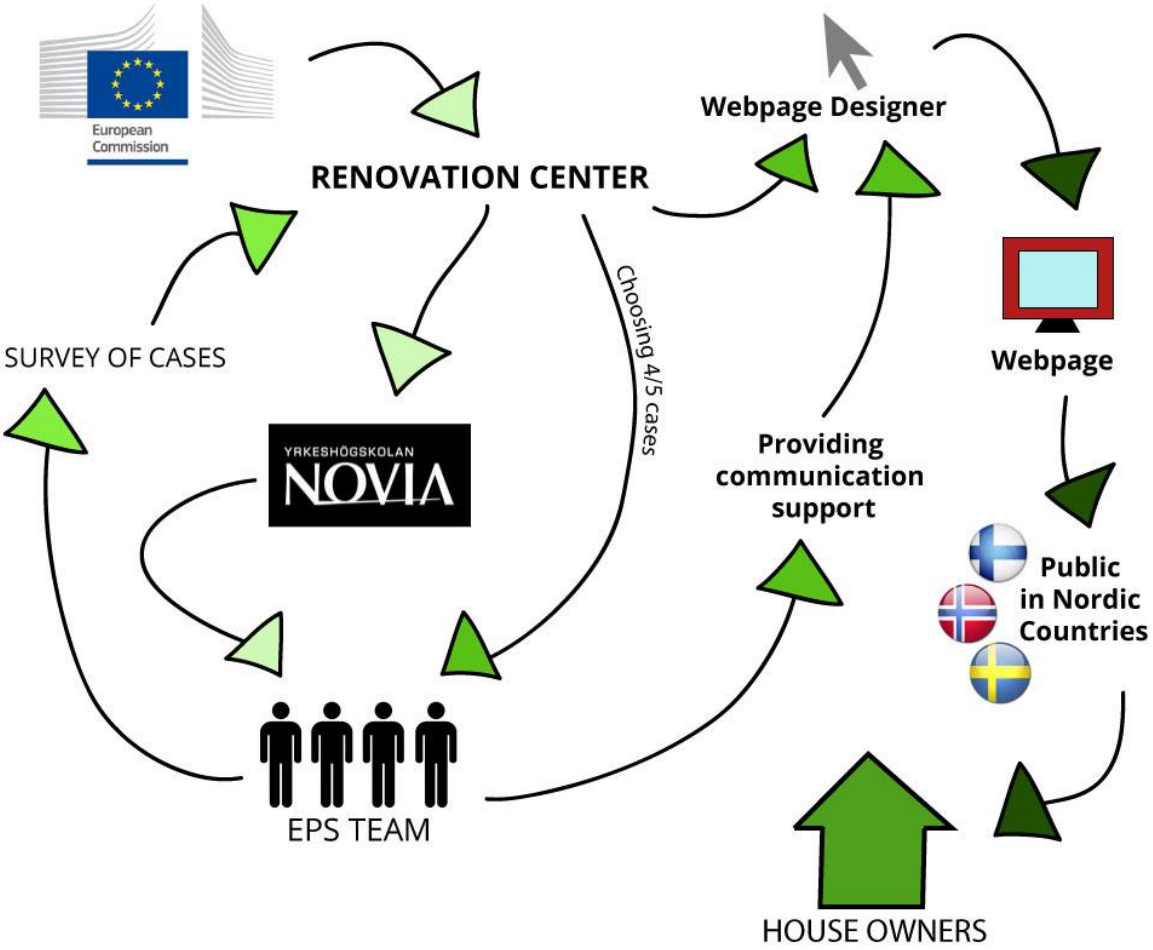

Figure 3 Students' mindmap of process of their project

The starting point of the process was then Renovation Center. This project was founded by European Union, therefore, it's presence is the effect of European Commission's actions. The project group of Renovation Center consists of several people from different Nordic universities. One of them is Novia University of Applied

Sciences at Vaasa. The EPS Team consists of students of Novia, thus they are directly subordinated by that university. The EPS Team is the first stakeholder that is in charge of an action. They are conducting the survey of cases presenting good examples of renovated houses. The results of the survey is then send to the project group of Renovation Center who is responsible of choosing 4-5 best cases. Having the cases, the EPS team can start with working on them. They have to provide the cases in easy-to-understand and interesting way, prepare communication support using e-learning tools. After that, the packages will be sent to webpage designer who is working for the Renovation Center project. He is in charge of the webpage. He is supposed to upload the results of the EPS Team's work on the Renovation Center webpage. From that moment, the cases will be available to the public in Nordic Countries who can apply similar or even the same renovations at their houses.

One can distinguish different types of elements on the graph:

- Stakeholders taking actions
    - Renovation Centre (founded by UE)
    - EPS Team
    - Webpage designer
    - Public in Nordic Countries
- Actions
    - Survey of methods
    - Choosing 4-5 cases
    - Providing communication support
    - Putting of the webpage

Moreover, different shades of green were used in arrows to show the order of the process. Then, the graph starts from the light green and ends at the darkest one.

Although the graph is not the perfect one, is was one of the team's first ideas how to describe the project clearly. Thanks to the graph, it is easier to follow the different tasks and see at what stage they are already.

V. Team's Identity

1. Team members

Before introducing the project one should always gather some details about a project team members. Behind each success stands people. It is their work that is visible at the end not their personalities or interests. However, in better understanding of their working habits helps the outline of their nature.

European Project Semester is based on a team work. Sooner or later it is important to know other members of the team to discover the way of their working, habits, personality etc. so to work in harmony and amity. It is crucial to gather the knowledge of others' behaviour and manners to build the good atmosphere in a team, achieve good results and together reach the goal of the project.

Renovation Platform team consists of four members. There are three women and one man. They are not really multicultural group as within it there are only two nationalities – two people from Spain and two people from Poland. All of them are from engineering fields.

A short description made by each member of a team is depicted below.

Marta Kaużyńska

Marta comes from Poland, she is 21 and studies Telecommunications and Computer Science at Lodz University of Technology. In her free time she swims and cycles as much as possible. Marta also enjoys sailing, long car trips to the unknown and caring too much.

Figure 4 Marta

Małgorzata Namiota

Figure 5 Gosia

Gosia is from Łodź, Poland. She is on the 3rd year of Telecommunications and Computer Science and she studies at Lodz University of Technology. She loves reading books about the philosophy and society. Gosia likes getting knowledge about other cultures and history by exploring new places.

Ana Maria Pérez Torres

Ana is from Valencia, Spain. She is 21 years old and studies a Bachelor's Degree in Industrial Electronics and Automation Engineering in the Polytechnic University of Valencia. She loves reading, drawing, travelling, and trekking with her friends. Ana spends her free time taking photos and cycling.

Figure 6 Ana

Alberto Silvestre Mesas

Figure 7 Alberto

Alberto is 21 years old and he was born in Alicante, Spain. He will finish his Bachelor's Degree in Electrical Engineering in May 2017. He spent three years and a half studying in the Polytechnic University of Valencia. Alberto likes climbing, traveling and partying.

2. Name of the team

A team decided to name themselves Renovation Platform team. "Platform" points the aim of popularisation aspect of their work and "Renovation" stands for the field they were to work on.

3. Logo and business card

It has to be admitted that people are visuals. That is why the logo is a company's first impression. Designing it to make a lasting impression on a client is a crucial thing to all businesses as it does impact customers' perception and purchases decisions. A well designed one can say thousands of words about a project or a company. Such a project or such a company is recognised as a trustworthy one and declares readiness

to cement a place in customers' niche. It acts like a trademark and should immediately trigger a reaction from the viewer.

The point of Renovation Platform was to include the energy-efficient aspect of the renovation that people can appreciate thanks to the results of their project as well as their focus on popularising the found cases of renovation towards everyone. They agreed to put the word "renovation" into a symbol by using a pointer as a built-in tool inside of the house that also stands for the popularisation of the cases.

Having determined that the inbuilt pointer describes the idea of sharing group's renovation ideas in the internet the best, they eventually decided to use different shades of green as a nonliteral path that goes from light green through darker green, so to reach the deepest one at the end intentionally featured by leaf. The path indicates the intention of the team to promote the renovation methods among society so to accomplish life quality and energy-efficiency of their buildings.

The final version of the logo is visible below.

Figure 8 Final version of Renovation Platform's logo

Having accomplished the logo and after choosing the name of a team, the Renovation Platform has started to work on a business card.

A business card is a tangible object providing the contact information to potential customers. The crucial idea is to irrespective of used tremendous design elements not sacrifice its' clarity. Keeping in mind the necessity of keeping comprehensibility of a business card, a team has created one pictured below.

Figure 9 The chosen business card

VI. Methodology

1. Research

The working of Renovation Platform was based on research, basically the online one. They search for the websites where the cases were described. Usually, more investigation had to be taken to gather the knowledge about methods used in specific case, country in which the renovation was performed, the kind of materials used, the costs or the pictures comparing the initial state of the building with the final one and some calculations of U-value or energy efficiency factor as well as the summary and evaluation of the work's propriety.

However, the documentations of found cases in most situations were not easily available as it may seem to be. So to gather deeper knowledge students had to write e-mails to different institution with ask for more information.

Also, by their supervisor they were given several helpful documents and links to webpages so to start an investigation from proper way.

2. Meetings

To keep contact between team members and also with the stakeholders, the EPS team had to use different communication channels. The most important communication channels are meetings. It is then possible to keep contact with different environments

even though there is a huge distance between involved. Meetings can be shared into few subtypes

f) Meetings with the Renovation Centre

One Skype meeting with the project team of the Renovation Centre took place during the first part of the semester. During the meeting, the EPS team were presenting themselves, the idea of European Project Semester and the topic of their project together with the plans how to achieve the goal. Thanks to the meeting, the team members had an opportunity to meet people for whom their working (one of the stakeholders) and gain a lot of advices and they were shown the direction they should go.

The meeting took place in Sweden, but thanks to the supervisor of the team, the EPS group could contact the Renovation Centre via Skype. Before the meeting, the have prepared the PowerPoint presentation to show.

Figure 10 Photos from the meeting with Renovation Center

a) Meetings of the team members

Team members were meeting few times a week, when they were discussing their work, doing brainstorms and making mind maps. Meetings were needed in order to make decisions easy and quickly. Also, they helped to build a good

team, meet each other and feel comfortable. Most of the meetings of the team members were taking place in the EPS room, where they were sitting together with their computers.

Figure 11 Photo of the team's meeting

b) Meetings with the coordinator

During the first part of the semester, one meeting with the EPS Coordinator took place. During the meeting, the team was presenting the results of the work from the first weeks of the project. They had an opportunity to ask questions directly connected to the EPS and organizational issues. They also got the feedback from their work from the Coordinator.

c) Meetings with the supervisor

Once a week, team members were meeting with the supervisor in one of the rooms at Technobothnia. Chair of the meeting is preparing the agenda for the meeting that the attendees were following. The team was using the template for the agenda for every meeting so it saved a lot of time. During those meetings, the team members were presenting the results of the work to the supervisor, they are also asking him questions. The supervisor was giving advices and presenting his expectations. During the meeting, the secretary of the meeting was taking notes and then, produced a Minutes of Meeting in order to keep arrangements made during the meetings.

Figure 12 Photo of a team's meeting with their supervisor

d) Meeting with Annika

In some point of a project, after finding several cases a Renovation Platform team needed to discuss them with Annika Glader, a Project Leader. They were asked to find more of the cases so to make a selection with Annika going from the most interesting ones. A team had prepared the PowerPoint presentation with gathered together the found by them cases with the tables of the required factors.

The table that is visible below was filled for each case.

Country	Method	Materials	Costs	U - value		Moisture Safety	Link
	WALLS	WALLS	WALLS	Before	After		
	WINDOWS	WINDOWS	WINDOWS	Before	After		

Figure 13 A table factors filled by Renovation Platform team

for each case presented to Annika at a meeting

Annika suggested that Renovation Platform team should choose four cases to implement in an easy to understand way for a Renovation Center webpage.

e) Meeting with Webpage Designer

After choosing the cases a team had to meet with a Webpage Designer to agree on the formatting of the cases that they want to provide on a Renovation Center webpage. Before a meeting they had created few ideas about their vision of the webpage's layout and so could present them during an online meeting via Skype with Webpage Designer.

Those ideas of the layout will be described later in this report.

3. Time Management

a) Timeline

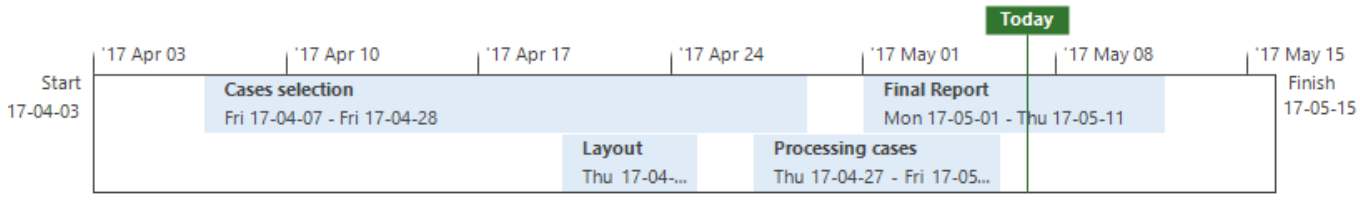

Figure 14 Timeline from midterm to final presentation

The above timeline presents the main tasks the team was working on after the midterm presentation, until the end of the EPS.

One can see that selection of cases was the longest task. It required a lot of research, making contacts with owners of websites and comparison of every refurbished building. In the meantime, the team was working on choosing the layout for the cases that will be available for the public via Renovation Centre website. They had started the processing and the final report after making both decisions. All of them were consulted with the supervisor of the team, Renovation Centre project group and Webpage Designer.

It was hard for the Renovation Platform team to meet all the deadlines. However, they had few problems that they did not expected, they have finally reached the goal. The timeline helped them remember about all tasks and also informed about the delays. Sometimes they had to work simultaneously on different tasks in order to keep the

time. Therefore, one of the lessons learned by the team during EPS semester was to estimate deadlines carefully and track the timeline.

b) Daily and weekly work

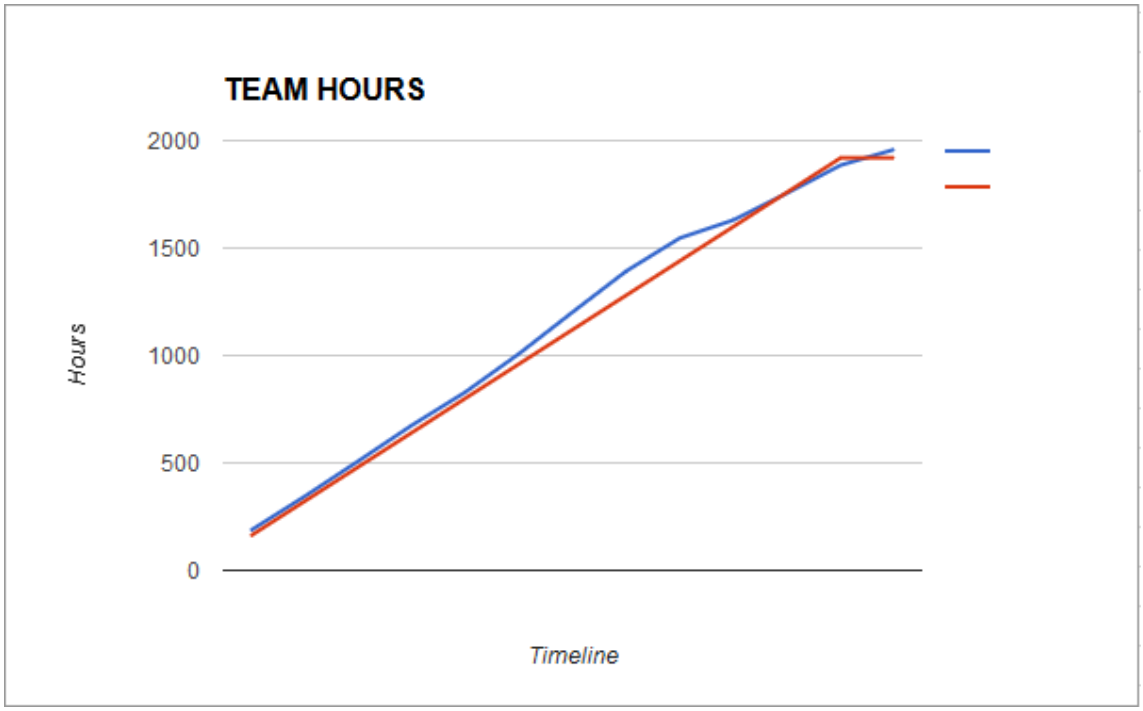

Figure 15 Graph presenting hours spend on the project

The above picture presents the graph of comparison the expected hours spent on a project with hours the team have spent on their work. Naturally, the had to focus also on different subjects of the EPS semester therefore, the workload is the sum of the project work and other tasks.
One can observe that the team has spent the required by the EPS rules amount of hours. Thanks to that work, they have reached the final goal. Updating the daily and weekly work helped them to work in an optimal way and create a daily routine of the work

c) Additional investigations in a field

To gain deeper knowledge into the field of not only renovation but also climate and problems in Nordic countries, the group decided to join the Energy Week event. The Vaasa region is powered by EnergyVaasa, the largest energy cluster in the Nordic countries. The annually organized Vaasa EnergyWeek is the place where the cluster companies gather to network and make business. Vaasa EnergyWeek offers interesting events and forums for experts in both the public and private sectors.[5] In the program there are several events both in Swedish and English. The events were

open for public and free to attend. As a matter of that, the students from Renovation Platform decided to join the event called Energy & Buildings that mainly focused on topics connected to energy efficiency as well as construction and automation solutions for new build and refurbishment purposes.

Figure 16 An advertisement for the Energy & Buildings day during the Energy Week [5]

On the event the students had the opportunity to hear the presentations from different institutions and individuals. The seminars took place on an assembly hall and the audience sat in front of the presenter that can be visible on the following pictures.

Figure 17 The layout of the assembly hall in an Energy Week day

The seminars were divided in parts. The first part included the opening speeches, one presentation about energy efficiency and sustainability in buildings and some from main sponsors. After the break students could learn something about energy savings measures, then smart buildings in Europe and renovation of buildings for energy efficiency. After the second break was the Seminar Part III that involved some theoretical and practical information about energy efficient thermal comforts, as well as a case of INSULAtE project and one presentation that described the impact and future challenges of European research for energy efficient buildings. On that day it was also possible to see the exhibition on the same field. This year's Energy & Buildings seminar was arranged by the Renovation Center, a Nordic center for energy efficient renovations, the same under which the Renovation Platform team were and for whom they were working on. During the day, the students were given the badges. They were taking the notes from the presentations and wrote the contact e-mails to the interesting institutions so to be able to contact with them for more information. The more detailed report from the Energy Week day is available at the Renovation Platform group blog at their website.

Figure 18 Renovation Platform students

at the Energy Week event

(picture above and on the right)

4. Webpage

The webpage was also a required by the EPS Coordinator. Every EPS team is supposed to create a webpage and upload it, so everyone have access to the teams's work. The Renovation Platform team is using the address:

https://epsrenoplatform.wordpress.com/

The home page of the website is visible below

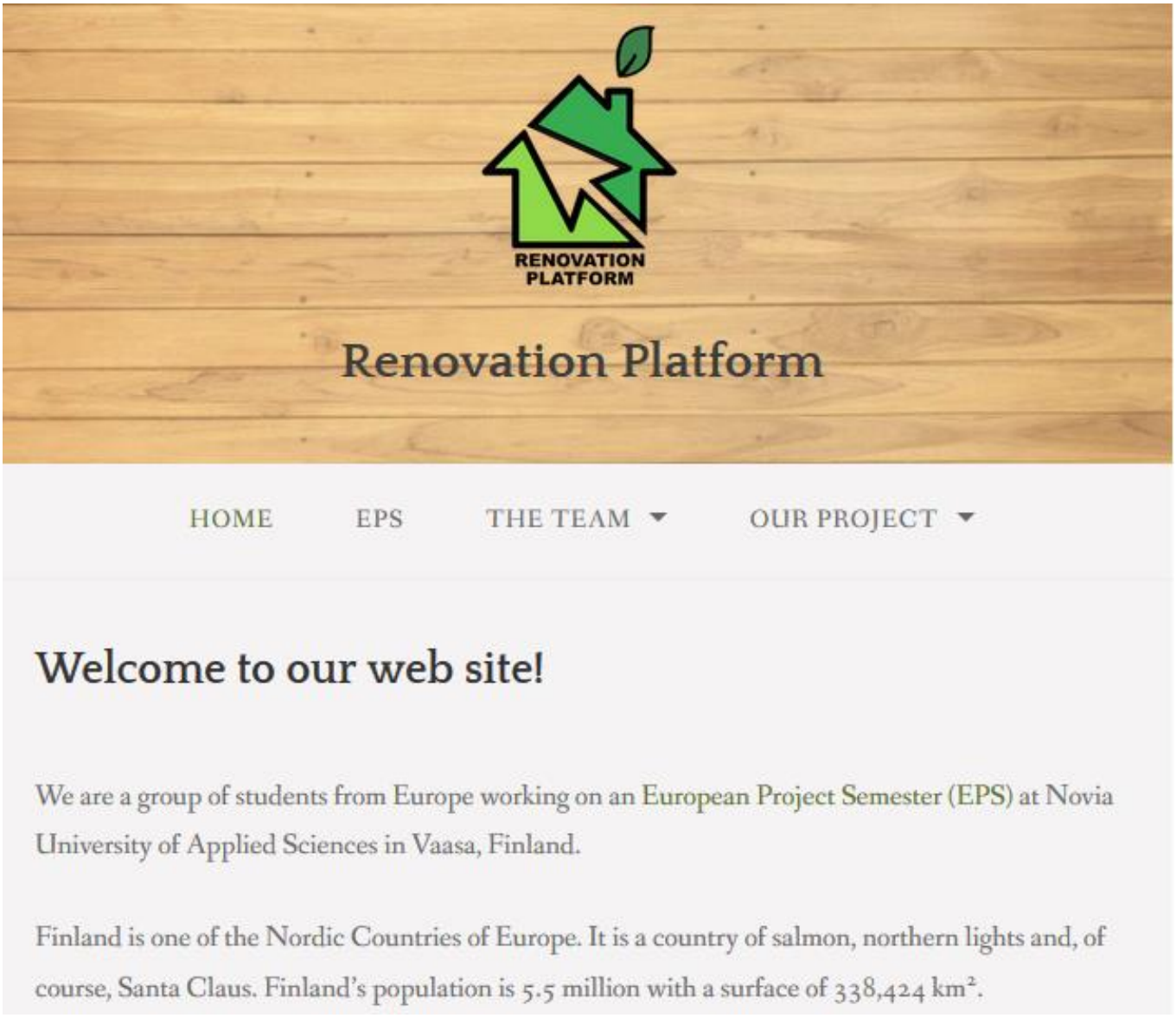

Figure 19 Home page of the website

The links below the logo (Home, EPS etc.) are redirecting to the specific information. If somebody is searching for the specific information, the searcher is available. One can also choose the language of the information. The default language is English, but the website is translated to both Spanish and Polish. A team has been also creating a weekly blog explaining what they were doing in each week.

Those sections are on the right side of the webpage and can be seen on the picture below.

Figure 20 The right side of the webpage

Figure 21 Team recognition button

On a webpage is available also a button called “Who we are” moving a visitor to the section of the team’s identity.

At the bottom of the page there is an information about the contact with the team. If the visitor of the website wants, he can write and email. He will also know where he can possibly find the team members. Then, there is a gallery of students from, for example, Energy Week that they participated. And the last information about the upcoming events related to project.

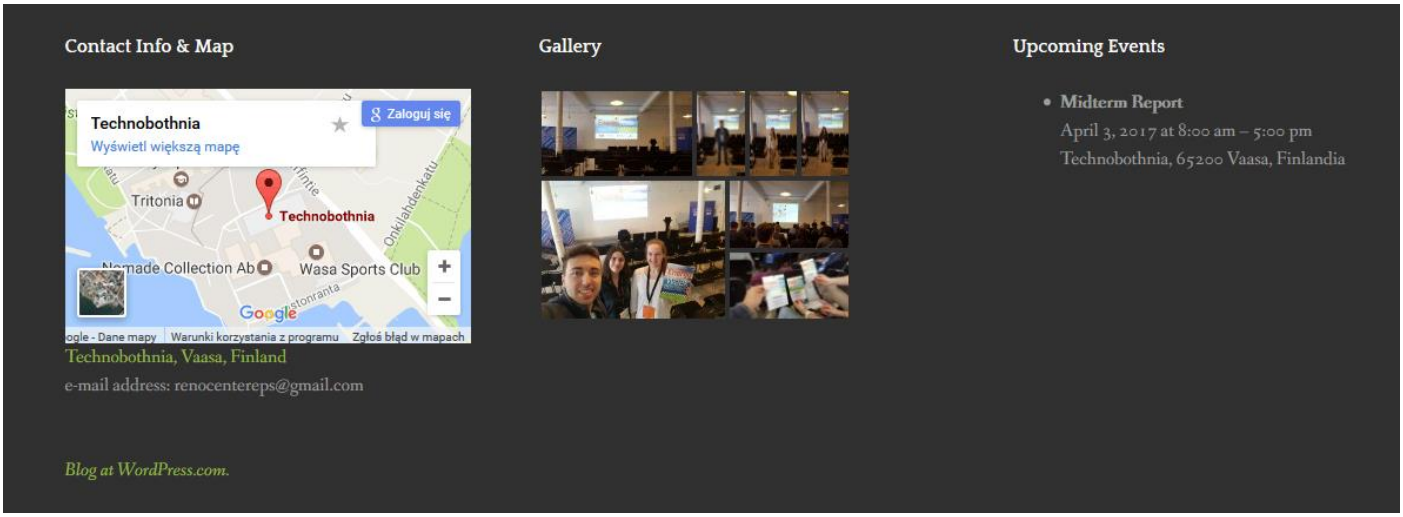

Figure 22 The bottom of the page

VII. Results

1. Main focus

There are two main ways to achieve the energy efficiency of a building: through the involvement of the building or the design of facilities. Regarding the involvement of a building, one can maximize the benefits or natural gains or, besides, can reduce the heat losses. A correct transmission and ventilation system are able to prevent the heat from escaping from within a building.

The team's focused on the thermal isolation which is part of the transmission of a building as depicted in the following diagram.

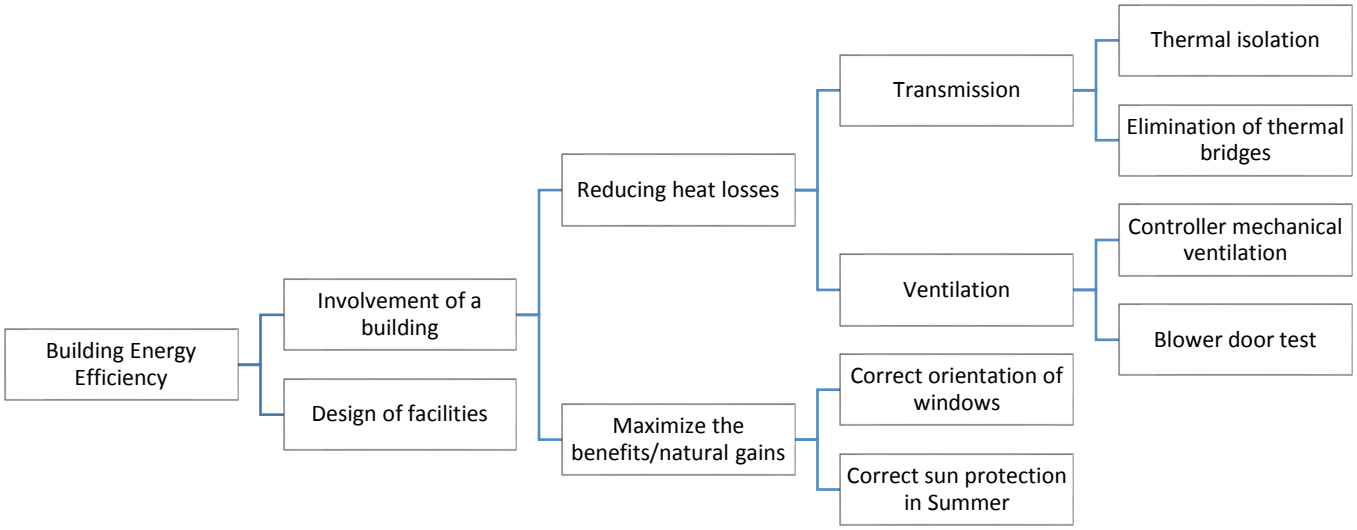

Figure 23 Main focusing

The heat can escape from the building through different sections: windows, roof, floor and walls. Considering that the façade (walls and windows) represents the largest part of a building, the team has decided to focus on theirs insulation.

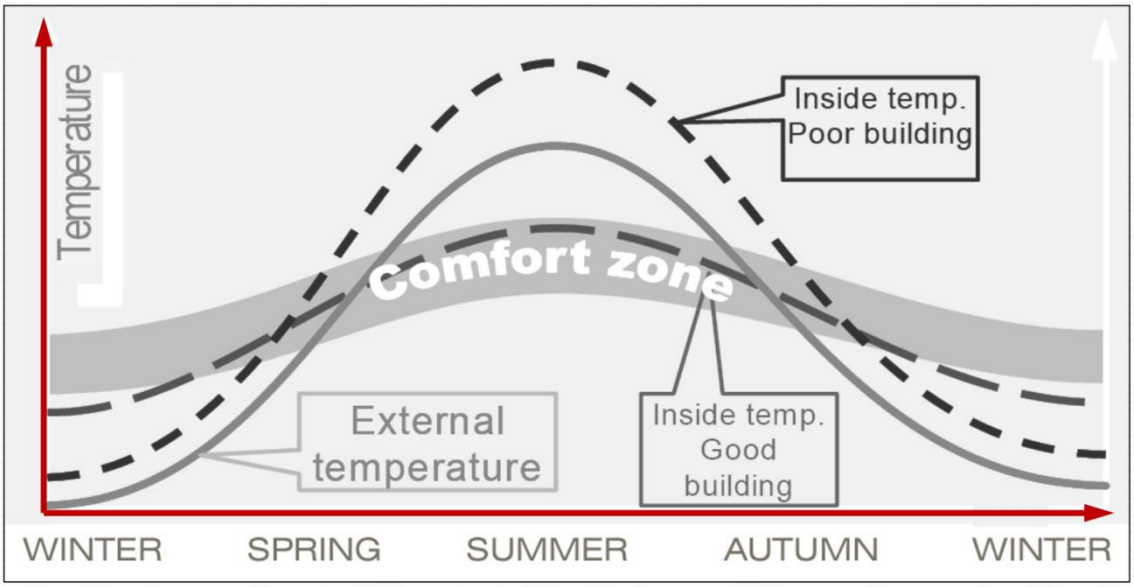

Figure 24 Comfort temperature graphic [6]

Which is the comfort temperature?

The comfort temperature begins at 20.5 °C while more than 25 °C is considered as quite hot. The main purpose of insulating a building is to achieve the temperature remaining in that range.

2. Quality factors

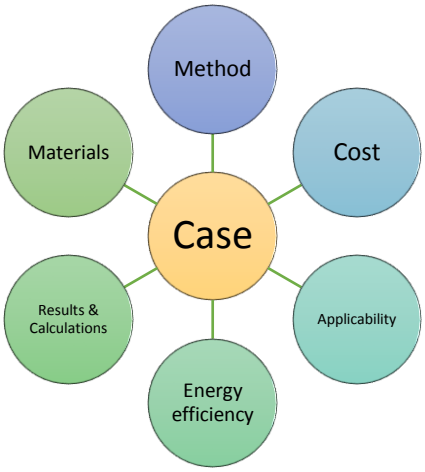

Figure 25 Related factors of a case

As was explained along of this report, the team must research about modern renovation cases. But, how to know if the found case is a good one?

The more information the case has, the better it will be. Besides, some quality factors are essential to be established.

To define the quality of the found documents, students have to point out the related factors such as applicability to the Nordic Countries, the kind of used materials, the final cost of the renovation, some calculations and connected to them results as well as the extent of the improvement in the energy efficiency of the building after the performed renovation. Some factors are more measurable than others. The ones that are more connected to the kind of chosen stuff like method or material will be presented later in this report. Other like energy-efficiency or the amount of heat loss can be calculated and then can be based on during the students' research.

As with other productive resources, efficiency in the field of energy refers to the relationship between the results obtained and the resources used to achieve them.

Energy efficiency consists of reducing the amount of energy required to provide the same products and services, seeking the generation of renewable energy and protecting the environment. The consequence of energy efficiency is energy saving, which translates into greater efficiency and lower energy consumption. It can achieve real reductions in greenhouse gas emissions to the atmosphere at low cost, becoming an indispensable element of sustainable development strategy.

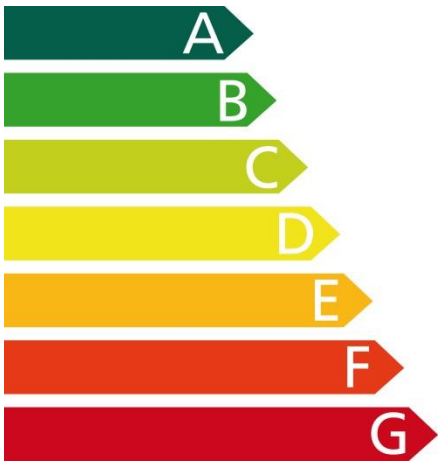

Figure 26 Energy label

In order to measure energy efficiency, there is a so-called energy efficiency certificate. The energy efficiency certificate or energy certificate is an official document written by a competent technician that includes objective information on the energy characteristics of a building.

In this sense, energy certification qualifies a building energy by calculating the annual energy consumption needed to meet the energy demand of a building under normal conditions of occupation and operation. All this includes the production of hot water, heating, lighting, refrigeration and ventilation.

The energy certification process concludes with the issuance of an energy efficiency certificate and the assignment of an energy label. The energy rating scale is seven letters and varies between the letters A (most energy efficient building) and G (least energy efficient building). The energy label expresses the energy rating of a building by giving one of these letters.

There are many measures that can be implemented to energy savings and many to implement and encourage energy efficiency, such as reducing the U-Value.

The U-Value represents the amount of heat through a material by time, area and temperature difference. The units are W/m2K. The U-Value is a specific characteristic of a constructive element, as a wall or roof, and depends on the thermal conductivity and the geometry of the materials that compose it, as well as thermal radiation and convection on the surfaces of the element. The insulation is better when the U-value is smaller.

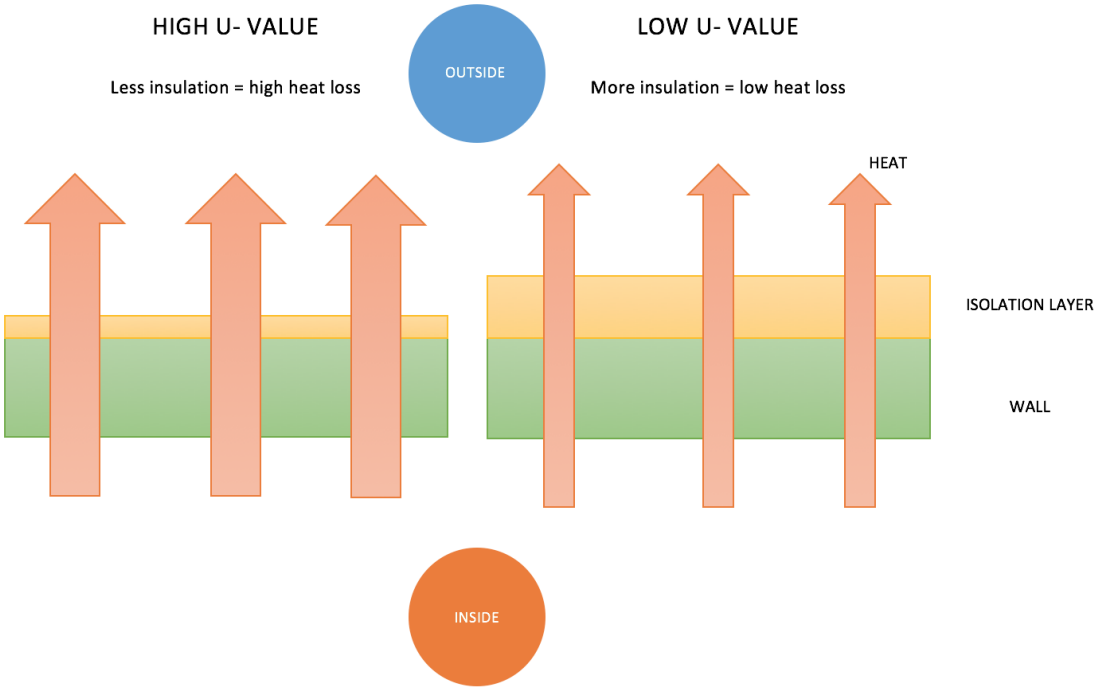

Figure 27 Thermal conductivity

The higher the U-Value, the lower the thermal insulation effect on the element. Conversely, the lower the U-Value, the better the thermal insulation and the lower the heat loss through the element.

For example, a wall with the value U = 1 W/m²K loses per hour, per square meter of surface and for each degree of difference of temperature between the interior and the exterior a quantity of heat of 1 Watt. For example, in the case of a $1m^2$ wall and

with an outside temperature of ± 0 °C, a 20 W heat source is required to maintain the indoor temperature at 20 ° C.

3. Nordic Countries background

The Nordic countries are a geographic and cultural region composed by five States in northern Europe: Denmark, Finland, Iceland, Norway and Sweden. They are most frequently known as Norden. In addition, the associated territories of the Faroe Islands, Greenland and Åland Islands are also included.

Figure 28 Nordic countries flags: Denmark, Finland, Iceland, Norway and Sweden

The Nordic countries have similarities as their way of life, language, history and social structure is concerned. The five Nordic countries and the three associated territories make up the Nordic Council, an inter-parliamentary cooperation organization.

Despite its nearly 3.5 million square kilometres of surface, more than half of its territory is uninhabitable and consists of layers of ice and icebergs. In 2017, its combined population has been estimated around 27 million.

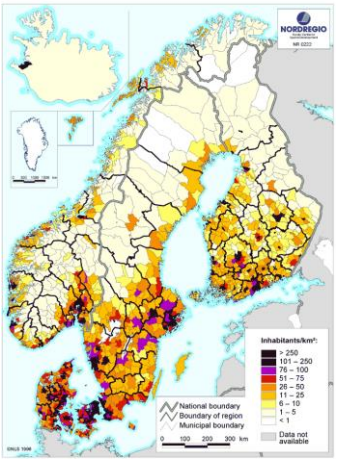

Figure 29 Density of population of the Nordic countries [7]

Both the climatic condition and the quality of the terrain determines the use of the land in Nordic Countries. In Denmark, there is barely wildlife; 60% of the total area of the country is cultivated or converted into gardens or parks and most of the scanty forest are plantations. However, there is still a lot of wild nature in the other Nordic Countries; is cultivated only 0-9% of the land. About 17% of Iceland's is used as permanent pastures. Finland, Norway and Sweden have extensive forested areas.

One of the things that the Nordic countries have in common is the climate. The Gulf Stream transport temperate water from the tip of Florida and causes that these countries have a moderated temperature compared to other countries situated in similar latitudes, even in winter. The climate zone is Artic in north of the Polar Circle, where winters are quite hard and summers are short. The coastal zones of the west of

Iceland, Denmark, Norway and Sweden has a rainy weather and is unusual see the snow covering the places, besides, summers are usually cool. All this is due to the huge influence of the sea.

Temperatures drop sharply during the winter as they move away from the Atlantic Ocean and the Gulf Stream. The cold winters, mainly with snow, and the temperate and long summers of Finland, Sweden and south-west of Norway are due to the influence of the extensive continent to the east.

The following graphs shows the climate of the Nordics countries:

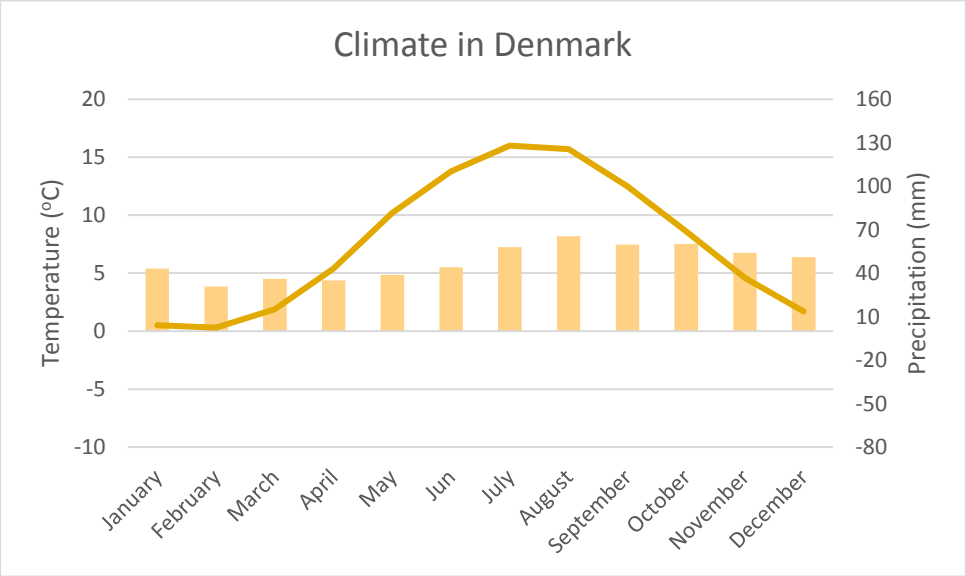

Figure 30 Climate in Denmark

Denmark is the warmest Nordic country. The coldest month is February, with an average of 0,3 ºC while the hottest month is August, whose average is 15,7 ºC. The annual average temperature in Denmark is about 7,5 ºC. Rainfalls in Denmark are fairly constant, although it rises slightly in summer and autumn. The rainiest month is August, with 65,5 mm.

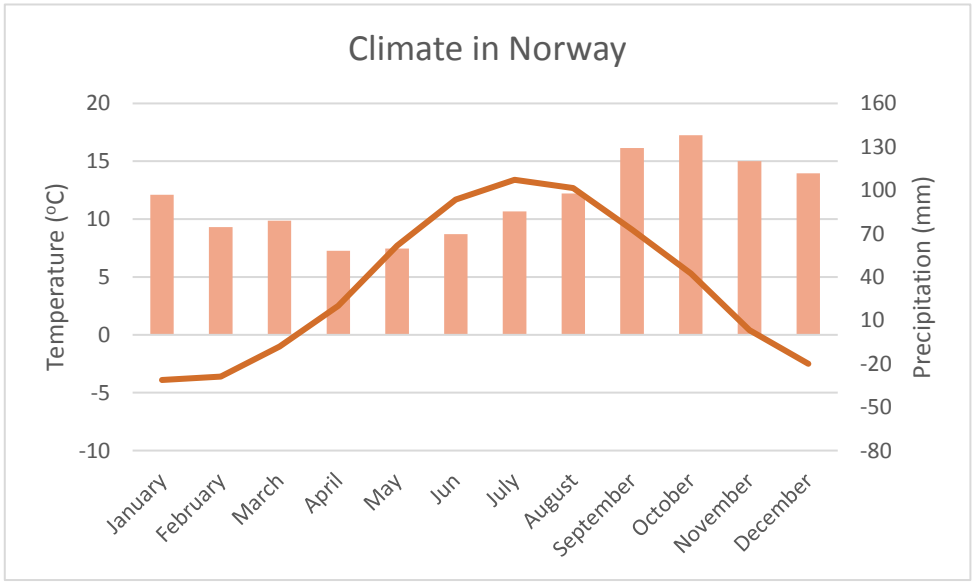

Figure 31 Climate in Norway

Norway has an annual average temperature of 4,3 ºC. Their coldest month is January, with an average of -3,9 ºC and their warmest month is July, with 13,4 ºC as an average. It is the rainiest Nordic country, with 1121 mm per year.

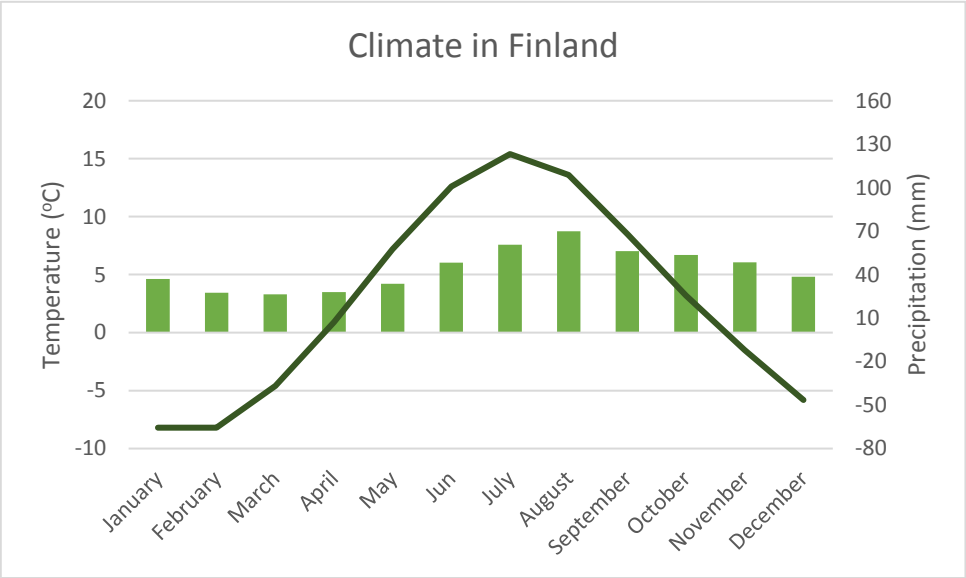

Figure 32 Climate in Finland

Despite the average of 15,4 ºC that July has, Finland is the coldest Nordic country. The colder months are January and February, with an average of -8,2 ºC. The annual average temperature in Finland is 2,7 ºC. About the precipitations, August is the rainiest month, with 70 mm, followed by July with 60,6 mm.

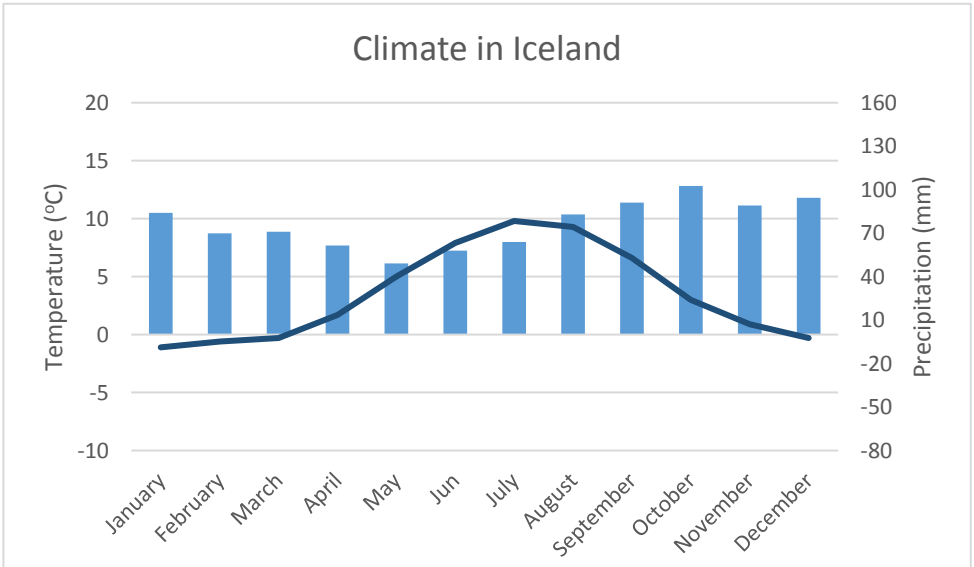

Figure 33 Climate in Iceland

Iceland is the second coldest Nordic country; their annual average of temperature is 3,4 ºC. Their colder months, January and February, are barely lower than 0 degrees; with -1,1 ºC the coldest month. July is the warmest month and their average temperature is 9,8 ºC. Iceland is also the second rainier Nordic Country, with an average of 920 mm. November is their rainiest month, and May the driest one.

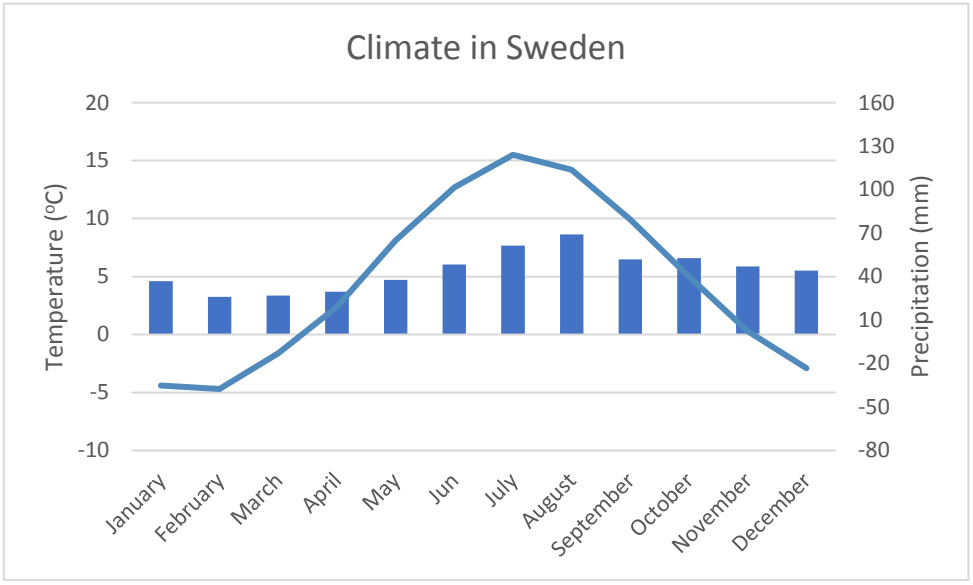

Figure 34 Climate in Sweden

Sweden is the second warmer Nordic Country, after Denmark. Despite this, the temperature of Sweden is much more similar to the temperature of Norway. His average temperature is 4,7 ºC. Both January and February are their coldest month, with -4,4 and -4,7 ºC respectively.

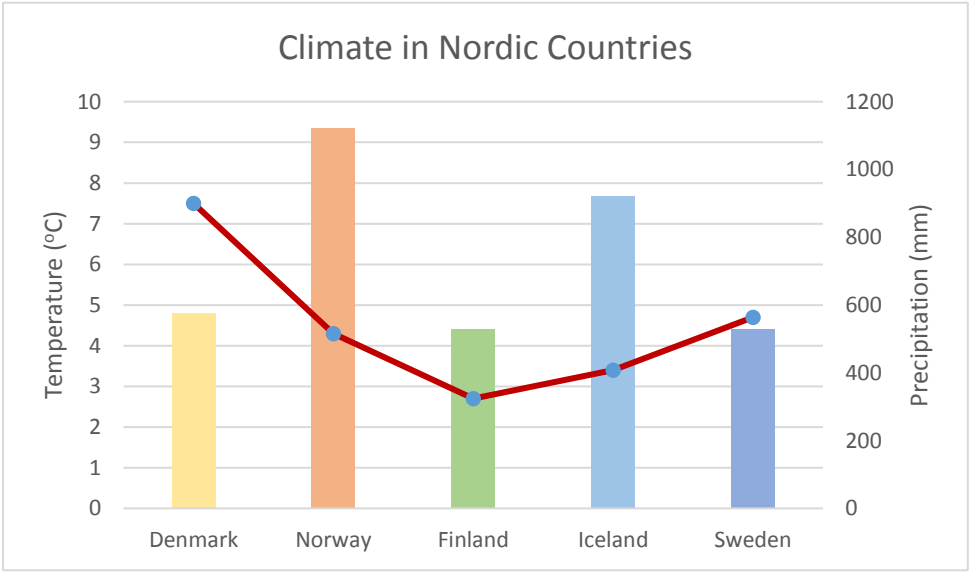

Figure 35 Climate in Nordic Countries

In the graphic above are the average temperatures and annual precipitation of each Nordic country. As it has been observed throughout this section, Denmark is the warmest country and Norway the rainiest. While Finland is the coldest and also the driest, with Sweden and Denmark.

One of the richest sources of energy in the world is the Nordic region. Nordic Countries have managed to have a satisfactory technology and infrastructure to exploit renewable energy sources; wind, water, geothermal heat and bioenergy.

Thanks to the large amount of water around them and their diverse lakes, the Nordic Countries have a lot of electricity production based on hydropower. Although Iceland and Sweden are the countries that exploit more this natural source, both Finland and Norway also use it considerably. In Iceland, the most important source of energy is thermal heat while both in Sweden and Finland nuclear power is produced. Due to the existing oil deposits in the North Sea, Denmark and Norway have could increase their native production, even though in the last decades it has increased in all Nordic Countries.

Wind energy is getting out of play to energy based on fossil fuels, such as coal and gas, in the Nordic countries. This effect will reach the Baltic region due to the fact that renewables are eroding thermal power stations. Wind power is expected to supply half of Denmark's energy consumption by 2020. In Sweden wind power accounts for 8% of total consumption and installed capacity since 2010 is forecast to increase to 7000 MW by 2017. On the other hand, Norway has plans to follow the same path as Sweden.

Right now, fossil-based power plants in Denmark and Finland are playing a secondary role. If demand for energy production in Norway and Sweden declines, they serve to supply their energy needs. Denmark and Finland have 11,000 MW of coal, gas and oil, which they want to get rid of by 2030, at least part of the coal to generate all the energy and heat from renewable by 2035.

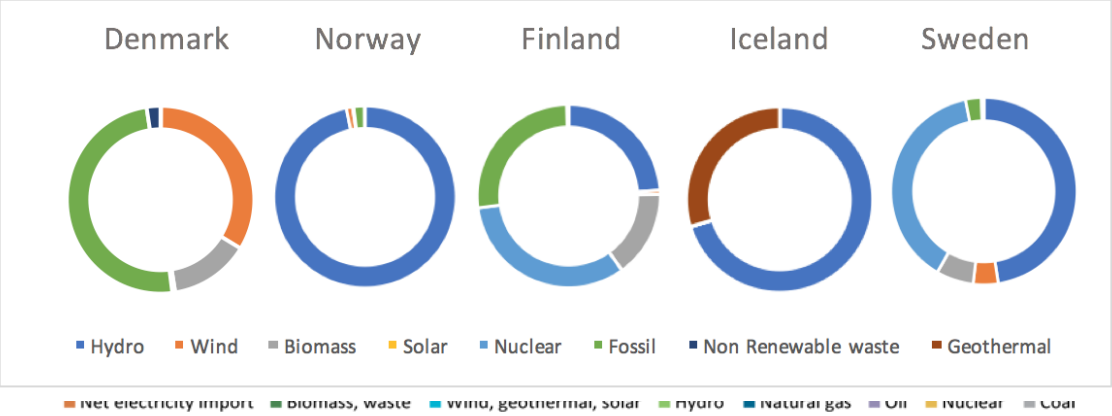

Figure 36 Structure of electricity production in Nordic Countries in 2012 [8]

Figure 37 Nordic primary energy supply in 2013 and estimated in 2050 [9]

Energy efficiency policy in Nordic countries

U-values in Nordic countries

The following table is providing the existing U-value requirements in Nordic countries. As the information bellow is corresponding to 2007, the U-values could be updated.

The values are ranged due to the application in different type of buildings.

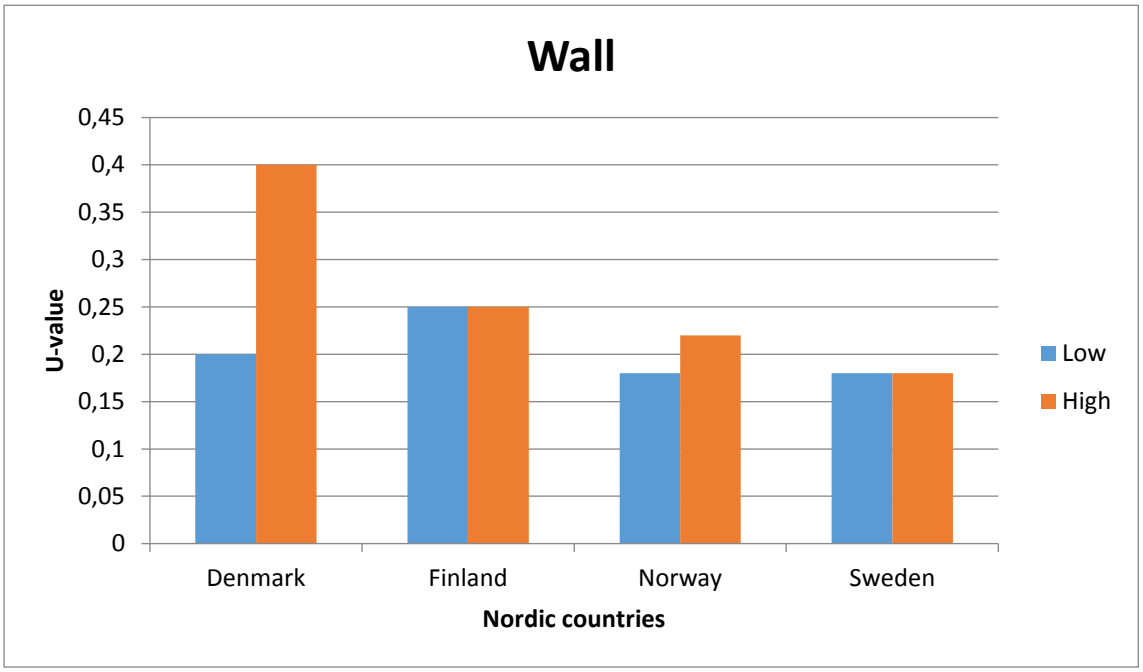

Figure 38 U-values in Nordic countries [28]

- Norway

Through the ZEB (Zero-Energy buildings) group, Norway is working on achieving energy efficiency buildings. The action plan is reducing the passive-houses consumption to 70-80 kWh/m^2 and introducing a nearly-zero energy building standard by 2020.

The following table is corresponding to the energy performance consumption in Norway:

Level	Commercial buildings kWh/m^2/yr	Dwellings kWh/m^2/yr	Factor
Existing buildings	238	201	Net energy demand
Estimated energy consumption after tradition rehabilitation	215	160	Net energy demand
Energy performance requirements-new buildings (TEK10)	150	120	Net energy demand
Low-energy buildings (prNS3701/NS3700)	80	70	Net energy demand
Passive-house buildings (prNS3701/NS3700)	60	55	Net energy demand

Table 1 Maximum consumption allowed in Norway [19]

- Sweden

  Three climate zones compose the country. It is established a different energy requirement for each zone. The north area is Zone I, mid-Sweden is Zone II and the southern area is Zone III.

Level	Commercial buildings kWh/m2/yr (zone 1/2/3)	Dwellings kWh/m2/yr (zone 1/2/3)
Energy performance requirements-new buildings (TEK10)	120/100/80	130/110/90

Table 2 Maximum consumption allowed in Sweden [19] [35]

- Finland

The implementation of EPBD requires a new building to show an energy certificate. Also, it's compulsory to present an energy performance certificate in a building that is going to be sold or rented.

Since 2011, new Government buildings have a high-energy efficiency label.

Since 2012, most of the public buildings possess an A energy label.

Depending on the section of the new building and the indoor temperature, the maximum values allowed in Finland are indicated in the following table:

	Unit	$\theta \geq 15^{o}C$	$15^{o}C > \theta \geq 5^{o}C$
Building components	**(W/m^2K)**		
Wall		0,25	0,3
Windows		1,7	2
Average of wall, windows and doors		0,8	1,1
Thermal bridges	**(W/mK)**		
Foundation wall		0,12	0,12
Intersection wall-window		0,03	0,03

Table 3 Maximum U-value allowed in Finland [19]

4. Research about renovation methods

While renovating a building, the different existing renovation methods have to be taken into account. Depending on the type of renovation that one is looking for, it is possible to use one or another method.

For this reason, the team had to research a large amount of renovation methods. Once the team understood and learned the methods, it was easier to find the right cases. As there are many methods to renovate houses, the team decided to focus only on those methods that are applicable in some way in the Nordic Countries.

Before talking about wall insulation methods, it is necessary to explain how the heat is able to go through a wall from inside to outside and vice-versa.

The heat can be transferred through three different ways: radiation, conduction and convection.

Through radiation, the heat does not require any medium to be transferred. It is transferred by means of electromagnetic waves.

The conduction is produced by the contact between substances that have different temperature. The heat will be transferred rapidly if the conductivity of the substance is high.

The convection occurs when there is a contrast between the temperature outdoors and indoors. This difference of temperature causes the movement of the warm and, as a consequence, the hot air increases and the heat disappears.

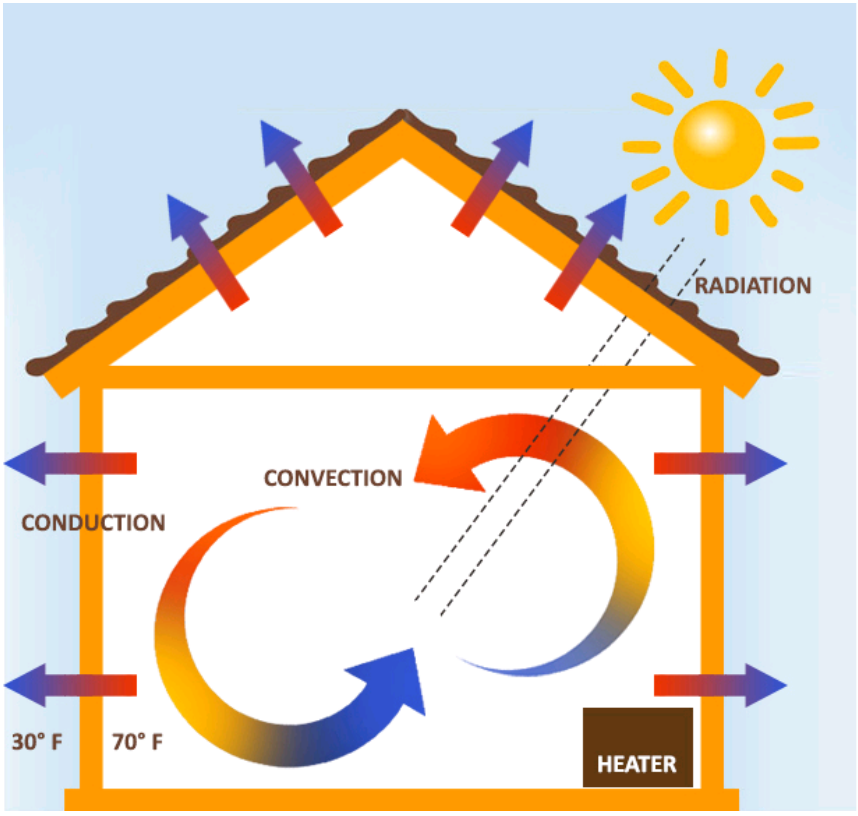

Figure 39 The idea of radiation, conduction and conversion [44]

WALLS

a) External thermal insulation layers

While adding an insulation to an existing building, the external one is usually the preferred method. It avoids the loss of exterior space and it is possible to be installed while the building is in use. In addition, it is possible to address moisture problems and thermal bridges in an extensive way.

As the external method alters the visual appearance of the building, it can be a problem since not all buildings can be aesthetically altered (such as historical ones, the maintenance of the original façade is needed). External thermal insulation causes also challenges, for example, verges and details around windows could need to be altered. [10]

External thermal insulation composite systems

The external thermal insulation composite systems (ETICS) consists in the placement, on the external face of the façades, plates of thermal insulation adhered to the wall. The usual fixation is usually done using adhesives and mechanical fixing. The most common panels are made using expanded polystyrene, but mineral wool boards are becoming more and more common. The insulation is protected with a consistent coating of one or more layers of protection, one of which carries a reinforcing mesh. The external coating is applied directly onto the insulation panel without any air cavities in between. [20]

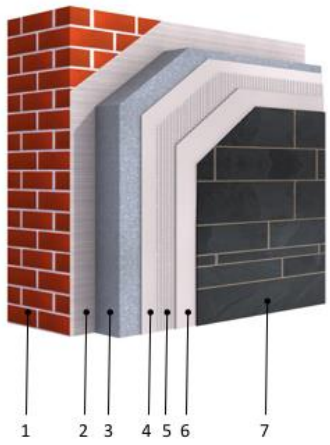

Figure 40 ETICS composition [20]

ETICS composition: wall surface (1), adhesive (2), thermo insulating boards (3), reinforcing coat (4)(6), reinforcing mesh fabrics (5), façade render (7).

Ventilated façades

The ventilated façade is an exterior cladding system consisting of an inner sheet, an insulation layer, and a non-waterproof outer sheet. This type of facade allows any type of durable finishes, great quality and offers excellent thermal and acoustic performance. After the ETICS, is the most common renovation method. [21]

Ventilated façade composition: inside sheet (1), isolation layer (2), substructure (3), exterior panel (4).

Figure 41 Ventilated façade composition [21]

The existence of joints between the facade pieces avoids the typical problems of expansion, so they are facades that look good for a long time. The outer sheet also cushions the temperature changes in both the thermal insulation and the waterproofing, extending its life. Finally, the existence of the outer sheet helps to reduce the thermal losses of the building: in the summer months, the outer skin is heated creating a convective effect that circulates the air inside the chamber. This "chimney effect" displaces the hot air and renews it with colder air. In the winter months, this effect is lower with indoor thermal insulation improving energy efficiency. [21]

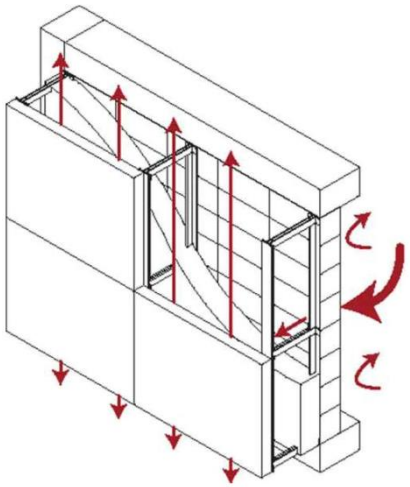

Figure 42 Thermal behaviour in winter [22]

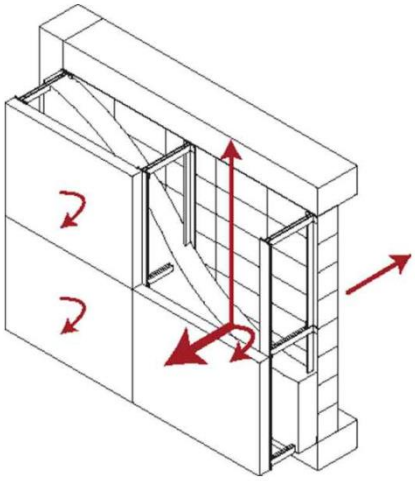

Figure 43 Thermal behaviour in summer [22]

External thermal insulation panel system

The external thermal insulation panel systems basically consist of inserting an insulation material inside a facade panel. The panels are made of metal (aluminium or steel) and filled with thermal insulation, for example, mineral wool. The panel systems can be attached to a new, lightweight supporting frame that is fixed to the existing wall. On the other hand, the panels can also be fitted to an existing structural frame where original panel system needs to be replaced. [10]

The main benefit is the transportation and rapid installation due to the length of the panels, up to 12 m long. External thermal insulation panel system is easy-to-install and may have different finishing materials. Nevertheless, the lack of flexibility to adapt to different geometries and existing windows makes it not usable too much.

Vacuum insulated panel

The vacuum insulated panel (VIP) is a form of thermal insulation consisting of a gas-tight enclosure surrounding a rigid core, from which the air has been evacuated. It is used in building construction to provide better insulation performance than conventional insulation materials. [11]

VIPs consist of membrane walls, a panel of a rigid highly-porus material and chemicals. The membrane walls are used to prevent the infiltration of the air in the panel. The panel rigid can be made of glass fiber, perlite, aerogel or fumed silica and is used to support the membrane walls against the pressure if the atmosphere. Finally, the chemicals are used to collect gases leaked through the membrane. Due to cores with

bigger cores size require a higher vacuum, the chemical is added to the vacuum insulated panels with foam cores or glass-fiber.

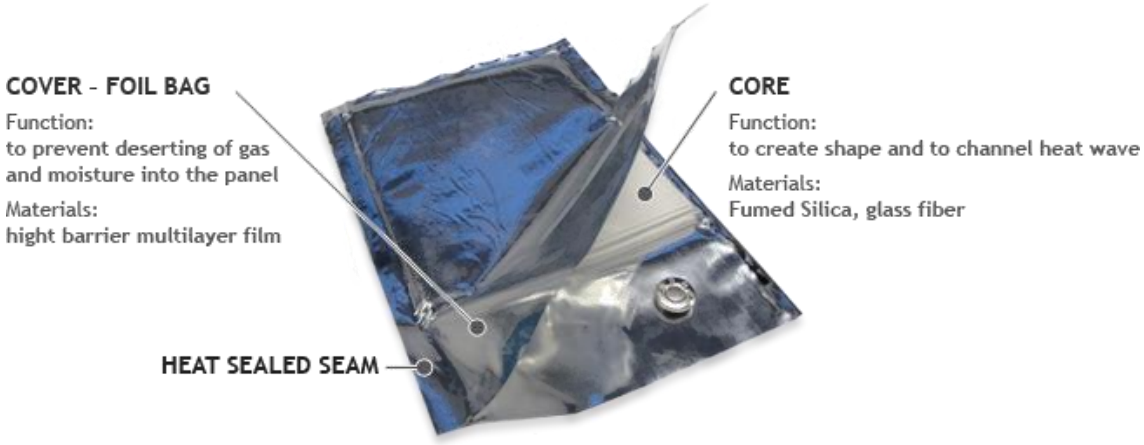

Figure 44 Vacuum insulated panel composition [23]

The weakness of this systems is the barrier film, as it needs protection. However, it can be possible to protect it encasing them inside a protecting EPS-covering. Besides, comparing to traditional insulation materials, VIPs can offer better insulation and requires a low space to be implemented.

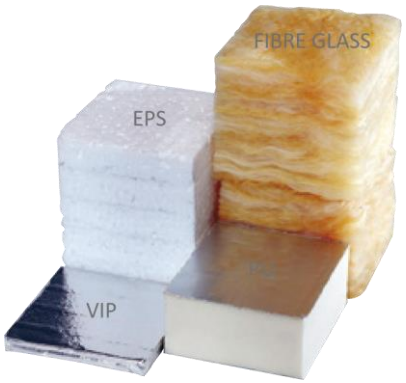

Figure 45 Traditional insulation materials vs VIPs [24]

Green walls

Green walls are thin layers of living vegetation installed on the façades. They are ideal for reducing the amount of rainstorm water generated by the impervious surfaces above buildings, and they also provide excellent insulating properties and actively reduce the urban heat island affect. Increasing the biological load on the façade of an urban structure offers several benefits such a reducing the energy consumed within the building, producing oxygen filtering out water and airborne toxins and even providing new ecological habitat.

Green wall systems may vary enormously; these are two general types: modular, which can be hydroponic or substrate based, and felt covered hydroponic panels. It

should be noted that the support structure and waterproofing are optional and depend on the site. [12]

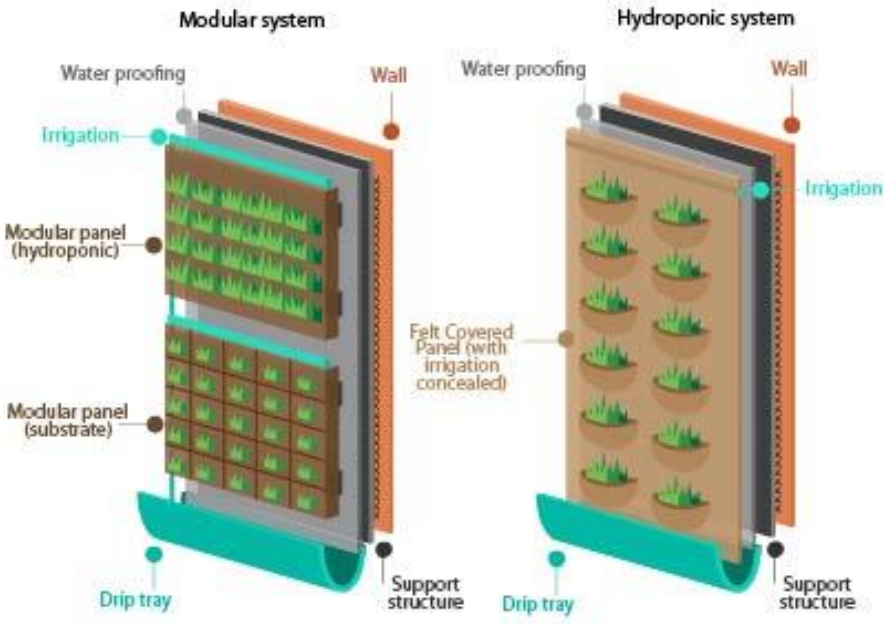

Figure 46 Two general types of green wall systems; modular and hydroponic [12]

Green walls also have several advantages as they are aesthetical favourable and provide a more restful and recreational environment for urban areas. Green wall reduces rainwater runoff flow rate. It improves water quality as it lowers the amount of sediment and pollution that reaches water sources. It also reduces dramatically the temperature fluctuations on the façade and helps balancing he the urban heat island effect through evaporation. Their main disadvantage is the complexity of design and the maintenance issues. It ls also attracts wildlife. [12]

b) Internal thermal insulation layers

There exists the possibility to renovate a building using internal thermal insulation layers. As the insulation thickness relates to its performance, it can be needed space for the insulation layers inside the building. It can cause a problem if the owner does not want loss space.

Therefore, it is necessary to consider the different materials to be used. High-performance insulation materials are often used because they have higher U-values being thinner. Polyurethane (PU) and phenolic foam (PF) are good examples because less insulation thickness is required to obtain the same U-value as other materials such mineral fibre or cellulose.

The main problem with the internal thermal insulation layers is the lack of a weather cover. It is necessary to use a weather cover that protects the existing structures on external insulation systems. Furthermore, lowering the temperature of the external walls adds stress of outer surface on the wall.

Internal thermal insulation concepts can be divided into two main types based on the fixing method of the insulation. The insulation can be fixed either to the existing structure or to a freestanding studwork. [12]

Plasterboard laminates fixed to the existing wall

As plasterboard laminates are easy to install, they are used extensively. The problem with this method is that it is difficult to obtain very high improvements in thermal insulation due to the available insulation thicknesses products.

To fix the plasterboard laminates, it may require to use an adhesive. Using plaster adhesive as recommended by the board manufacturer, this method is applicable where the background plaster is smooth, level and dry. The adhesive is applied to the board in strips. To prevent air movement behind the board, it is important to seal the perimeter and the surround of any openings with a continuous band of adhesive. In addition to adhesive, boards incorporating plastic insulation should be secured using screw fixings. [13]

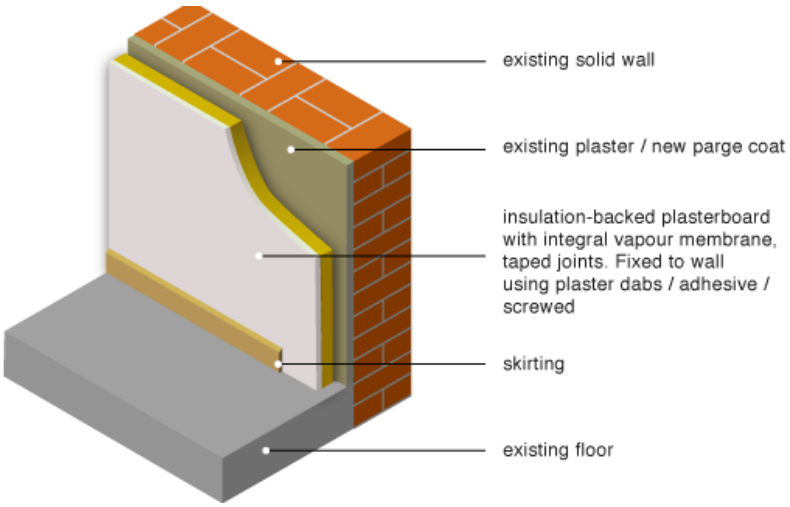

Figure 47 Plasterboard laminated fixed to the existing wall [13]

Insulation boards fixed to the wall with timber battens

Timber battens are useful when the background has been damp or is uneven. To fix the timber battens, screwing or nailing has to be done. Insulation boards fixed to the wall with timber battens are covered with plasterboard; the system is practically the same as the previous one, but there is one difference: the systems components are installed separately. Despite the installation is not fast, this system has benefits as can be that the insulation thickness can be chosen voluntarily and their costs are low. [13]

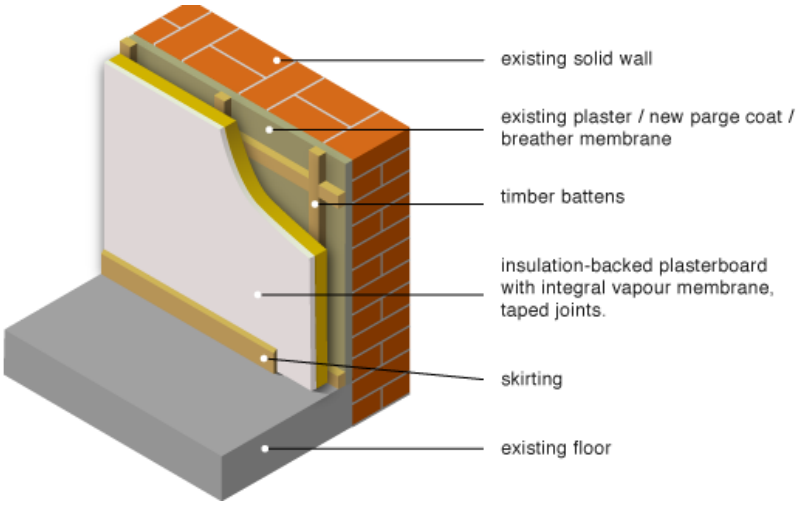

Figure 48 Insulation boards fixed to the wall timber battens and covered with plasterboard [13]

Insulation fixed to a freestanding studwork

This method is appropriated if the existing wall use to have rain penetrations or if the wall is bowed or uneven. It is possible to use different materials while they fit tightly between the studs since it rests between the ceiling and the floor.

Freestanding studwork leaves an empty air cavity behind the additional thermal insulation layer. Is useful if need ventilation due to the moisture can penetrate the outer wall structure. Comparing it with the other solutions, it might take more of the limited space that is available for installed the internal insulation; this is the main disadvantage.

Freestanding studwork can be made from steel or wood. The benefit of steel studwork is the faster installation speed. However, due to higher thermal conductivity of steel, the steel studwork can cause significant thermal bridges. [13]

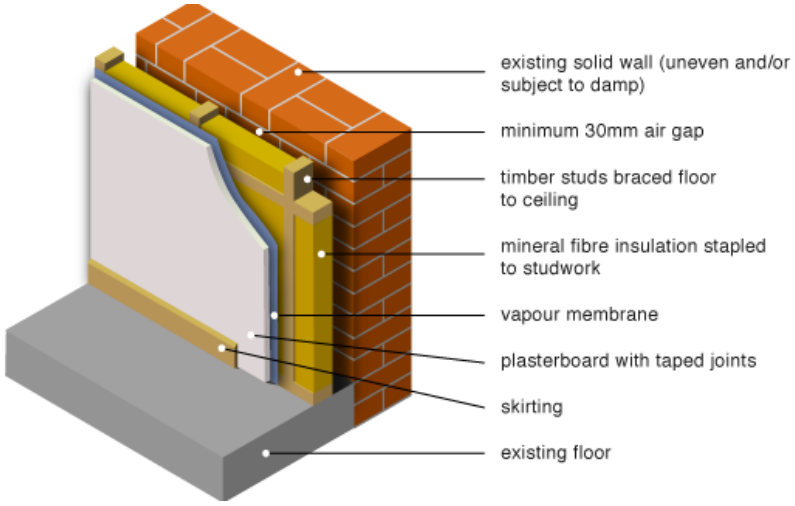

Figure 49 Insulation fixed to a freestanding studwork [13]

Phase-changing materials (PCMs) [14]

The Phase Change Materials are able to store the latent heat from the solar energy. The phase change allows liberating the heat to maintain a comfortable temperature in a building.

The serious increase in temperature, while the PCMs are solid, causes the melting crystallization. It takes time to store the energy from the phase change. During this phase is occurring, the temperature remains proportionately constant providing the latent heat. The latent heat is supposed to be released when the temperature reached in the liquid phase start falling. PCM is turning into solid again.

While the temperature outside reaches low values, the temperature from the outer surface of the wall remains high and vice-versa. Around 4:00 AM, the surface temperature becomes to be the same as the room temperature.

One advantage of this system is that it requires a small volume to store thermal energy, but that's a real advantage if only limited temperature range can be accomplished. Further the temperature range can be accomplished and it remains during the melting crystallization phase.

The main disadvantage of this method is the high investment cost. It has also inflammable characteristics that limit the size of the storage conduction. Besides, the solid state limits the peak power due to its limited conduction. What is more, the lack of experience with long-term operation of many thousands of charge-discharge cycles and the risk of stability and deterioration of the encapsulation material supposes a risk.

Organic compounds	Paraffin waxes	Inexpensive
		Reasonable thermal storage
		Low thermal conductivity
		Large volume change during the phase transition
	Non-paraffin organics	Excellent melting and freezing properties
		Expensive
Inorganic compounds		High heat of fusion
		Good thermal conductivity
		Cheap and non-flammable
		Corrosive to most metals
		Undergo supercoiling and phase decomposition
Inorganic eutectics or eutectic mixtures	Organic-organic eutectics	Sharp melting point
	Inorganic-inorganic eutectics	High volumetric storage
	Inorganic-organic eutectics	Limited data on thermal and physical properties

Table 4 Materials of PCMs [14]

c) Cavity insulation

This popular method of additional insulation during renovation is a simple way of insulating cavity walls (a cavity wall is the gap between two walls). This method of insulation is used to reduce the heat loss that was produced in a cavity wall. To be able to do it, the air space with material that constrain heat transfer has to be filled; preventing convection. After achieving this, it is possible to keep the house warmer and therefore be more profitable. Furthermore, while installing the cavity insulation, the occupants can remain in the building. [15]

You can isolate the cavity wall using blown mineral wool, EPS beads and polyurethane Foam (PU foam).

Blown mineral wool

The mineral wool used for cavity wall insulation consists of mechanically granulated spun glass or rock wool, treated with a binder or water repellent during manufacture. Equipment for blown mineral wool is also required to conform to, and the installation must be carried out. Once installed, mineral wool is sufficiently stable to remain an effective insulant for the life of the building. [15]

Figure 50 Cavity wall Insulation with blown mineral wool [25]

Properties:

- Thermal Conductivity: For the purpose of U Value calculations to determine if the requirements of the building (or other statutory) regulations are met, the thermal conductivity (K-value) of the insulation may be taken as 0.040 W/M ^{o}C.
- Density: Typical installed densities range from 18kg/m^3 for glass wools to 40kg/m^3 for rock wools.
- Fire: Blown Mineral Wools are non–combustible.
- Water: Mineral Wool is resistant to water penetration and will not transmit water across the cavity or from below DPC level by capillary action. It does not however act as a water vapour barrier. [15]

EPS beads [15]

The polystyrene used for CWI is in the form of virgin pre-formed bead which is usually combined with a binding agent or adhesive at the time of injection. Polystyrene beads are produced to a specified size and density which remains unaltered during the installation process. Once installed, the bead filling in the cavity will remain an effective insulant for the life of the building and will require no further maintenance.

Figure 51 Cavity wall insulation with EPS beads [26]

Properties:

- Thermal Conductivity: The k value of white expanded polystyrene bead should be taken as 0.038 W/m ^{o}C - 0.040 W/m ^{o}C.
  The k value of Carbon (Grey) expanded polystyrene bead should be taken as 0.032 W/m ^{o}C - 0.034 W/m ^{o}C
- Density: A typical installed density is 12kgm^{3} +/- 2kgm^{3}
- Fire: The use of polystyrene bead for cavity wall insulation does not prejudice the fire resistance properties of the wall.
- Water: The material is resistant to water penetration and will not transmit water across the cavity by capillary action or from below dpc level. Any rainwater penetrating the outer leaf will drain harmlessly to the footings. Is not designed to be a water vapour barrier.

Polyurethane Foam (PU foam) [15]

Injected PU foam is a two-component chemically modified polyurethane foam which achieves superior U-value and air-permeability results. Once installed, PU foam in the cavity will remain an effective insulant for the life of the building and will require no further maintenance. Injected PU foam can be used in cavities for a superior performing insulation which also helps to bond the inner and outer leaves providing strength to the building. Besides, U foam is often the most cost effective solution.

Figure 52 Cavity wall insulation with polyurethane foam [27]

Properties:

- Thermal Conductivity: For standard construction 65mm cavity u-values of 0.33 W/m^2K can be achieved and in a 100mm standard construction cavity the U-value can be down to 0.22 W/m^2K.
- Density: Approx. $40Kg/m^3$
- Water: Closed cell polyurethane foam provides an extra layer of resilience against the ingress of wind driven rain and flood water through the cavity

d) TES method

A façade renovation method was developed in a project called TES EnergyFacade. This project, coordinated by the Dipl. Ing. Frank Lattke, was realized in 2008-2009 and had a budget of €848.744. The purpose of the TES EnergyFacade was to achieve that the method developed would be applicable throughout Europe. The main target of the project is to improve building's energy efficiency and reduce GHG emissions, adopting an ecological and sustainable method based on biogenic materials. [16]

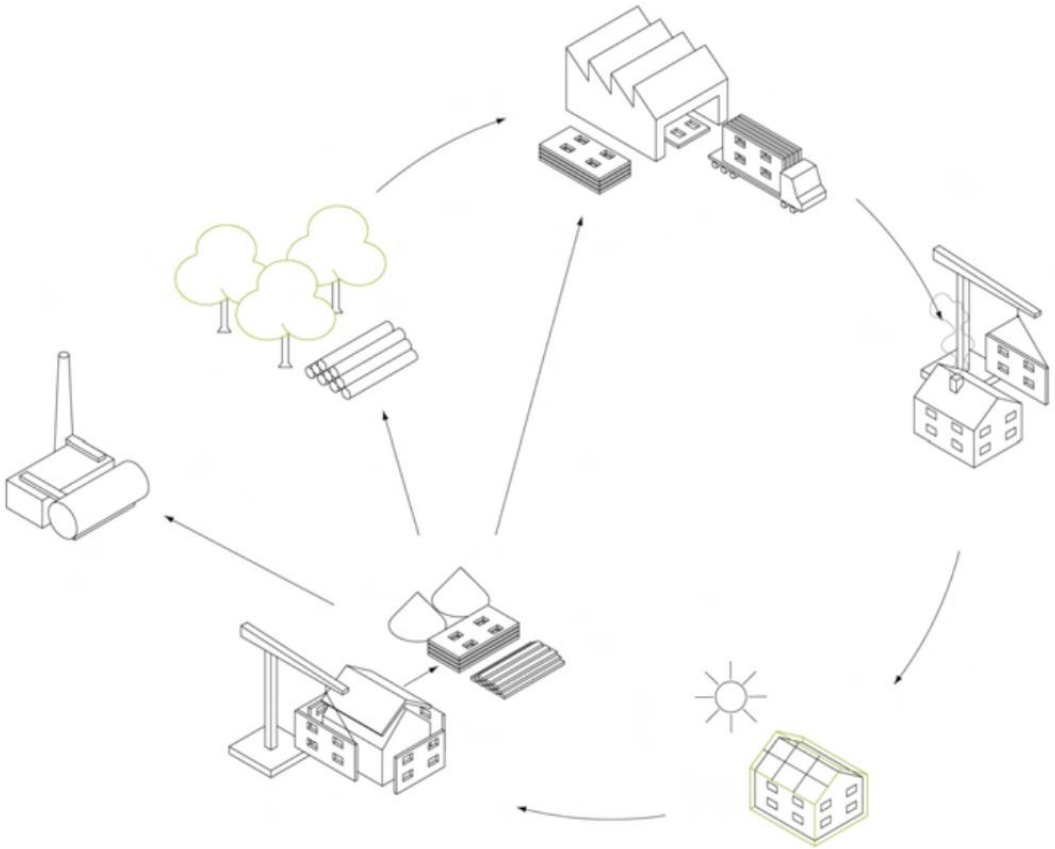

Figure 53 Timber based value chain - building modernisation offers new chances. [16]

TES method is based on large scale and timber based elements for the substantial improvement of the energy efficiency of a renovated building. The timber based value chain offers an enormous potential to activate the carbon stock as timber is the only regrown building material. Along the value chain of timber, combustion of wood has to stand last. [16]

The method developed consists in prefabricate large-sized timber frame elements. To do that, it was necessary a workflow from survey, planning, initial 3D measurement, off-site production and on-site mounting.

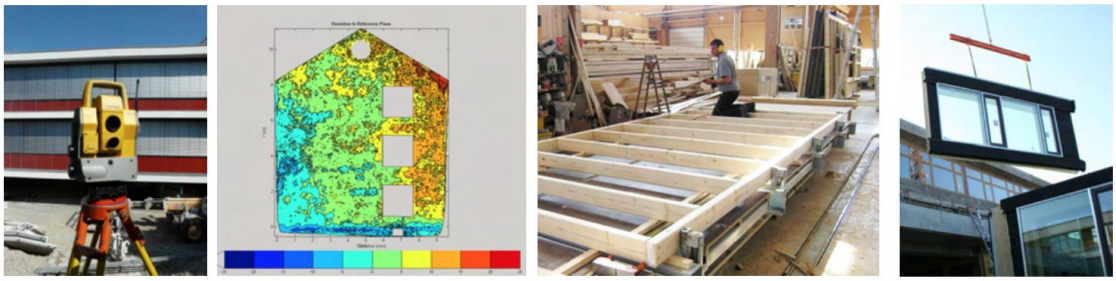

Figure 54 TES method; From survey to assembly [16]

TES EnergyFacade has achieved high precision and quality of ecological buildings, reduced in-house work and predictable prices. In addition, due to the off-site work, a reduction of the noise and annoyance to the inhabitants is obtained. With this system, a wide variety of coating materials are applied, integrating load bearing elements, HVACs and solar-active components. [16]

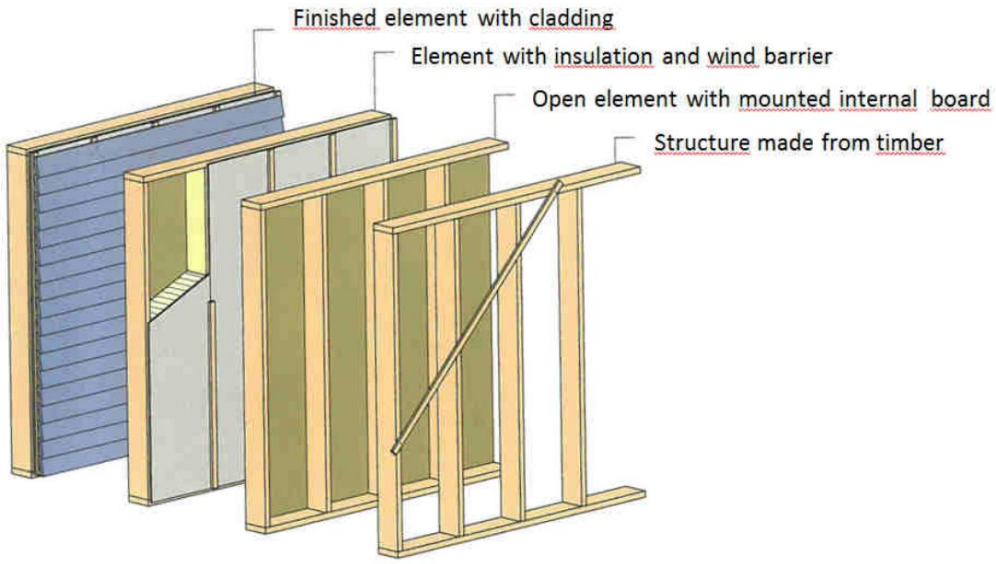

Figure 55 Construction of timber façade [17]

a) Triple glazing

This method joins double glazing with one extra simple glazing. There are in total three pieces of glass. There is an air gap between each pane, so that provides better thermal insulation. The U value can be decreased through filling the air gaps with gas and using low emissive coats.

The condensation is reduced due to the air gap. Besides, the dampness can be deleted through adding a drying agent before the sealing process.

Compared to double glazing, triple glazing reduces better the heat loss, as well as it improves the acoustic insulation.

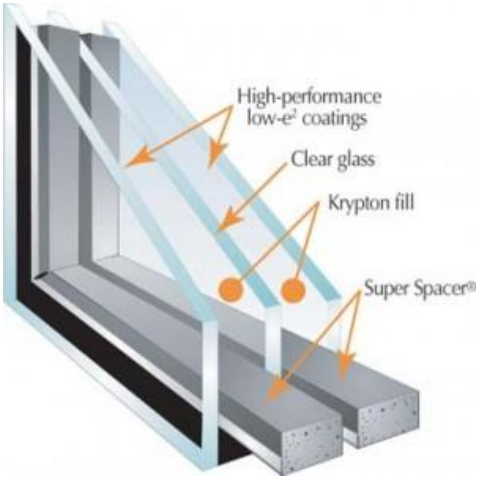

Figure 56 Triple glazed windows [29]

b) Gas

This method consists of filling the air gap between the current panes with gases (commonly argon, krypton and xenon). It reduces more heat loss through convection than the usual air. Krypton and Xenon are not as used as Argon. Argon is cheaper than them and it has better thermal qualities.

The best advantage is the possibility to add the gas to the current glazing (low emissive coats, double glazing, etc). The main disadvantage, probably, is the unavoidable leak of the gas. Besides, when the inner seal of the window fails, it is then unable to be used. [30]

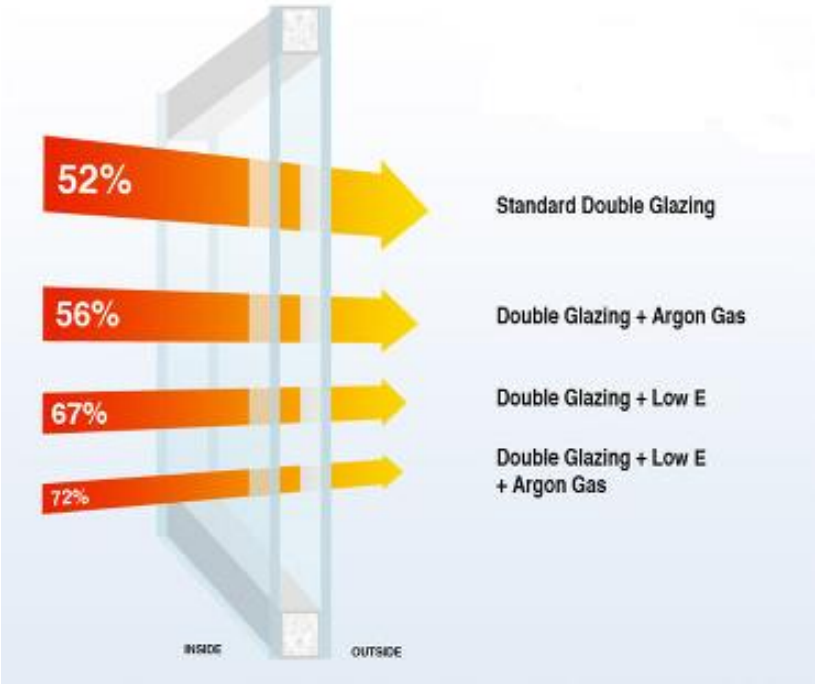

Figure 57 Heat loss reduction according to the method [30]

c) Low emissive glass [31]

These coatings do not let the heat escape the building. Their function is to reflect the heat back to the room in winter and maintain the heat back outside in summer. The low emissive glass avoids the heat escape from one pane of glass to other, maintaining the thermal activity.

As its name says, the low emissive glass is able to limit the emissivity through minimizing the ultraviolet and infrared rays. This limitation allows only the transmission of the visible light.

The U-value can be further lower if they are combined with triple glazing and gas. The main disadvantage is the significant rise of the whole window's price. Low emissive glass can intercept the mobile phone signals, and probably form slight hazes in the window.

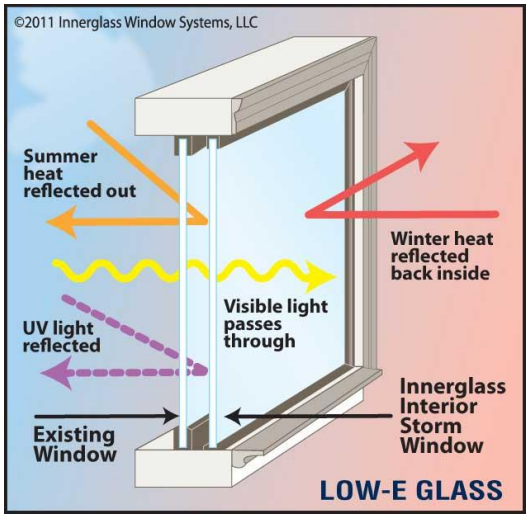

Figure 58 Low-e glass system (1) [31]

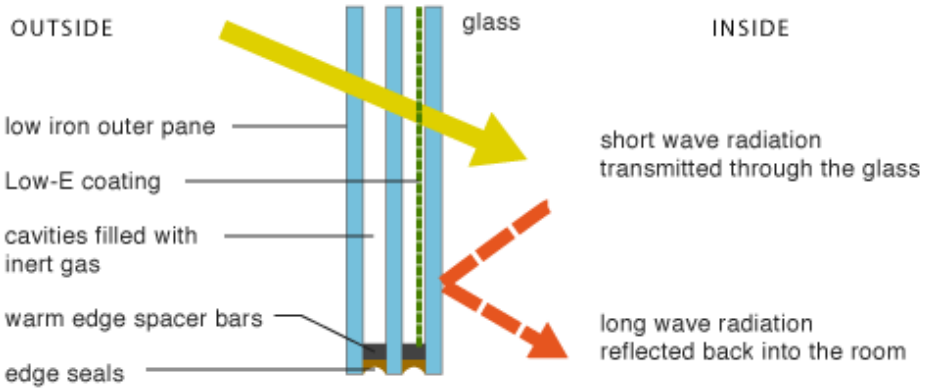

Figure 59 Low-e glass system (2) [32]

d) Secondary glazing [33]

Secondary glazing consists of installing an auxiliary glazing on the building inside face of the window. It is more adapted to stop the heat loss than single glazing. It also provides acoustic insulation.

In case of draught-proofing installation, condensation could be built up between the secondary glazing and the outer windows due to the lack of ventilation. Secondary glazing can be installed through different ways: fixed, removable or open-able.

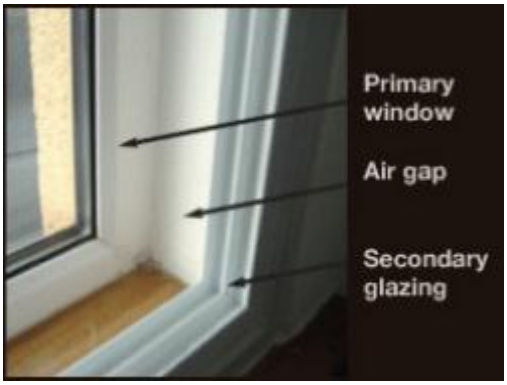

Figure 60 Secondary glazing system [33]

e) Blinds [34]

It's a supplementary window insulation method. Window blind can be added to any window insulation method, except the additional ones. It consists on multiple vertical or horizontal slats. They can be made of plastic, wood or metal. A cord through the blind slats holds them together. The position of the blind slats can be controlled manually or remotely

Figure 61 Window blind [34]

f) Overhang, shelves

The main function of the roof overhang is to balance the solar heat gain. It stops the entry of unnecessary heat gains caused in the warmest months. The structure of the building will have repercussion on the sunlight influence. They are fixed to the façade or inserted in the window frames. Their orientation can be controlled or adhered.

Furthermore, they can be used to increase the load of daylight indoors. The sunlight can be blocked in summer while in winter can be reflected into the room's roof.

They are easy to install. As it is an exterior issue, their performance does not disturb the tenants. The main disadvantage could be they are difficult to clean. If the building location is extremely wind exposed, their use might be limited.

Sidefins

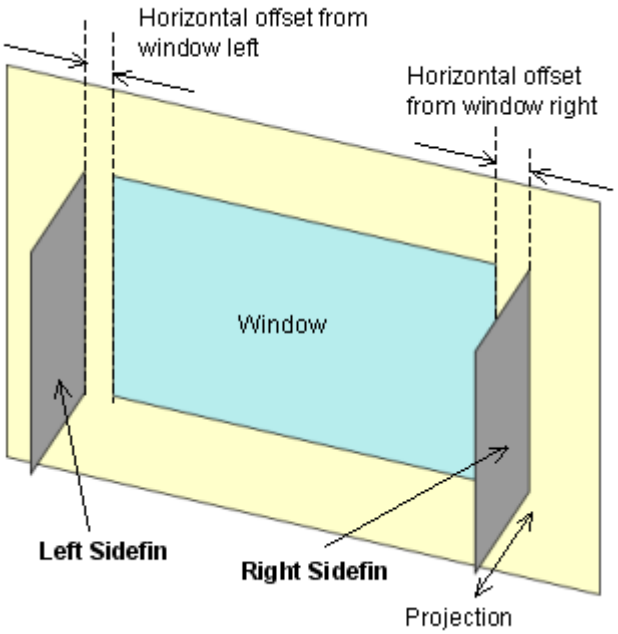

Figure 62 Local shading – sidefins [18]

Known as the sunblades or vertical louvres also is a solution for the windows that may be used from either west or east side of the wall. The main purpose of situating the window at those sides it to prevent the sunlight to enter the room.

Putting the fin outside of the window is blocking the direct rays. On the other hand, putting the fin at the internal part of the window helps to reflect diffuse light into the room.

Sidefins may be either fixed (as elements of the façade) or moveable (amount of blocking is adjustable). Therefore, during winter, more light may be let inside while during summer (especially hot months), more sun may be kept out of the building. According to ICTs, orientation of the sunblades can be adjusted.

This solution is applicable in all of the countries, climate zones and building typologies.

Although the sidefins solution is easy-to-install and reduces the undesired solar gains very effectively, it also has its disadvantages. Sidefins are reducing the view of landscape and it is rather difficult when it comes to cleaning.

5. Case – what is it?

A case study could be mainly defined as the refurbishment report. From a consumer point of view, there is a need to characterize the main interesting sections that should be present in the report. They are described below.

Renovation method

The first aspect is the renovation method referring to the information the owner gives about the materials used to refurbish the building. It is preferable to have as much information as possible. Furthermore, the consumer should know the thickness and the position of the layer (e.g. 380 mm of mineral wool added to the inner surface of the wall).

Energy performance

Energy performance or energy assessment could be identified as the final consumption determined by comparing the initial consumption with the energy saving. The energy saving is indispensable to calculate how long the investment will take to recover the costs.

Renovation costs

It is necessary to know renovation costs to expect the amount of money a customer may invest during the refurbishment. Renovation costs will help to imagine how much people that will execute a refurbishment in a similar way (same renovation method and similar area of the building) will spend. Additionally, people that have a limited budget will be able to value if they pay for the method the case study includes or they prefer to spend less money in a cheaper method.

Thermal efficiency

A great thermal envelope is synonym of a low U-value. The U-value calculation shows the effectiveness of the renovation performance. Once the refurbishment has been finished, the U-value must be calculated to be compared with the U-value before the refurbishment.

Even if many companies decide not to publish data from their refurbishment, other companies collect the data and upload it to internet. Their goal is teaching and informing. A case study can be identified as a suitable issue to solve a problem. Companies teach you, through experience, how they dealt with a real problem. Thus,

you will be able to learn and find support when a similar problem comes to your building.

Besides, it is important to highlight a case study can provide practical information that is not included in theoretical material. For instance, it is necessary to contact the Heritage Centre when a refurbishment takes place in a historic building. Another example is giving the name of the institution where they obtained public funding from.

The case studies are mainly uploaded by energy agencies. Sometimes, publishers are hired to edit and publish the material online in a professional format.

There are two levels of information. The data can be classified in general and specific one. For instance, the renovation method can be firstly explained generally (naming the surface where the insulation was applied and the material used). Secondly, deep information about the materials mentioned before should be explained in detail.

As a part of the case study, pictures must be taken before and after the refurbishment to appreciate the improvement.

6. Project's results

As stated above, the purpose of the project was to popularize modern renovation methods for Nordic Countries citizens interested in make houses efficient. Thereby, once the bests cases are identified, the team clarified them in an optimal way.

Renovation Platform Team found a large number of cases, most of them being indeed interesting and useful for the project. Although the decision was not easy for the team – due to the high quality of several cases – the students have decided four successful projects of building renovation to develop. These cases were chosen in consequence the amount of material and documentation the team could found, besides the excellent results of energy savings that the renewed building has.

The studied buildings have been built in Norway, Finland and Italy. While it is true to say that Italy is not a Nordic Country, and the climate on this country could be remarkably different, in fact the method used in the renew was studied in detail and it was concluded that the same method could be perfectly used also in remarkably cold climates.

The duty of the students were to rewrite the information found in each case making it more understandable for people who lack knowledge about the subject.

Students processed the information about the chosen cases and provided their own cases' studies ready to send and publish on the Renovation Centre webpage.

The short summary of each case is presented on next pages and the whole cases are available in Appendices 1,2,3,4.

a) Ca' S. Orsola [more at Appendix 1]

1. Background

Ca' Sant'Orsola is a historic building converted into residential building. It is listed by Historical and Architectural Heritage Superintendence of Veneto Region. After being a convent for 40 years, it was inhabited by the Polish Institute until 2007. Then, it was bought to be totally refurbished after obtaining a bureaucratic permission.

Mainly, the crooked walls and the moisture affected wooden elements determined the ruined state of conservation of the building. Specific goals of renovation project were:

- to achieve the A class energy classification according to Italian regulations;
- to consolidate and to reinforce the building structure;
- to improve the indoor thermal and acoustic quality;
- to transform it in a prestigious residence with all comforts.

The building refurbishment was developed with a particular regards on thermal insulation of the building envelope and special attention has been paid to the mechanical ventilation and the renewable energy utilization (both solar thermal and photovoltaic system). [36]

2. Method and efficiency

The walls were insulated internally and externally: firstly, expanded polystyrene (EPS) foam was placed in the inner part of the façade; in other words, directly on the masonry. Secondly, rigid mineral wool covered by plasterboard was applied to the internal wall. Ca' Sant'Orsola's windows are made of 5 glass sheets (inner safety glass, gas chamber, 4mm central glass, gas chamber, outer safety glass).

The energy performance involved improving, to achieve the nZEB Italian regulations, the envelope of the façade and the cavity wall (0,18) and the glass of the windows and doors insulation (1,9488-2,035) to obtain the A class energy classification.

Figure 64 Ca' Sant'Orsola in Treviso before renovation [36]

Figure 63 Building after renovation with EPS and low energy glass [36]

b) RISØR technical college [more at Appendix 2]

1. Background

The case is the result of the project called RENEW SCHOOL in cooperation with TES Energy Façade project, which the main goal is retrofit school buildings to achieve as much energy savings as possible. *Risør videregående skole* is a technical college in Risør, a town located on the south of Norway. The main reason for the renovation was due to the energy loss that the building had, caused by the poorly insulated walls and the large windows area. The renovated building was built in the mid-1960s and it has two main buildings with laboratories and workrooms, and a one wing with classrooms.

2. Method and efficiency

The building was retrofitted with new facades and improved roof insulation mainly using the TES method. As explained in a previous chapter, the TES method is based on wood framed prefabricated facade elements for the considerable improvement of the energy efficiency of a renovated building. The method consists in pre-fabricate large-sized timber frame elements - it was necessary a workflow from survey, planning, initial 3D measurement, off-site production and on-site mounting. The insulation in the roof was also improved by blowing mineral wool fibre into the existing frame roof structure. The heat energy demand for the school building was reduced from 325 kWh/m2a to 49 kWh/m2a, being the new U-Value 0.13 W/m2K. Besides, the project was financed by the Aust-Agder County Council and the net cost was 14.8 million € - including new facades and additional insulation of the roof [37].

Figure 65 Pictures before (left) and above (below) the renovation [37]

c) Powerhouse Kjørbo [more at Appendix 3]

1. Background

Two buildings from 1980s were to be renovated to a plus energy standard and to become a powerhouse (a building that during its lifecycle produces more energy than it consumes). The energy production must have been based on energy sources. The target BREEM classification score was "Outstanding". One of the goals was also reducing electricity costs and achieve healthy indoor environment. [38]

The Powerhouse Kjørbo is a project of the Skanska company that is the part of Powerhouse Alliance. The building is situated in Sandvika, 15 km from Oslo (Norway). It is a typical office building with about 240 occupants and 12 hours per day of the utilization. [38][39]

2. Method and efficiency

Wood facade construction with few thermal bridges, and 200 mm insulation in front of slabs were installed. [38] As the renovation focused on using the environmentally responsible materials, the constructors used charred wood for façade cladding . It is a natural material that is designed to have a long and relatively maintenance-free lifespan.[40] Such material is created by burning the planks. Board are then cooled and processed. Charred wood lack of chemicals so it is eco-friendly. [41]

Windows of the building were replaced with new, having easily reusable aluminium profiles. They were designed to allow a high level of daylight transmission and distribution in the rooms to reduce the need for artificial light (so that the energy usage decreases). Mounting of new windows was supposed to help with reducing thermal bridges.[38][40]

The U-Value of the windows decreased from about 1.8 W/m²K to 0.8 W/m²K and the walls it decreased from about 0.3 W/m²K to 0.15 W/m²K.[39]

The whole renovation took about 1.5 year. The costs were about 2 654 €/m2. [42]

Figure 66 Powerhouse Kjørbo before and after the renovation [38]

d) City-owned social housing block in Riihimäki, Finland

[more at Appendix 4]

1. Background

The case is about city-owned social housing block located in the Peltosaari suburb of Riihimäki in Southern Finland. The building had been decaying for the last years, which decreased its market value and also created social problems; it needed urgent renovation. It is a representative of the building stock of the period when large residential areas were built using pre-fabricated concrete elements for people moving to the cities from the Finnish countryside in the 60's and 70's and therefore the solutions implemented can be easily replicated in other parts of the country, where there are plenty of similar buildings. [43]

2. Method & efficiency

The facade of this building was made of concrete sandwich elements. In this case, the poor condition of the insulation and the outer pane of the sandwich elements called for their demolition and substitution. A more radical intervention was proposed, by introducing a timber-framed TES-facade, which incorporates not only insulation and windows, but also ventilation ducts and the first layer of facade rendering. The improved insulation of the exterior walls resulted in U-value of 0.1 W/m^{2}a. The windows were replaced with two double glazing panes, argon fill and selective film. The balcony doors have triple glazing, argon filling and selective film. The old reinforced concrete balconies were demolished and replaced by steel-framed balconies. The new windows have a U-value of 0.66 W/m^{2}a. As a whole, the building's energy demand is reduced by 75%. [43]

Figure 68 Social housing building block in a suburb of Riihimäki before renovation [43]

Figure 67 Building after full renovation with TES facade, new balconies and new tilted roof (created by arch. Kimmo Lylykangas) [43]

7. Layout of final webpage

Renovation Platform Team contacted with the webpage designer of Renovation Center to provide all the information developed about the cases for the consequent upload to internet.

Nevertheless, before the meeting with the webpage designer, the team decided to create a couple of templates of the website in order to ensure that all necessary information corresponding to the cases was included.

The first template that was created consists on a main page of a possible webpage where is visible as most of the quality factors, that were described in a previous section, are settled as categories of the case.

The idea basically is that when the user clicks on a category, a pop up window would be opened with more information about the category chosen. The diverse categories have different sizes depending of the relevance; while is true that a case background or the method used is very important, other aspects as pictures lack importance. Moreover, the title of the case was included as well as the symbols used in the project. The purpose of the symbols is to identify different issues related to the case, such as moisture, conservation and energy. A picture of the layout is shown below.

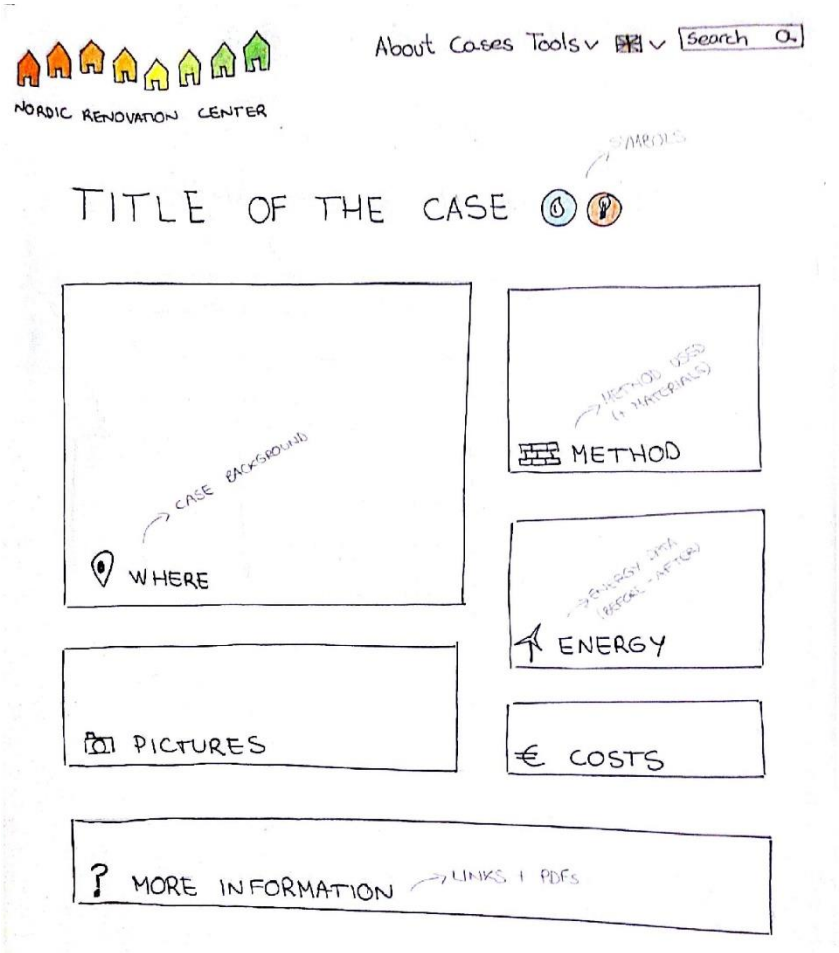

Figure 69 First sketch of the webpage

Besides, the team developed an example of a possible pop up window, which is shown below. In the pop up, it would include the information about the category and a different section or pictures if necessary.

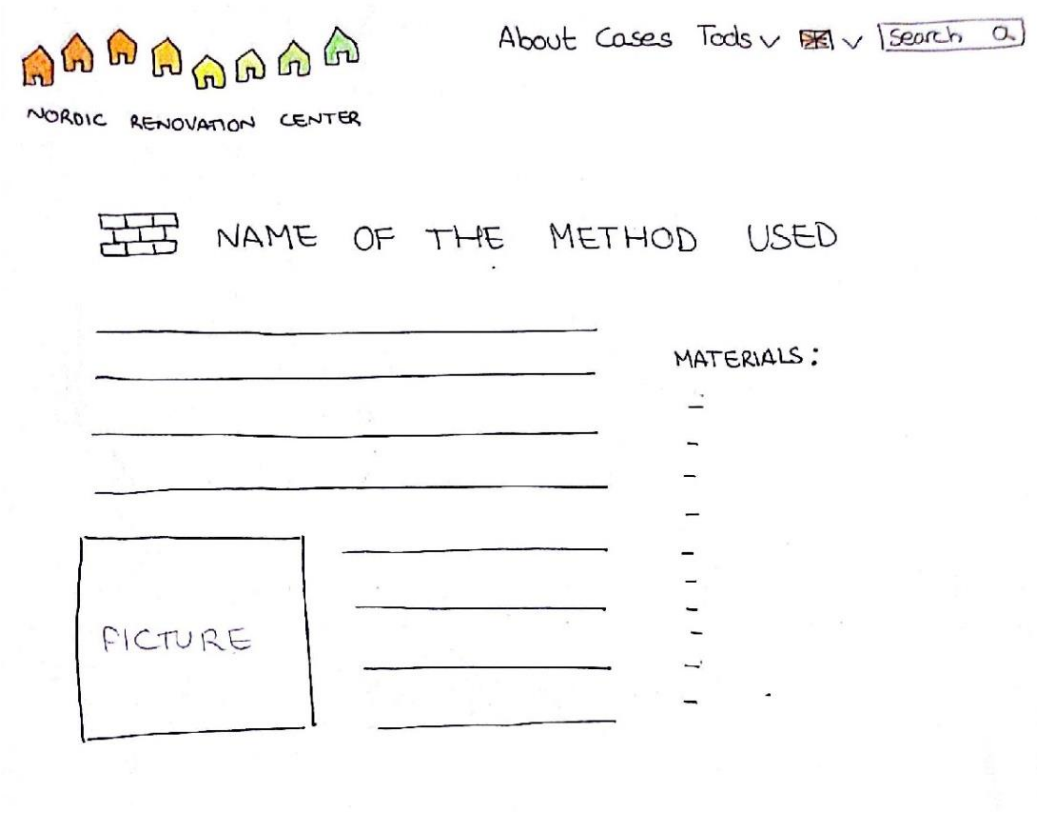

Figure 70. Sketch of a pop up window.

In addition to this idea, the team also develop another one. Due to the project is aimed at people who lack knowledge of building renovation, the team thought it might be a good idea if the different categories of the case were questions that users might have. Thus, it would be easier to find the information sought. Furthermore, when the user clicks on a question, the information would be opened in an accordion way - where the sub-options are displayed while folding the ones that might be previously open.

Possible layouts of the explained idea are shown below.

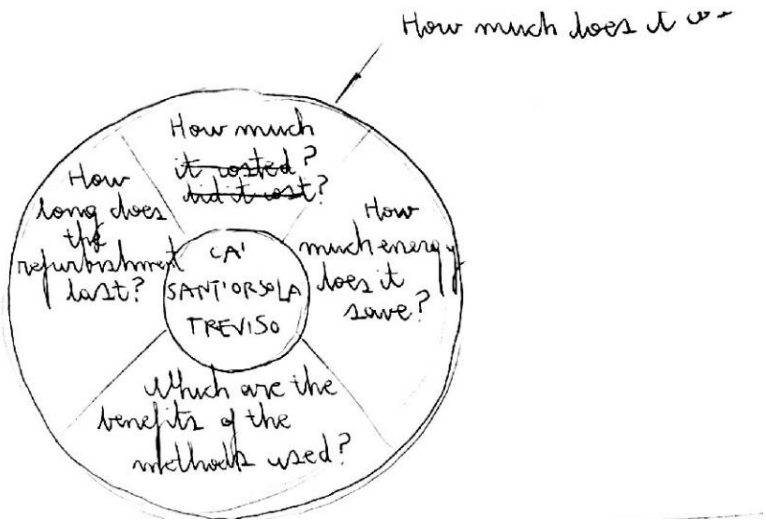

Figure 71 Sketch of a menu for the webpage

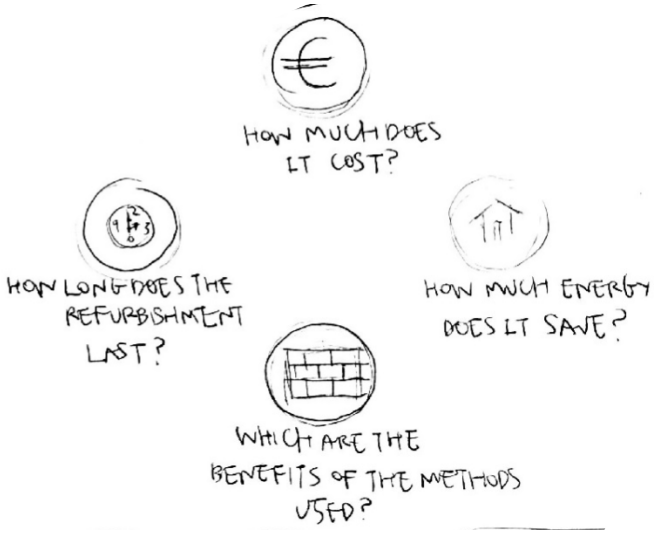

Figure 72 Another sketch of a menu for the webpage

During the meeting with the webpage designer, Renovation Platform team shown the different ideas to the designer, who thanked the proposals since no one had previously provided any help or advice on the format of the web. After a long discussion, it was agreed to try to develop the first option and then evaluate its usefulness.

The webpage designer sent to Renovation Platform an example for cases which could be used as a template for the final layout; different screenshots of the template are shown below.

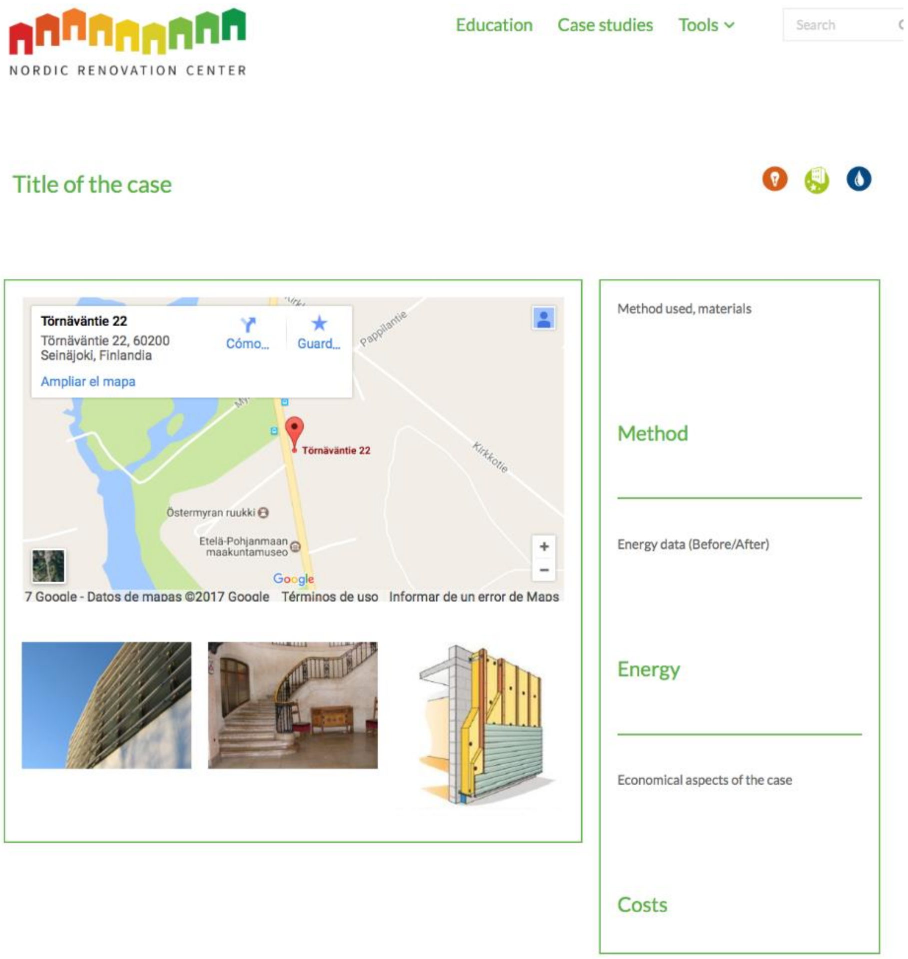

Figure 73 Screenshot of the template for the

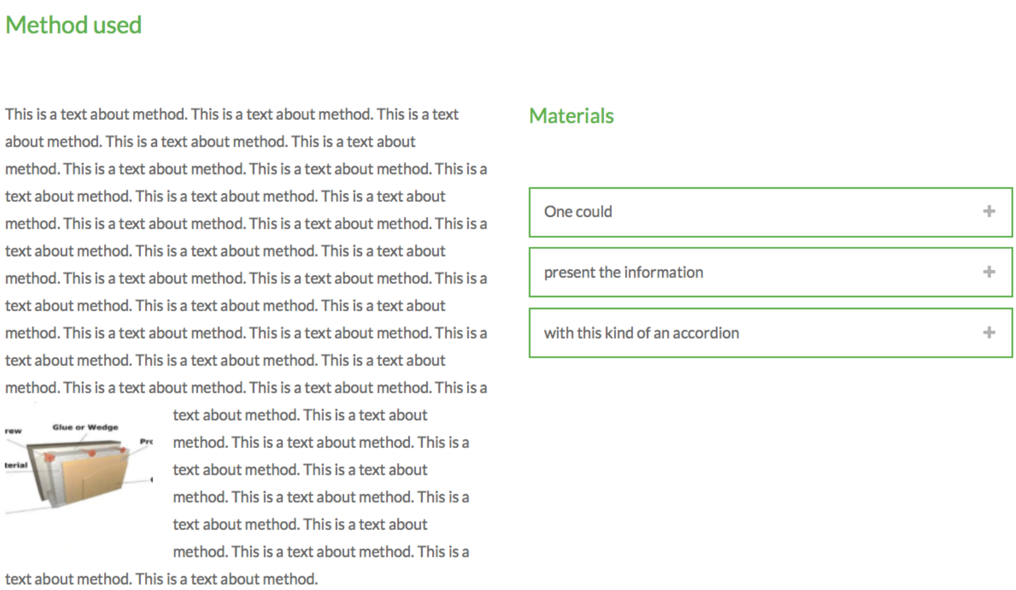

Figure 74 Screenshot of an example of a window

The team will be constantly in contact with the webpage designer via email due to in case the designer cannot implement the demands in an appropriate way, the students can propose an alternative. Finally, the information will be published on the Renovation Center website to facility the access as many of the Nordic countries citizens as possible.

VIII. Conclusions

Finally, the team has been able to specialize in a different field than the usual of each member and spread the knowledge they gained through creating new case studies based on original and additional data.

It has been reported that some case studies, despite the fact that they were not executed in Nordic countries, are useful to instruct future refurbishments in Nordic countries. Weather is not the only influential factor when it comes to plan a building refurbishment. It is worth mentioning that executing a refurbishment to obtain nearly zero-energy consumption involves using similar measures, independently the country where it takes place.

Through analyzing the energy saving from the online case studies, it has been revealed the consumption is extremely reduced. Thus, the monthly electrical consumption, the dependency on fossil energy sources and the coal emissivity to the atmosphere are reduced. In other words, it contributes to reach a sustainable future.

To conclude, the team achieved to overcome adversities. Despite the existence of several risks related to the project and the Erasmus environment, the group anticipated and avoided them.

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Appendix 2 – Risør Technical College Case

Appendix 3 – Powerhouse Kjørbo Case

Appendix 4 – Social housing block Case

Appendix nr 1

Ca' Sant'Orsola

1. Case background

Reason of the renovation

Mainly, the crooked walls and the moisture affected wooden elements determined the ruined state of conservation of the building.

More information

Specific goals of renovation project were:

- to achieve the A class energy classification according to Italian regulations;
- to consolidate and to reinforce the building structure;
- to improve the indoor thermal and acoustic quality;
- to transform it in a prestigious residence with all comforts.

The building refurbishment was developed with a particular regards on thermal insulation of the building envelope and special attention has been paid to the mechanical ventilation and the renewable energy utilization (both solar thermal and photovoltaic system).

(Source: http://www.iea-annex56.org/Groups/GroupItemID6/08.IT.pdf/)

Country and it's climate

The building is situated in the historic center of Treviso, in Northeast Italy. The city experiences a high moisture level during the beginning of the year. The maximum average rainfall amount noticed during 2016 was 201.26 mm (February). Actually, it rained 22 days and there was noticed an average humidity over 75% during January, February and November.

However, sun hours, maximum, minimum and average temperature in Italy exceed Nordic countries. The coldest temperature in Treviso varies 10ºC from Southern Finland. Treviso is almost 0ºC while Helsinki is -10°C during January

Despite the fact that temperature is not similar in both countries, Treviso has to face a high humidity level during the beginning of the year. Moreover, the goal of the performing is the achievement of a nearly zero-energy building that means the insulation is applied in order to require nearly zero-energy to supply the building.

(Source: https://www.worldweatheronline.com/)

Building type

Ca' Sant'Orsola is a historic building converted into residential building. It is listed by Historical and Architectural Heritage Superintendence of Veneto Region. After being a convent for 40 years, it was inhabited by the Polish Institute until 2007. Then, it was bought to be totally refurbished after obtaining a bureaucratic permission.

(Source: http://www.iea-annex56.org/Groups/GroupItemID6/08.IT.pdf/)

2. Main picture of the building

3. Methods & materials used

Walls

The walls were insulated internally and externally: firstly, expanded polystyrene (EPS) foam was placed in the inner part of the façade; in other words, directly on the masonry. Secondly, rigid mineral wool covered by plasterboard was applied to the internal wall.

More information

The polystyrene used for CWI is in the form of virgin pre-formed bead which is usually combined with a binding agent or adhesive at the time of injection. Polystyrene beads are produced to a specified size and density which remains unaltered during the installation process. Once installed, the bead filling in the cavity will remain an effective insulant for the life of the building and will require no further maintenance.

Properties:

Thermal Conductivity: The k value of white expanded polystyrene bead should be taken as 0.038 W/m°C - 0.040 W/m°C.

The k value of Carbon (Grey) expanded polystyrene bead should be taken as 0.032 W/m°C - 0.034 W/m°C

Density: A typical installed density is 12 kg/m^3 ± 2kg/m^3

Fire: The use of polystyrene bead for cavity wall insulation does not prejudice the fire resistance properties of the wall.

Water: The material is resistant to water penetration and will not transmit water across the cavity by capillary action or from below DPC level. Any rainwater penetrating the outer leaf will drain harmlessly to the footings. Is not designed to be a water vapour barrier.

The EPS is breathable. It is able to avoid the absorption of the moisture. If the moisture tries to be absorbed, the polystyrene is able to let it escape.

The moisture content in the insulation is 4.8 % after the 15 year time period. EPS is a non-nutritive source.

The mineral wool used for cavity wall insulation consists of mechanically granulated spun glass or rock wool, treated with a binder or water repellent during manufacture. Equipment for blown mineral wool is also required to conform to, and the installation must be carried out. Once installed, mineral wool is sufficiently stable to remain an effective insulant for the life of the building.

Properties:

Thermal Conductivity: For the purpose of U Value calculations to determine if the requirements of the building (or other statutory) regulations are met, the thermal conductivity (K-value) of the insulation may be taken as 0.040 W/M^{o}C.

Density: Typical installed densities range from 18kg/m3 for glass wools to 40 kg/m^{3} for rock wools.

Fire: Blown Mineral Wools are non–combustible.

Water: Mineral Wool is resistant to water penetration and will not transmit water across the cavity or from below DPC level by capillary action. It does not however act as a water vapour barrier.

Mineral wool insulation is hydrophobic: it will not absorb water and moisture.

Plastic foams are not particularly liable to absorb moisture and neither are such materials as rock wool or glass fibre.

The insulation is permanent, will not rot, does not burn or melt, does not absorb moisture, and will not support mold or mildew.

Windows

Ca' Sant'Orsola's windows are made of 5 glass sheets (inner safety glass, gas chamber, 4mm central glass, gas chamber, outer safety glass).

More information

These coatings do not let the heat escape the building. Their function is to reflect the heat back to the room in winter and maintain the heat back outside in summer. The low emissive glass avoids the heat escape from one pane of glass to other, maintaining the thermal activity.

As its name says, the low emissive glass is able to limit the emissivity through minimizing the ultraviolet and infrared rays. This limitation allows only the transmission of the visible light.

The U-value is further lower when they are combined with gas. The main disadvantage is the significant rise of the whole window's price. Low emissive glass can intercept the mobile phone signals, and probably form slight hazes in the window.

(Source: http://www.iea-annex56.org/Groups/GroupItemID6/08.IT.pdf

https://www.mouldedfoams.com/eps-frequently-asked-questions.htm

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R.M.E. Diamant, Insulation of Buildings – Thermal and Acoustic, (The Chapel River Press, Ltd. 1965), p.106/)

4. Costs

Costs	EUR	EUR m^{-2}
Craftsmen	2.94 millions	1463.41
Consultants	130.000,00	64.71
Electrical and Plumbing	700.000,00	348.43
Total construction	3.77 million	1876.56
Thermal solar and PV system	32.000,00	15.92
NPV	13 years	

From economic point of view, renovation of listed buildings is too much expensive than standard, because it need specialized operations and the preliminary count evaluation is upset during the construction phase. After intervention, however, market value increased for this property and also for the surrounding area: in this case study all apartments have been sold by the end of the construction phase.

(Source: http://www.iea-annex56.org/Groups/GroupItemID6/08.IT.pdf/)

5. U-value & energy savings

Energy need		Before	After	Saving
Heating	kWh m^{-2} a^{-1}	342.7	42.3	88%
DHW	kWh m^{-2} a^{-1}	44.4	33.6	24%
Electricity	kWh m^{-2} a^{-1}	45.0	20.0	56%
Total	kWh m^{-2} a^{-1}	432.1	95.9	92.5%
Energy label		G	A+	
Carbon emissions	Kg CO_{2Eq} m^{-2} a^{-1}	29.8	5.8	81%

Element	Area (m^2)	U-Value before ($W\ m^{-2}K^{-1}$)	U-Value after ($W\ m^{-2}K^{1}$)
Façade	1300	0.90	0.18
Ceiling	508	1.65	0.788
Windows, doors	140	2.70	1.948 - 2.035
Roof	508	1.09	0.158

The U-Value represents the amount of heat through a material by time, area and temperature difference. The units are W/m^2K. The U-Value is a specific characteristic of a constructive element, as a wall or roof, and depends on the thermal conductivity and the geometry of the materials that compose it, as well as thermal radiation and convection on the surfaces of the element. The insulation is better when the U-value is smaller.

(Source: http://www.iea-annex56.org/Groups/GroupItemID6/08.IT.pdf)

6. Pictures before & after

7. Summary of the case

The energy performance involved improving, to achieve the nZEB Italian regulations, the envelope of the façade and the cavity wall (0.18), the ceiling (0.788), the roof (0,158) and the glass of the windows and doors insulation (1.9488-2.035) to obtain the A class energy classification. Moreover, HVAC generation system was installed to improve the water comfort. Finally, thermal solar panels for DHW production and a photovoltaic power plant were installed to produce 3.300 kWh of total annual energy.

Despite the fact that investing in a historic building refurbishment involves much money than a standard building, the carbon emissions were reduced to 81% according to the energy saving calculations. Furthermore, the energy label was improved from G to A+.

(Source: http://www.iea-annex56.org/Groups/GroupItemID6/08.IT.pdf)

8. More information

The whole building is a total area of 4500 m^2 and a gross volume of 6300 m^3.

Renovation measures decreased global energy consumption, reducing up to 90%; solar and photovoltaic system contributed to minimized energy consumption.

Ca' Sant'Orsola is anti-seismic, which is the normal standard for new buildings but a real rarity for the old town center buildings, particularly the listed ones.

Ca' Sant'Orsola is certified to the I level intensity of sound of the relevant European legislation (UNI 1136, 2010).

More information can be found at:

http://www.cazzarocostruzioni.it/eng/proposte-immobiliari/ca-sant-orsola

http://www.iea-annex56.org/Groups/GroupItemID6/08.IT.pdf

Appendix nr 2

Risør Technical College

1. Case background

Reason of the renovation

The main reason for the renovation was due to the energy loss that the building had, caused by the poorly insulated walls and the large windows area. The existing façade were not in good condition and needed lots of reparations, especially the windows. Besides, the wide window area was purposeless, considered to be inappropriate for the activities in the laboratories and classrooms.

More information

Existing structure:

The main building and the wing are constructed of concrete (columns bearing prefabricated floor elements), with the facades made of timber frame with mineral wool insulation fixed to the concrete structure. The outer cladding is made of mineral particle board and the inside boards made from various materials. It was decided to remove the existing walls completely due to the bad condition of them and all the existing materials that were took apart were then recycled.

(Source:
http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf)

Country and it's climate

The building is situated in Risør, a coastal town located on the west shore of the Oslo Fjord. The neighbouring area includes many small lakes and hills, and is also known for its beautiful coastline.

In the city, all the historical buildings of the 18th and 19th centuries are built of wood with an outer cladding of wooden planks. The town authorities claim that Risør will be a modern wooden town, adopting a strategy that forces all new structures to be built with wood.

Norway has an annual average temperature of 4.3 °C. Their coldest month is January, with an average of -3,9 ºC and their warmest month is July, with 13.4 °C as an average. It is the rainiest Nordic Country, with 1121 mm per year.

Kind of the building

Risør Technical College is a historical building which consists of six individual edifices that contain classrooms, laboratories, workrooms and offices for the administration. The renovated building was built in the mid-1960s. It has two main buildings with laboratories and workrooms, and a one wing with classrooms.

(Source:
http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf)

2. Main picture of the building

(Source:
http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf)

3. Methods & materials used

The building was renovated using a TES method. It is based on large scale and timber based elements for the substantial improvement of the energy efficiency of a renovated building. The method consists in pre-fabricate large-sized timber frame elements. To do that, it was necessary a workflow from survey, planning, initial 3D measurement, off-site production and on-site mounting.

First of all, a 3D scanning was used to document the existing structure but, as the current walls were going to be removed, the fabricator manually made a detailed measurement of the existing structure in order to secure the appropriate

documentation for the detailed planning of the new elements. The concrete structure was imprecise with deviations of up to 150 mm.

Then, a draft project - using a scale of 1:200 - was presented by the architect. The client approved the project plan and, based on the draft project, the fabricator developed the technical details.

The new walls are constructed as a timber structure with an outer cladding of 21 mm thick spruce boards (Picea abies) and an inner cladding of 22 mm OSB plates. The outer cladding is treated with a mineral paint, and the total thickness of the wall is 500 mm.

The basic element consists of an inner part with the OSB board fixed to a 96 mm thick timber frame filled with mineral wool insulation. And an outer part with a 198 mm thick timber frame that was filled with wood fiber insulation and then assembled.

More information

The basic elements:

- An inner part with the OSB plate fixed to a 96-mm thick timber frame filled with mineral wool insulation. During assembly, this inner element was first put into place between the concrete floor and ceiling, and fixed with Heco concrete screws.

- The outer element has a 198-mm thick timber frame that was filled with wood fiber insulation. The outer element has a 12-mm OSB plate on the inside, and on the outside, an 18-mm impregnated wood fiber plate, 48 mm vertical slats for ventilation and 48 mm horizontal slats fixed to these which serve as the basis for the external vertical boards. The outer elements rest on steel brackets fixed to the concrete foundations and are connected to the inner elements with screws; between the two elements there is a “tolerance gap” filled with mineral wool insulation.

→ Diagrams are available in section 8

The elements were fabricated in a controlled environment and left the factory complete with windows mounted, external cladding pre-treated with mineral paint, and wrapped in plastic foil. It was transported by truck to the site, where the truck’s crane was used to assemble the elements.

Finally, the existing walls were dismantled room by room and the new elements afterward mounted. The total thickness of the wall is 500 mm.

The insulation in the roof was also improved by blowing mineral wool fiber into the existing timber frame roof structure.

(Source:
http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf)

4. Costs

The renovation of this building was part of a project called RENEW SCHOOL, which goal was the promotion of energy retrofits of schools, principally using timber prefabrication. Besides, the school is a Norwegian pilot project under the international research project TES EnergyFacade, which purpose is to develop a method based on wood-framed prefabricated facade elements for the energetic modernisation of the building envelope.

The pilot project was financed by the Aust-Agder County Council and the nest cost was 14,8 million € - including new facades and additional insulation of the roof. The price of a square meter was 4.993 €.

(Source:
http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf)

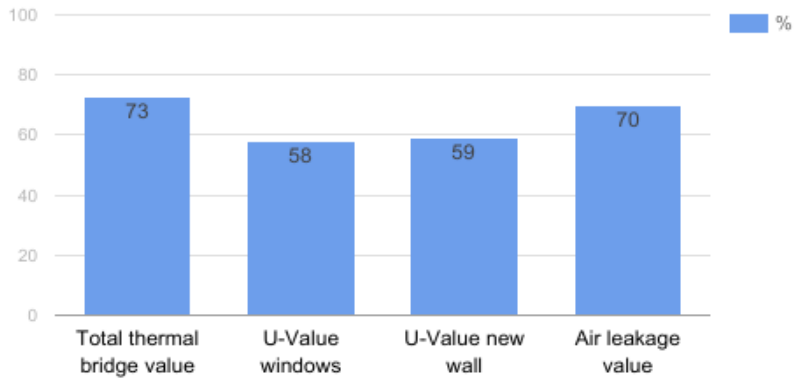
5. U-value & energy savings

The aim of the project was not to achieve a passive house standard; the goal was achieved a high improvement of the energy performance of the school building.

Due to the renovation of the facade and roof, the heating demand for the school building was reduced from 325 kWh/m^{2}a to 49 kWh/m^{2}a - a saving in energy use of 275 kWh/m^{2}a.

The U-Value represents the amount of heat through a material by time, area and temperature difference - the insulation is better when the U-value is smaller. The new U-value is 0.13 W/m^{2}K.

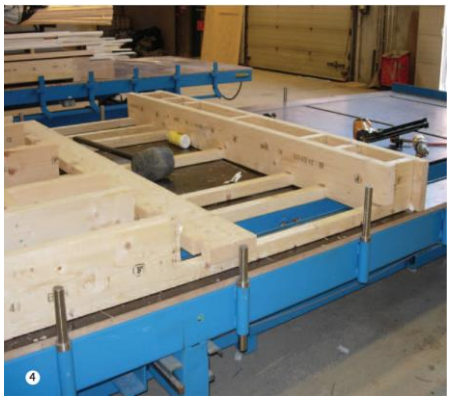
In the chart below is possible to see the improvement in % of the thermal properties of the wall in relation to the situation before the renovation.



(Source:
http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf)

6. Pictures before & after

More pictures:



(Source:
http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf)

7. Summary of the case

Risør Technical College was retrofitted with new facades and improved roof insulation mainly using the TES method, based on wood framed prefabricated facade elements for the considerable improvement of the energy efficiency of a renovated building. The heat energy demand for the school building was reduced from 325 kWh/m2a to 49 kWh/m2a.

Using prefabricated façades the renovation costs are more predictable and the construction work on site is considerably shorter. The building envelope can also easily be improved using different cladding materials and components

(Source:
http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf)

8. More information

The preferred material for the structural parts is timber because it is abundant, lightweight, sustainable and with relatively small heat losses. For that reason are called prefabricated timber facades; often referred to as wooden element facad

The bests advantages of prefabrication are the time savings and quality; The entire process was extremely smooth, leading to only a minor disruption of the school's daily activities - the students had to leave for 24 hours and were back in the classroom the following day. Besides, as the fabrication of the façade was in a indoor facility, the weather could be controlled getting a good quality of the construction

In addition, due to the off-site work, a reduction of the noise and annoyance is obtained. With this system, a wide variety of coating materials are applied, integrating load bearing elements, HVACs and solar-active components.

More information can be found at:

http://www.woodwisdom.net/wp-content/uploads/2014/08/TES_final_report.pdf

http://support.sbcindustry.com/Archive/2010/june/Paper_347.pdf?PHPSESSID=ju29kf

h90oviu5o371pv47cgf3

https://www.renew-school.eu/en/home/

http://www.tesenergyfacade.com

http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf

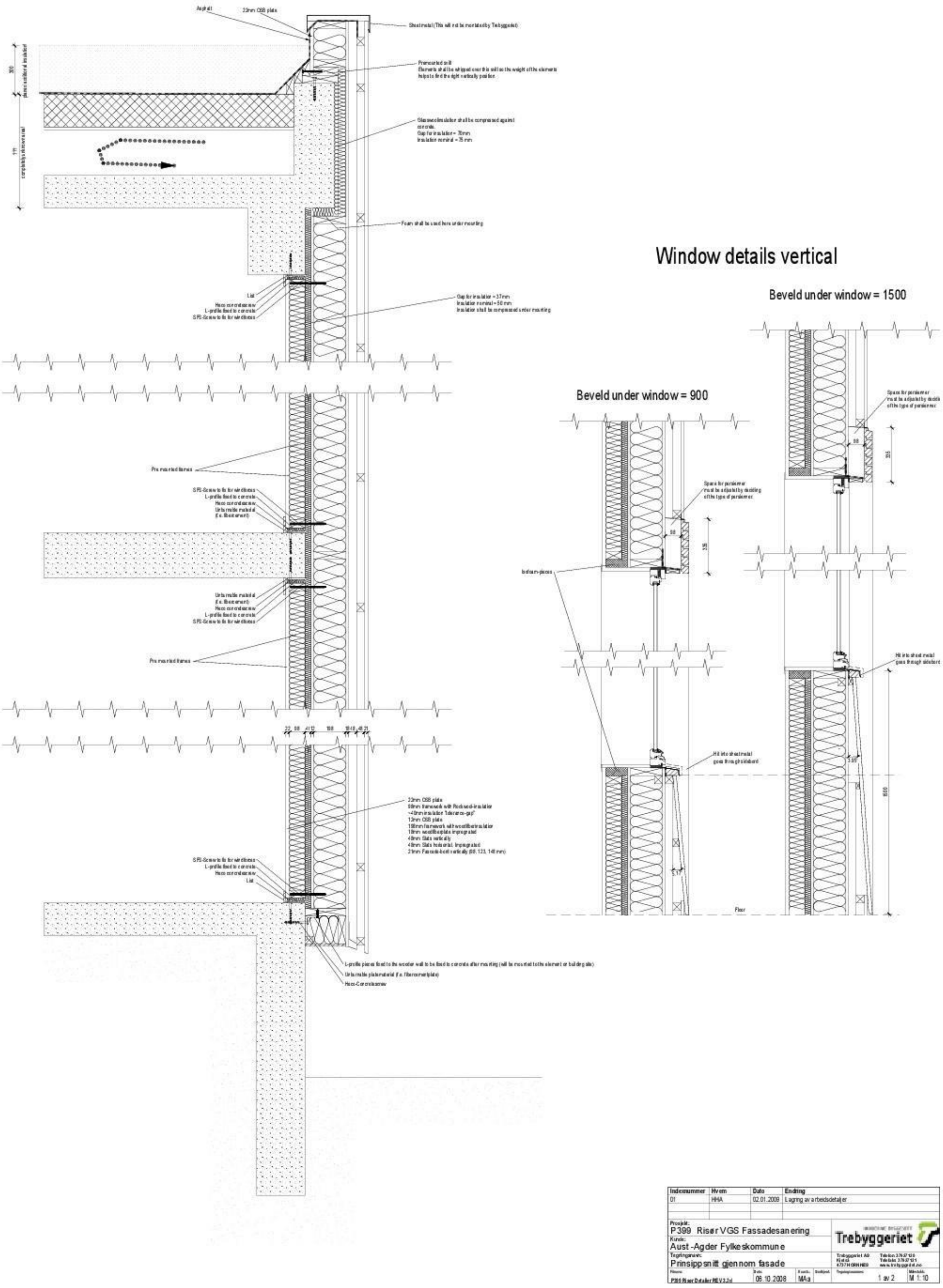
http://www.renew-school.eu/wp-content/uploads/2016/07/RENEW-SCHOOL-

D4.1_Schools_technical_Signpost.pdf

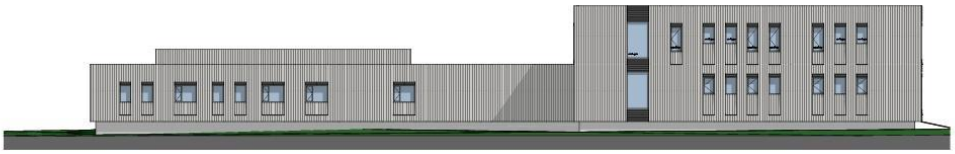
http://www.renew-school.eu/wp-content/uploads/2016/08/RENEW-

SCHOOL_D2.3_Lessons_learned_from_rontrunner_buildings.pdf

X-section Vertical



elevation north



elevation south

elevation west, workshop

elevation west

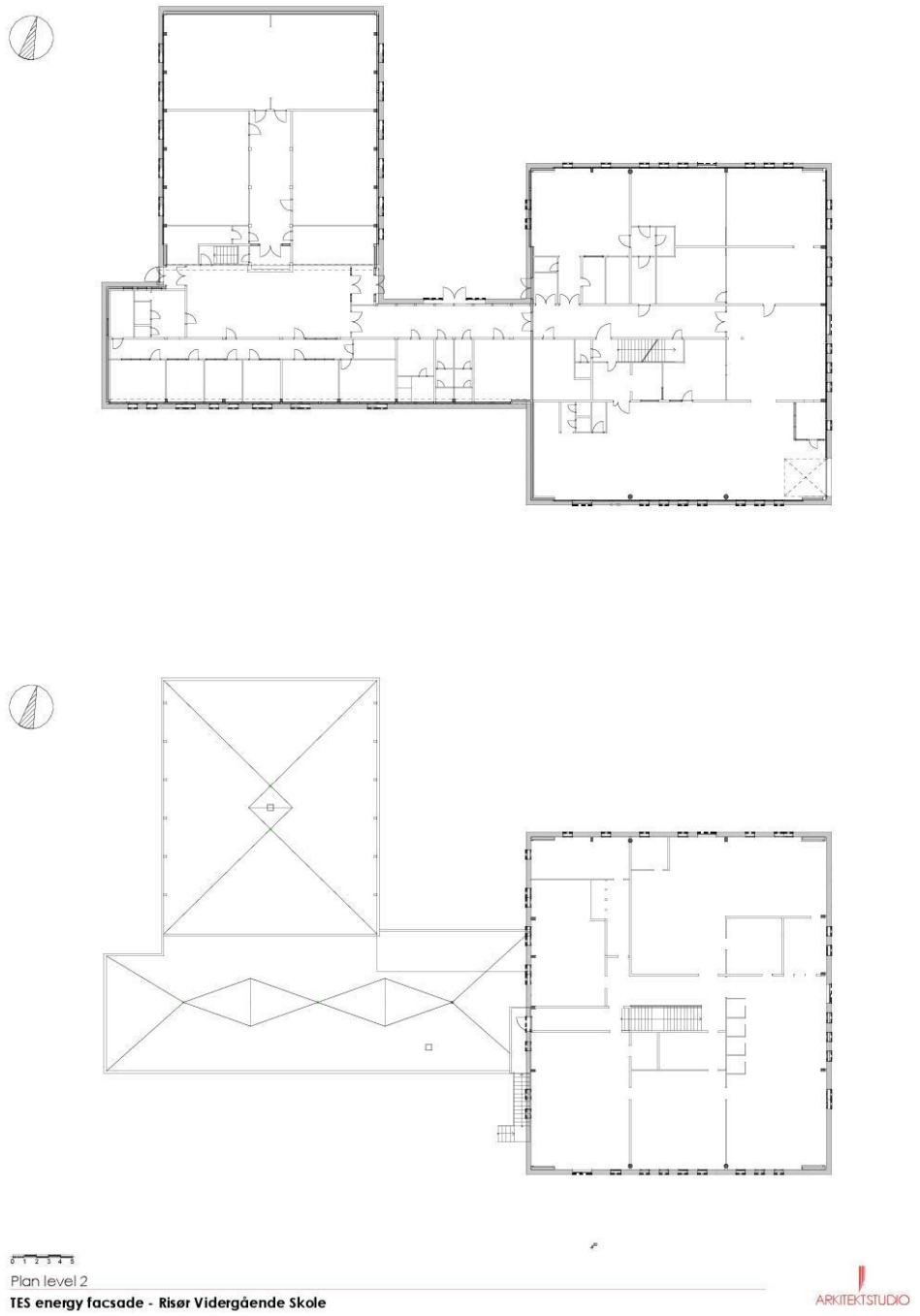
elevation east

elevation east, classroom

Elevation

TES energy facade - Risør Videregående Skole

ARKITEKTSTUDIO



(Source: http://www.tesenergyfacade.com/downloads/pilotproject_risor_small_290509.pdf)

Appendix nr 3

Powerhouse Kjørbo

1. Case background

Reason of the renovation

The renovation included two office buildings out of a total of nine of the entire site from 1980s. Both were to be refurbished to a plus energy standard using high insulation standard, Pv and ground coupled heat pump. The building was supposed to become a powerhouse. There were no past energy renovations. Skanska was the main consultant of the renovation. The whole process started in 2013 and ended in 2014.

More information

Powerhouse is a type of a building that during its lifecycle, produces more renewable energy than it consumes for construction and maintenance. The building was supposed to be renovated within commercial marketable conditions. The energy production must have been based on energy sources on site or nearby with access from the site.

What is more, the energy use for electrical appliances should have not be included in the energy balance account. The target BREEAM classification score was supposed to be "Outstanding". Beside, one of the green aspect goal was to reduce the electricity costs by 100% in comparison to the conventional Norwegian office building. Another objective was to achieve Healthy indoor environments by saving 10% of water use environmentally friendly materials.

The building was renovated by Skanska, which is a part of Powerhouse Alliance. This association is constructing multiple energy-positive buildings in Norway. Powerhouse Kjørbo was the first project of the Alliance. The idea of the renovation was born in 2011. The contract with the main contractor was signed at 18.03.2013 so the work had started. The renovation was completed in 2014.

(Source:
http://www.sapagroupmedia.com/share/download.php?docid=doc6icp7szwq681yhc07uo&type=original)

Country and it's climate

The building is situated in Sandvika, 15 km from Oslo (Norway) from the northeast to the southeast side, with a highway with heavy traffic on the northwest. Southern

Norway features a temperate humid continental climate with fairly warm summers and mild winters (for such climate zone)

More information

Precipitation in Norway varies between 500 and 3000 mmm per year. Southern part of a country never has continuous daylight, though it averages 19 hours of daylight a day in midsummer. Those parts, have a Cfb Climate* according to the Köppen classification** , a warm temperate humid climate with the warmest month lower than 22°C over average and four or more months above 10°C over average.

**Cfb - Marine west coast climate,* *major climate type of the Köppen classification characterized by equable climates with few extremes of temperature and ample precipitation in all months. It is located poleward of the Mediterranean climate region on the western sides of the continents, between 35° and 60° N and S latitude. Precipitation totals vary somewhat throughout the year in response to the changing location and intensity of these storm systems, but annual accumulations generally range from 50 to 250 cm (20 to 98 inches), with local totals exceeding 500 cm (197 inches) where onshore winds encounter mountain ranges. Not only is precipitation plentiful but it is also reliable and frequent. Many areas have rainfall more than 150 days per year, although the precipitation is often of low intensity. Fog is common in autumn and winter, but thunderstorms are infrequent. Strong gales with high winds may be encountered in winter.*

(Source: https://www.britannica.com/science/marine-west-coast-climate)

****Köppen climate classification -** widely used, vegetation-based empirical climate classification system*

(Source: https://www.britannica.com/science/Koppen-climate-classification)

Building type

Powerhouse Kjørbo is a typical office building with about 240 occupants and 12 hours per day of the utilization.

(Source: http://task47.iea-shc.org/data/sites/1/publications/SHC_Task47_STC_report_11SEP2015.pdf)

2. Main picture of the building

(Source: http://www.skanska-sustainability-case-studies.com/index.php/latest-case-studies/item/209-powerhouse-kj%C3%B8rbo-norway)

3. Methods & materials used

The main strategy of the building's design was based on:

- Providing optimal technical system
- Optimizing the envelope of the building
- Renewable energy usage

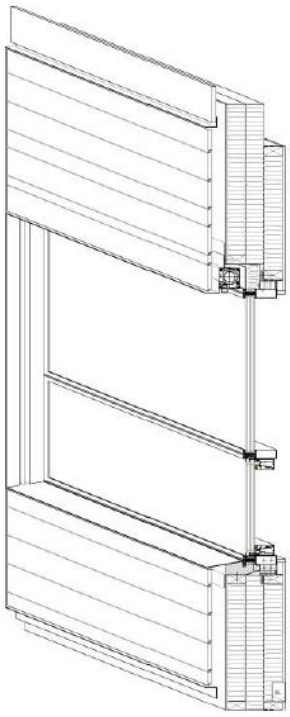
The black glass façade* of the building was replaced with a new one made of charred wood panels** and also window frames made of aluminium. The constructors were reusing and incorporating existing structures and building elements.

What is more, the Powerhouse consortium equipped the buildings with new energy, ventilation, heating and lighting systems.

More information

The main idea for the renovation was to use environmentally responsible (eco-friendly) materials from a lifecycle perspective. One of the elements, the charred wooden façade is a natural material that is designed to have a long and relatively maintenance-free lifespan. Materials were retained and reused in the building where possible, such as the structural elements. Many new elements added to the buildings were intended to be easily reusable after usage: e.g. aluminium window profiles. The

new windows were designed to allow a high level of daylight transmission and distribution in the rooms to reduce the need for artificial light.



The whole renovation focused mainly on reducing thermal bridges***.

The renovation according to the thermal bridges:

- Mounting of new windows
- Insulation thickness where concrete slabs meets the façade
- Wood facade construction with few thermal bridges, and 200 mm insulation in front of slabs

Overall demand to thermal bridges are: < 0,03 W/m2 k

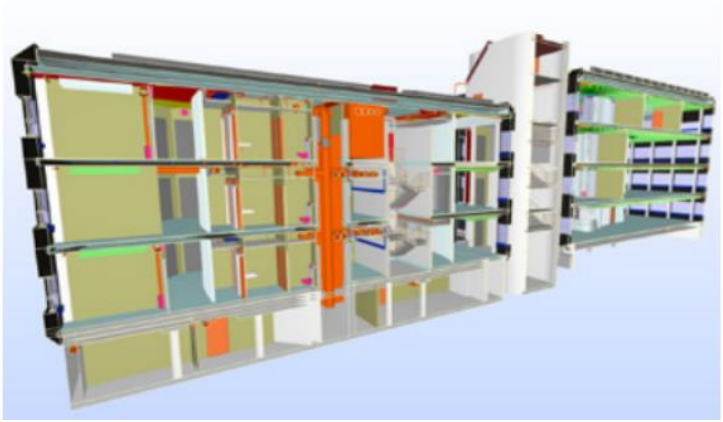
Ecological materials:

- Building materials with lowest possible embodied energy****
- Charred wood for façade cladding
- Labelling materials or materials with low polluting according to EN 15251*****

The consortium was the first who used the BIM - Building Information Modelling. Such modelling is was based laser scanning on the Kjørbo project. It was supposed to map and model the exterior and interior parts of the building. The building's exterior façade and the surrounding trees were accurately modeled using laser scanning to

enable detailed BIM solar studies to calculate the extent of shading from trees and to optimize the placement of roof-mounted solar panels. Laser scanning was also used to create an accurate as-built BIM model of the building's load bearing structure, which was retained and incorporated into the refurbishment.

BIM-based laser scanning was pioneered on the Kjørbo project to map and model the exterior and interior of the building.



(Sources: http://task47.iea-shc.org/data/sites/1/publications/Task47-Power-House-Kj%C3%B8rbo-Norway.pdf

http://www.sapagroupmedia.com/share/download.php?docid=doc6icp7szwq681yhc07uo&type=original)

**Façade* *is generally one exterior side of a building, usually, but not always, the front. From the engineering perspective of a building, the façade is of great importance due to its impact on energy efficiency*

(Source: https://en.wikipedia.org/wiki/Facade)

***** Charred wood -*** *The wooden material created from the burnt planks on both sides to the desired amount of char. The carbon exterior releases the moisture inside the board as gas and steam. Then he boards are being cooled, brushed and washed to aesthetic liking of the user. The amount of char cleaned off changes the look of the wood. Finally, the board is sealed with a natural oil or left it unvarnished.*

This method of burning the surface of wood building materials began in Japan 300 years ago. Since Japanese builders traditionally used cedar, as well as cypress, the process is called shou sugi ban, or "burnt cedar". Using charred wood for construction is a viable eco-friendly option, particularly since this completely natural manufacturing process requires only fire and wood; the harsh chemicals used in pressure-treated lumber are eliminated. Shou sugi ban also yields an extremely durable building material. Wood treated with fire is paradoxically fire resistant, as well as resistant to insects. The material is also durable due to its low reactivity and is rated to last 80 years.

(Source: https://architizer.com/blog/burnt-is-the-new-black/)

****Thermal bridge is a localised area of the building envelope where the heat flow is different (usually increased) in comparison with adjacent areas (if there is a difference in temperature between the inside and the outside).*

The effects of thermal bridges are:

- *Altered, usually decreased, interior surface temperatures; in the worst case this can lead to moisture penetration in building components and mould growth.*
- *Altered, usually increased, heat losses.*

(Source: https://passipedia.org/basics/building_physics-basics/thermal_bridges/thermal_bridge_definition)

***** Embodied Energy is the energy requirement to construct and maintain the premises, for example, with a brick wall, the energy required to make the bricks, transport them to site, lay them, plaster them and (if necessary) paint and replaste over the life of the wall.*

(Source: http://www.yourhome.gov.au/materials/embodied-energy)

****** EN15251 specifies indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*

(Source: http://www.rehva.eu/publications-and-resources/rehva-journal/2012/042012/revision-of-en-15251-indoor-environmental-criteria.html)

4. Costs

The cost for refurbishment: 2 654 €/m^2.

The Powerhouse Kjørbo was to be built within commercial marketable conditions. The enterprise Enova supported the project with US$ 2.7 million through the program New Technology in Buildings of the Future, and the Passive House program. The rent was higher than for a similar office building with an average energy standard. However, when the reduced energy costs are included, the total cost for the tenant was at about the same level as for a standard office building.

(Sources: http://task47.iea-shc.org/data/sites/1/publications/Subt.A%20Summary%20report.pdf

http://www.sapagroupmedia.com/share/download.php?docid=doc6icp7szwq681yhc07uo&type=original)

5. U-value & energy savings

The buildings were redeveloped to ensure very low energy consumption through a well-insulated and airtight building envelope that meets Norwegian passive house standards for commercial buildings (NS 3701).

U-value (thermal transmittance) is the rate of transfer of heat through a structure divided by the difference in temperature across that structure. The units of measurement are W/m²K. The better-insulated a structure is, the lower the U-value will be.

	Walls	Roof	Windows	Ceilings	Floor
Before	~0.3	~0.2	~1.8	~0.3	-
After	0.15	0.08	0.8	‘’0.3	0.12-0.16

Therefore, because the U-Values have decreased, one can conclude that the energy consumption decreased.

Energy savings:

Annual delivered before: 240 kWh/m^2 (including data facilities.)

Annual delivered after: 20,4 kWh/m^2 (without data and technical equipment); 50 kWh/m2 year (including data facilities)

(Source: http://task47.iea-shc.org/data/sites/1/publications/Task47-Power-House-Kj%C3%B8rbo-Norway.pdf)

6. Pictures before & after

Facade before refurbishment

Facade after refurbishment

(Sources:

http://task47.iea-shc.org/data/sites/1/publications/Task47-Power-House-Kj%C3%B8rbo-Norway.pdf

http://www.sapagroupmedia.com/share/download.php?docid=doc6icp7szwq681yhc07uo&type=original

http://www.powerhouse.no/en/prosjekter/kjorbo/)

7. Summary of a case

Renovation of the building - Powerhouse Kjørbo demonstrated that it is possible to renovate existing properties into energy-plus buildings even in Norwegian, cold climate., Such renovations make commercial and environmental sense to all parties involved. A holistic approach to the project that simultaneously considered materials and embodied energy, technical systems, architecture, and energy efficiency and generation over the lifespan of the buildings was crucial to achieving the project's ambitious objectives.

Powerhouse Kjørbo is going to be an important demonstration project for plus-energy buildings, both in Norway and abroad, which will influence green refurbishment projects in the future.

The Kjørbo buildings were certified to BREEAM- NOR "Outstanding" classification for the design stage. BREEAM is the world's leading design and assessment method for green buildings and BREEAM-NOR is specifically adapted to Norwegian standards and criteria. There are five assessment levels in BREEAM-NOR, and "Outstanding" is the highest possible level. In addition, the buildings fulfill all the requirements of the Norwegian Passive House standard for commercial buildings. Powerhouse Kjørbo is also a Norwegian Zero Emission Buildings (ZEB) pilot, as part of a project run by the Research Centre on Zero Emission Buildings that aims to promote very low carbon emissions during the lifetime of buildings. Powerhouse Kjørbo was nominated for the 2014 Norwegian Technology Award for its outstanding energy performance.

(Source:
http://www.sapagroupmedia.com/share/download.php?docid=doc6icp7szwq681yhc07uo&type=original)

8. More information

Under links below, one can see the informative and advertising videos of Powerhouse Kjørbo:

https://www.youtube.com/watch?v=M1VHb6-ROrs

https://www.youtube.com/watch?v=ZcqqSZL70rE

More information can be found at:

http://task47.iea-shc.org/data/sites/1/publications/Task47-Power-House-Kj%C3%B8rbo-Norway.pdf

http://task47.iea-shc.org/data/sites/1/publications/Subt.A%20Summary%20report.pdf

http://task47.iea-shc.org/data/sites/1/publications/SHC_Task47_STC_report_11SEP2015.pdf

http://www.sapagroupmedia.com/share/download.php?docid=doc6icp7szwq681yhc07uo&type=original

http://www.powerhouse.no/en/prosjekter/kjorbo/

Appendix nr 4

City-owned social housing block in Riihimäki, Finland

1. Case background

Reasons of the renovation

General information

It is the city-owned social housing block located in the Peltosaari suburb of Riihimäki in Southern Finland. The building had been decaying for the last years, which decreased its market value and also created social problems; it needed urgent renovation.

More information

In order to allocate the mass of people moving to the cities from the Finnish countryside in the 60's and 70's, large residential areas were built using pre-fabricated concrete elements. This technology, that is, the use of industrially made concrete sandwich elements, made it possible to build in short period of time housing for hundreds of thousands families. Building has flat roofs, concrete bearing wall structure, and its facade is made of prefabricated sandwich elements with a washed concrete finish. The facade elements had serious problems, common to this type of structure: insufficient insulation of both walls and windows, decay of the element joints and deterioration of the outer surface of the sandwich elements due to aggressive weather conditions.

In order to make the process fast and economically feasible, standardized solutions (layout, floor plans) were implemented in all the new housing areas. Due to this fact, the problems which appeared in those buildings after 30–40 years of service are very similar. During the past few years, the number of housing estates in need of integral renovation has increased all over Finland.

The most common features of such buildings were:

- linear multi-family blocks with staircases serving 3-4 apartments
- 3-storey buildings with no elevator or 5-8 storey buildings with elevator
- common spaces and services in the ground floor and/or basement
- facades composed of modular elements (usually repetitive)
- double windows with 3 glass panes (2 + 1)
- modular balconies for all apartments of more than one room (earlier versions of this type of buildings did not include balconies at all)

- flat roof (non-accessible)
- common laundry and drying room/s
- common sauna (electrically heated) with showers and dressing room
- shower rooms with no shower plate (the floor has a slope towards the drain)
- bathrooms with bathtub were built applying the same principles as in case of the shower rooms
- floor drains in every bathroom

The new energy efficiency requirements are putting pressure on the building owners to improve the energy performance of the buildings. This is planned to do in connection with the other refurbishment measures required. The building elements in greatest need of upgrading are the piping (cold and hot water, drainage), the heating system including thermostatic regulation, the windows and balcony doors, and the ventilation system. An integral renovation intervention can introduce energy efficiency measures to comply with present regulations.

(Source: http://www.rea.riga.lv/files/Handbook_on_Buildings_Renovation_in_Central_Baltic_Region.pdf)

Country and it's climate

General information

The residential area is located in the Helsinki region (Finland) - a residential suburb in the city of Riihimäki. It is a representative of the building stock of the period previously described, and therefore the solutions implemented can be easily replicated in other parts of the country, where there are plenty of similar buildings. Finland is one of the Nordic Countries so there is no problem with satisfying the Nordic Countries weather requirements of renovation process.

More information

Due to the outdoor air temperature, the number of degree-days in Finland varies between 4250 in Helsinki and 6240 in Sodankylä, 17.5°C is used as the basis. High level and large geographical variation sets high requirements on the heating systems reliability and costing. In Helsinki, the heating systems are designed according to -25°C and in Lapland to -35°C outdoor temperature.

The coastal areas of Finland are rather windy, which increases the sensation of cold in winter. In addition, rainfall in the windy areas causes additional problems to the facades of buildings (so-called horizontal rain). Though a large portion of central and eastern Finland is covered with lakes, the climate in those regions is mainly continental. There are four weather zones in Finland (Fig. 1). The climate description is presented in Table 1 and Table 2.

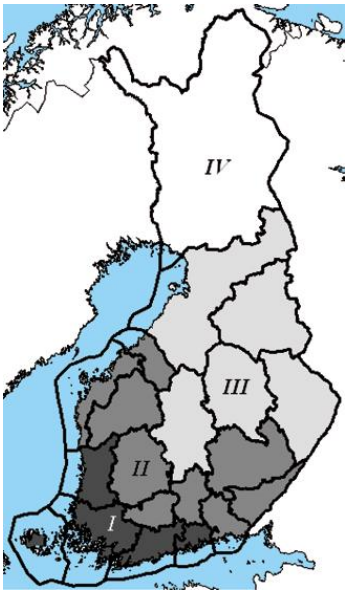


Fig. 1 Weather zones in Finland

Weather zone	Default outdoor temperature, °C	Yearly average outdoor temperature, °C	Heating season average outdoor temperature, °C
I	-26	+5	+1
II	-29	+4	0
III	-32	+2	-1
IV	-38	0	-5

Table 1 Calculation of default and average temperatures

for the different weather ones

Month	Average outdoor temperature, T_u °C	Total solar radiation on horizontal, $G_{sr,horizontal}$, kWh/m²	Degree-day values for normalized calculations, S17, Kd
January	-8.53	7.1	791
February	-9.75	27.9	749
March	-1.68	55.2	579
April	+1.80	103.7	456
May	+10.8	167.8	160
June	+16.0	195.2	0
July	+14.7	131.7	0
August	+16.0	130.6	0
September	+9.69	72.1	193
October	+3.95	33.2	405
November	+1.42	6.9	468
December	-3.85	4.7	646
Yearly total	4.29	936	4447

Table 2 Monthly weather data in Weather Zone I, Helsinki-Vantaa

(Source: http://www.rea.riga.lv/files/Handbook_on_Buildings_Renovation_in_Central_Baltic_Region.pdf)

Building type

The case is about a city-owned social housing block located in Southern Finland.

2. Main picture of the building

Fig. 2 Social housing building block in a suburb of Riihimäki

(Source: http://www.rea.riga.lv/files/Handbook_on_Buildings_Renovation_in_Central_Baltic_Region.pdf)

3. Methods & materials used

General information

The facade of this building was made of concrete sandwich elements. In this case, the poor condition of the insulation and the outer pane of the sandwich elements called for their demolition and substitution. A more radical intervention was proposed, by introducing a timber-framed TES-facade (Fig. 3), which incorporates not only insulation and windows, but also ventilation ducts and the first layer of facade rendering.

Fig. 3 Timber-framed TES-facade

More information

The solution to be implemented was the winner in a competition (Innova refurbishment), and it stressed the importance of a fully industrialized prefabricated new facade, achievable at a reasonable cost (feasible). The project was funded by Sitra, the Finnish Development Fund, and monitored by VTT, the Finnish Technology Institute.

The renovation included new doors and windows, balconies, additional thermal insulation, and new mechanical ventilation with efficient heat recovery (rotating heat exchanger). The building envelope was scanned with a thermal camera to detect heat losses (Fig. 4). It was also measured by laser scanning and modeled for dimensioning the new facade elements that were going to be manufactured at a factory. The finished elements were going to be transported to the building site and lifted vertically, as each element had a height of four full floors (12 m). This method was going to reduce the construction time down to 5 months, which is half the time it took to complete the renovation of similar buildings in the suburb of Peltosaari.

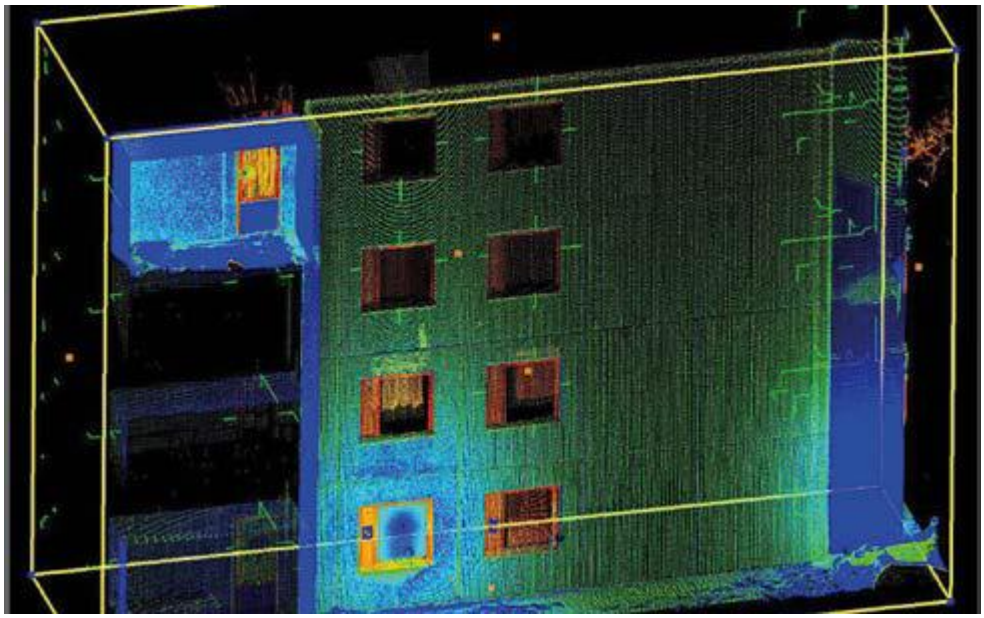


Fig. 4 Results of a thermographic analysis

General information

The windows were replaced with two double glazing panes, argon fill and selective film. The balcony doors have triple glazing, argon filling and selective film. The old reinforced concrete balconies were demolished and replaced by steel-framed balconies. In Fig. 5 and Fig. 6 demolition of old insulation is shown.

Fig. 5 Demolition of old insulation and outer pane of facade

Fig. 6 Demolition of old insulation and outer pane of facade

More information

What Are Argon Gas-Filled Windows?

Argon gas windows feature a sealed unit, filled with gas between panes of glass to increase energy efficiency. Argon is an inexpensive, non-toxic, odorless gas that is used on residential windows to prevent frost from occurring at the bottom of the window and at the same time will increase sound proofing characteristics of the window.

Argon gas windows, energy star rated too, offer better insulation than natural windows because the gas is heavier than air. There are also three paneled argon-filled windows that provide two layers of insulation.

Argon gas window can offer the following benefits:

- Offer increased R-values
- Increases the soundproofing characteristics
- Minimizes heat exchange through the window
- Triple pane windows offer superior benefits than even double pane argon gas windows
- Reduces the possibility of condensation and frost
- Can be used in all climates as the windows are sealed with the gas and it will not leak out.
- This type of windows can even block ultraviolet rays
- The additional cost of having argon gas windows will be recouped on a really short time

- Available in different commercial sizes depending on how they are going to be used
- Argon will not corrode the window material as Oxygen will do.
- Your heating and cooling systems will work more efficiently when you install argon gas windows
- Can be installed from floor to floor ceiling, shorter windows or open/close design
- The gas is non-toxic and will not contaminate the environment.
- The ideal spacing between glass panes for argon is ½”
- Argon gas filled windows will only add $30 USD to $40 USD per window

Argon gas windows although really beneficial for homeowners, also have some drawbacks, for example:

- Argon gas windows will not expand or contract, however, the glass does and you would like to make sure it has been sealed properly, especially in high altitude area. Pay special attention if these types of windows are being installed at altitudes of 5,000 feet or more, you might have to look other alternatives.
- It will eventually dissipate from the window; however, there is no actual information on the rate that this will happen.
- If the window seal has even a small gap in it, you will lose your argon but worst of all you will not notice it.
- If the argon has been pumped using two holes, the window is more likely to fail than one hole window.
- Metal spacers are not good because they will allow gas to leak out over time as well as conduct heat and sound. Considered should be non-metallic spacer to reduce the failure probabilities

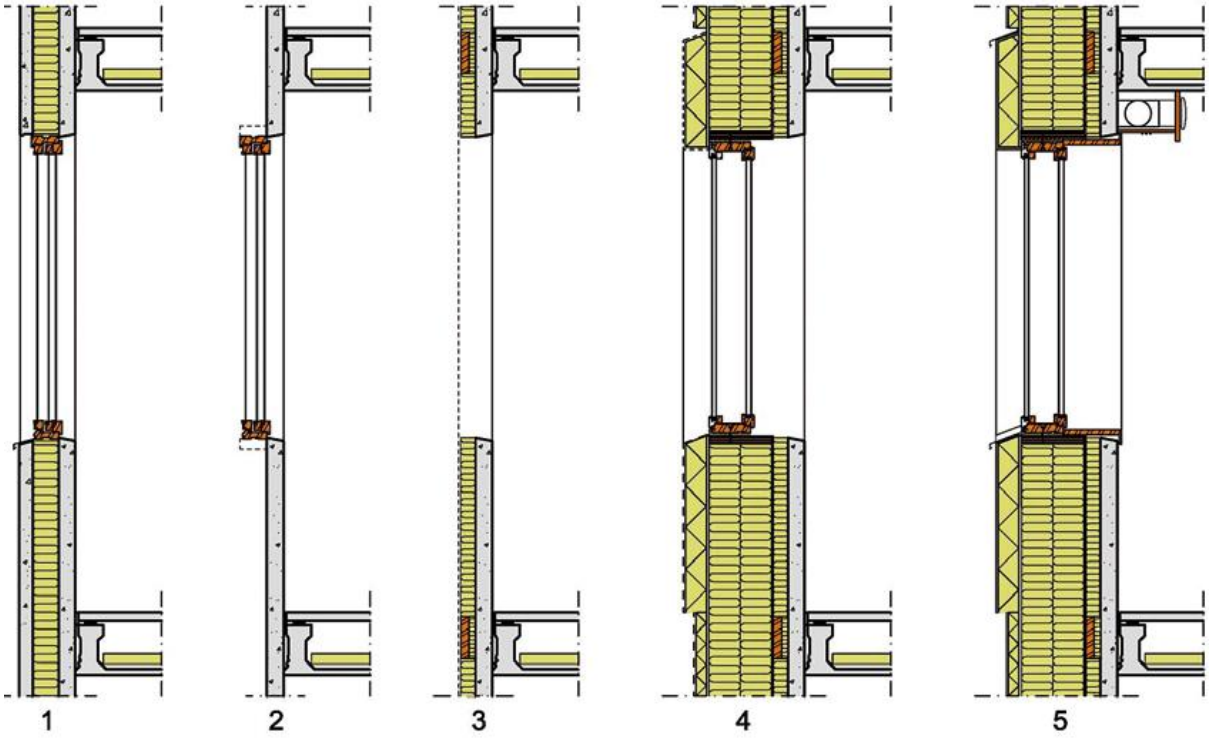


Fig. 7 Phases of full renovation with TES facade elements (source: arch. Kimmo Lylykangas)

Fig. 8 Building after full renovation with TES facade, new balconies and new tilted roof (source: arch. Kimmo Lylykangas)

(Sources:
http://www.rea.riga.lv/files/Handbook_on_Buildings_Renovation_in_Central_Baltic_Region.pdf

https://www.thebalance.com/cost-benefits-and-drawbacks-of-argon-gas-windows-84455)

]

4. Costs

There are no available information about the costs of the renovation.

5. U-value & energy savings

Thermal transmittance, also known as U-value, is the rate of transfer of heat through a structure (which can be a single material or a composite), divided by the difference in temperature across that structure. The units of measurement are W/m²K. The better-insulated a structure is, the lower the U-value will be.

The new windows, with two double glazing panes, argon fill and selective film, have a U-value of 0.66 W/m^2a.

The improved insulation of the exterior walls resulted in U-value change from 0.40 to 0.10 W/m^2a.

The building's energy demand is reduced by 75%.

(Source:
http://www.rea.riga.lv/files/Handbook_on_Buildings_Renovation_in_Central_Baltic_Region.pdf)

6. Pictures before & after

Fig. 9

a. Social housing building block in a suburb of Riihimäki before renovation

b. Building after full renovation with TES facade, new balconies and new tilted roof (source: arch. Kimmo Lylykangas)

(Source: http://www.rea.riga.lv/files/Handbook_on_Buildings_Renovation_in_Central_Baltic_Region.pdf)

7. Summary of a case

A better energy performance of the whole building, targeted to meet the Passive House standards, is achieved by the improved insulation levels of the envelope (exterior walls = 0.1, roof = 0.08) and a highly efficient heat recovery in ventilation (75%). The use of very efficient windows (U = 0.66) contributes to improve the energy performance of the envelope.

Energy simulation of the building was carried out by VTT using IDA-ICE software. According to the simulation, the building's energy demand is reduced by 75%. Also the performance of the new wall structure is being monitored by VTT after the completion of the building's renovation. The target level for air-tightness is 0.6 l/h or less.

The high degree of manufacturing in all new structural elements contributes to radically shorten the construction time, which can thus be reduced to 50% of the standard in Finland for similar renovation projects. Industrialized construction also guarantees a better quality control, less waste, a reduction of faulty assemblies, and prevention of moisture damage during installation.

(Source: http://www.rea.riga.lv/files/Handbook_on_Buildings_Renovation_in_Central_Baltic_Region.pdf)

8. More information

General information

The case was performed thanks to a project named "Central Baltic Cooperation in Energy Efficiency and Feasibility in Urban Planning - ENEF" with Central Baltic INTERREG IV A Programme as a funding programme. It was held from January 1, 2011 till December 31, 2013.

More information

First objective of the project was to develop a practical handbook of best practices in EST, FIN, SWE and LV on how to increase energy efficiency in buildings considering architectural and cultural values. The investigated buildings were both single use public buildings like schools, kindergartens and dwelling buildings built in 1960-1980 as well as building blocks and areas of cities.

Secondly, it was to develop national and joint networks to transfer innovative practices and tools of increasing the energy efficiency of buildings to regional and municipal planners, architects, engineers of construction companies, etc. within and among the participating countries.

Then, to exchange and transfer experiences of the use of different computer programs for calculating energy efficiency or analyzing the impact of different architectural or technical solutions in the planning stage on practical level.

And finally, to organize an International Conference and exhibition in 2013 to discuss and transfer results of the project.

The main result was a development of a handbook containing information about climatic conditions of participating countries, best case examples of building retrofitting as well as giving the overview of commonly used simulation software and calculation programs to determine the energy use of buildings.

General information

According to a case, weather protection during demolition and installation of new structural elements of the building's envelope has been provided and carefully planned. The importance of weather protection during the demolition, storage and assembly process is very high, as any rain or condensation accumulated during the process will lead to moisture damage and subsequent appearance of mold. Therefore, the roof was protected with a temporary tube structure (Fig. 10) covered with a canvas, after which demolition of the existing waterproofing and thermal insulation could be performed.

Fig. 10 Protected roof structure with a temporary tube structure

(Source: http://www.rea.riga.lv/files/Handbook_on_Buildings_Renovation_in_Central_Baltic_Region.pdf)