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Problems concerning the implementation of energy efficient measures in the buildings sector.

A comparative study of Sweden and Hungary

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Author's declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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ABSTRACT OF THESIS submitted by:
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Today the state of our environment is one of the main issues in the world. The problem is very complex and concerns many areas of our economy, society and politics. It is a well-known fact that the needs for energy supply and electricity constantly increases, which puts the environment under a huge pressure.

The aim of this thesis is to highlight the problems concerning the implementation of energy efficient measures in the buildings sector in Sweden and Hungary, where the implementation of innovative technologies could lead to a significant reduction of greenhouse gas emissions. The thesis partly concentrates on the policy side of the implementation problem, but not only. It also aims to show all the implementation levels on which the problems can occur regarding the fulfilment of new requirements set by new policies, and also provides arguments as to what should be taken into consideration when a new construction takes place.

The introduction of low-energy buildings and passive systems are the innovative solutions this thesis explains more in depth, also illustrating the problem with some case studies in Sweden and Hungary. Innovative energy efficient solutions are applied in the case of new buildings, but the challenge of retrofitting the old building stock is a vital issue in both countries. Besides being a comparative study of Sweden and Hungary, the thesis provides a general overview of what could be improved regarding policies, and what the current state of energy-efficient measures is.

Keywords: environment, buildings sector, energy efficiency, policy, passive houses, innovation

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Budapest, July 2010
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1. INTRODUCTION

This thesis is a comparative study comparing measures towards the implementation of energy efficient technologies in Sweden and Hungary. I view the technologies of low-energy buildings and passive systems not only as innovative solutions applied mainly in the case of new buildings, but also, and importantly, as the challenge to the renovation of the old building stock.

The main focus of my thesis is on Sweden, since this country is recognised as one of the leading innovators in the European Union, the major question concerning the Swedish experience and its relevance to the possible developments in the case of Hungary, provided there is indeed enough improvement taking place in Sweden. Thus, I concentrate mainly on the problems concerning implementation, such as policy issues. I also attempt to show all the levels on which problems can occur regarding the fulfilment of new requirements set by new policies, and overview possible measures that should be taken under consideration when a new construction takes place.

The idea of doing a research on the topic of energy efficiency in the buildings sector comes from my personal interest in architecture, ecological housing and low-energy buildings. The argument to do a comparative study between Sweden and Hungary is based on the hypothesis that Sweden has been always acknowledged as one of the leader countries regarding innovation in the European Union and the passive house concept also originates from Lund University in Sweden. Therefore it seems to be a good idea to take Sweden as a good example of a country where energy efficiency is implemented well, and then, on the basis of the findings, analyse what could be done and improved in Hungary regarding policy issues and implementation practices.

Surprisingly during my research it soon turned out, that although till the mid 1990s Sweden in fact was the leader of Europe's ecological innovation industry, since then the country has lost its leadership, and now it is Austria and Germany that would be much more the places to look for role models in this area. In spite of this finding, the idea of looking at the problems that Sweden has to face at the moment and compare them to Hungarian ones seemed like an interesting idea, offering new possibilities of finding out more about the challenges of the implementation process regarding innovative technologies and solutions in the buildings sector.

Although Sweden is not the best example any more, the country still has the history and the experience that justifies it to be taken as an example and look at its improvements that have been done in the country so far. The fact that Sweden has difficulties can be even seen as an additional asset, because despite of the problems many projects are taking place (of which some are very ambitious ones), and energy efficiency is still on the agenda. This only proves that barriers can even inspire further development, and therefore Hungary should be able to profit from the knowledge and experience of Sweden.

More specifically, the major tasks of my thesis are to define why energy efficiency is important, how it is related to the building stock, what energy efficiency measures are currently in force and what are the future plans and perspectives for further improvements in both countries and also in the EU. In addition to that I would like to look into the problems of design and construction phase, the question of qualified architects, contractors, workers, etc.

Since I do not want to concentrate on the technical and construction side of the issue, but focus on the concerns regarding policy background and management of the implementation process as well as on the question of co-operation between the stakeholders participating in the development of energy efficient housing, I believe there is no contradiction in comparing two countries which are not located in the same climate zone and have different geographical locations.

Interestingly, concerning the policy and implementation issues, Sweden is facing similar problems as Hungary, for instance the lack of proper policies, appropriately qualified workers and architects. In both countries there is the heritage of blocks of houses built in the 1950-60-70s, which need deep renovation. Still, it cannot be forgotten that there are also major differences concerning history, population, economic situation and culture, for instance, Hungarian and Swedish dwellers may have a very different approach to energy efficiency issues. This all may have a significant impact on the condition of the existing building stock and on how fast and how easily can any development be achieved.

It is also a question if there is market for such investments, if it is profitable for the real estate market to invest in low energy houses arguing with lower bills and better environment even though the preliminary investments can be costly and the pay back time can be long. Thus, the general question is if there is any real future for such investments, and whether low energy buildings will ever be a widely spread alternative offering better quality and, most importantly, highly energy efficient building stock.

After the introduction my thesis consists of the following chapters:

- Literature review, which focuses on the issues of energy efficiency and explains how the buildings sector is connected, and what passive energy systems and passive houses are. The chapter provides a brief review about the policies and its history mostly focusing on

Sweden, and explains why innovation can be a challenge on the market. In the final part of the chapter there are examples of programmes that are focusing on energy efficiency.

- Research methodology explains the research process, including from data collecting, research problems and limitations and the scope of the research.

- The chapter entitled The study is one of the main parts of the thesis and concerns the case studies I have done during my research trip as well as the library research carried out at the International Institute for Industrial Environmental Economics (IIIEE) at Lund University and at the Central European University, Budapest. Altogether there are six separate case studies presented, three from Sweden, three from Hungary. In the final part I discuss general insights on policies and current problems.

- In the last two chapters, Discussion of findings and Recommendations, there are general conclusions about problems concerning energy efficiency measures in the building stock, as well as my personal reflections and suggestions for further improvements.

2. LITERATURE REVIEW

2.1 Energy efficiency and the building stock

It is a well-known fact that in the future we will have to face the challenges of climate change and global warming, and that many related problems already exist, therefore there is a great need to reduce the emissions of greenhouse gases. In the European Union the building stock is responsible for 77% of all the emissions (www.eurima.org). Therefore there is a significant potential of reducing the GHG emissions by improving construction solutions and renovation technologies in the buildings sector. It takes a very wide plan as well as an overall investment and design to properly implement policies and programmes to achieve success.

If we look only at Sweden, "the sector of residential buildings and service organizations uses 36% of the total energy in Sweden" (Janson 2008). In Hungary the buildings sector is responsible for up to 87% of heating and cooling energy use and corresponding CO_2 emissions could be avoided by a wide-spread deep retrofit programme by saving 75-90% of energy (Diana Ürge-Vorsatz 2010).

The following figure shows the breakdown of CO_2 emissions by final energy users in Hungary, and it shows that households are responsible for 29%. It is the second most significant sector responsible for CO_2 emissions (Novikova 2008).

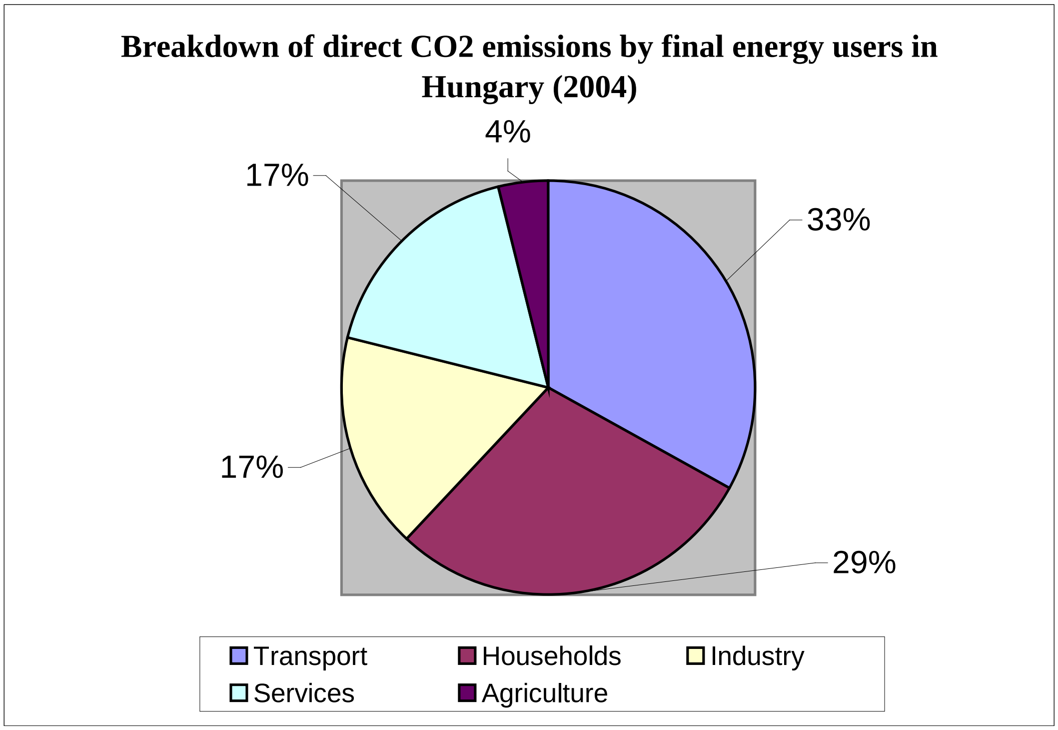

Figure 1

Source: Novikova 2008

The variable to define the energy use in numbers is kWh/m^2. Today the average total energy demand in buildings is 220-250 kWh/m^2 of the existing building stock. In the case of single-family houses the best performance is around 70 kWh/m^2, which according to many sources could be even less, only around 20-50 kWh/m^2. This demonstrates that even though there is great potential in energy-efficiency improvements, the improvements do not get implemented as soon as they could (Neij and Öfverholm 2001). It is easily noticeable that there is a gap between practice and theory.

In the residential sector definitely single-family homes are the major energy users, buildings space heating is the dominant end-use of energy, water heating is the second most important use (Hirst *et al.* 1986).

The Kyoto-protocol is the baseline for the future targets of energy-efficient measures. In the case of Sweden and Hungary the expectations are not that high, but to meet the obligations further improvements are essential. In November 2009, the Environment Council of the European Union has issued a conclusion, that; by 2050 the greenhouse gas emissions should be less by 80-95 % compared to the level in 1990. The resolution takes into consideration what measures are necessary to avoid dangerous climate change (Feiler and Ürge-Vorsatz 2010).

The European Union unilaterally agreed to reduce greenhouse gas emissions (GHG) by 20 % through 2020, and if other industrialized countries agree to take a comparable degree of commitment than this reduction can raise up even to 30%. In addition to that the EU also wants to achieve a 20 % share of renewable energy sources in the total energy production (Feiler and Ürge-Vorsatz 2010).

As Neij and Öfverhol (2001) argue, the long-term goal in Sweden suggested by the Climate committee of the Swedish government is a reduction of CO_2 emissions by 50 % from the level of 1990 till the year 2050. Hungary signed the Kyoto protocol undertaking the 6 % emission reduction compared to the average emission level of 1985-87, but the current emissions are even 34% less than the requirements. The sharp decrease can be explained by the impact of the previous socialist regime, which failed in 1989. By 1992 the emissions already decreased by 30% because of the decline in the energy, industry and agricultural production (Feiler and Ürge-Vorsatz 2010).

In 2007 the GHG emissions in Hungary equaled with 75,9 million tones of CO_2, which was the lowest value between 1985 and 2007, and it counts as a relatively low value in Europe as well. In the years 2008 and 2009 the trend was the same regarding the amount of average emissions (Feiler and Ürge-Vorsatz 2010). In Hungary three-quarters of the total GHG emissions can be attributed to the energy sector, 13% to agriculture, 7% to industrial processes, while waste management represents 5% of the inventory (Feiler and Ürge-Vorsatz 2010).

As it is stated in as one of the Energy Use in Buildings (2020/2050) objectives, "it is required that total energy use in residential and non-residential buildings be reduced by 20% through to 2020 and by 50% through to 2050, compared with the 1995 level. By 2020, dependence on fossil fuels must be reduced and there must be a continous increase in the proportion of renewable energy" (www.passivhuscentrum.se).

Also, in June 2006 the Swedish parliament decided that "the energy use in residential buildings and premises should decrease by 20% per heated unit area before 2020" (Janson 2008). To reach these goals "more energy efficient buildings must be produced as well as energy efficient improvements must be performed on the existing building stock" (Janson 2008).

Another achivement of the Swedish Parliament was that it "has produced 16 environmental objectives which specify the desired status of nature and the environment in Sweden in the long term. One of these objectives is A Good Built Environment. Buildings must be located and designed to take account of and promote good, long-term management of land, water and other resources" (www.passivhuscentrum.se).

There is also a new EU directive, which states that from 2016 all the newly built houses have to be passive-houses. It is a very important step towards the energy-efficient future, which will push the buildings sector into a more energy-efficient direction.

It is a fact that around 75 % of today's buildings will still be in use by 2050, therefore the improvement of the performance of the existing building stock will be a great challenge. Although it is possible to achieve with the help of innovative solutions, still, it will require major policy improvements (Neij and Öfverholm 2001).

The short and medium term policy documents and strategies have a significant impact on the implementation of the long-term emission reduction targets. Today's decisions have also an impact on future feasibility and cost implications. If the policies will be targeted in the right directions and will be ambitious enough, than it is possible to achieve the goals (Feiler and Ürge-Vorsatz 2010).

2.1.1 The benefits of introducing energy-efficiency

It is essential to pursue further energy conservation in the buildings sector, mainly because "without major reactions in world coal use through conservation and other means, atmospheric CO_2 levels will dramatically rise by the end of the next century, which might cause significant climatic changes" (Hirst *et al.* 1986).

There are other economical dimensions of energy conservation as well, which affects more the general public, and perhaps is more tangible in our societies, like energy costs and possible saving solutions. Fuel costs are becoming a major concern more and more, especially since the latest economic crisis, which also hit the European Union. "The trend towards increasing fuel prices is not expected to subside for either natural gas or electricity. Lower income families have been hit particularly hard by increasing energy prices" (Hirst *et al.* 1986).

If we look back in history, from the 1960s the level of residential and commercial activities has increased substantially all over Europe, even though there are differences between regions according to used energy unit per household because of climatic differences. Between 1950 and 1973, the energy use of the buildings sector grew at a steady rate of 4.4 % per year (Hirst *et al.* 1986). That shows a continuously rising demand for energy use, and this trend was growing till the 1990s.

These numbers lead us to think about future energy supply problems, and therefore the solution could be to decrease conventional energy supplies and in the same time pursue energy conservation. These measures can also reduce such environmental problems as air pollution and, in particular acid rain (Hirst *et al.* 1986).

The introduction of energy efficient measures is also beneficial for the economic market. There are benefits regarding employment, which can be seen as an externality additional to such obvious benefits as the previously mentioned energy savings. "Some forms of energy conservation in buildings are highly labour intensive and provide much greater employment opportunities than alternative investments in energy supply systems" (Hirst *et al.* 1986).

In the case of Hungary for example, as it was said by professor Diana Ürge-Vorsatz at the presentation of the results of the research about the Employment Impacts of a large-scale Deep Building Energy Retrofit Programme (the case of Hungary) Project, "131 000 net jobs can be created by the year 2020 alone, including the losses in the energy supply sector, and deep renovation activities are much more labour intensive than other economic recovery activities. For instance, five times more jobs are created than with the same investments in road construction." (Ürge-Vorsatz 2010)

As Hirst *et al*. (1986) argues, energy efficiency is not only important in the case of new buildings, but it is significant in the case of the existing building stock as well, "because in any given year the number of new buildings constructed is very small compared to the existing ones". Therefore any increase in the efficiency of the existing buildings has a great impact in the efficiency of the buildings sector in general.

To convert the currently existing building stock to the level of passive buildings (meaning a conversion to a very-low energy use per household in a year) would mean 95% emission reductions. The good news is that the needed technology is already available on the market, and is applicable on an industrial scale, but it is true that in the case of existing buildings the conversion is more costly than designing and building a low-energy house from the ground up (Feiler and Ürge-Vorsatz 2010).

All in all the economy as a whole should only gain from improving energy efficiency, because cost-effective conservation investments free up capital that would otherwise be spent on other facilities which produce energy, like power plants etc. (Hirst *et al.* 1986)

2.1.2 Buildings as functional environments

In the following chapters first I would like to give a general overview of the technical side of the construction of a low-energy building to demonstrate major features and conditions that have to be considered, and second I want to explain how a passive system and a passive house can be defined and how it works.

As a definition Hirst *et al.* (1986) said that "buildings create a functional environment" and they "provide the temperature, humidity, and lighting necessary for people to live and work in comfort". The building mainly consists of two things: the envelope and the interior space. To provide that comfort energy is needed for heating, cooling and lighting, since the desired temperature and light can be achieved through technological devices that use energy and electricity for operation. (Hirst *et al.* 1986)

The building envelope can be defined as "the boundary between the building and outside conditions. It filters light, affects air and thermal flows into and out of the building" (Hirst *et al.* 1986). The envelope includes four subsystems: roof, wall, floor, and earth contact. These subsystems are made of different materials, and are put together during the construction phase. (Hirst *et al.* 1986) High quality and innovative solutions of these materials can ensure better energy use in newly constructed buildings, and basically the appropriately adjusted insulation materials and methods will help achieving low energy standards of already existing buildings as well.

"The particular aspects of climate that are of interest to the building designer are:

1. Temperature,
2. Wind,
3. Humidity,
4. Insulation,
5. Precipitation" (Hirst *et al.* 1986).

Analysis of the local climate is essential in designing an energy efficient building. "Buildings in different regions will have different shapes, materials, orientations, envelope characteristics, and earth-ground relationships. For example, in cool climates, the design might use the sun as much as possible for winter heating, while buildings in temperate zones may have much more open interior configurations" (Hirst *et al.* 1986). The urban context is also very important, such as building density, street layout, types of buildings and their location, because they all influence the energy aspects of a building (Hirst *et al.* 1986).

It is important to mention that comfort is a relative concept and it depends mainly on temperature and humidity conditions, but also on other factors such as age, sex, health, activity patterns etc of the inhabitants. There are several psychometric charts, which define a general human comfort zone where the majority of the population would feel comfortable (Hirst *et al.* 1986).

Also, the system providing comfort needs to be flexible and responsive to occupant needs. The general concept is that occupants should be able to regulate inside temperature by opening/closing windows and by heating. But with new alternative energy efficient solutions the conservative approaches might need to be changed (Hirst *et al.* 1986).

A new concept is the passive concept, where the main idea is to insulate the building envelope so well that little or no heating is needed, and the air temperature is regulated by well-designed ventilation system. Energy is gained from renewable sources, such as solar energy or geothermal heat for example (Hirst *et al.* 1986).

2.1.3 Passive energy systems and the passive house concept

According to Hirst *et al.* (1986) "Passive energy systems reduce the amount of fuel required by a building by using renewable sources for heating, cooling, and lighting. Passive energy systems involve the selection of site, location, orientation, floor plan, circulation patterns, window placement, and building materials".

Occupants of the building obviously greatly influence energy use. For example, by lowering indoor temperature the annual space heating can be cut in a single-family home by 10 %. The number of people in a building and the amount of time spent in the building also affects energy use. (Hirst *et al.* 1986)

The Passive House standard originates from Professors Bo Adamson of Lund University, Sweden, and Wolfgang Feist of the Institute for Housing and the Environment, Germany 1988. Their concept was developed through a number of research projects, and the idea was first realized in 1991 in Darmstadt Kranichstein, Germany in a house built for four private clients (Janson 2008).

The Passivhaus-Institute, which was established in 1996, is responsible for the classification and for the certification standards. Since the construction of the first passive house more than 14 000 passive houses were built all around Europe. This type of ecological architecture is most popular in Germany, Austria, Switzerland and in Scandinavian countries. This passive house technology gives a realistic possibility to reduce energy dependence and to spread carbon-neutral buildings (www.passivhuscentrum.se).

The first passive house in Sweden was built in 2001 in Lindås, then in 2006 in Oxtorget, Värnamo, and gradually the number of those energy efficient buildings started to grow. This shows that although the original passive house concept is coming from Lund Sweden, it took ten years to build the first passive house in the country. (www.passivhuscentrum.se)

In Hungary the first newly built passive house was built in 2009 in Szada, Pest County near Budapest. That building has the Passivhaus-Institute's official certificate. The designer of the house is László Szekér Hungarian architecture. But this is not the only success in Hungary, there is also a multi-dwelling building in Dunaújváros which was renovated in 2005, and received the official certificate after the renovation.

As it is defined on the official website of the Swedish Passive House Centre "passive houses are well-insulated buildings that are largely heated by the energy already present in the building", which is partly generated by people and household equipment. "The heat inside the building is utilised and the sun is also used to heat both the building and tap water whenever possible" (www.passivhuscentrum.se).

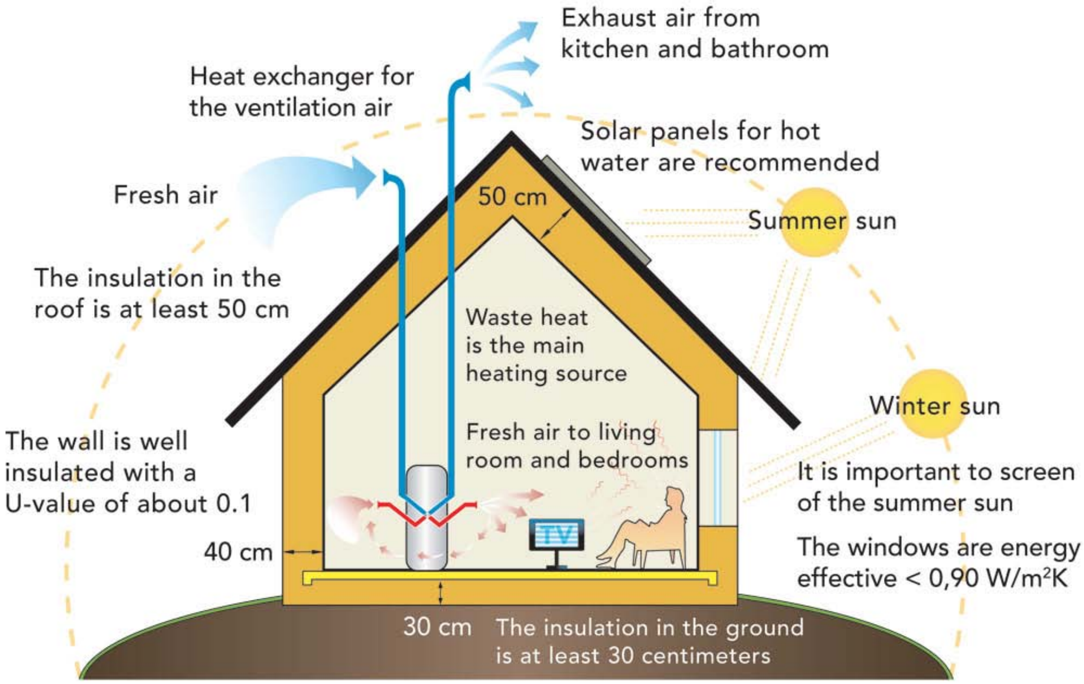

Figure 2 Model of a single-dwelling passive house

Source: www.passivhuscentrum.se

On the picture above it is well explained how a passive house works. Insulation, localisation, energy effective windows, good ventilation ensured by a heat exchanger and the use of renewable energy are the major components that need to be well coordinated and implemented. Designing and building a passive house should not result a complicated system, since passive houses should be easy to handle in every day use.

As Hirst *et al.* (1986) explains, the heating system of a passive house is usually based on south-facing glass (that collects the heat) and thermal storage. The collectors on the roof take up solar radiation than the absorber converts it into heat, then the distribution happens through convection, conduction, or radiation. The cooling system is based on a well-designed ventilation, which is necessary to cool the inside space and to ensure fresh air. There are many ways to reach that goal, but usually heat can be transferred to the sky through long wave radiation, or to the earth surrounding the building. (It must be remembered, that the technical details should be always adapted to the local climatic conditions and the local environment.)

Although only those buildings should be called passive-houses, which meet the official requirements of the German Passivhaus Institut in Darmstadt, Germany, the definition of a passive house often varies. In some cases buildings built as "passive houses" do not even meet the high requirements of the passive house standard, therefore it would be much more convenient to call all energy-efficient buildings using a common label such as, for instance, low-energy houses.

According to Hanne Dybro from the Isover company in Sweden, multifamily houses function better than single family homes for a passive-house concept, because the area that has to be heated up equals with the area of the building envelope, while in single family homes the inside heated area is 2.5 times bigger, and it makes the whole system less efficient (Dybro 2010).

The passive house concept has its limitations. In the northern parts of Sweden passive-house technology is not possible, but low-energy buildings still are (Dybro 2010). Also, the construction costs might have been much higher in Sweden at the beginning of the spread of new ecological housing. Nowadays the prices are getting cheaper, because there are more and more contractors on the market (Dybro 2010). Prices seem to be still quit high in Hungary, but this can be related to the fact, that these innovative energy efficient solutions are not widespread yet.

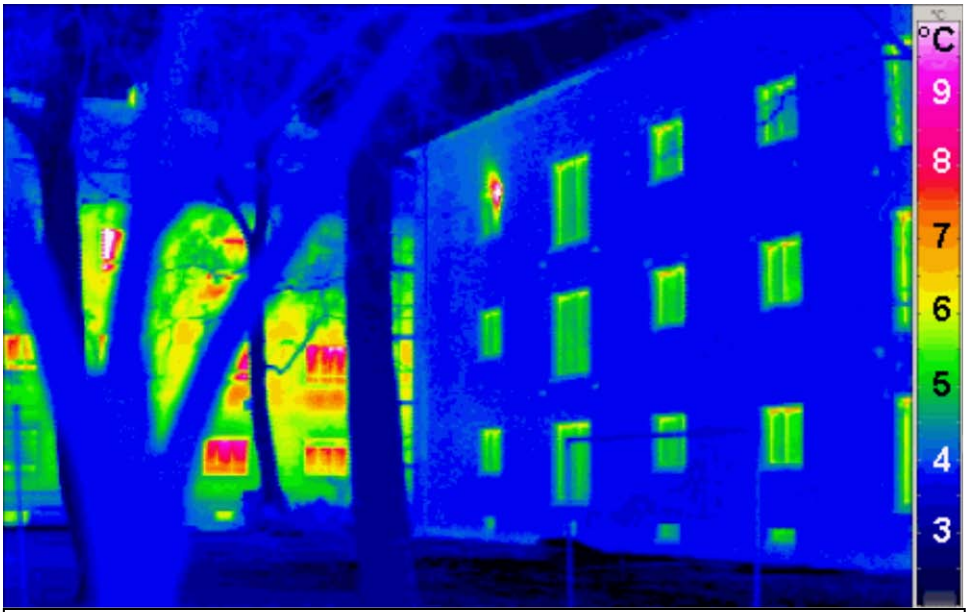

Figure 3 Thermogram of a passive house

Source: http://www.our-energy.com/low_energy_passive_and_zero_energy_houses.html

Finally to demonstrate what a difference it makes if a house is well insulated a good example is this thermogram picture of a multi-dwelling passive building, that clearly shows how little heat is escaping compared to a traditional one that is placed in the background. The scale on the right represents the colours for temperature, the more orange or red is the surface the more heat escapes through the walls. In the case of the passive house the whole outside surface is blue, which means there is no heat loss in the building, higher temperature can be only observed at the windows.

2.2 Policies concerning energy-efficiency

2.2.1 Historical background

In order to gain understanding of a given policy system concerning the buildings sector and energy efficiency it is convenient to look at the building codes. Building codes prescribe material usage, structural and safety requirements. Originally the purpose of the building codes was to protect the general health, safety and welfare, and also to ensure protection in the case of fire. The modification of building codes is accomplished through legislative processes (Hirst *et al.* 1986).

In most cases the building codes, just like in the case of Sweden and Hungary, do not really match today's requirements. The biggest problem is that since their establishment they have not been re-assessed except for some minor changes, therefore the best solution would be to change them and adjust them to better meet energy efficient trends and needs of today.

Historically, the Swedish policy has traditionally had a strong focus on social and distribution policy and the Swedish government has always played an important role in the development of the sector, which is similar in Hungary as well (Rozite 2006). After WW II the buildings sector experienced a phase of growth and intense production in both countries, promoted by the "million programme" (Rozite 2006).

In Sweden, due to increasing urbanisation and need for housing the program was established by the government in 1960. The goal of building one million new rental units in 10 years was set and achieved (Rozite 2006). A little later, in the 1970s the construction slowed down dramatically, leading to unemployment. Even though they tried to help the situation by applying new subsidies and renovations, the sector experienced a period of construction crisis, characterised by a low number of projects (Rozite 2006).

The issue of energy efficiency became important in Sweden between 1972 and 1985, when oil prices increased, but then as the oil prices stabilised so did the level of energy efficiency (Nässén and Holmberg 2003).

As for Hungary, the issue emerged at the beginning of the 1990s, which were the time of a change of the political system and a time of recession. The Hungarian government reduced financial support to the sector, Hungarian tenants could buy their apartments from the local municipalities for a relatively low price and previous regulations on building design were replaced by more flexible ones.[1]

The good thing about the decreased support from the state in the case of Sweden was that the buildings sector developed its own initiatives to manage various issues, creating networks and organisations, for instance, aiming to promote environmental standpoints. The government's objective was to promote the implementation of new technologies and it also meant increased responsibility for contractors who had to become more customer-oriented (Andersson 2003). Also, because of the recession middle size companies largely disappeared, and a few companies started to dominate the market, from which some of them have become international (Rozite 2006).

[1] This was not necesseraly a good decision, because now the owners do not have the capital to renovate their own homes in the old buildings, and the government does not give any support.

As Rozite (2006) explains, "the buildings sector in Sweden has established the Eco Council for the Buildings sector and a new organisation The Energy Alliance, which is a cooperative effort between the Building Developer Forum and the Eco Council. There is also a newly established state and sector initiative - the Building-Living Dialogue, which also works on energy efficiency related issues"

2.2.2 The task of policy measures

According to Rozite (2006) “The building process is regulated by a framework that consists of rules and regulations. The main regulatory instruments are the building regulations or building codes, but environmental legislation and other legislation may also regulate the process". Municipalities have the influence on what type of buildings can be built in different locations, and also on the specific demands regarding the site in certain areas (Rozite 2006).

Also, there is a division between residential (single or multi dwelling houses), commercial or public and industrial buildings. In each case ownership structures vary, where dwellings or office space can be rented or privately owned (Rozite 2006).

The main concern of these policy measures is to pursue all the external elements, such as climate change, risks associated with nuclear power and health effects of fossil fuels to be somehow quantified, and not set their value at zero in the energy price (Neij and Öfverholm 2001).

In the case of new buildings, in Sweden building codes for energy efficiency have been applied since the 1970s, which turned out to be an effective way to accelerate energy efficiency (Neij and

Öfverholm 2001). Still, although the codes are quite good, they have not been evaluated since the 1970s. And even these old building codes are not always taken into account. Although they have been partly improved, an overall improvement would still be needed to meet nowadays expectations towards an energy efficient building stock (Neij 2010).

As Nässén and Holmberg (2003) observe, "The SBN 75 standard which came into force in 1977 meant a significant strengthening of the insulation requirements, but no major changes are seen in that year, although it may have been important for raising the lowest level of performance."

There are a number of methods that can be applied like, for example, energy taxes that raise energy prices to encourage efficiency and encourage the adoption of energy-efficient products and technologies in the long run. Taxes are price-regulating instruments that can be used to generate income to the state budget or to force a change in behaviour (Rozite 2006).[2] "In Sweden, energy taxes have been used since the 1950s as a policy measure, in 1989 for instance, a general energy tax was levied on electricity and fuels, with the exception of bio fuels and peat" (Neij and Öfverholm 2001).

The other policy measures would be subsidies that can be applied in the case where the initial price of the product is too high to allow immediate market penetration. Indeed, "subsidies contribute to price reductions and market creation, which ultimately results in real cost reductions due to increased product acceptance and volume demand" (Neij and Öfverholm 2001). In Sweden

[2] A good example, though from a different sector could be the new environmental tax on airplane flights in Germany, to encourage people to take other sorts of transportation.

in the 1970s and 1980s, financial support was given to energy-efficiency investments in buildings in the form of subsidies and loans (Neij and Öfverholm 2001).

There are other areas that can regulate policy measures, like deregulation of the electricity market, which allows a change from a monopolistic system to a more competitive environment, which pursues suppliers to lower their electricity prices and pushes them towards more energy efficient technologies. In Sweden such deregulation reform happened in January 1996 (Nilsson 1998), in Hungary major privatisation started in 1995, but it was rather a process that started in 1990 and evolved after 1995 (Pesic and Ürge-Vorsatz 2001).

If the influence of such policies and standards is small it means that the regulations have been too easy to meet without major improvements. Another possible problem can be that "the computer program used for the calculations is simple in relation to the complex physics of the building" and it is also possible that "components and materials are changed for economical reasons later in the building process, without making new energy calculations" (Nassén and Holmberg 2003). Also, inspections are not completed afterwards to ensure the effectiveness of the development.

A similar situation occurred in the case of the zero-emission building of the Regional Environmental Conference Centre in Szentendre, Hungary, where during the construction phase many changes were introduced regarding the methods of implementation, and as a result the building does not operate as efficiently as it was planned. Now further calculations need to be made to first find out what and where the problem is, and then additional measures have to be taken to fix the problem. This all could have been avoided if changes would have been introduced in time, and recalculations would have taken place (Bauer 2010).

Interestingly, the Swedish Energy Sector is pushing the energy–efficient approach itself, but subsidies and loans that would support more energy-efficient investments are more common in Germany, while there are no subsidies or loans in the case of Sweden. So far only projects and research have been subsidised, never the construction itself (Dybro 2010).

2.2.3 The challenges of innovation

In Sweden innovation governance is organised along two lines: growth policy and research policy. Supporting and sponsoring the sector of Research and Development (R&D) is, I think, fundamental to be able to come up with results that can lead to technological breakthroughs and new innovative solutions in energy efficient technologies and products on the market.

"The Swedish innovation system is relatively decentralised and it is characterised by the use of ad hoc groups and temporary coalitions." Although this provides flexibility there is lack of coordination, which may lead to the problem of fragmentation. According to the European Trend chart on Innovation there may be a need for a clearer innovation policy to guarantee that the importance of innovation is recognised by all policy makers. (European Trend Chart on Innovation 2004-2005: Sweden) “Innovation in the buildings sector has received increasing interest since the 1990s” (Widén 2002).

In the Swedish national innovation system large international corporations have a dominant position, showing that there is a considerable level of foreign dependence in the R&D system (European Trend Chart on Innovation 2004-2005: Sweden). This can be helpful to purchase foreign capital, but it has an impact on the independence of the system as well.

In Sweden currently demonstration projects and support schemes for product development have been shifted to the Swedish Energy Agency, and to further promote innovation the so-called Buildings sector Innovation Centre (BIC) has been developed (Rozite 2006). Still, a general conclusion is that the level of innovation in the sector could be improved (Atkin 1999, Barlow 2000, Gann and Salter 2000, Winch 1998).

2.2.3.1 Market barriers

There are certain market barriers that make energy efficiency improvements to be implemented more difficult. Such barriers are low energy prices, high initial cost of technologies, limited access to capital, high risks, lack of information, and many more (Nadel 1992).

The literature indicates a considerable potential for improved energy efficiency, however, as (Neij and Öfverholm 2001) recognise, there are many approaches to how that potential should be defined and from what aspect it should be discussed, as such potential could be theoretical, technical, techno-economic and market-based. "Estimates of the potential for Swedish energy savings through improved end-use efficiency vary between 10 an 50 % or more, depending on the end-use application and the definition of potential used" (Neij and Öfverholm 2001).

Although "a common misconception about energy-efficiency is the idea of ever-rising costs, which claims that energy efficiency is an added value that can be achieved at a higher price" (Neij and Öfverholm 2001), it is important to remember that the real market is constantly changing, and there are new technological breakthroughs, which allows lowering the costs and introducing high volume production at a lower cost. Still, energy efficient products should in the first place equal with better quality, which means higher value, and allows products to be more competitive on the market (Neij and Öfverholm 2001).

Neij and Öfverholm (2001) mention a very interesting fact to me, that even though the best available technology (BAT) on the market today is very efficient the energy efficiency in the building stock is not improving at the same speed. Even though there are possibilities for well-insulated building envelopes and for gaining energy from renewable resources through innovative appliances such as solar panels, the energy-intensity of newly built buildings is often even worse than that of the buildings built 100 years ago (Nässén and Holmberg 2003). This problem concerns not only Sweden but Hungary as well.

Thus, "the energy efficiency of the average new construction is not improving and in a longer perspective this is problematic given the long life cycles of buildings. The statistics for new-constructed multi-dwelling buildings indicate increasing energy intensity since 1995" (Nässén and Holmberg 2003).

A well-functioning energy standard for buildings would be very much needed to pursue transition towards an energy efficient building stock in the long run. Unfortunately, the current standards have little effect since the requirements have only been marginally tightened (Nässén and Holmberg 2003).

2.2.3.2 *Market transformation*

Market transformation programmes (MTP) were first developed in North America and in Sweden in the late 1980's. These programmes are strategies for introducing more energy-efficient products on the market. The programmes have been designed to achieve a dynamic market transformation and a long-term permanent shift of the market towards more energy-efficient products and services (Neij and Öfverholm 2001).

Although these programmes are still at an early stage, "the results so far have shown evidence of shifts in the markets for a number of energy-efficient products" (Neij and Öfverholm 2001), but experience has showed so far that the process takes time (Lund 1999).

In my own research carried out for the present thesis the participants in the interviews indicated that countries such as Germany and Austria have initiated programmes, which were especially successful in energy efficiency in the buildings sector, therefore probably good examples could be shown from Germany as well.

2.2.4 Programmes focusing on energy-efficiency

Since Sweden and Hungary are both in the European Union, they have to adjust not only to national but also to EU legislatives and directives. The EU is working on common European measures, such as standards and labelling schemes. It is often easier to gain acceptance for voluntary agreements, because they have less of a mandatory character, especially when we talk about achieving agreements in EU-wide minimum efficiency standards.

Voluntary agreements are generally "contracts between the government and a company or association of companies aimed at achieving a negotiated goal, which may be a certain energy efficiency target, emission reduction, or development of a technology" (Neij and Öfverholm 2001). In the form of compensation the company may receive a tax credit or technical support for example if the negotiated goal is accomplished (Neij and Öfverholm 2001).

In Sweden there have been introduced new programmes promoting energy efficiency, related innovative technologies, and the main idea is not only to introduce but also to commercialise new technologies and products, which could penetrate the market. These programmes have all been based on voluntary approach though, and have rather just promoted not regulated energy efficiency improvements (Neij and Öfverholm 2001).

A good example for such a voluntary agreement was the Swedish programme called EKO-energi, which started in 1994 and which was organised in the form of contracts between the government and companies. In total contracts have been signed with approximately 30 companies till 1999, and involved about 80 plants or sites. The contracts were based on ideas similar to ISO 14001 standard (Helby 2001).

The contract offered companies the use of the EKO-energi label for promotional purposes and help in gaining certification to ISO 14001 standards. In return, among others the companies had to formulate an environmental policy, have long-term energy saving goals, establish a plan of action for energy efficiency measures, and accomplish a verifiable increase in energy efficiency (Helby 2001).

These rules should be applied in general to all companies to make energy efficiency a successfully widespread practice in the future. Unfortunately EKO-energi was at best a very modest success (Helby 2001). No significant use of the label for marketing purposes has been noted (Neij and Öfverholm 2001).

Another good example of such a programme would be a program by STEM/NUTEK for technology procurement established in 1988, which has brought purchasers and experts together to identify potential improvements. "Over the years STEM/NUTEK has initiated some 30 technology procurement programmes, and more then 100 contracts have been signed" (Neij and Öfverholm 2001). Definitely that is a good example that could be also applied in Hungary, and in general a similar approach would be needed from the Hungarian side as well.

Also, the STEM/NUTEK program showed that even though improvements sometimes take time and need additional effort from both sides, the architects and the program commission, a satisfying solution is always possible. As a good example to demonstrate this approach would be the first technology procurement programme for windows that was undertaken in 1992, where the goal was to achieve a better design for windows regarding energy efficiency and noise reduction (Neij and Öfverholm 2001).

The requirement of the windows was a U-value (which means the thermal transmittance) below 0.9 W/m2K. The average U-value of the replaced windows was 2-3 W/m2k. Two winners achieved the U-value of 0.73 and 0.88 W/m2K respectively (Neij and Öfverholm 2001). Since these windows required four glass panes the winning windows were not popular among architects who said that they were heavy and not attractive from aesthetical point of view. In order to find a solution the requirements were changed to 1.0 W/m2K, which resulted in triple-glazed windows and four additional producers, could meet met the requirements (Neij and Öfverholm 2001).

The STEM/NUTEK programme has increased awareness of energy efficient technologies among several groups, from producers to users, and it evoked a positive attitude of many architects and building contractors towards energy-efficient windows (Lund *et al.* 1996).

2.2.5 Large-scale deep renovation program in Hungary

In Hungary there have been a few steps taken so far to promote and improve energy efficiency in the building stock, also by inducting new policies such as the new Directive of the European Parliament of the Energy Certification of Buildings 2002/91/EC, which was supposed to be in force from 2006. The training of professionals has already started and therefore a background of professionals will be anticipated for the future needs.

Recently a new program has been accepted by the government which aim is to renovate the majority of the existing building stock, which stands for as the main problem all over Europe. The upgrading can be achieved only with the help of a well-prepared long-term project.

2.2.5.1 General description

The Large-scale Deep Building Energy Retrofit Programme was accepted in June 2010, by the Hungarian government (Ember 2010), which is a great success of the Centre for Climate Change and Sustainable Energy Policy (3CSEP) Research Institute in Budapest, Hungary, placed at the Central European University.

The project's aim was to demonstrate what a deep renovation program was, why should it be applied in the case of the existing building stock and how it would be possible. Currently all the renovation programmes that are running are sub-optimal, or even less efficient than that level. The project focused on residential buildings and it concentrated on heating issues.

Based on the research up to 85 % of the energy can be saved (70-80 % for sure), the project is cost effective and it also pays back (although the investment and implementation themselves are costly), but lots of the costs can be saved at the end if deep renovation is applied in the case of the existing building stock. There are two main types of renovation: deep renovation and sub-optimal renovation. In the case of sub-optimal only 40 % can be saved, which is not satisfying enough, because then it means that 45 % of the energy is locked. Therefore, based on the previous arguments, deep renovation program is the only advisable one.

As it was mentioned before in panel buildings heating requires 230 kwh/m^2/year, and in single-family houses it is even up to 300 kwh/m2/year. These are very high numbers. If we look at buildings in other countries it can be only around 70-80 kwh/m^2/year, and even then it is not considered that low. Truly energy efficient buildings should have around 30-40 kwh/m^2/year energy uses.

The implementation of the deep renovation program brings many benefits: 39 % of the annual gas import needs could be saved by the year 2030, and 59 % could be saved from gas import only in January, which means that it would be possible for Hungary to loosen its dependence on the Russian energy sources. Deep renovation would also mean higher employment, since 52 000 new jobs could be created by the year 2020.

Regarding the budget approximately 1 billion euros of public funds per year could be potentially made available, partly from EU funding, partly from redirecting current energy supplies. The initial costs would peak at 2 billion euros per year, and around 1 billion towards the end of the project, but it will never happen on its own. Governmental support is needed because of the long payback time.

Unfortunately in the case of this program there are no economic incentives, since the payback time is very long. Appropriate technology is available mainly abroad (Germany, Austria, USA); high-tech is not available in the country. That means that all the competitive manufacturers should come to Hungary, which would increase the potential for Hungary to become a leader in that business area in the region.

The benefits of an energy efficient building are the following:

1. Good for our climate, less CO_2 emissions,
2. Better indoor health environment,
3. Higher level of education with better lighting,
4. Creates jobs, it has two times higher employment intensity.

To make this project possible more support would be needed from the government. Also, there is a great need for new technology and for new know-how. It takes a long time to reach the desired goals since all of the renovation and implementation of innovative technologies and building materials require a learning process. The time magnitude of the program is around 17-18 years in the fastest scenario, and 40 years in the case of the longest scenario.

2.2.5.2 Possible problems

As local companies would carry out the renovation, the renovation itself is local as well. The problem that emerges is that the time period for the renovation takes up 20-30 years, which is basically a whole working time of a worker. The previously mentioned employment effects are probably over-estimated, although future maintenance after the renovation is finished is also calculated.

The question remains whether there will be enough people to fill these jobs in. It is also a question of education, and the number of people educated in the needed fields so far. Currently the answer is probably yes, but surely it would take good management, and also lots of promotion to attract young people to work in the buildings sector. It would be a good incentive if for example; wages were to be higher, especially at the beginning.

At the moment there is not enough supply material, therefore the sector has to adapt to higher demand. A positive thing is though, that once a building is renovated, and the energy costs decrease, then it is easier to rent a place since the bills are lower, and such a building will always be more competitive on the market.

Hungary, unfortunately "is addicted to public subsidies" (Ürge-Vorsatz 2010), but this can be changed. Since there are subsidies for gas supply and energy costs, then the message is the following: do not renovate your building, it is not worth it. On all that money that goes for subsidies we could have renovated the whole building stock so far. People are “locked in” for gas use.

The constructors and experts say the preparation for that project should not take longer than five to ten years, while the projects estimates are five years. There is also the question of renovation versus demolition of houses. While demolition is also costly deep renovation does not have to be that expensive, although renovating the entire building stock is definitely challenging, and some of the buildings will still have to be destroyed.

Unfortunately most of the Hungarians have to deal with the problem of fuel poverty, which means a household needs to spend more than 10 % of its monthly income on total fuel use. Additionally to that Hungary is the only country in the EU where energy intensity went up in the last decade. These are major challenges Hungary has to face, but it can be solved with the help of deep renovation.

It is still a great challenge to teach people about energy-efficiency and to make them want to change their homes. You need to see your house as a complex building, and also cultural change takes time. The SOLANOVA project in Dunaújváros is a very good example of a well-renovated building of blocks of flats (panel) and the living experiences are very positive so far. There is less cleaning needed since the doors, windows are better insulated, less dust comes inside of the house, and the number of people with allergies decreased.

The project was accepted by the Hungarian government in June 2010, which is a great success, although there are many question marks still regarding the details of the implementation, but it will be definitely beneficial for the small and medium-sized enterprises (Ember 2010).

3. RESEARCH METHODOLOGY

Since environmental sciences do not only include hardcore science, but also a wide range of issues concerning policy, management, sociology, demography etc. therefore it always deals with society and social issues, and people are always involved. This explains why it is necessary to deal not only with quantitative but also with qualitative data and information, which needs a different approach, but is equally valuable and needed to find out more about a certain problem or issue.

There are several methods that can be used during qualitative research, and more than one method can be used at the same time in order to gain a better understanding of the research problem itself. Also, different methods can be helpful in different situations, depending on the topic and the nature of the issue under research.

During the writing process it was needed to take into consideration that energy efficiency is a complex and multidisciplinary subject and "knowledge is not centralised in one place but dispersed between a large number of actor groups" (Rozite 2006). There are different approaches when elaborating a thesis while doing a comparative study, from which "one possibility is to look at other countries and investigate what types of policies they have used, another approach is to collect ideas for solutions from actors within the sector" (Rozite 2006). Both of the approaches were used in this thesis, since it gives the opportunity to gain a deeper understanding of the topic of energy efficiency in the buildings sector.

3.1 Data collection

The main part of my research was based on library research, which consisted of reading relevant materials in the topic, related books, articles, and publications in the library or on the Internet. The research took place partly in Sweden, in the International Institute for Industrial Environmental Economics at Lund University, partly in the library of the Central European University in Budapest. The other part of my work was based on interviews, which also took place in both countries.

3.1.1 Interviews

In the case of this thesis the so-called snow-ball method was chosen, since it seemed to be the most practical, because of the limited time for the preparations for the research trip and the unfamiliar foreign Swedish environment. With the help of this method contacts with several people could be ensured during the research trip, since only a few contacts and appointments had been agreed in advance. Thus, the people that were interviewed were the first to suggest further contacts for the following interviews, since they were well oriented in the field, and could help identify the right people to make interviews with according to my topic.

All together six interviews were made, four in Sweden and two in Hungary. Among the interviewed people there was the director of the International Institute for Industrial Environmental Economics (IIIEE) at Lund University in Sweden, professor Lena Neij, one of the PhD students in the IIIEE institute Bernadett Kiss, one of the co-workers of the ISOVER company Hanne Dybro, the project leader of the JM Construction Company Maria Hagman, the project manager of the new headquarters project of the K&H Bank in Budapest István Szalai and one of the co-workers at the Regional Environmental Centre in Szentendre, Hungary, Zsolt Bauer. (At the end only the most relevant material was included in this thesis.)

The lengths of the interviews depended on the available time of the people who were interviewed, but usually it was a one-hour long conversation. During interviewing I had only some guiding questions concerning energy-efficiency policies, and then the conversation could go to directions, which seemed to be most interesting, because additional, voluntary information could be always useful, and turn out to be something important, that could have been easily missed in other case.

Questions were separately prepared for each person I had appointments with; since they all had different backgrounds, different positions and therefore they all had different approaches and views on the same issue. That was even an asset, since it made it possible to get access to several types of information, and at the end get a better understanding of the whole problem.

Taking all the interviews was a time consuming process, from finding out each and every person's address through arranging the exact time to actually make the interview itself, but in my belief it is one of the most effective methods of collecting data. It is because nothing can replace the direct contact with the source, the experts and the people who decided to move into the buildings with lower energy consumption or passive-houses.

The interpretation of the interviews is an important task, it means much more than just repeating the exact words the interviewed person said. It is necessary to be able to see the whole meaning of the recorded or noted material, and be able to find out and highlight the key issues and words, that describe the main point of view of that person. Besides, only when seen together will the interviews give a better picture of the researched problem, and it is essential to be objective, or even critical if it is needed and to compare the results at the end. Comparison of the results should be a general approach in the case of all research methods, since data will provide us with information only when compared and weighted against each other.

3.1.2 Visiting building sites

The sampling method was mainly limited by the time period for the research, and the distance from Lund and Malmö, since the budget was limited as well. Despite of these limitations it was possible to visit some interesting building sites, which were newly constructed and had the idea of green architecture, energy-efficiency by their construction and design methods to decrease CO_2 emissions. Also, it is important to mention that the research itself was designed in advance to make sure that some of the low-energy buildings would be available in a short distance, to ensure that the research trip will achieve its goal, and it will provide expected results to contribute to the topic of the thesis.

All together five sites were visited, three in Sweden (two in Lund, one in Malmö), and two in Hungary (one in Szentendre, one in Sándorfalva). In Sweden all sites were residential, in Hungary the one in Sándorfalva was a four dwelling house, the one in Szentendre was a public building, the zero-emission building of the Regional Environmental Conference Centre.

The visits added a visual feature to the work, to make low-energy buildings more tangible for the reader, than a very necessary part of the research trip. More information was received from the architects, project managers, company workers and residents, but obviously my personal curiosity was also a reason to actually go and see some of these buildings, and not just to talk about them without visiting even one.

The general impression of such a building is also important, to be able to imagine what would it be like to live in a low-energy building and it was good to have a look from the construction side as well, to see how well these buildings were built up, whether the high quality standard was indeed there, whether they proved themselves for the potential customers. It was also interesting to see that each of these buildings had a unique design, because each of the buildings had to be designed accordingly to the local climatic conditions and geographical locations.

3.2 Problems and limitations

When doing a research there are always problems and limitations that have to be faced. One can be the length of the research trip, meaning the time period devoted for doing actual research, which can be especially problematic when it is done in a foreign country, like in the case of this thesis. There is always a risk, that the available time will not be long enough to do the entire research. In my case an additional week in Lund would have been useful in order to do more research in the library of the IIIEE institute.

Time frame also concerns problems emerging during the research trip, since there is a possibility that people with whom interviews had been arranged with have to cancel the appointment, which changes the timetable for the research. There is a possibility that a new appointment during the research cannot be arranged, and therefore the interview is not possible any more. This indicates further problems, such as being able to find a new person, a professional to talk to, and being able to arrange an appointment during the time the research takes place.

The time frame was limited mainly by the costs of living expanses; unfortunately financial issues can always limit the possibilities. The number of interviewed people was also limited by the time period; still it was possible to talk to a few experts in the field.

Mostly all the interviewed people were willing to have an appointment, and were happy to talk about low-energy buildings, policies and other issues. In some cases though it turned out that some companies or people at the municipality were not available in person because of their tight schedule, and therefore they provided information via e-mail, suggesting Internet websites and a few other pages that were most relevant to the topic in their opinion.

I believe that in most cases this information also covered most of my questions, but still meeting with someone in person and having the chance to make a personal interview seems the most effective way to gather the needed data.

At the end I also want to emphasize that a big challenge of doing a research abroad is the foreign language itself. Since I do not speak Swedish I was communicating and also looking for literature in English. Also one of the main reasons I chose to go to Sweden was the high probability of finding literature and being able to make interviews in English as well.

Fortunately communication was not a problem, since Sweden is famous for the very high percent of English speaking inhabitants, but the literature in the field of policy turned out to be very limited. This does not mean that I did not get access to any, because with the help of the researchers in the IIIEE institute I got guidance for literature in foreign language, but it turned out to be less than I expected.

The problems I have been talking about can appear unexpectedly, and have to be taken into consideration in advance. There is no real way to prepare for them, but it is important to remember that some things might go differently as planned, therefore enough time and a reasonable amount of work should be planned for a research trip in order to be able to complete the task and return with a suitable amount of data and information for the thesis.

3.3 Scope of the research

The results and findings are based on reliable scientific textbooks, articles and official websites and a master's thesis from the IIIEE Research Institute. The magnitude originally was planned to be more comprehensive and more in depth, but this kind of research can be continued in the future therefore there is always the possibility to deepen the knowledge. Still, this work should be able to give a general idea concerning the situation and the potential of low-energy buildings in Sweden and Hungary. Certainly finding additional sources relevant to the topic will always help to understand the problem on a deeper level.

4. THE STUDY

4.1 The current state of passive house investments in Sweden

According to the Passivhus Centrum in Alingsås, Sweden it is difficult to say how many of passive houses exist in Sweden so far, since noone knows for sure whether all passive houses are indeed passive houses according to the standards or not. Still, there are certainly several low-energy houses in the country (Hemström 2010).

4.1.1 The current number of passive buildings

To have an idea what is the current situation in Sweden Rebecca Hemström sent me the following inormation by e-mail (the data is coming from March, 2010):

- The number of completed houses
  - 26 single family-houses,
  - 1331 apartments,
  - 103 terraced houses,
  - 1 school,
  - 2 nursery schools.

- Buildings planned or in progress:
  - 18 single family-houses,
  - 1344 apartments,
  - 2 schools,
  - 4 nursery schools,
  - 1 big office.

But most probably even more are in progress without the centre's knowledge. According to Hemström (Passivhus Centrum) the interest among people about passive house and passive house technique is very big, and the Passivhus Centrum gets a lot of phone-calls and e-mails every day (Hemström 2010).

4.1.2 Today's challenges concerning the construction of a passive house - experiences in Sweden

The construction of a new passive building should not cost more than the construction of any traditional house, and the paper work should not take more time either. But it has to be remembered, that the whole buildings sector has not experienced passive house construction yet in the long run, therefore some "learning costs" should be expected (Dybro 2010).

Many people would like to build a passive-house, but some companies refuse the construction right away, because they are still testing and monitoring the measures in those buildings that have been built so far, and it takes about five years to make sure that houses are functioning well. In the opposite case some details have to be changed or further improved. But in 5-10 years the progress should be significant (Dybro 2010).

Interestingly an additional contract has to be made, if someone wants to build a passive-house, otherwise better energy performance than stated in the building code cannot be required. If a community wants passive houses or any other low energy house standard in a new area a new separate contract has to be made when the building site is on sale (Dybro 2010).

4.2 Case studies

4.2.1 The case of Brogården apartments

First I would like to mention a study by Ulla Janson, one of the researchers at the IIIEE Research Institute, whose thesis, entitled *Passive houses in Sweden – Experiences from design and construction phase* was an interesting case study about a newly renovated three-story building in Brogården, where heating, consumption of electricity and hot water was measured. There was a significant difference in the use of electricity and hot water after the renovation, having been more than halved, and heating requirements have fallen from 115 to 25 kWh/m2/year, representing a reduction of approximately 78% (www.passivhuscentrum.se).

The way the 300 apartments at Brogården are renovated is the following: there is supplementary insulation applied, sections of the outer walls will be replacement, there will be new windows and cooling/heating is solved by exchangers. "Accordint to Ing-Marie Odegren, president of the housing company Alingsåshem, the extra costs will be recouped within 6-10 years as a result of lower operating costs" (www.passivhuscentrum.se).

But this is just one retrofitted building from the 1.5 million apartments in Sweden built in the '50s, '60s and '70, and it might stay like that since there is no requirement for climate smart principles to be applied to the rest. Hungary can also present only one good example of a well renovated apartment building so far, which is the Solanova project in Dunaújváros, where the savings are similarly impressive as they are in the case of Brogården apartments. (www.passivhuscentrum.se).

4.2.2 Energy-smart homes in Östra Torn district, Lund

The JM company is a Swedish international construction company well known in Scandinavia, which has set new building standards, which should guarantee lower energy consumption and are therefore more environmentally friendly. Naturally the company is proud of its achivements, but researchers from the IIIEE Institute undermine the success that they claim was achieved. Nevetheless it is still good to see that construction companies do take the challange of improving their systems and building solutions for better energy efficieny, although it is important that the implementation is successful each time a new construction takes place.

The developments the JM company applied to its standards are the following (Hagman 2010):

- Thicker walls
- Better windows
- High quality insulation
- Downstairs floor heating
- Upstairs radiators
- IVT heat pumps – indoor air is used for water heating, if its not enough energy than electricity can be used (for instance, on a very very cold day)

In the new Östra Torn area in Lund 30 new two-floor single-family houses have been built. All of them have already been sold out, and the construction works started in November 2009. As for the building costs, these houses might be slightly more expensive because of the high quality building materials, but at the end the buyer should not feel the difference in the price compared to other houses designed in a traditional way (Hagman 2010). As it was mentiond before the JM company has set its new standards, and they will only built energy-smart homes in the future. Suprisingly the company is against passive houses, they rather see the future in buildings that have somewhat less demanding requirements, but are better designed than traditional ones (Neij 2010). This attitude is rather dissapointing to some of the stakeholders on the research side.

Figure 4 Newly built low-energy buildings, family houses, Östra Torn, Lund

Figure 5

Figure 6 Inside space

Figure 7

4.2.3 Malmö – Western Harbour (Västra Hamnen)

Currently there are many projects going on in Swedens major cities, one of them takes place in the eleventh district of Malmö by the seaside in Western Harbour. This part of the city used to be an industrial area, an oil port, and home to shipyards and many other factories. In the 1970s there was a project to built the world's largest dock there, but unfortunately the oil crisis in 1973 hit the area very badly (www.malmo.se).

Today the production mainly consists of wind power stations, railway carriages and subcontract work, but there is a transformation going on into the direction of premies for offices, exhibitions, commerce and education. Also Malmö University was placed in Västra Hamnen, and today this district has become the centre for the IT industry in Malmö. The district is designed with the help of innovative technologies, and residential buildings are planned in an ecological way, low-energy use is priority (www.malmo.se).

This district has become Malmö's one of most prestigious places, it lies next to the sea and the permanent area now consists of some 350 to 400 apartments. The plans were very ambitious, but as it turned out lately the energy efficiency of the new buildings do not meet the high goals, more than that, they are inefficient in some cases. Evaluations started to take place receintly, the final results are not known yet, but surely it will bring some dissapointment (www.malmo.se).

Although the Western Harbour might not be the most successful project, still it should be remembered that developing well designed energy-efficient buildings is still a big challenge, and there has to be a learning process behind it. Also in this particular case I believe the problems might have occurd at the implementation phase. With time these investments should bring the expected results (www.malmo.se).

Figure 8 The Western Harbour district, Malmö

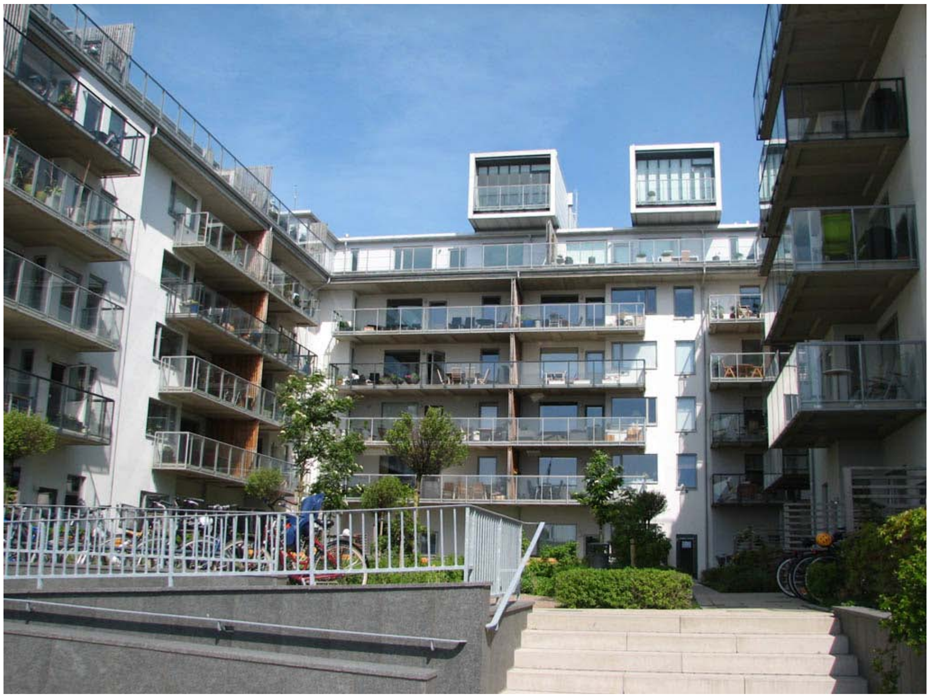

Figure 9 Multi-dwelling houses

Figure 10 Family houses

4.2.4 Passive house in Sándorfalva, Hungary

There are many examples in Hungary, that sow that low-energy buildings start to penetrate the market more and more. One example would be the four-dwelling family house in Sándorfalva in the south of Hungary, which was built by the company called Holcim Kft. This house contains four apartments for young families for rent for a five-year term, and is in the ownership of the local municipality (Vass 2010).

The dwellers could move in December 2010. This environmentally conscious architecture is absolutely unique in the country, but it needs environmentally conscious residents, who follow the needed instructions to ensure the house will function properly. In the passive-house the utility costs are much less, there are solar panels placed on the roof for energy production, the building has its own sewage treatment system, and part of the water network is based on treated rain water (Vass 2010).

Figure 11 Passive house, a four-dwelling building, Sándorfalva, Hungary

Figure 12 Evacuated-tube solar collectors on the roof

The house was built with the help of the Holcim Hungária Foundation

4.2.5 SOLANOVA project in Dunaújváros

For the SOLANOVA project an average multi-dwelling house was chosen in Dunaújváros, because these types of blocks of houses built in the 1970s (with 42 dwellings in this case) represent well the average standard of residential buildings in Hungary. The project is supported by the European Commission (Osztroluczky and Csoknyai 2005). At the moment this is the only deep renovation project that is already available in Hungary.

The goal of the renovation was to reduce the building's annual energy use for heating from 220 kWh/m^2 to 20-30 kWh/m^2, which can be characterised as ultra-low. This goal could be achieved with the help of a thick insulation layer (16 cm) and well insulated windows, also properly designed ventilation and regulation systems. The hot water supply is partly delivered with the help of solar panels that are placed on the wall surfaces (Osztroluczky and Csoknyai 2005).

That particular building's renovation and transformation into a passive-house was part of a research taking place in Hungary, which included technical, economical and sociological investigations as well, where the sociological investigates the residents satisfaction, and their opinion for further improvements. The projects aim is to find the ideal energy, economic and technical solutions for the future. Also, the goal is to prepare recommendations for further support systems that would cure the financing problems arising from the Hungarian ownership conditions (Osztroluczky and Csoknyai 2005).

The construction works ended in October 2005, but the monitoring period lasted for another one and a half years, to get the results of the building's energy efficiency. The evaluation based on the results was very positive, the renovation achieved 90% energy savings, and additionally to that the building received an official certificate from the German Passive House Centre in Darmstadt recognising that the building after the deep renovation meets the passive house standards (Osztroluczky and Csoknyai 2005).

Figure 13 The SOLANOVA project, a multi-dwelling house before renovation, Dunaújváros, Hungary

Source: Osztroluczky and Csoknyai 2005

Figure 14 After the renovation

Source: http://koos.hu/2009/02/07/passzivhazak-es-energiahatekony-epuletek-konferencia-2/

4.2.6 The case of the Regional Environmental Centre (REC), Szentendre, Hungary

Although this case study is not about a residential building that my thesis has been focusing on so far, I still thought it would be interesting to include it, since this particular building is well known all over Hungary, and even though it is a unique construction it turns out it still needs many improvements to achieve the desired efficiency.

The Regional Environmental Centre is famous for its newly renovated conference building and for its biggest solar panel in Hungary that can be found on its roof. The conference Centre was retrofitted in 2008 and now operates as a zero-emission building. The whole building process took two years, but the construction itself lasted for only six months, the rest of the time was spent on getting the construction permits. At the beginning there was little support and belief that an old, very inefficient building could be renovated into a highly energy efficient one.

Unfortunately problems occurred at the construction phase, professionals did not really know how the building functioned, each stakeholder had its own idea what could the problem be and how it should be fixed, which resulted in additional costs and a very difficult complex system that cannot be changed easily any more. Dysfunctions are still being discovered two years after the construction was completed (Bauer 2010).

This only proves that a lot is left to learn about the construction of such buildings, and better constructors and maybe architects would be needed. The evaluation of the energy use has been started recently, so the exact numbers are still unknown, but most probably the building is not efficient enough (Bauer 2010).

Still it was a great improvement, and many data on daily energy use and consumption can be followed on the REC website. The Regional Environmental Centre not only works on projects and programmes but gather plastic, metal and batteries for recycling, operates a compost heap, and encourages its staff to use ecologically sound means of transport (http://archive.rec.org). The daily solar energy production of the zero-emission building is 77.35 kWh, the daily energy consumption is 139.37 kWh and the total daily CO_2 savings are 3.09 kg (http://archive.rec.org/conferencecenter).

4.3 Challenges of energy efficient housing

Based on the previous examples of case studies the following challenges can be summarized. Implementing a new product into the market is always challenging, there are a lot of barriers, and innovation requires innovative thinking from all the stakeholders to make the change possible, which does not mean that barriers will disappear, but with an appropriate approach can be overcome. It takes time, perspectivical thinking as well as willingness to take the risk. (Rozite 2006)

The questions that need to be answered are whether there is capital for R&D (at least in the case of Sweden there is for sure), and whether there are innovative technologies already available on the market. Also, it needs answering what the reason is that innovative systems are not implemented immediately, and why there is a lack of interest for innovation in general. According to Winch and Atkin different causes can be identified including inappropriate innovation models and lack of supplier integration (Winch 1998, Atkin 1999). Also, little is known about the market for environmental innovations in general and first of all there is lack of knowledge about the effects of policies (Markusson 2001). To achieve success in the future networking and learning processes would be essential.

As it was stated before, the buildings sector is very diverse - many groups of different actors with different specialities are working together to create a complete building. The sector can be recognised as a system where the building material producing companies develop products and the construction companies help adapt these new technologies and products into the building projects (Sundqvist 2005).

According to Nam and Tatum, immobility, complexity, durability, costliness and a high degree of social responsibility are the five features that hold back the development of the building technology (Nam and Tatum 1998).

The problem is that there is a learning process that comes with the implementation of any type of innovation, which functions not only in the buildings sector. This process is constant and can take up more time than the time duration of a new construction, therefore implementing new technologies can take some risk, since there is not enough practice behind it. On the other hand new solutions and technological breakthroughs can appear any time, so by the time the new construction is ready it is possible that there would be a better solution already available on the market.

Also the actors are constantly changing and the communication, the information flow among them can be poor or slow. These factors all slow down the process of innovation. Also, the sector often becomes fragmented, and unfortunately it is rather common in Hungary that not only the environmental issues get limited attention but also the governmental approach and bureaucracy make the whole process even more complicated.

Another aspect of the problems of implementation of energy efficient solutions is that, in these countries a majority of the buildings is owned by the government which means that the government itself has a role of a developer and a client as well (Manseau and Seaden 2001). “The buildings sector is typically a home market industry, which is characterised by national traditions, standards and practices” (Rozite 2006).

As an example of good incentives one can mention competition regarding price when it comes to a new product on the market, which can have a stimulating effect regarding economy, and access to new technological energy efficient solutions. It gets much easier once low-energy buildings become a standard (Rozite 2006) although there are also problems regarding inappropriate procurement forms, inefficient methods of construction and management (Rozite 2006).

Problems also concern user behaviour, since in some cases there is no incentive to save on energy when it is well subsidised by the government and the payment is not measured by individual usage. Therefore, for instance, in a multi-dwelling building everyone pays the same amount since the costs are equally distributed among the dwellers, and it is nearly the same amount every month since the bill is a fixed part of the rent. To change that, and to “force” people to change their behaviour, the measurement of individual energy use was introduced, the argument being that everyone pays for his or her share, and people do not pay for others. In most cases the bill people have is smaller then before.

Through individual measurements energy savings can be up to 5-10 % for space heating and 15-30 % for water heating (Nassén and Holmberg 2003). Individual measurements of space and water heating are wide spread in Hungary but the implementation in Sweden is rather limited (Nässén and Holmberg 2003).

In the case of multi-dwelling buildings the problem can be also hidden in the distribution of strength and responsibility between the construction companies, the contractors, the residents and the authorities, since it is not always clear. The law regulations say that the contractor should guarantee the technical quality of the construction and the authorities (the municipality) should only carry out inspections. However, in practice the building company controls often the whole building process for multi-dwelling buildings since the contractor does not have enough knowledge of building technology, law and property management (Nassén and Holmberg 2003).
As for a final comment in this chapter it was interesting to find out that according to Ulla Janson "Sweden will fail to meet the EU requirement of a 20% energy saving in the housing sector through to 2020 unless a climate smart approach is adopted in the renovation of the buildings

constructed during the building boom of the 1969s and 1970s" (www.passivhuscentrum.se). 1.5 million apartments are involved in the renovation project taking place during the next few years, and for such an investment a successful example would be the previously mentioned case of Brogården where heating costs have been cut by almost 80% (www.passivhuscentrum.se).

4.3.1 Public policies in Sweden

Nowadays, because of increasing energy prices and especially since the economic crisis, the interest in energy efficiency seems to be growing, but still, as mentioned before, it is a question of number of factors. To strengthen the situation of energy efficiency the introduction of well-designed policies can be very helpful. In my belief policies should not only ban or forbid certain activities that are harming the environment but should first of all encourage and help people to make decisions towards energy efficient investments.

"Sweden has used various types of public policies aimed at increasing energy efficiency. The country has developed technology development and procurement systems for promoting new technologies" (Rozite 2006). As a member of EU Sweden complies with EU legislation, it had developed action plans for improving energy efficiency in the built environment. Since 2006 Sweden has issued new building regulations with increased energy efficiency demands, and is implementing the EU Directive on energy performance of buildings (Rozite 2006).

The basic objective of the directive is to promote the improvement of the energy performance of buildings within the EU. The directive sets a framework intended to lead to increased co-ordination and harmonisation of legislation between member states in this area. However, the practical application of the framework is primarily the responsibility of the individual member states (Rozite 2006).

"The directive covers four main elements:

1. Establishment of a general framework of a common methodology for calculating the integrated energy performance of buildings
2. Application of minimum standards on the energy performance to new buildings and to certain existing buildings when they are renovated.
3. Certification schemes for new existing buildings on the basis of the above standards and public display of energy performance certificates and recommended indoor temperatures and other relevant climatic factors in public buildings and buildings frequented by the public.
4. Specific inspection and assessment of boilers and heating /cooling installations" (Rozite 2006, EC Directive on energy performance of buildings 2002).

Although Sweden does not have to decrease its green house gas emissions to perform the required expectations of the Kyoto Protocol, still, in 2002 the parliament decided that Sweden would work on reducing greenhouse gas emissions by 4 % during 2008-2012 (Rozite 2006).

Now, after eight years of practice, it would be time to evaluate these measures and see if they have come up to the expectations, and if not, then what could the reason be. Promotion of energy efficient solutions in the buildings sector is hard, especially if we look at the energy efficiency of new buildings, which has in general been increasing in both countries, but the rate of this increase is not near to what could be seen as technically and economically feasible, and in many cases it is even worse than in the case of a 100 year old building stock. These results are rather disappointing, and draw our attention to the problems of energy efficient construction methods (Rozite 2006, Lena Neij 2010).

Also, even though as mentioned before, there is money invested, and has been for the past 20 years, in energy research and development, there is not that much invested into energy use in buildings. It is also the question of allocation of the research funds (Rozite 2006). It is interesting that while there is an increase for public R&D, the share of university research and development financed by businesses has declined during the past years (European Trend Chart on Innovation 2005).

Still, Sweden has a variety of networks and programmes working on energy efficiency in the built environment. For instance, the Climate Investment Programme (KLIMP) as well as the research programme called Sustainable Building (Rozite 2006). What is noteworthy is that not only the municipality or companies initiate demonstration projects, but the Swedish Energy Agency provides funding for demonstration projects as well (Rozite 2006).

4.3.2 Public policies in Hungary

Policies in Hungary that concern energy efficiency including the buildings sector were set along the requirements of the European Union, but it is questionable whether enough support will be provided during implementation and if they will be successfully accomplished on time. All these measures were established and introduced recently, therefore it might be too soon for evaluation, but hopefully they will help also in the transformation towards an energy efficient building stock.

Currently there are two main documents which received parliamentary approval, one of them is the National Strategy for Climate Change (NSCC) [Nemzeti Éghajlatváltozási Stratégia] (NÉS) for the time period between 2008-2025, the other one is the Parliamentary Decision on Energy [40/2008 (IV. 17.) O.Gy határozat] between 2008-2020 (Feiler and Ürge-Vorsatz 2010). According to The NSCC the Hungarian energy consumption should decrease by 70%, and only 5% will be needed of the current heat consumption for hot water production and industrial processes. 40% of the building stock will be operating without any GHG emissions, and the emissions of the buildings built without the passive house technology will also decrease by 75% due to energy efficient renovation programs (Feiler and Ürge-Vorsatz 2010).

Another document, the Strategy for Renewable Energy was accepted in 2008 by the Hungarian government and it sets goals for the time period between 2008-2020 along with the Climate-Energy program of the European Union. The first goal of the document is to guarantee a framework for the use of renewable energy sources and to contribute to the dissemination of innovative technological solutions. Also, the program aims to win social support for energy efficient measures. It determines 13-15% share of renewable energy in the future. The strategy also set out the principles for direct and indirect support for the promotion tools of renewables (Feiler and Ürge-Vorsatz 2010).

According to the guidelines of the Energy Efficiency Action Plan (2008-2016) till 2016 Hungary should cut its final energy use to 15.955 GWh/year (57,4 PJ/year), which means 1.773 GWh (5,38 PJ) energy savings on a yearly basis. The plan mainly supports investments in the areas like the residential and institutional buildings sector, and wants to introduce changes in energy consumption, transportation, in the architecture and construction of new buildings, and in all highly energy intensive products. To achieve these goals further financial sources would be needed, but the availability of these sources is currently uncertain (Feiler and Ürge-Vorsatz 2010).

The New Hungary Development Plan ensures the framework of EU funds for innovation for the Hungarian use between the years 2007-2013. The Operative Programs of Environment and Energy contribute to the reductions of GHG gases, and three of their priority areas focus on the reduction of greenhouse gases. It includes the increase of the use of renewables, energy efficiency and the promotion of sustainable production and consumption patterns (Feiler and Ürge-Vorsatz 2010).

4.3.3 Current problems and challenges

What can be challenging about the buildings sector is that "there is a widespread perception that it is conservative and would rather optimise the system of today than develop new ones. Many believe to already have the best solutions and they are already using the solutions that work best" (Rozite 2006). Still, conservative attitudes may not necessarily be true, although in some cases they can block the development (Rozite 2006).

I n my belief a conservative attitude means rather being precautious than not being opened to new solutions. We cannot forget that the market can be very unstable and is sensitive to many externalities, therefore introducing a new product or technology on the market means a lot of risk in itself. Implementing and promoting innovation from the supply side also depends on the companies' potential, whether it is a bigger one with more capital or a smaller one that is more vulnerable to market fluctuations.

Furthermore, the buildings sector is currently dealing mainly with mainstream requests, and standardised products. It is a large market, so companies do not have incentives to develop new products (Rozite 2006). Moreover, since economic profits connected to innovations may be low since the market for these is limited, there is a tendency to try to sell standard conventional solutions (Rozite 2006).

That is why good policies could give support in more vulnerable cases to ensure that smaller companies could also take the "risk" of innovation, and this way the market could become more balanced, and not dominated by mainly international or foreign investors.

This brings up the problem of access to resources and building materials, which therefore also has to be limited (as there are only a limited number of companies who produce them, it needs capital and means risk), there is the question of access to human resources as well appropriately qualified professionals, who are the base for the project realisation.

An important element could be to introduce clear and long-term policies, which would definitely contribute to stability. "In the case of energy efficiency, long-term policies and programmes enable actors to adapt their behaviour and develop products in accordance with the set rules" (Rozite 2006). However, if policies are short term and shifting their effect will be just the opposite, only insecurities will be increased (Rozite 2006).

What can be quite surprising is that regulations can also block the implementation of innovative technologies and products. When we refer to building codes we immediately think of newly built houses, while the majority of the building stock consists of older houses. The building codes were established a while ago, and they have requirements adjusted to previous times, when practise and features of new buildings were much different than today.

In the United States, for example, it was not possible to built a passive house since the building code required a heating device inside of the house, as a guarantee that the inside space will be heated. To go around that code the heating device first was installed, and then after the whole construction was finished it was taken out. But it is not the way development should take place (Dybro 2010).

The cost of solutions promoting energy efficiency often comes at a higher initial cost than conventional solutions. This is also connected to market conditions and reasons mentioned above, since the whole buildings sector works as a system where every level is dependent on other levels. "However, over time the total cost of the solution may be lower since savings are made. Thus, in a long-term perspective energy efficiency promoting solutions may be cheaper than conventional solutions" (Rozite 2006). The problem is, that maintenance and operation costs are often not included in the calculations, which then raises the question how could they be covered, and if they should be included into the price of rents (Rozite 2006).

Another relevant issue is payback time. It can be problematic when the duration of use is much shorter than the payback period, because in that scenario investments typically do not happen. Duration and payback have to be designed in a way that it does not influence the investment negatively, and it has to be ensured for the investor that investment will be worth it. Still, calculating payback period might be challenging because of the changing market (Rozite 2006).

An additional issue is that the green housing or building concept may be perceived as more difficult to live in or use. It can also be a problem that some energy efficient products are still new and not sufficiently tested, which leads to further problems as they do not live up to expectations and are difficult to handle. Since negative information spreads quickly such cases can be detrimental for the success of future innovation. The source of these preconceptions could be the lack of information about the products and their characteristics; therefore different types of marketing approaches may be needed (Rozite 2006).

As in many fields education on academic level does not prepare future expert with actual practical knowledge, but there is an increasing focus on environmental issues emphasising the issue of life-cycle costs, and long-term thinking. The education system is the base, but there is a lack of holistic approach, and more education, for instance in the form of workshops run by experienced specialists, could help the situation (Rozite 2006).

In most cases researchers are ahead in innovation solutions, but it takes time till the new possibilities get tested and can get into the market. Therefore more emphasise should be put on the importance of the work of research institutes, to be able to explore more possibilities way ahead in time, and to have the chance for the industry to make the new innovations available for everyone on the market. But this requires good organisation, cooperation between the actors and time.

Also traditional building technologies may provide useful inspiration for new products. It may be therefore important to collect knowledge, experience and information concerning traditional building technologies and find the potential of combining them, for instance combining floor heating and solar technology with other traditional methods (Rozite 2006). This type of combination occurs in most cases of the newly built low-energy family houses in Hungary as well as in Sweden.

At first glance finding ways to save energy does not seem to be particularly exciting. As actors have explained, people invest in things that are interesting to them. Therefore, perhaps efforts need to be directed into making the issue of energy efficiency more interesting or trendier (Ürge-Vorsatz 2010).

A general approach is that tax should be put on low energy efficiency, but this may be difficult in the case of building materials. Improved energy efficiency is dependent on the system, how various types of products and elements are put together and how they interact with each other. Therefore the emphasis is not just on the quality features of the materials separately, but rather on the performance of a group of materials used during construction. Thus it cannot be easily defined which products or building materials are actually more or less energy efficient (Rozite 2006).

In Sweden increasing demands for energy efficiency have been integrated into the building code. But on the other hand norms place limitations on innovation possibilities. Or some norms may even favour some sort of solutions not giving the incentive for advertising alternative solutions (Rozite 2006).

Coordination and timing of policies are also very important factors because even perfectly elaborated initiatives may have limited effect if they are implemented at the wrong time. For instance, product development in the buildings sector during times of growth is constrained by lack of time and manpower, as well as lack of funding and security (Rozite 2006).

If we talk about retrofit programs of the existing building stock, it is an area which is not always seen as a process that needs serious investment, in many cases short term goals are targeted and instead of quality quantity is important. That is not a good approach for many reasons. First of all the investment will not give the needed results regarding, for instance, insulation, and in a while renovation will be needed again. Secondly the capital invested will not be paid back, since new investment will be needed shortly (Ürge-Vorsatz 2010).

In spite of all the challenges and effects that may slow down the process of development, my experience so far has shown that energy-low buildings are becoming more fashionable and more and more widespread even in Hungary. Maybe not on the level of single-dwelling houses, but in the case of large office buildings, a good example is the K&H Bank new headquarters' project which is under construction, but will be one of Hungary's most energy efficient buildings, the only one with a gold certificate in the American Lead System (Szalai 2010). Currently the trend in the building industry is going towards functionality, user satisfaction and productivity and fortunately in more and more cases it includes increased environmental concern (Manseau and Seaden 2001).

5. DISCUSSION OF FINDINGS

In this chapter I would like to draw conclusions that sum up and illuminate the discussion presented in the previous parts of the thesis.

As for the construction of new energy efficient buildings, currently there are many products available on the market to choose from to gain increased energy efficiency. Still there are many factors that can hold back the immediate implementation and the use of these innovative materials. To penetrate the market, to achieve the level of "mass production" takes time and good marketing, and also it is the question of demand for such solutions to become widespread and common in use.

One of the main challenges in the buildings sector in general is to be able to keep good connection among many stakeholders that participate in the whole process of the realisation of energy efficient projects. It is enough to think about the payback period, one of the very first issues that appears as a potential problem, since the longer it takes the lesser the motivation to use innovative solutions. In a more general perspective it can be stated that since energy efficient housing is a new type of building process not only higher level of cooperation is needed but also clearer targets and objectives (Rozite 2006).

Improving the energy efficiency of the buildings does not simply mean applying one innovative solution, like, for example, a better-insulated window, and then continue the construction process as usual. Improved energy efficiency is the sum of various solutions; it functions as a complex system. For instance, by improving the air tightness of a building, not only the energy losses will be decreased, but the flow of air as well. This will require a new solution for ventilation, but these changes might also affect other parts of the system. "Consequently, energy efficient buildings are not only buildings that have some products that promote energy efficiency, they are systems in which the interaction between various products or elements has been carefully investigated and assessed" (Rozite 2006).

5.1 The levels of implementation

The process of designing the new energy-low building starts at the architect's table, who has the possibility to develop and propose ideas about localisation, heating and cooling needs, proper building materials, but then when it comes to actual costs it needs to be discussed with the building developer, and proper calculations have to be made, at least preliminary ones, to see if the whole project is feasible. Engineers also carry out calculations (e.g. of the effect of insulation thickness), which is essential to see how the ideas proposed by the architects work out in reality (Rozite 2006).

The implementation of new solutions is also a question of the difficulty of realisation, calculation and control. For instance, even if natural ventilation seems like an effective solution it still might not be applied or even considered because of lack in experience and therefore potential difficulties in control (Rozite 2006).

One side is the project's design; the other one is the implementation part where well-qualified professionals and constructors are needed. Even if the project seems to be perfect the success depends very much on the level of realisation, on whether good materials are used and whether the construction phase follows the project properly and recalculations are made in time if needed.

There are two main issues a company has to be capable of, one is "to be able to provide professionals that can work with new products and new types of designs", the other is to make subcontractors "aware of the need to take energy efficiency into consideration" (Rozite 2006). These are important factors, because any mistake has an impact on the whole system (Rozite 2006).

But even taking all these factors into consideration, still there is risk that the construction will not be in accordance with the energy efficient approach. Unfortunately, the question of responsibility can be easily transferred from one stakeholder to the other, which often complicates the progress of the whole building process (Rozite 2006). But all these preconditions that can be seen as trouble can actually lead to improvements both, in the construction and the realisation phase of a project.

5.2 Policies and building codes

As it can be seen from the previous paragraphs introducing new innovative and energy efficient technologies is always a challenging act, for that reason the government owns a number of instruments to help that process. One of such instruments are policies, which aim at giving guidance and support for further implementation processes. If policies are well designed then they should achieve that goal, but unfortunately in many cases the situation is just the opposite: policies tend to hold back further implementation of innovation.

As it was said before the building codes are the base for all the construction works that take place in the case of new as well as old buildings, but since no major changes have been introduced for the last few decades, in most cases they do not meet today's' requirements. The average standards should be raised from time to time to make sure that improvements take place regarding quality standards, since investors tend to stick to the minimum value that is required and are not keen on improving their work unless the expectations for quality standards become higher.

The key element would be to evaluate the old building codes, since this has not been done properly for a long time, and adjust the requirements for today's houses, building techniques and energy efficiency measures. It is especially important since the responsibility for the reason of high CO_2 emissions has been clearly defined: it is the buildings sector that has a major part in it, and it has to be reduced for many obvious reasons (climate change, energy use, better health conditions in the inside space etc.).

5.3 Findings

As this thesis was written as a comparative study, one of the main questions was if there was any major difference between Hungary and Sweden regarding policies that would act as incentives on the market for further development and implementation of energy efficient solutions, products and technologies. As surprising as it was the result have showed that no major difference can be noticed, there are no specific incentives, subsidies or support systems, neither in Sweden nor in Hungary, therefore the main situation is similar.

Nevertheless, as for my personal observations based on the interviews with various professionals and informal conversations, and based on the research I have done, there are more initiatives taking place in Sweden than in Hungary, and also more programs are running the aim of which is to develop energy efficient building stock. The reason for that difference is the strong academic background and the strong support and co-operation between research institutions and other developers and stakeholders in Sweden. Even though in most of the cases these projects are started on a voluntarily bases to have a sample piece, and starting from that, further developments and corrections can take place.

It was also interesting to find out that the future of low-energy housing is also a question of the openness of the construction companies on the market. For some reason some of them are not willing to raise the standard as high as a passive house quality would require, but are willing to introduce more energy efficient solutions to lower the energy bills for the house in general, and implement it as a new standard level of the buildings built by the company.

As a general comment on the interviews, it was very interesting to me to observe that all the participants had different opinions and points of views on the same question: some of them were really enthusiastic about the possible future of low-energy buildings, while others were much more critical and disappointed with the developments taking place so far.

Stakeholders involved in the construction and design part, like contractors, architects or company leaders, see a much more prospering future for innovation than do researchers working in an academic environment. What they agree on is that there is a learning process that comes with the implementation of new technologies, which takes time, and improvements can only take place once the first versions of energy efficient buildings have been built. It is all the matter of experience and practice.

An additional challenge is the behaviour of inhabitants. Behavioural change in the case of dwellers is very important, since new solutions need new approach and need new conscious use of the low-energy houses to ensure that the whole system works well. But the responsibility also lies on the side of the constructor company to guarantee access to information about house instructions, and to make people pay attention to them. After all, it all serves the comfort of the residents.

5.4 Conclusions

Being involved in a research for a longer time gives the possibility to get a more in depth insight of a topic. In the case of energy efficiency in the building stock I can say that many problems came to the surface only when I had the chance to talk to people involved in such projects in person. Reading relevant literature also helped me realize how complicated and complex the whole buildings sector was.

It takes many steps to achieve significant success in applying energy efficient measures, starting from having well qualified professionals through having access to high quality building materials to be able to make low-energy buildings desirable on the market for customers.

This all has lead me to a reflection that it may be somewhat idealistic to believe that not only the newly built houses but also the majority of the old building stock will be renovated and improved regarding energy efficiency. New standards set by the EU from 2016, that new houses will be built only with low-energy technology is a significant step to take measures into a new direction, but the challenge is still very big.

Still further improvements need to be taken, and innovation and implementation of new technologies should not stop, but significant results will be achieved only when strong co-operation will take place among all the stakeholders on all levels. This takes strong will and belief in future progress, but with the help of technological breakthroughs and proper policies and support for R&D, it is possible.

But it is still not enough, since the implementation of such innovative solutions have to be widespread and available for everyone, not depending on the size of the investment or capital. This requires new technology and products to become widespread and affordable, but then the costs must be well designed at the production stage as well. It is difficult to coordinate, and since every stage is connected with each other then one change in the market can start a chain reaction.

What is mostly needed is access and exchange of information and knowledge, which also includes communication between local and national governments and organisations, as well as between the actors of the whole building process, such as companies, contractors, constructors etc. In addition to that decisions should be made carefully, and decision makers should always be aware of the complexity of the system.

Promotion of energy efficiency in the new construction seems to be particularly complicated since the distribution of costs and benefits between actors is ineffective. In a shorter perspective, there are no obvious incentives for the building companies to invest in energy efficiency and the formally responsible contractors of new multi-dwelling buildings often do not possess the appropriate knowledge of energy issues. Moreover, to the residents energy cost is a small and well hidden part of the total rent and energy efficiency is merely one of many qualities valued in a building. Some of these, such as large glass surfaces, may even counteract energy efficiency. (Nässén and Holmberg 2003).

One of the main changes that have been introduced was the deregulation of the electricity market, which has started competition among the companies and lowered the energy prices. Although from an economical perspective it was an important step, still it made energy efficiency more difficult to achieve due to the same reason, lower prices. This is just one of the examples why the government needs to apply strategies to accelerate energy efficiency (Neij and Öfverholm 2001).

The base is the building code, which would need to be evaluated again. People see the minimum requirements as the maximum they need to do, therefore it is essential for the regulations to be changed and require more and more to ensure future progress. The current state of the market will change in the next 5-10 years, and we can say already today that it is already moving towards energy-efficient solutions. So if unchanged building codes are the base, then not much can be done when the code still says that a heating device has to be installed in the building. Under such conditions a passive house cannot be built (Dybro 2010).

All it takes to make improvements is money and confidence. Usually the younger generation sees the problems first in the system, but they also see the opportunities and they are the driving force that are willing to try out new things, are open to new solutions and are willing to experiment. Just like in many other fields, in general (Dybro 2010).

Effectiveness is a significant issue, because although these houses are effective they still need to be improved. The first passive houses were rather not too efficient. At the moment the passive house is not a standard even in Germany. It is also important to teach the inhabitants how to operate such a building, what it is that they can or cannot do (e.g. in the case of the passive-house certain types of chemicals cannot be flushed in the toilet) (Dybro 2010).

But if policies are bad and the state does not give support either, than how it is possible to built up such a green district in Malmö? Maybe it is simply better that these buildings can get meterialized with the help of voluntary projects, without the money of the sate government. But the question is whether the same approach would be possible in Hungary or not? Will voluntary projects make it possible to start building buildings in a greener way? The question is still opened.

6. RECOMMENDATIONS

When it comes to designing future policy strategies in my belief all the policies that affect energy-efficiency in any way should be evaluated and changes should be introduced in a complex way. "In Hungary but also in Sweden the government will have to develop and implement policy measures for energy efficiency that are cost effective and that suit the deregulated market", because the traditional policy measures used so far "may not be the most effective or even desirable alternatives" any more (Neij and Öfverholm 2001).

As it was well summarized in the article entitled *Strategies for improving energy efficiency* written by Neij and Öfverholm (2001) there are a few measures that can be taken to achieve higher energy efficiency, like expanding the market for energy efficient products including better technology procurement and obtaining better products. Also building codes need to be evaluated and changed if necessary to match the needs of the 21st century, and well-targeted R&D is needed to pave the way for even more efficient products and systems (Neij and Öfverholm 2001).

According to Neij and Öfverholm (2001) the following steps should be established regarding future policy measurements:

- Certification systems,
- Standard contracts,
- Measurement and verification protocols,
- Constant monitoring, and
- Evaluation of the policies (Neij and Öfverholm 2001).

The improvement of policies is currently one of the major tasks, and in order to avoid unexpected problems in the future the evaluation of policies on a regular basis would be important. Applying this practise ensures constant monitoring of the whole instrument, and this way the supervision of accomplishments and needed further developments is easier. As an additional asset, the results of evaluations work as guidance for policy makers.

It is important to notice that evaluations of innovative policy measures may require also the development of new evaluation methods. In particular, such new evaluation methods should include not only estimated savings, but also parameters to describe technology development, market development and changes in the behaviour of various players (Neij 1999, Lund 1999, Lund 1996).

Energy standards for buildings should ensure a low maximum level of energy use per floor area. The current standard is not based on the total function of the buildings (kWh/m2/yr); therefore the numbers in fact show only the technical performance of components (e.g. W/m2K for windows). In addition to that the system is flexible enough to let some of the components to be of worse quality if other parts are of better brand (e.g. windows are allowed to be worse if the roof is better than the standard level). All these measures seem to lead to a situation where it is not guaranteed that the end result will provide adequate information regarding the actual efficiency of the building stock (Nässén and Holmberg 2003).

"In Sweden the Climate Committee suggests a tightening-up of existing standards for new buildings. It is suggested that the current standard of 130 kWh/m2 should be reduced to 110 kWh/m2 by 2003, to 90 kWh/m2 by 2010, and to 60 kWh/m2 by 2020" (Neij and Öfverholm

2001). These figures include heating, domestic hot water and electricity. As for the existing buildings the best potential is in changing the windows, insulation, energy-efficient lighting and implement an efficient heating system. It is also true in general that heat pumps, windows, lighting and ventilation have a great potential to be improved and exchanged for energy efficient solutions. In general the aim is to reduce domestic energy use (Neij and Öfverholm 2001).

To generate faster changes, it would be reasonable to introduce energy standards for those buildings as well, which are renovated. Standards for retrofitting are also included in the new Energy performance of buildings directive (2002/91/EC) from the European Union (Nässén and Holmberg 2003). A good example of a new deep-renovation program is the recently accepted Hungarian project directed by professor Diana Ürge-Vorsatz from the 3CSEP Research Institute.

An already existing example also in Hungary is the SOLANOVA project in Dunaújváros, where a multi-dwelling building was renovated with the help of high quality insulation materials and an energy efficient heating system together with new windows and doors. The investment was so successful that the building received the certificate from the Passive House Institute in Darmstadt, Germany since its energy use became very low.

Giving recommendations is a hard task, since the topic of energy efficiency, innovation and related issues is very widespread, and it evolves continuously. This makes the whole process of the research more complex, and requires constant monitoring of the latest improvements and newly introduced policy measures including also future plans of the governments regarding the buildings sector. Therefore the research should be continued and the findings should be upgraded in the future. The results presented can be insufficient because of the limited time frame, and also the magnitude of the research could have been extended, but still this thesis presents valuable information as for the current state of energy efficiency in the buildings sector in Sweden and in Hungary.

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