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EXPERIENCE AND LESSONS LEARNED FROM WESTERN EUROPE AND FROM CEE COUNTRIES ON BEST PRACTICE EXAMPLES OF ENERGY SAVINGS IN BUILDINGS

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FOREWORD

In the year 2002 European Parliament and the Council brought on the table new directive which set out a new discourse for Member states on low energy consumption related to a building sector. New policy discourse and its implementation on the local level brought fresh impetus to and it's becoming a driving force triggering an action and what is more important, it is influencing all actors which are engaged to the building sector. Besides mentioned influence on policy arrangements on national and regional level, influence on all actors, influencing behaviour of variety of housing users and owners, it is enforcing maximum energy performance of buildings, while maintaining the lowest energy consumption level through the efficient technical measures.

Overall goal of our work package is to bring technical solutions supporting maximum energy performance of buildings for CEE countries and moreover, to complement the work of INTENSE project.

Within the framework of the Intelligent Energy Europe funded project, "From Estonia till Croatia: Intelligent Energy saving Measures for Municipal Housing in CEE – INTENSE" we are pleased to present the first deliverable of the work package 3 - "Experience and lessons learned from Western Europe and from CEE countries on best practice examples of energy savings in buildings".

INTENSE team members

Table of Content

Used Abbreviations

CEE – Central and Eastern Europe
CEN – European Committee for Standardization *(Comiteè Eurepèen de Normalisation)*
EPBD – Energy Performance of Building Directive
EU – European Union
e.u.z. – energie + umwelt zentrum (energy + enevironment centre)
IEPD – Inštitút pre Energeticky Pasívne Domy (Passive House Institute)
MCRD – Ministry of Construction and Regional Development, Slovakia

List of Figures

List of Graphs

List of Pictures

List of Tables

1) INTRODUCTION

According to the Directive 2002/91/EC of the European Parliament and of the Council directive *the best practice should in this respect be geared to the optimum use of factors relevant to enhancing energy performance* (European Parliament, 2002).

One of the aspects to reach the goal of improved energy efficiency is the technical measures which the level of the performance is dependent on. Additional value of the overall INTENSE project is that all of the relevant aspects concerning energy efficiency are not considered solely, but are linked to others from legislation through holistic planning, to trainings and work with the general public.

Recently, there has been increasing demand for energy supplies in order to keep residential, commercial and/or public buildings and their overall inner-living environment comfortable. According to studies, the building sector is emerging as the biggest potential for energy savings. Therefore, to reach the maximum energy performance of buildings, while maintaining the lowest energy consumption level, requires a combination of various technical measures ranging from a building's foundation to its roof construction. In some cases, small technical changes can cause a huge difference in energy consumption. To explore these technical potentials, there is an activity as a part of the INTENSE project trying to bring better understanding to how technical measures can help us reach the overall goal which is – "saving energy".

The background paper on lessons learned from Western European countries, elaborated within the framework of the INTENSE project is bringing the overview of the best practices with respect to technical measures. The target group, or better said, the final users of this information can be subdivided in two major groups:

- The first, it is closely linked to other activities of the project and it is providing important knowledge for all 28 project partners;

- The second group is the larger family of professionals at the building sector and energy professionals at municipalities whom this knowledge will be transferred through the national seminars.

Proceeding of the background paper, firstly, all required background information has been assembled by literature review and by the assessment of already implemented projects and through the expert consultation (e.u.z.;

Auraplan[1]; and others). The conceptual framework preparation phase was mainly focused on information gathered from already implemented projects and their success became the source of important knowledge.

Our goal within the framework of the project is to demonstrate best practices which ensure that buildings and their energy systems are operated at their optimal designed efficiency and that the building is reaching its lowest energy demand. Therefore we have searched throughout projects which are successfully presenting technical measures maintaining low energy demands as passive house standard or in some cases low energy standard.

[1] *Auraplan* GmbH – it is the German architect and consultation Limited Company with expertise on planning and energy efficiency, they are partner in INTENSE project.

2) FRAMEWORK OF THE BACKGROUND PAPER

"*Best Practice*" is a superior method, innovative practice and or using of innovative material that contributes to the improved energy performance of a building, usually should be recognized as "best" by other more practitioners. In our understanding, the best practice should be proven by real physical calculations. It implies accumulating and applying knowledge about what is working and not working in different situations and contexts, including lessons learned and the continuing process of learning, feedback, reflection and analysis (what works, how and why).

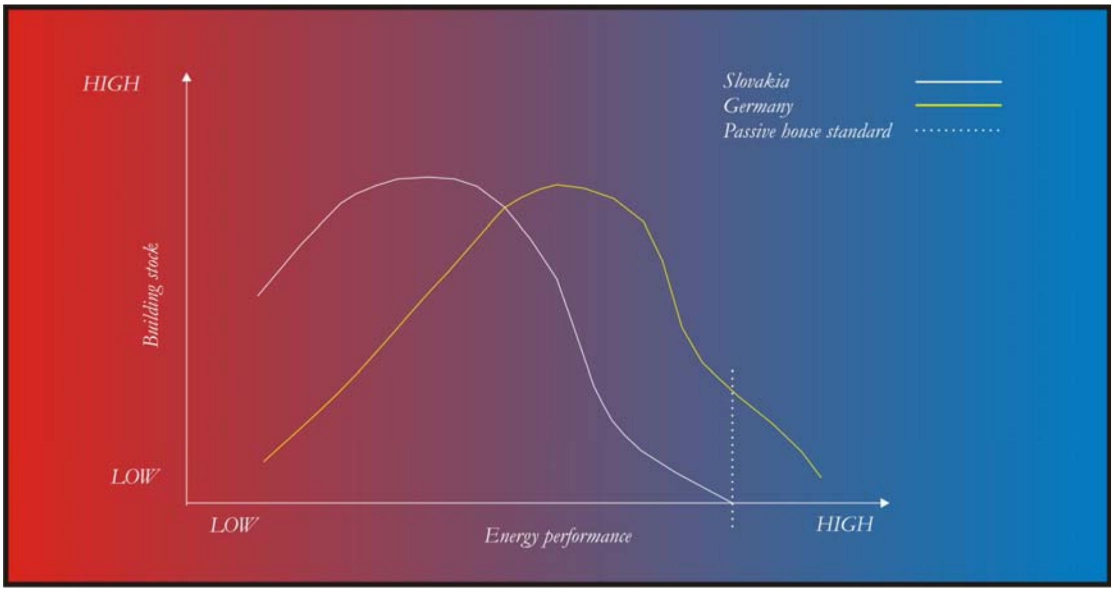
Methods and techniques that have consistently shown results superior to those achieved with other means, and which are used as benchmarks to strive for. There is, however, no *"universal cure"*, in other words practice that is best for everyone or in every situation, and no best practice remains best for very long as people keep on innovating and progress of doing things.

To pick up the right best practice options, we have had to go through the plethora already successfully implemented projects and to do appropriate assessments we set up the basic conditions which has been deemed while choosing the best practice options. On the one hand, we are aware about what do we expect from the best practices – conditions on the other hand we considered what are the boundaries of the background paper.

2.1 Condition of our best practices

THE BEST PRACTICE in energy savings – is the most used term in our work package, and therefore it was the crucial to bring the understanding how this term will be used through the all activities. The first, it is any kind of technical measure which can secure or decrease an average heating demand which is usually expressed as a kilowatt hour per square meter of the building.
For selection of the best practices following conditions are considered:

- **It is proven by real results** (existing building and energy consumption recorded and monitored);
- **It can be used as a benchmark** (expressing a level of quality which is possible to use as a standard and easily replicate and there are not considerable constrains such as technical high-end or extreme costs fro technology);
- **Successfully implemented and not just blue print** (commonly used in Western countries and not at the stage of a pilot action);
- **It is expressed in energy consumption of the buildings** (different technical approaches adjusted to climate conditions will incorporated in adaptation concept);



Graph 2.1: The frequency distribution of housing stock in different heat energy standards (Data source Slovakia: The Ministry of Construction, 2008; Data source Germany: Auraplan).

Setting conditions for finding "the best" and to decide what to present in lessons learned, the first we need to prove our self that passive house standard is the right way. Graph 2.*1* simply sketches the frequency distribution of energy performance of buildings from very low (≥ 200 kWh/m^2.year of heat energy demand) to high energy performance of building (almost none heat energy demand) on the background of comparison between Slovakia and Germany. It has to be emphasized that this graph it is a quantitative reflection of mentioned performance and input data for Slovakia refers to building stock excluding family single houses and are from the year 2007 (MCRD, 2008). Therefore, a passive house standard equals to zero. More importantly, the graph is proving that presented standard from Western Europe (in this case Germany) is not just a pilot action a that chosen standard has all conditions set out for a best practice.

What is recently known as a best practice option is still very rare in CEE countries and in the form of pilot projects. According to Passive-On (2007b), the passive house standard in Western countries is becoming more common. Based on this lesson learned we need to set out on one hand best practice but then we need to be aware that it is not only in the stage of pilot actions with low share at the market.

Lesson learned from Kronsberg (Germany)
Kronsberg district was built in 2000 on the outskirt of Hannover as a residential area which aimed to fulfil Agenda 21. They erected around 3000 new houses. Besides other goals, to reach the status of

ecological city, one of the main concepts was the concept of energy efficiency in buildings. In a new area, in 2000 they reached average consumption 56 kWh/m^2.year, in that time it was 42% less than conventional buildings. Moreover, they built up 32 single (also simple) family houses in passive house standard (Czorny, Rumming, 2007). When they planed to build up the Kronsberg district the best practice in terms of energy consumption was 50-60 kWh. Now after 10 years they claimed that it is not that interesting anymore and they would go for lower energy performance. It is proving what we stated concerning the best practices, what is known as the best recently tomorrow can be just a standard.

Boundaries of our best practices:

- *"Not everlasting"* –what we see as a best practice example today – doesn't need to be tomorrow (this is limitation of the best practices);
- *"Universal cure"* – that not a single measure will solve the problems with energy consumption, but complexity of measures can enhance energy efficiency in buildings.

2.2 The scope of background paper

Recently, when we go through the possibilities to enhance energy savings in buildings one can end up with the term "passive house". It is not anymore only the modern and expensive way of living but in last ten years proven by experience in many countries in Europe that this is the way how to reduce energy consumption in buildings. As one of the barriers can be seen higher construction costs, according to Krajčovič, Martin, Pifko (2007) it can be between 10 – 20 percent higher than expenses spent on conventional building. Antonov (2007) states if you go very green, it will cost 5-10 percent more than conventional building.

Contrary, according to studies, to apply sounds technologies and build up a building in a passive house standard, whether single family house or block of flats, does not increase costs dramatically. Moreover, it doesn't need to be futuristic creation looking sky-high expensive. Nevertheless, one could expect rise in construction price but it should be payback in savings for energy costs. In new residential area, in Frankfurt, the main motto promoting newly erected passive houses was "no heating costs anymore". Moreover, they claimed that construction costs were a little bit higher, about 3 %, than construction costs of conventional building.

Generally, "passive house standard" is expressed via heating energy demand per square meter of a house and primary energy demand.

In definition**, a passive house** is a building in which a comfortable interior climate can be maintained without active heating and cooling systems. The house heats and cools itself, hence "passive". The annual heat demand for passive house is very low - in the middle of Europe about 15 kWh/m^2.year. The need for total primary energy use should not exceed 120kWh/m^2.year, including heating and cooling, domestic hot water, and household electricity. (Faltin, J., von Knorre, Ch., 2009). Although this is generally recognized standard given by the German inventors Wolfgan Feist and Bo Adamson of the passive house, in some countries it can be 17 kWh/m^2.year like in France (Passive-On, 2007a) or even lower as in Spain, 5,8 kWh/m^2.year (ibid).

For better understanding and to reach broader audience, in Germany it is common to use expression in "a car fuel" consumption. This concept is often used in education seminars of the "*e.u.z.*". The comparison is made between the car fuel consumption per 100 km and a building energy demand. Then heating consumption is expressed in litres of crude oil consumption (demand) per square meter and year.
That means for example: a new house with heat energy consumption about 100kWh/m^2.year equals to oil consumption 10 liters/m^2.year (expressed in natural gas, it is about 10 cubicmeter/m^2.year).
In a simple calculation if one lives in a passive house with a living area 100 m^2 than spends annually amount of oil which allows to get from Vienna to Riga, but if one lives in a conventional house in any CEE country you are "wasting" the same amount of oil which one could use for a trip to Beijing and back. This explanation is making technical expressions more tangible and it will be used within the framework of the work package 3.

To construct a passive house one should consider: compact form and good insulation; southern orientation and shade considerations; good air tightness of building envelope; passive preheating of fresh air; highly efficient heat recovery from exhaust air; using an air-to-air heat exchanger; hot water supply using renewable energy sources; using energy-saving household appliances. The design of passive houses is a holistic process of planning and realization. It can be used for designing new buildings or for energy renovation of existing buildings. Group of pictures is showing different types of buildings from a single family house to the dwelling with 171 apartments, but with a common feature, all of them are in passive house standard.

Picture 2.1: Different building types but reaching the same standard – passive house standard or low energy standard (A,B,C,D pictures explanatory note is bellow)

Explanatory note to a group of pictures (See: Picture 2.1):

A. Single family house in the Kronsberg district (Hannover, Germany), constructed 10 years ago;
B. One of the houses which has undertaken refurbishment in Stichworten (Germany) in NeuErkerode foundation. House on the picture - Elm House was built in 1972, energy consumption before retrofitting was 330 kWh/m^2.year, after they reached 80 kWh/m^2.year. Even though it is not passive house standard they decreased energy consumption by 75%;
C. An example of applied technical measures at the building which is protected by the law on cultural monuments. EUZ building (Springe, Germany), built in 1928 and now protected as a cultural monument;
D. Construction site of new passive multi-storey buildings in Hansaallee (Frankfurt, Germany), nine buildings with 171 apartments are under construction.

The scope of the background paper is generally subdivided into *inner part* and *outer part* of a building and there is considered mainly technical aspect of the passive house construction. As we pointed out, we dealt with the two insights into a building and two different approaches are examined. Mentioned approach we have attempted to visualize. Abstractly, it implies what we have taken into consideration while presenting lessons learned from Western European countries. (see *Figures 2.1 and 2.1 bellow*).

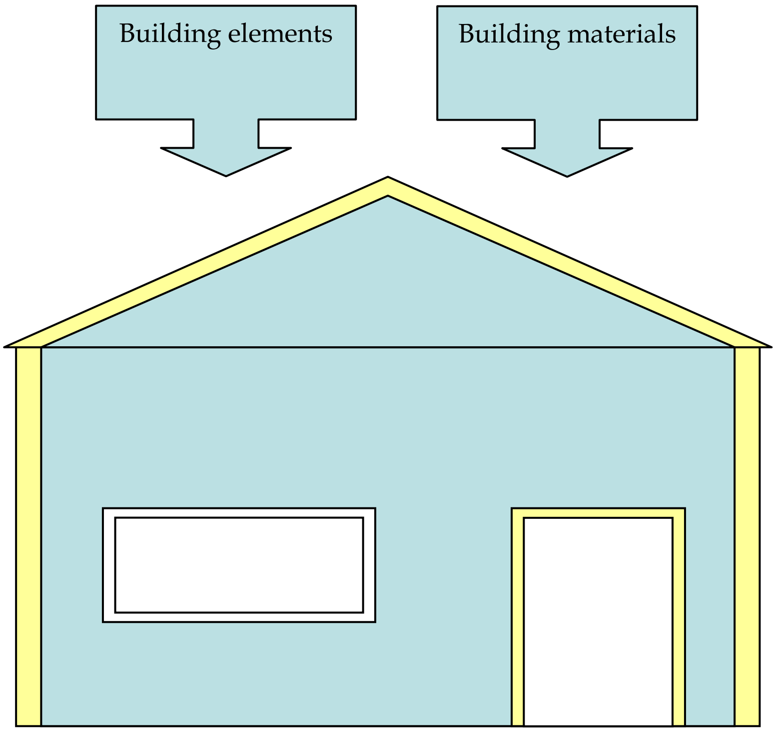


Figure 2.1: Approach to describe the best practice examples – outer part of the house (envelope, windows/doors, roofs, foundation, airtightness).

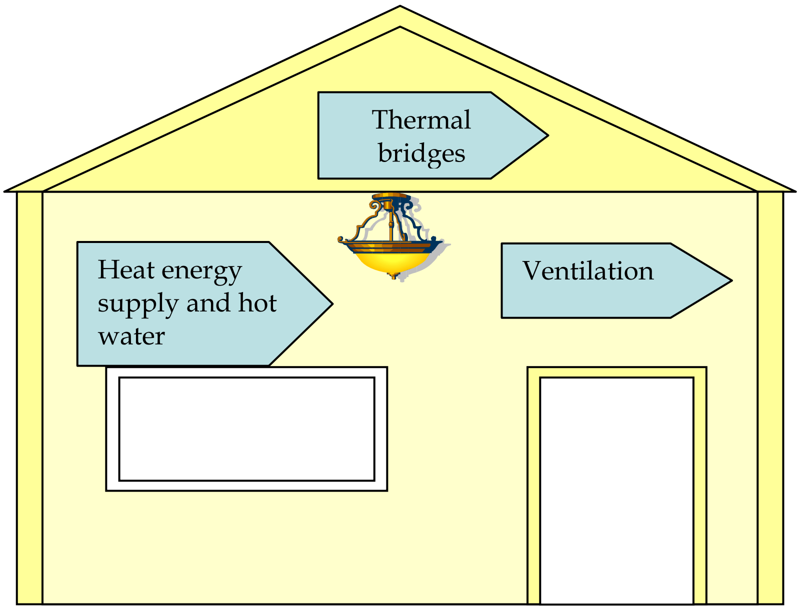


Figure 2.2: Approach to describe the best practice examples – inner part of the house (ventilation system, heating and cooling, thermal bridges).

3) METHODOLOGY AND USE OF THE BACKGROUND PAPER

In the preparation phase relevant information were collected from the relevant literature sources and web sites concerning the best practices with respect to energy performance of the buildings and arrangement enhancing the energy efficiency and sound technical solutions. This background information is becoming an outline for the further work in finding solutions for CEE countries and for the assessment of the technical possibilities.

The source of information for the best practices options can be three folded:

1. Assessment of relevant EACI implemented (or ongoing) projects;
2. Assessment of other EU funded projects which are innovative and demonstrative (e.g. LIFE projects);
3. Assessment of applied projects which stemmed from local or regional initiatives and which became pioneers in low energy buildings; they were selected according to expert consultation (Hanover/Krönsberg; Malmö).

Simplified approach to the building	*Element or technical aspect*	*Covered in a selected project*
Outer part	*Floor slab*	*Lessons learned are selected from implemented projects or local initiatives*
	Walls	
	Windows	
	Doors	
	Roof	
	Airtightness	
Inner part	*Ventilation*	
	Heating energy and hot water	
Technical specification	*Thermal bridges*	

Table 3.1: Operationalisation of the concept - 'Assessment of lessons learnt from Western European countries and from the CEE countries'

The table 3.1 (above) is narrating the steps how to operationalise of the multi-dimensional concept of lessons learnt and best practice on passive house in Western European and CEE countries. The assessment of already implemented projects is crucial and therefore we distinct its dimensions in all chosen cases. More importantly, in the analytical part of the background paper this table was more elaborated in details and subdivided and indicating which project is covering which topic. As was stated before, passive house

standard was considered as the best practice option and to be able simplified and generalized mentioned concept we basically divided insight on the building what you can see from outside and what you can see inside. Accordingly, there are listed technical solutions based on lessons learned. Very similar approach but from different perspective (retrofitting of old building reaching passive house standard) was used in the EACI project "New4Old".
The "New4Old" used this concept in the way how new technologies can be applied in/on old historical buildings (3E, EREC, et al., 2009). In our methodology this approach has more idea of generalization of huge amount of information related to construction works maintaining passive house standard.

4) EXPERIENCE AND LESSONS LEARNED

To bring the "*BEST*", best practices all over the Europe, it was scanned more then 80 implemented projects (48 EACI, 13 LIFE project, app. 20 local and regional initiatives).
With regards to EACI projects (48 projects), the majority was focused on old building stock and retrofitting. We found inspiration in more than third of EACI projects which are complex and they are covering variety of topics ranging from legislation, through technical aspects to passive house standard promotion. The other third of projects touched the problem of energy certification from different aspects. The results from more then 10% of these projects we found highly relevant for our work and for promoting technical solutions which are maintaining low energy standard and lessons learned are delivered to the INTENSE target group.

4.1 Projects overview and lessons learnt on passive house as the best practice

Project "Promotion of European Passive houses" (Strom, I., Joosten, L., Boonstra, Ch., 2006) reports presents an overview on passive house solutions for new built residences applied in the partner countries. The most common basic solutions, e.g., the performance of the thermal envelope, such as high insulation of walls, roofs, floors and windows/doors, thermal bridge-free construction and air tightness have been described in further detail, including the extent to which solutions are applied in common and best practice and expected barriers for the implementation in each country considered. Most frequently encountered barriers in partner countries were identified as limited know-how, limited contractor skills and acceptation of passive houses in the market. Suggested approaches to overcome barriers include providing practical solutions to building professionals, providing practical training to installers and contractors and communication about the passive house concept to the market.

Project "*The Passivhouse standard in European warm climates*" (Ford, Schiano-Phan, Zhongcheng, 2007) reports review technical passive house standards and presents examples of how this standard can be applied in the five project partner countries (France, Spain, Portugal, Italy and the UK) under climatic and socio-economic conditions there. The national proposals were formulated by reference to the standard typology of a semidetached three-bedroom house. This was adapted and optimised from the design point of view in order to achieve the required level of comfort and low energy demand. Performance analysis of the proposed options was undertaken with the aid of dynamic thermal simulation; however, it was not possible to use the same simulation tool across the group. The analysis aimed at exploring the ranges of heating and cooling demand in the various locations and the feasibility of the proposed standard. The exercise revealed that heating loads are relatively low in many southern European countries and generally stay below the $15kWh/m^2$ mark. Comparatively, however, they are marginal to other household energy requirements such as water heating, lighting and appliances. It emerged that in many cases there are cooling loads to take into account but that often these can be met by passive strategies alone. This has lead to a wide range of design solutions reflected in the national proposals described hereafter. These show that it is possible to design low energy comfortable homes adopting a raft of appropriate solutions which can avoid the use of active cooling in many locations.

Project "European high quality low energy buildings" (Euleb, 2007) intended to provide information on good examples of energy efficient buildings in use, in order to reduce prejudices, like mistrust the real energy efficiency in use, the quality of architecture, the user comfort and the cost effectiveness and to eliminate the lack of knowledge on energy efficient buildings of many key actors in the building market. A total of 50 public buildings have been identified. To cover the large variety of climatic conditions in Europe, buildings from the very far north (Scandinavia) as well as from the very south of Europe, (Mediterranean countries), were included. For the selection of buildings a simple evaluation system was designed. In this first step, each building was evaluated concerning its qualification to the project. Seven categories (such as quality of architecture, energy consumption, availability of monitored data etc.) with different weightings were used. This process led to the selection of 25 buildings from all over Europe.

Although, our attention is more focused on residential houses, we also found inspiration on technical solutions in a project which demonstrates that the 'Passivhausstandard' (energy efficiency standards) can be used in the construction of a multifunctional, multi-storey administration building. Besides used technologies which brought saving of energy, this project applied ecological construction material and eco-efficient materials. They made timber construction administrative building (ca. $2000m^2$) according to the 'Passivhaus' energy efficiency standards ("Christophorus Haus"), and moreover they established a demonstration site for ecologically friendly construction techniques within the project consortium and its network.
This is an advanced aspect to use local materials (e.g. timber), reaching high ecological status of the building and not only energy saving. The same concept is forced by the "energie und umwelt zentrum" in Germany in their trainings and seminars. Although this is not a scope of our background paper this advanced aspect is necessary to mention.

Country	PEP project	Passive-On	EULEB
Austria	*		
Belgium	*		
Denmark	*		
Finland			*
France		*	*
Germany	*		*
Greece			*
Ireland	*		
Italy		*	*
Malta			*
The Netherlands	*		
Norway	*		
Portugal		*	
Spain		*	*
Sweden			*
United Kingdom	*	*	*

Table 4 .1: Western European countries and their experiences in projects related to the enforcement of the passive house standard

An importance of presented cases from Western countries and their involvement in projects can be nicely sketched via simplified *Table 4 .1.* We have chosen by chance (from projects related to the passive house) three projects and it can be observed eminent interest in enforcement of the energy saving measures in these countries via project implementation. Next to the quantitative expression when we juxtapose their results presented in further chapters, there are no doubts about our intention about introducing of lessons learnt in CEE countries.

With respect to analysed project, passive house standard as the best practice is reflected in 16 countries all over the Europe in different climate conditions, what will be important for the INTENSE project due to possibility to replicate it in countries from Estonia to Croatia. Our expectation is that different climate zones and conditions require also different technological solutions. There has to be emphasized again, that there will be difficult to find mentioned "*universal cure*" and this will be more elaborated in adaptation concept but the report from the Passive-On project (Passive-On, 2007) proving that it is not always necessary to use advanced (expensive) technological solutions to assure high energy performance.

4.2 Building elements and materials

With this respect our attention is paid to the three main criteria mentioned above to make an order for a vide variety of users of this background paper. Presented lessons learned (best practice options) refer to different technical aspects and are divided into two major groups as a follow:

Our approach in presenting lessons learned	
Outer part of the building	Inner part of the building

4.2.1 Outer part of the building (building envelope)

Simply, the building envelope can be described as an outer shell consisting of floor slab, outer walls, roof, and windows and compactness of this shell is a very important precondition with regards to passive house, preventing the heat loss.
According to Bastian (2009), there are five basic principles (or elements) which are important for a passive house and four of them are directly linked to the performance of the building envelope. There are as follow:

1. *Wall, roof and floor slab thermal insulation with U-values: U ≤ 0.15 W/(m²K);*
2. *Three pane windows Ug ≤ 0.8 W/(m²K);*
3. *Air tightness of a building n50 ≤ 0.6 /h;*
4. *Applying measures avoiding thermal bridge effects ψa ≤ 0.01 W/(mK);*
5. *Mechanical ventilation system with heat recovery η ≥ 75%.*

The first four of mentioned five basic principles are elaborated more in following subchapters which concern building envelope. The fifth one *„Mechanical ventilation system with heat recovery η ≥ 75%"is* described separately in a subchapter *4.2.2 Inner part of the building*.

Walls

According to variety sources (Ford, B., Schiano-Phan, R., Zhongcheng, D., 2007; Strom, I., Joosten, L., Boonstra, Ch., 2006; Urbášková, 2008) the thermal envelope of a passive house, seems to be as the most important aspect to reach the passive house standard and it includes both, excellent wall insulation in order to minimize the heat loss through the envelope. The most common expression is via U-values[2].

According to research of Strom, I., Joosten, L., Boonstra, Ch., (2006) the passive houses standard in Western countries is usually reaching U values in the range between 0.09 to 0.15 W/(m^2K). As it is emphasized in Urbášková, (2008), not just thickness and material of applied insulation is important but the quality how it is applied on the building envelope. If there are gaps with the air then it is place for thermal bridges.
According to applied technologies in CEE countries the construction materials for walls and insulation materials have the same values, but high quality materials require careful installation for effective performance and this factor is sometimes underestimated. On the group of picture bellow are shown different kinds of used materials, but these are just samples of a range of wall insulation materials.

*Pictu**Chyba! Nenašli sa žiadne položky zoznamu obrázkov.**re 4.1: Different types of insulation applied in Germany (A,B,C,D pictures explanatory note is bellow)*

[2] The U-value expresses how much heat is transported through one m^2 of the construction at a temperature difference of one degree between the inner and the outer side of the construction. The lower U-value the better insulating property. The unit for U-value is W/m^2K (K=Kelvin-degrees) and is a result of the thermal conductivity and the thickness of a material. The U-value is therefore improved by both choosing a material with a low thermal conductivity (good insulating property) and by increasing the thickness of the material. (Bramslev, S., Hammer, E., A., Synnefa, A., et.al., 2009).

Explanatory note to a group of pictures (See: Picture 4.1):

A. Polystyrene insulation, very commonly used in CEE countries (Seminar centre e.u.z.);
B. Mineral wool insulation (Seminar centre e.u.z.);
C. Timber construction ready for cellulose insulation (Refurbishment of the building from the 50's „Rotlindstraße" Frankfurt, Germany)
D. An example of cellulose insulation, it is composed of 75-85% recycled paper fibre (Seminar centre e.u.z.).

While choosing appropriate insulation and material, thickness of the material there might be considered climate conditions.
For example in Portugal, in hot climate conditions to reach the passive standard it was sufficient to apply insulate n 100mm of insulation are proposed for the roof and exterior walls, with U-values of 0.23 W/m^2.K and 0.32 W/m^2.K (Ford, B., Schiano-Phan, R., Zhongcheng, D., 2007).
Contrary in mild climate conditions, in the UK, according to Ford, B., Schiano-Phan, R., Zhongcheng, D., (2007a), U-Values ranging from 0.2W/m^{2}K to 0.15W/m^{2}K for walls and roof respectively.

Windows and doors

When we look on the building from outside, as the one of key elements, there are windows with multiplied functions. The main functions are illumination of the house and also commonly used for exchange of air in ventilation, the latter one in a case if we don't speak about passive house. In order to ensure passive house standard the U-value of the window needs to be under 0,8 W/m^{2}K (Strom, I., Joosten, L., Boonstra, Ch., 2006). But again, there has to be emphasized that climate condition needs to be taken into consideration.

As it was stated in New4Old project (3E, EREC, et al., 2009) the windows are reaching usually higher U-values than outer walls of the building. In construction practice they are considered as a weak point with regards to the thermo-technical characteristics of a building. Moreover, building materials (for windows) and application techniques preventing the heat loses which guarantee air tight junctions between window frames and wall constructions are getting common in Western European countries just last decade.

Although in the PEP project claimed that triple-glazed window was not common standard (Strom, I., Joosten, L., Boonstra, Ch., 2006) (e.g. in the Netherlands in average windows have U-value about 2,4 W/m^{2}K), recently it is becoming standard in construction works in Germany, especially in house targeting passive house standard. According to German experts, paradoxically, or maybe not, to purchase a single pane window would be more expensive that to buy double-pane window (due to mass production and high demand on the market). The same tendency can be observed in CEE countries. As was described at the beginning of the Windows subchapter not only window pane plays here significant role. For production such a window more expensive manufacturing techniques are used and for instance, the gas krypton substituted argon (Brinkley, 2008).

Picture 4.2: Best practice example of applied triple glazed window in apparment house in Hansaallee in Germany. Important is technical detail of the frame insulation preventing heat losses.

The German experience from Hansaalle (Frankfurt), reaching U-value 0,76 W/m²K in Windows. The windows are prefabricated insulated construction (80-100 kg weight), which avoids thermal bridges; they are fixed to the walls but lays within the insulation layer. The glazing is triple as the space between glasses is filled with krypton (U-value 0,76).
The same technique is presented at the picture 4.3 as a practice which was used on a brand new hotel in Slovakia.

Picture 4.3 The same example, but from the CEE countries, brabd new hotel recently built in Bratislava (2009).

Considering doors as the one of elements usually in perception of people have more safety reasons than thinking about prevention of heat losses. It is not that astonishing, although in complexity of applied measures the doors should be considered. On one hand we have complexity which is forcing us to consider every element on the other hand usually each house or a unit in apartment house in most cases has only one entrance door. Nevertheless, there are solutions preventing heat loses from the entrance door or if we will include also into discussion doors inside the house or flat, then can be also presented best practices ensuring inside ventilation through the door frames.

Roof

There are no doubts, that as other elements which are part of the building envelope might be also well and proper insulated wall can maintain energy efficient performance of a building. Generally, in winter well insulated roof is contributing to reduction of heat energy demand and in summer times it is reducing summer heat load.
The passive houses according to climate requires different thickness of insulation but generally, in a mild climate zone U-value of the roof will be below 0,3 W/(m^{2}K) a colder regions roof needs to reach 0.1 W/(m^{2}K), to keep passive standard (Ford, B., Schiano-Phan, R., Zhongcheng, D., 2007).

Building foundation or floor slab insulation

With regards the floor insulation again, it is important to consider climate conditions. According to Ford, Schiano-Phan, Zhongcheng, (2007), on one hand in the climate zones with ground temperatures which are low enough, insulation against the ground is indispensable to achieve PH standard. On the other hand in a hot climate as southern Italy or of the Iberian Peninsula, where heating energy demand can already be minimized by other means, insulation of the floor slab and the basement can be omitted. Contrary, heat flow can be directed to the cooler ground and reduce the inner temperature. This is again provoking us in the WP3 include climate zoning in the adaptation criteria.

Besides the heat flow from the floor slat to the ground important role of the insulation is its protection against moisture. In Germany while retrofitting dwelling from 50-ties of the last century, they applied protective insulation on the side walls. For the detail see the picture 4.4 bellow. It was applied as the one of complex measures to assure passive standard of the building.

Picture 4.4 (Frankfurt, Germany 2009): Protection against moisture and heat losses in Frankfurt, old house refurbishment into the passive house standard.

Air tightness

Recently, there is an increasing interest in execution of blow-door test to find out how the building is airtight, although only in 4 of 13 surveyed countries (DE, DK, NL, NO), are made rarely, and very rarely in others (Guyot, G., Rémi Carrié, F., 2009).
Despite, it is getting more common in Germany and it is very important to measure the performance of the building, especially when one is trying to reach passive house standard.
Constant applying of measures to assure airtigthness in Nordic countries such as Finland, airtightness has improved during past 30 years due to of the transition from natural ventilation to mechanical ventilation with heat recovery systems. Recently, it concerns about 100% of the buildings. A guideline value recommended for well functioning mechanical ventilation and heat recovery is : n50 = 1 h-1. Guyot, G., Rémi Carrié, F., 2009).

There is not single method for measuring and presenting results of the airtightness and it is making data less comparable among the European countries, both old EU member states and new EU member states (ibid.).

Picture 4.5 (e.u.z, Springe, Germany 2009): Blower-door test demonstration in e.u.z training centre Germany.

Usually, the air tightness is expressed in terms of airflow rate through the buildings envelope at a given conventional pressure weighted either by the heated building volume V or by an area A (Guyot, G., Rémi Carrié, F., 2009).

One of the most used methods for calculation which can be applied in all project countries is airtightness calculation using an air flow needed to create a 50-pascal pressure change in the building envelope.[3]

The best practice how to test airtightness of a building it is possible to use testing method so-called blower door to reveal leakages in a envelope and to find cracks in the wall, gaps on windows' frames, wrong cladding around duct works and others. A ventilator is placed in an entrance door (See: *Picture 4.5*) or in some cases in window which creates a pressure difference of 50 Pa. The corresponding air change rate of the building (n50, expressed in ach-1) indicates the level of airtightness (Information provided by the e.u.z at the seminar in 2009).

Picture 4.6 (e.u.z, Springe, Germany 2009): detail at the picture is indicating by smoke where is the flow of the air to the room.

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[3] The airflow rate can be calculated through a power law :
Q= CTPn where Q is the volume airflow rate through the leakage site (m3/h)TP is the pressure difference across the envelope building (Pa) n is the flow exponent (0.5 ≤ n ≤ 1) C is the airflow coefficient (m^3h-1Pa-n) The airtightness of a building is often expressed in terms of airflow rate through the buildings envelope at a given conventional pressure weighted either by the heated building volume V or by an area A. Area usually used is the envelope area defined in standard EN 13829.
Commonly used measurements is with a pressure difference of 50 Pa Guyot, G., Rémi Carrié, F., 2009)

4.2.2 Inner part of the building

Ventilation

While we mentioned five basic principles of a passive house standard, four of them were linked, according to our scope, to outer part of a building and last one is directly related to the inner part of the building.
It is **mechanical ventilation system with heat recovery η ≥ 75%** as claimed Bastian (2009) in his presentation.

The main purpose of the good ventilation system is to ensure good indoor air quality with respect to protect people's health and to maintain desired levels of comfort in inner part of the building. Requirements for the good indoor air quality are determined by the national norms derived from the CEN (European Committee for Standardization).
Basically, ventilation systems are subdivided into natural ventilation and/or controlled ventilation with heat recovery. But natural ventilation in passive houses is very rare and almost not applicable, only maybe in a special climate conditions. Therefore, in the line with Bastian (2009) we exclude discussion on natural ventilation.
Technically, it is a necessary procedure of replacing the used interior air by air from outside. Through a duct – systems, the air from outside is being drawn in by electrically propelled fans (direct current motors) (Faltin, Knorr, et al. 2009). The important part such a system is a heat recovery unit (See: picture 4.6)

Picture 4.7: Heat recovery unit, enough to recover heat at a flat area about 80 m².

The heat recovery unit is connected to the duct work and at the *picture 4.7* bellow, there are pipes where one is an outlet pipe bringing extracted air out of the building flat and the second is an inlet pipe bringing outbound fresh air. The heat is exchanged at the heat recovery unit.

Picture 4.8: Outlet and inlet pipes at reconstructed house in Frankfurt (Germany).

According to Strom, Joosten, Boonstra, (2006), this measure became essential to meet passive house standard. It is widely used in Western European countries, for example in the Netherlands the ventilation with heat recovery became common best practice with a share up to 95 % (inbid.).

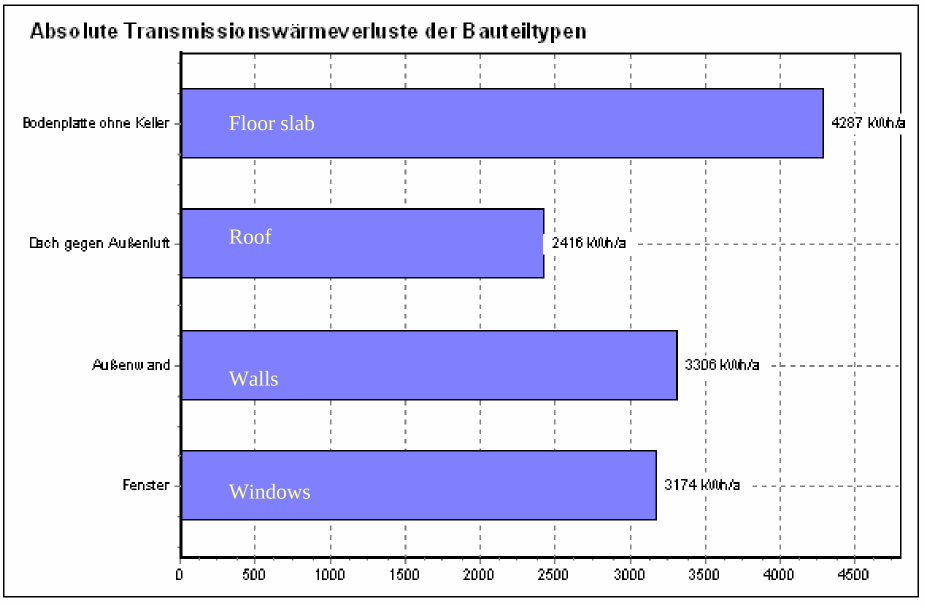
Heat energy sources and hot water preparation

We defined five basic principles (Zeno, 2009) of a passive house standard which are closely related to the technical aspect. In spite of that a passive house has very low heating energy demand; we briefly need to refer where the heating energy is coming from.
It is obvious that low heating energy demand is advantage of the passive house, despite there still remains a small heating which need to be supplied to keep inner comfort.
Zeno (2009) and Strom, Joosten, Boonstra (2006) brought overview on different types of heating systems usually designed and depending on variety of conditions. They stressed again that the heating is directly depending on level of heat recovery. Thus heating necessity is depending generally on the balance of heating loses and gains. The primary source of gains is solar

radiation through the solar panes so-called passive solar energy (inbid.). Besides conventional heating systems usually, preferable renewable, heat gain counts also with energy emitted by humans and electronic appliances at home. Strom, Joosten, Boonstra (2006) listed the most conventional such as heat pumps, solar thermal, biomass boilers but also CHP and connection to the district heating when it is necessary. Mentioned technologies are useful also for preparation of hot water.
An interesting example, there are brand new passive houses in Hansaallee, Frankfurt (Germany), where heat pumps are not used for heating but vice versa for cooling designed to the floor of each apartment.

Thermal bridges

In this second section "Inner part of the house", we decided briefly to talk about thermal bridges for the reason because thermal bridge refers to energy losses coming from inner part of building, nevertheless technically it is more in detail described in *Chapter 5*. Generally, the most of reviewed projects (Strom, Joosten, Boonstra 2006; Zeno, 2009; Ford, Schiano-Phan, Zhongcheng, 2007a) concluded that it is necessary to keep passive house "thermal bridge free".
Thermal bridge refers to heat flow and is it influenced by conductivity of materials. It is critical for passive house standard to lower than 0,01 W/(mK) (Strom, Joosten, Boonstra 2006). There was stressed that details can cause huge difference and mainly how the work is executed. Expertise of Auraplan bellow, on the *graph 4.1* is sketching picture which building element is the most sensitive and has to be taken into consideration.



Graph 4.1: Outlet and inlet pipes at reconstructed house in Frankfurt (Germany).

5) WHAT BASIC PRINCIPLES SHOULD BE TAKEN INTO ACCOUNT TO AVOID COMMON MISTAKES IN PASSIVE HOUSE CONSTRUCTION?

Based on reviewed projects and according to experts experiences there are basic principles which should be taken account to help to a developer avoid mistakes which can have influence on energy performance of a building. These considerable principles can be three-folded according to stage of works on building as follow:

Considerable principles in three process stages		
Planning	*Constructing*	*Using*

The most of the European building stock prevailingly consists of existing buildings. For instance in Slovakia, the most of these buildings are coming from 70ies and 80ies of the last century, from the period, when there were different requirements for the energy standard. The same situation can be observed also in Western European countries and therefore, high number of EACI projects put attention on retrofitting and it stimulated extensive retrofitting programs all around Europe. Therefore, in some cases we are referring to experiences and lessons learned from retrofitting and not only from construction of new buildings.

5.1 - Planning

There has to be emphasized, that in some cases, it brought fast solutions where there is apparently missing the complexity of applied measures, especially in CEE countries "*development is faster than planning*". There is plethora examples where retrofitting of residential building applied outer wall insulations, but they did not change old single pane windows in wooden or aluminium frames with high U value. At the end, fast solution with misconceived approach is not bringing desirable results in energy performance and even though they save some energy they did not use the whole potential.

At the *picture 5.1* bellow you can see very usual example from CEE countries where is applied wall insulation but windows are not changed. Solely applied technical solutions and not as a part of proper planning decreases energy performance of a building.

Contrary, at the *picture 5.2* from Frankfurt Germany, the retrofitting was preceded by the planning and all aspect which should be applied on an outer part were executed – wall insulation, double pane windows, roof insulation, balconies are situated on the special frame outside of building to prevent thermal bridges and at the end CHP heating system was designed according to a need. This is a result of a proper planning.

Picture 5.1 (Bratislava, Slovakia 2009): Applied wall insulation planned solely without other measures in retrofiting, a proof of not holistic planning.

Picture 5.2 (Frankfurt, Germany 2009): Proper planning is behind complexity of a range of applied technical measures ensuring low energy demand of houses originally built up in 50ties.

In a subchapter 5.1 we put our attention on importance of planning from vantage point, when one is applying technical measures, but this can be considered from different approaches. Table 5.1 bellow is summarizing the most common mistakes in planning which should be avoided if one wants to reach passive house standard. It is based on projects review and expertise of *Auraplan*.

The planning and the most common mistakes	
Causality	*Consequences*
Lack of knowledge in ***optimized design***	*Thermal bridges due to not considering of relation between outer surface and building volume* *Inappropriate orientation of a building* *Inappropriate orientation of a roof*
Missing holistic ***concept for heating and water supply***	*Energy loses in networks because of remote places* *Overestimated or underestimated production* *Not incorporated CHP in planning of district heating*
Lack of knowledge about ***building physics***	*Increased humidity* *Higher heat conductivity of the construction* *Low sound protection*
Excluding of ***quality of used materials*** *while planning*	*Health problems* *Technical problems* *Higher conductivity of materials*

Table 5.1 Mistakes which should be avoided with respect to planning proces and listed most common consequences.

In conclusion with respect to the planning, beside mentioned most common mistakes, it is important to keep in mind a building orientation which has to be considered to increase the solar load and to have a house in a passive standard.

5.2 - Constructing

The project Promotion of European Passive houses (Strom, I., Joosten, L., Boonstra, Ch., (2006) is providing us within the information how this standard is reached in several Western European countries. Surprisingly, the concept of the passive house still requires making big step further with respect to get this standard more common. In each important technical aspects are defined the main obstacles of its application. Moreover, in many cases with respect of construction works they are pointing to a problem of

lack of skills. Passive house standard is demanding in a way how construction work is done.
In an article, speculating on passive house standard enforcement in CEE countries, besides the costs they are emphasizing the fact, that there is a lack of skilled workers without training. Wrong application of sound technical solutions, consequently, evolving to problems with energy loses (Antonov, P., 2008). Table 5.2 bellow is narrating the most common mistakes with regards to construction works.

The constructing and the most common mistakes	
Causality	*Consequences*
Using of inadequate materials	*Health problems* *Energy loses*
Inappropriate combination of materials and elements	*Thermal bridges* *Energy loses*
Incorrect installation	*Significant energy loses* *Unwanted ventilation*
Mistake in connection of elements and materials	*Significant energy loses* *Unwanted ventilation*

Table 5.2 Mistakes which should be avoided with respect to construction and listed most common consequences.

As an example of presented most common mistakes in construction work see the picture 5.3 bellow. This is a duct for mechanical ventilation bringing the air inside a room. Insulation around the tube is note fixed properly and therefore one can expect energy loses and lower air tightness of the building.

Picture 5.3 (e.u.z, Germany 2009): Demonstration of inproper insulation lowering air tightness of a building and energy loses.

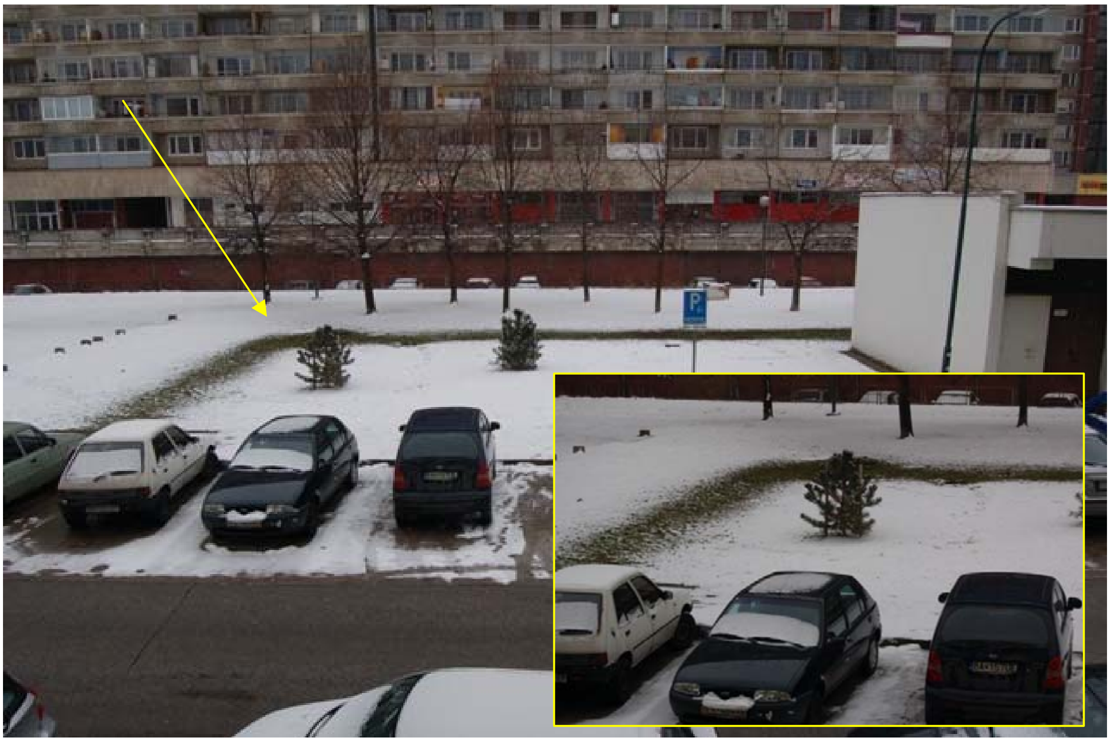
5.3 - Using

Although it is not a goal of this background paper there is necessary briefly mention one of the factor when sounds technical measures, preventing energy loses, can fail. Even it sounds simply there has to be paid attention on usage and operating of a passive house. The list of the most common mistakes are listed in the table below and one which should be stressed more is using of ventilation, because natural ventilation in a passive house with the mechanical one can cause unwanted energy loses.

The using and the most common mistakes

Causality	*Consequences*
Inappropriate using of ventilation	*Energy loses*
Indoor drying clothes	*Increased humidity*
Not using of energy efficient appliances	*Operation of the house can exceed "allowed" total energy consumption of a passive house (120 kWh/m^2.year)*

Table 5.3 Mistakes which should be avoided with respect to usage of a building.



Picture 5.4 (Bratislva, Slovakia, January 2009): District heating system with inefficient insulation, melting snow is proving heat loses from pipes, picture related to both wrong planning and not proper applying of technologies.

CONCLUSSION

The background paper on experiences and lessons learned from Western European and CEE countries has sought positive examples which are enhancing the energy savings in buildings. With regards to the background paper, it dealt primarily with the following:

- Defined what experts consider as the most recent "best practice options" related to energy savings in buildings;
- Drew attention to a passive house standard as a big challenge for CEE countries;
- Reviewed already implemented and existing projects, and providing information on requirements and technical possibilities to reach passive house standard;
- Set out an approach to reach a broader audience in/out of project's consortium.

The empirical chapters have attempted to demonstrate that technically, it is achievable to construct a building with very low energy demand, and in some cases consuming eight times less than the national averages in CEE countries. It has been proven that there is a relation between energy savings and the material element in which a building consists of. Moreover, technical aspects are also related to the broader concept of planning – constructing – and the building's use. The mentioned concept we have supported with experiences and lessons learned from Western European countries.

In spite of using a vague term such as, "the best practice option", we were not afraid to focus our discussion on passive house standard. On one hand, some may argue that for CEE countries, it can be too challenging. On the other, the technical progress in the construction industry has a really high velocity, and what we perceive today as the best tomorrow, can be just a standard. If we just look at the UK as a prime example, they have already come up with a policy statement promoting a greener future and zero-emission buildings. There is a lot of buzz surrounding "zero emission building" and it should be a concept with zero heating energy demand, and electricity should be supplied using renewable sources. Therefore, discussing passive house standards in the background paper was due more to our commitment, than to our will.

To sum up, according to projects which have already been implemented in general, we can conclude that technical solutions are in place. The promoted passive house standard is neither a new discourse, nor a pilot action, and there are continuously diminished constrains and worries from opponents.

Technical application is neither a barrier, nor financial. What we found as critical, was this voice has to be heard by all the actors who play vital roles in the development and construction industry, from the early stages of planning and development, to the construction, maintenance, and everyday use of the building. Moreover, continuity of this work must keep in mind the particular conditions in CEE countries, meaning not only climate, but also political, economical and social, and an even further challenge will be to define the criteria and adaptation. This challenges us to speak, to be heard, and to change.

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