



Clearinghouse Facilitation

Cost and Energy Savings
for RUE measures in buildings

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**Paving Way for Better Energy Building
Performance in EU Less Developed Regions**

<http://www.clearsupport.eu>

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1. Introduction

This report is a result of the work conducted as a part of the project “Clearinghouse Facilitation - Paving the Way for Better Energy Building Performance in EU Less Developed Regions. The project acronym is ClearSupport and the project is based on the EC’s intentions for establishing a clearinghouse for promotion of small and medium scale sustainability energy projects as stated in the EU Green Paper on Energy Efficiency. The technology focus is on RUE in building measures.

Dedicated to bring in front rational use of energy (RUE) in buildings, its main focus is on building retrofitting, and to a minor extent also designing for RUE in new buildings. A wide range of measures exists for RUE building retrofitting and must be made operational for the operation of project service facilities (PSF) and thus shall facilitate ClearingHouse penetration in general.

Latvia, Lithuania, Poland, Czech Republic and Crete have a PSF in place. Slovenia is participating as observer. The role of each PSF is to provide practical assistance to project owners on project identification, documentation and financing. Project owners include housing associations, municipalities and building project developers having the possibility to implement increased rational use of energy in larger building stocks.

The overall goal for this report on “*RUE Design in Buildings*” is to develop standardised solutions of key type of RUE in building measures. The objectives of the work are:

- To collect and prepare structured information on technical issues within building retrofitting for the use in the PSFs,
- To ensure an adequate RUE level for new buildings,
- Evaluate the impact of RUE building retrofitting,
- To generate a RUE package for PSF operation,
- Extraction of the replication value of the performed activities of relevance for other EU less developed regions.

This leads to the following four reports

Ref	Report title
D.4.1	Report on cost and energy savings for RUE initiatives in buildings
D.4.2	Report on regional/local impact of RUE initiatives in buildings
D.4.3	Report on EU wide energy saving potential due to RUE initiatives
D.4.4	RUE Technology guide / catalogue for Project Service Facilities

The target group for this report is the project service facilities in Latvia, Lithuania, Poland, Czech Republic and Greece and also the relevant entity in Slovenia. The report focuses on the energy saving potential for building retrofitting and is therefore also relevant for municipalities, housing associations, local and central authorities and the house owners or tenants in the PSF countries in general.

The report seeks to establish the most relevant potential in the five countries, which can be reached with rather standardised methods.

Closely linked to this report is a report “RUE Technology guide / catalogue for Project Service Facilities” which focuses on the technical and economical matters related to recommended energy saving measures for the PSFs.

The report is based on questionnaires sent to the PSFs in the spring of 2007 and spring 2008 and on follow up correspondence between the PSF representatives and the WP leader. The final version of the report is based on discussions during a workshop meeting in Copenhagen on the 24th of April 2008 and a later revision.

This report consists of three main parts:

- Characterization of existing building and saving potential for large building stocks in PSF countries
- Identification of most relevant rational use of energy measures for PSF countries
- Estimation of the cost of the relevant RUE measures in the PSF countries.

2. An Overview - the Energy Savings Potential

This section is based on data provided from the PSFs on the status of the building stocks in their respective area and estimates of magnitude of the saving potential and most interesting building types. In section 4 to 10 please find a more detailed description on the most promising potential for energy savings in the specific countries.

The four more northern countries (Latvia, Lithuania, Poland and Czech Republic) are characterised by a heating demand, which to a large degree can be satisfied by district heating. The four countries also have some similarities in the building stock. A large part of the building stock consists of standardised building types for apartments built before 1990, which has poor energy saving characteristics. Because of the high degree of standardisation some common retrofitting measures can be recommended.

Also the governmental or public building stock built before 1990 are characterized by common standards. In this report focus is on administrative buildings, schools, hospitals and (for Crete) hotels.

Compared to the Northern countries Crete on the other hand is characterised by a much warmer climate, and district heating is probably not the most relevant measure. There exist only two district heating networks in Greece situated in the northern part.

On the other hand energy savings can be obtained in Crete by more simple measures for the building stock in combination with utilisation of solar energy and renewables. This is especially relevant to the large hotel sector, with the need for hot water and cooling in the summer period.

Less focus in this report is on RUE in new buildings.

In order to enable replication of the obtained results of this study for use in other EU less developed regions the five PSF countries are divided into three regions:

Name of region	Countries	Description	Degree days
Baltic Sea Region	Latvia, Lithuania and Poland	Cold climate	> 3700
Central Europe	Czech Republic, Slovenia	Moderate climate	2700-3700
Southern Europe	Greece (Crete)	Warm climate	< 2700

Hereby, the RUE measures can be grouped in terms of relevance for each region and other countries than the PSF countries can identify the relevant RUE measures for their specific region.

In EU the building sector accounts for approximately 40% of the total energy consumption. This large sector has therefore considerable interest for saving measures, which among others are illustrated in the many initiatives to implement savings and the work and revisions of the directive on energy performance of buildings.

In the 6 countries participating in the ClearSupport project the energy consumption in the residential sector alone represents 1.353 PJ and in the service sector 499 PJ (these figures include electricity). In figure 2.1 the energy consumption is illustrated and in figure 2.2 the same consumption as per capita in the six countries.

Figure 2.1

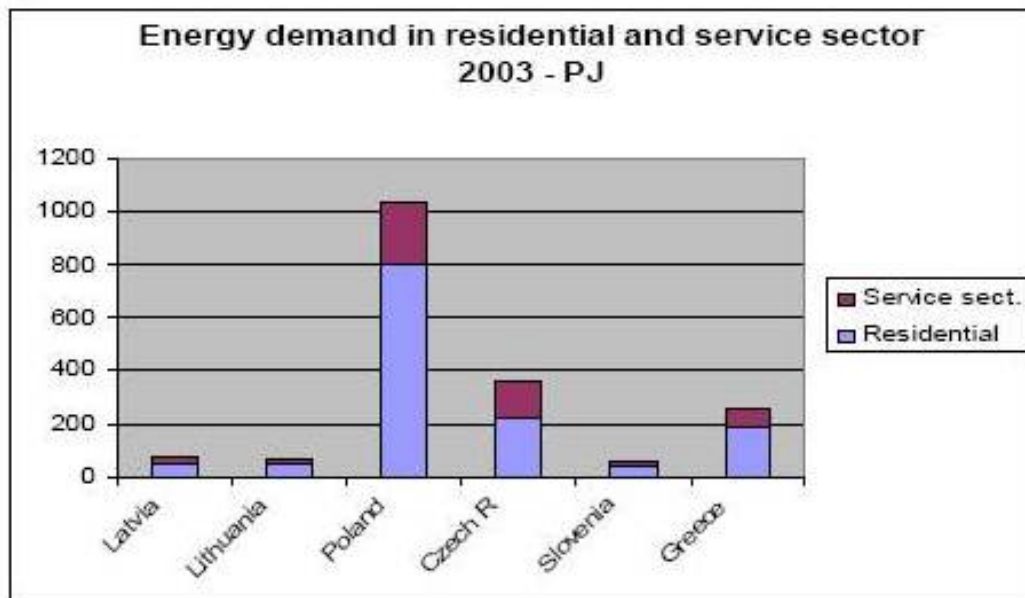
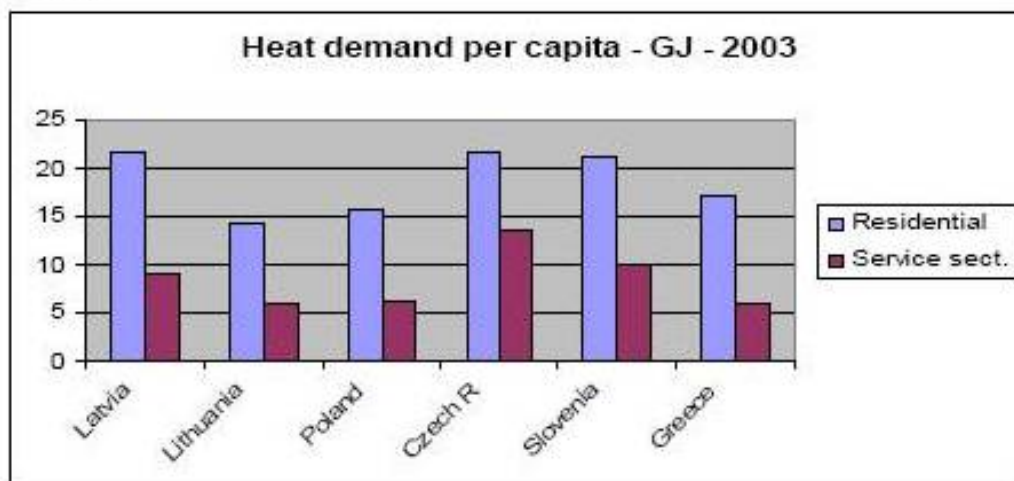


Figure 2.2



(Source: Ecoheatcool)

The PSF's have each estimated the saving potential for residential buildings and buildings in the service sector. These estimates are dealt with in more detail the following sections but it seems appropriate to estimate a common saving potential of 20-50% for the residential sector and at least 25% in the service sector. An average estimate of 30% for the residential sector and 25% for the service sector gives a saving potential of 406 PJ in the residential sector and 125 PJ in the service sector. It must however be noted that the ClearSupport does not cover all part of the countries concerned. In Poland only the Pomeranian region is partner and in Greece only Crete.

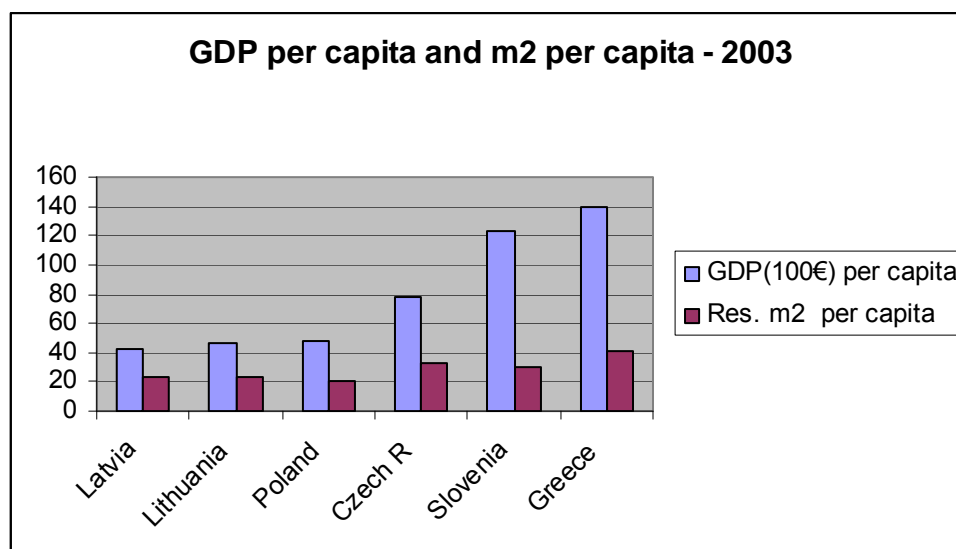
Table 2.0 given an overview on the building sector in the participating countries.

Table 2.0 Building data for ClearSupport countries - 2003

	Residential Dwellings (1000)	m ² per dwelling	Residential area mio. m ²	Residential m ² per cap.	Service sector area mio. m ²	Service sector m ² per cap.
Latvia	967	55,4	54	23,0	23	10,0
Lithuania	1292	60,6	78	22,7	14	4,2
Poland	11764	68,2	802	21,0	382	10,0
Czech R	4366	76,3	333	32,6	100	9,8
Slovenia	785	75,0	59	29,5	16	7,8
Greece	5465	82,7	452	41,0	149	13,5

(Source: Ecoheatcool)

Figure 2.3

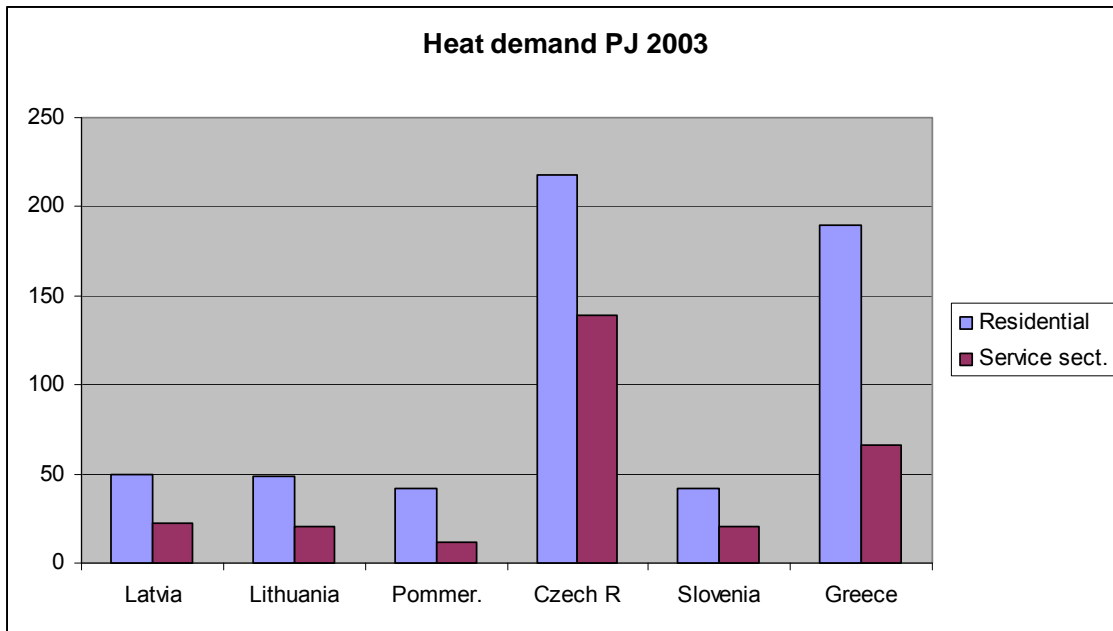


(Source: Ecoheatcool)

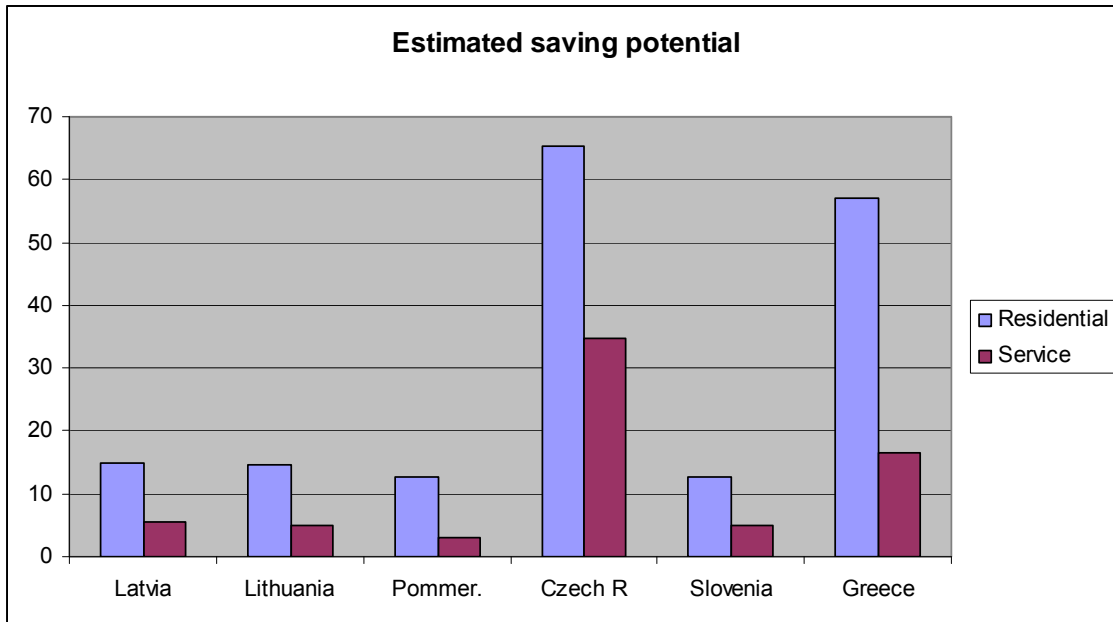
Figure 2.3 illustrates the correlation of GDP and living area per capita.

Since Poland is represented in ClearSupport with Pomerania the energy consumption is estimated one more using the scaling unit of 5,2% since Pomerania constitutes 5,2% of the Polish building stock. Thereby a somewhat lower estimate for the saving potential for the ClearSupport project can be established as follows: Heat demand in residential sector for all ClearSupport countries (Poland represented by Pomerania) is 591 PJ and heat demand in the service sector is 279 PJ. Thereby the saving potential will be 177 PJ in the residential sector and 70 PJ in the service sector.

Fig. 2.5 Heat demand in residential and service sector



The saving potential for the Clear Support area can be estimated as illustrated in Figure 2.6



2.1 Baltic Sea Region

2.1.1 Latvia

PSF has focused on the large stock of apartment buildings built before 1990. The standardised buildings comprise 65% of the building stock. Most are now privatised. District heating is widespread. For the most common of these houses a saving potential of 1,8

TWh/yr (6.5 PJ) is estimated. (Savings 14-25%). The estimate is a careful one. For the whole building sector PSF estimate a saving potential of 30-50% resulting in 15 PJ.

There is no specific data on public buildings (schools, hospitals etc.) but since there are many similarities with the situation in Lithuania savings on 30-50% should be realistic. Real estate prices have increased considerably in recent years. In order to cover part of the rehabilitation investment it could be considered to establish new apartments/penthouses when roofs are renovated.

PSF Latvia suggests a rehabilitation strategy in 3 groups with first groups of more simple and inexpensive measures and the last group for major rehabilitations.

- Group 1: Water receiving devices adjustments and meters installation. Windows and doors packing/renovation, loggias glazing, change heat substations. (20-30% savings/4.5 years pay back)
- Group 2: Insulation external walls and balks covering, aut. ventilation in bathrooms and kitchens. (15% savings additionally)
- Group 3: windows/doors replacement, individual heat meters, thermo controller valves, insulation of cellars coverings, side walls, and gable roofs. (Savings 50-60% with group 1-3. medium/long pay back).

For the public buildings (schools, hospitals etc.) PSF estimate a saving potential 20-60% resulting in 2.052 PJ.

2.1.2 Lithuania

Like other Baltic countries a large share of the building stocks are standardised. Especially for the residential buildings from before 1993 there exist a large saving potential. Privatisations of apartments are widespread. District heating is well developed.

PSF Lithuania has estimated saving potentials for apartment, single/double family houses and public buildings. In Table 2.6 please find overview on the saving potential.

There are public programmes to ensure low income people are able to pay their energy bill.

2.1.3 Poland

In Poland the saving potential is estimated for the Pomeranian Province. Even if technical saving potential is as high as 50% the PSF prefers rather conservative estimates (minus 25%) due to the fact that some rehabilitation already have been made and that in some other cases rehabilitation is not possible for various reasons.

2.2 Central Europe

2.2.1 Czech Republic

For Czech Republic the estimates are based on data from the inception report. Again the most interesting potential is for the older residential building stock, with potentially savings around 50%

2.2.2 Slovenia

There is no PSF in Slovenia, but it is a project partner as well.

For older residential buildings the technical potential is estimated to 60%, but the economically realistic potential to 30%.

Also for the public buildings, schools, administration, hospitals etc. the economical potential is estimated to 30%.

2.3 Southern Europe

2.3.1 Greece/Crete

For Crete the saving potential for residential buildings is estimated to 18%. For public administration buildings the saving potential averages 20%, for schools average 19% and for hospitals 23%. It is not surprising that the saving potential is somewhat lower in Crete due to the warmer climate.

2.4 Overview on saving potential

1. In the table below, we have gathered information about saving potential in the addressed countries. We have information about the estimated total potential saving percentage in buildings in all PSF countries except Lithuania. For Lithuania, absolute figures are available (potential saving in TWh/yr or PJ/yr).

Based on this information we can conclude that there is a huge saving potential (14-60%) in buildings in all addressed countries. On the average it should be possible to save 25% of energy consumption in buildings. There is no clear overall indication that the saving potential is higher for the public sector (governmental buildings) than for the residential sector.

Table: 2.1.1 Overview on saving potential.

	Saving, %	Savings, TWh/yr	Savings, PJ/yr	Share of energy consumption
Latvia				
Total building sector	30-50%	4.2 TWh	15.0 PJ	9%
Most common standard ap.	14-25%	1.8 TWh	6.5 PJ	4%
Public buildings	20-60%	0.57 TWh	2.05 PJ	2%
Lithuania				
Apartment buildings before 1993		3.0 TWh	10.8 PJ	5%
Single/double fam. houses		1.6 TWh	5.8 PJ	3%
Office buildings		0.525 TWh	1.9 PJ	1%
Schools		0.666 TWh	2.4 PJ	1%
Hospitals		0.175 TWh	0.6 PJ	0.3%
Hotels		0.359 TWh	1.3 PJ	0.6%
Poland, Pomeranian				
Apartments buildings before 1988	20-50% (average) 25%	1.8 TWh	6.6 PJ	
Public administration	20%			
Schools	18%			

Hospitals	23%	
Czech Rep.		
Residential and public buildings	50%	177 PJ
Slovenia		
Residential buildings	30%	13 PJ
Public buildings	30%	6 PJ
Crete		
Residential buildings	18%	
Public buildings	19-23%	

3. Energy consumption, RUE measures and saving potential

3.1 Baltic Sea Region

The Baltic Sea Region is in this report represented by Latvia, Lithuania and Poland. In the following please find a general description of the building sector with identification of topics relevant for building retrofitting projects.

Even though there are comparable characteristics, the data available and the needs for renovation differ among the countries in the Baltic Sea Region.

The PSF's have different approaches on how to estimate the saving potentials. The structure and details of the following analysis will therefore differ a lot.

3.1.1 Latvia

Average degree days in Latvia is more than 4000 per year.

In recent years Latvia has experienced a high economic growth also resulting in strongly increased real estate prices. Economic growth is mainly taking place in specific developed regions like the Riga Region which accounts for almost 60% of GDP.

After the independence it was decided to allow for privatisation of formerly municipal/state owned apartments and enterprises. Privatisation certificates were therefore issued to inhabitants of apartments enabling also less wealthy people to acquire their own apartment. The certificates could also be sold at the open market.

In 2005 86% of the housing stock was privatised (measured in m²).

With this high degree of privatisation there are several examples that when major building renovations are decided some inhabitants cannot afford to stay and might have to move to cheaper apartments. This is especially the case for low income groups like pensioners.

In Latvia the households sector accounts for 36% of the energy consumption. It is part of the government's energy efficiency strategy to reduce average energy demand in buildings from today's 220-250 kWh/m² to 150 kWh/m² in 2020.

Latvia has one of Europe's highest coverage of district heating. The remaining heating demand is covered by mainly natural gas and biomass (in rural areas). For the district heating there has been a substantial fuel shift from heavy fuel oil towards natural gas and biomass (Latvia has significant resources of the latter). In many cases the heating systems in multi family houses cannot be regulated.

For the multi family houses 76 % of the buildings are erected from 1958 to 1992. Especially for this category there is a large saving potential because many of the buildings are standard buildings and standard measures can be applied.

The total housing stock comprises 57 million M². The most common 13 standard multifamily houses comprises 37 million M² or 65 % of the housing stock.

PSF of Latvia has concentrated the analyses of the energy saving potential to the residential sector of which the major part is dominated by standard buildings representing a potential which are in reach with standardised measures.

Table 0.1: 13 Standard multi-family houses in Latvia.

Series/stores/ year	Floorage, M² (% of total housing stock)	energy consumption kWh/m²	Construction principle
1-316/4-5/ 1957-1964	5,655,000 (10%)	187-211	Base longitudinally walls of silicate brick, Ceiling panels: armoured concrete panels. Gable roof.
1-318/5/ from 1964	1,889,000 (3%)	187-211	Same but flat roof.
1-464/5/ From 1959	996,000 (2%)	187-211	Spatial construction. Walls of ceramic concrete, Ceiling panels of armoured concrete panels by circuit, gable roof.
464A/5/ From 1961	976,000 (2%)	187-211	Same as above
464A/π From 1964	976,000 (2%)	187-211	Same as above
464A/π66 5/ From 1966	976,000 (2%)	187-211	Same as above but flat roof.
467A/5/ From 1967	3,848,000 (7%)	124-224	Base cross walls, wall material: aero-concrete, Ceiling panels: concrete panels, flat roof.
467/9/ From 1976	3,848,000 (7%)	124-224	Same as above
467B/9/ From 1976	3,848,000 (7%)	124-224	Same as above
602/9/ From 1967	3,715,000 (6%)	155-212	Spatial construction. Walls of ceramic concrete, Ceiling panels of armoured concrete panels by circuit, flat roof
1045-6 From 1969	2,654,000 (5%)	134-218	Base cross walls, ceramic concrete walls, ceiling panels: concrete panels, flat roof.
103 5-6 From 1969	7,298,000 (13%)	124-224	Same as above
119 6-9 From 1980	407,000 (0.7%)	171-194	Carcass construction, wall material: three-group panels, Ceiling panels: concrete panels, flat roof.

In 2004/2005 91 of the standard buildings were tested for energy consumption with the following results: (column 4-6 are indicative calculations)

Table 3.1.2: Energy saving potential apartment buildings.

Series	Total stock in m ²	Average heat consumption kWh/m ² /year	Indicative heat consumption per year	Indicative saving potential compared to national strategy (150 kWh/m ²)	Indicative saving potential in %
103	7,298,000	174.22	1,271 GWh	176 GWh	14%
104	2,654,000	198.85	528 GWh	129 GWh	24%
467	11,544,000	176.06	2,032 GWh	301 GWh	15%
602	3,715,000	181.00	672 GWh	115 GWh	17%
Total	25,211,000	178.65	4,503 GWh	722 GWh	16%

Another survey in 2004/2005 based on a questionable low number of test revealed average consumptions in 2-6 floor buildings erected after 1945 to be 199.38 kWh/m². If the above mentioned 13 standard buildings with 37 million m² is compared with the strategy to reduce consumption to 150 kW/m² a saving potential of 1,846 GWh/a – or 1.8 TWh/a - can be indicated.

Please note that the above indicative potentials are speculative and based on a limited amount of statistics. However it is clear that a very large saving potential for building retrofitting is present in the standard buildings.

3.1.1.1 RUE measures

PSF in Latvia has described relevant RUE measures for buildings in three stages as follows:

Group 1, measures

Cold and hot water receiving devices adjustment

water consumption meters installations in apartments

Apartments windows and doors of loggias renovation/packing,

Street door renovation

Loggias glazing

Reconstruction or change of existing heat substations, providing automatic heat supply in accordance with regulation from outdoor temperatures

Risers pipelines balancing

Comments: These measures are required for the main part of the buildings. It is possible to obtain 20-30% savings and payback time can be 4-5 years. Buildings with insufficient savings will have smaller benefit and longer pay back time. Heating and hot water supply systems and distribution systems must be made. Measures can be realised when it is financially feasible. Often heat energy providers carry out heat substations reconstruction in stages.

Group 2 Measures:

Insulation of external walls

Insulations of the balks covering

Automatically regulated ventilation systems installation in the bathrooms and kitchens

Heating system reconstruction from one pipe system to two pipe systems (might be considered)

Comments: These measures can be realised if group 1 is made. Additionally savings is approximately 15% of heat energy economy. Construction time of pumped ventilation systems depends from humidity problems after windows renovation/packing – it should be

done one year after problem determination. Heating systems reconstruction depends on actual situation, it is not obligatory. It is relevant after group 1 and the first group 2 measures are applied.

Group 3 Measures:

Windows and street doors replacement

Thermo controller valves and individual heat energy meters installation in the apartments

Insulation of the cellars coverings

Insulation of the side walls

Insulation of the matching part of the gable roof for 316 and 318 series and others 5 stores buildings and higher buildings.

Comments: These measures should be realised only after group 1 and 2 measures, and requires large investments. Maximum energy efficiency is a result of the above measures. Total savings from all measures are estimated to 50-60%. Long term investment planning is necessary for group 3 and pay back time is long or middle.

PSF Latvia mentions other relevant RUE measures: Modernisation of heat sources by replacement of heavy fuel oil or coal boilers by gas/biomass boilers, replacement with energy saving lamps or fixtures, installation of solar thermal systems, geothermal systems.

3.1.1.2 Experience with RUE measures in residential sector

Measures: Windows changing, wall insulation, top floor ceiling insulation, installation of new radiators with thermo regulation, installation of heat meter on each radiator, insulation of basement ceilings. These measures which are rather similar to the above group 3 have resulted in savings from 46% 55%. For a 5 floors residential building the investments ranges from 120000 € to 390000 €.

3.1.1.3 Energy saving potential

With 13 standard types of residential buildings there is an obvious potential for standardised saving solutions. Some of the building types are rather, so in reality there are 8 different standard types. Group 1 and 2 measures could contribute significantly to the savings, where as Group 3 measures require a longer pay back time. Since a lot of these standard buildings are coming at age, it should be considered to introduce Group 3 measures, when major renovations are necessary. With the high degree of standardisation there is a lot to be gained with standardised solutions. Planning and audits can be carried out after common methodology and the retrofitting programmes should also benefit from economy to scale.

With regards to the organisation and decision-making of the tenants there will also be similarities which will also call for organisational standard measures – and also with regard to financial solutions.

With implementation of Group 1 and 2 measures an energy saving effect on 35-45%. This is probably an optimistic estimate, but alone savings on 25% seems to fulfil the governments plan to reduce energy consumption to 150 kWh/m². As estimated from table 4.2 an energy saving potential of 1846 GWh seems to be within reach.

3.1.1.4 RUE measures for hospitals

For hospitals PSF Latvia suggests the following measures: Windows changing, walls insulation, top floor ceiling insulation, installation of new radiators with thermo regulation, installation of heat meters on each radiator, insulation of basement ceiling, placing of lamps with energy saving lamps.

3.1.1.5 RUE measures for schools

For schools PSF Latvia suggests the following measures: Windows changing, walls insulation, top floor ceiling insulation, installation of new radiators with thermoregulation, installation of heat meters on each radiator, insulation of basement ceiling, replacing of lamps with energy saving lamps.

3.1.1.6 RUE measures for Public buildings

For public buildings PSF Latvia suggests the following measures: Windows changing, walls insulation, top floor ceiling insulation, installation of new radiators with thermo regulation, installation of heat meters on each radiator, insulation for basement ceiling and replacing of lamps with energy saving lamps.

3.1.2 Lithuania

Lithuania registers degree days for 20 different climatic zones. The average degree days per year varies from 3460 to 4081 averaging approx. 3793 degree days per year, thereby being slightly warmer than Latvia. The district heating season is from late September to early May and lasts approx. 220 days.

3.1.2.1 Residential sector

For Lithuania building stock data are available for single/double family houses and apartment buildings.

Table 3.1.3: Residential buildings single/double family houses.

Age	Extent	Energy consumption	Thermal resistance parameters m ² k/W
Before 1993	377,408 pcs 41,622,300 m ² bricks, concrete, panels No insulation typically	estimate 250-340 kWh/m ² (simple average 295)	Roof: 1.37 Outside walls: 0.90 Windows: 0.435 Doors: 0.385 Floor: 2.70
1993-1999	11,891 pcs 2,964,002 m ²	170-195 kWh/m ² (simple average 182.5)	Roof: 4.76-4.17 Outside walls: 3.57-1.67 Windows: 0.526 Doors: 0.5 Floor: 3.33
2000-2005	10,135 pcs 2,430,230 m ²	128-168 kWh/m ² (simple average 148)	Roof: 5.56 Outside walls: 3.85 Windows: 0.526 Doors: 0.526 Floor: 3.85
2006	1,589 pcs. 354,642 m ²	n.a.	Roof: 6.25 Outside walls: 5.0

Windows:	0.625
Doors:	0.625
Floor:	4.0

Table 3.1.4: Residential buildings, apartment buildings.

Age	Extent	Energy consumption	Thermal resistance parameters m ² k/W
Apartment buildings			
Before 1993 Bricks, concrete, panels	35,343 pcs 46,905,725 m ²	estimated 165-250 kWh/m ² (simple average 207.5)	Roof: 1.37 Outside walls: 0.9 Windows: 0.435 Doors: 0.385 Floor: 2.7
1993-1999 Bricks, concrete, panels	1,234 pcs 2,827,676 m ²	115-155 kWh/m ² (simple average 135)	Roof: 4.76-4.17 Outside walls: 3.57-1.67 Windows: 0,526 Doors: 0,5 Floor: 3.33
2000-2005 Bricks, concrete, panels	822 pcs 2,034,867 m ²	design 66-83 kWh/m ²	Roof: 5.56 Outside walls: 3.85 Windows: 0.526 Doors: 0,526 Floor: 3.85
2006 Bricks, concrete, panels	94 353,758 m ²	n.a.	Roof: 6.25 Outside walls: 5.0 Windows: 0.625 Doors: 0.625 Floor: 4.0

Thermal resistance values according to standards: SNip II-3-79, RSN 143-92 and Str 2.05.01:1999.

Total residential building mass is approx. 125 million m². Of this apartment buildings from before 1993 accounts for 48 million m² (38%) and single/double families houses 42 million m² (34%). For the apartment buildings the energy consumption for buildings before 1993 is quite similar to the data from Latvia, and the buildings are also to a high degree standardised. If the thermal resistance parameters are compared there are considerable differences in the parameters for roofs, outside walls and floors. The difference (old vs. new) is factor 5 for roof, 5 for outside walls and 1,5 for floors. For windows and doors the difference is not that outspoken. It could therefore be relevant to concentrate renovations on these elements. It is probably too optimistic to expect same performance as for new buildings but if the Latvian goal to reduce consumption to 150 kWh/m² per year is used then a saving potential in the older apartment buildings could be estimated as 2.7 TWh per year. And there would be advantages to introduce standardised measured because of the standardised nature of a lot of the building stock.

PSF Lithuania estimates that for the apartment blocks built before 1993 with a theoretical goal 80kWh/m²/year points to a saving potential of: 165 kWh/m²/a – 80 kWh/m²/a X 46,905,725 = 4 TWh/a. A more realistic energy saving potential is assumed to be 25% less

because practically not all RUE measures will be implemented during refurbishment, which leaves an energy saving potential of 3 TWh/a, which is similar to the estimate above. Typical heating for apartment buildings are: Natural gas, oil, wood and district heating.

Also for the older single/double family houses there is a huge saving potential, but these are of more individual nature. FSP Lithuania estimates the theoretical saving potential as 109 $(270 \text{ kWh/m}^2/\text{a} - 150 \text{ kWh/m}^2/\text{a}) \times 41,622,300 = 5 \text{ TWh/a}$. A more realistic estimate results in an estimate of 2 TWh/a, which again is reduced to 1.6 TWh/a excluding buildings not feasible for refurbishment.

Typical heating for single/double family houses is: natural gas, oil, wood, coal and peat.

3.1.2.2 Public buildings

Data are available for administrative buildings, educational buildings and hospitals.

Table 3.1.5: Administrative buildings.

Age	Extent	Energy consumption	Thermal resistance parameters $\text{m}^2\text{k/W}$
Before 1993 Bricks, concrete, panels	8,776 pcs 321,824 m^2	185-250 kWh/m^2 simple average: 218	Roof: 1.37 Outside walls: 0.9 Windows: 0.435 Doors: 0.385 Floor: 2.7
1993-1999 Bricks, concrete, panels	506 pcs 420,796 m^2	115-155 kWh/m^2 simple average: 135	Roof: 4.76-4.17 Outside walls: 3.57- 1.67 Windows: 0.526 Doors: 0.5 Floor: 3.33
2000-2005 Bricks, concrete, panels	289 pcs 240,455 m^2	65-90 kWh/m^2 simple average: 78	Roof: 5.0 Outside walls: 3.33 Windows: 0.526 Doors: 0.526 Floor: 3.33
2006 Bricks, concrete, panels	38 pcs 77,996 m^2	60-80 kWh/m^2 simple average: 70	Roof: 5.0 Outside walls: 4.0 Windows: 0.625 Doors: 0.625 Floor: 3.33

PSF Lithuania estimates that for office buildings before 1993 the theoretical energy saving potential is $(195 \text{ kWh/m}^2/\text{yr} - 100 \text{ kWh/m}^2/\text{yr}) \times 7,321,824 \text{ m}^2 = 0.7 \text{ TWh/yr}$.

The realistic energy saving potential is assumed to be 25% less because practically not all RUE measures will be implemented during refurbishment:

$0.7 \text{ TWh/yr} - 25\% = 0.525 \text{ TWh/yr}$.

Typical heating for such buildings are: Natural gas, oil, wood and district heating.

Table 3.1.6: Educational (cultural) buildings.

Age	Extent	Energy consumption	Thermal resistance parameters m ² k/W
Before 1993 Bricks, concrete, panels	6,452 pcs 344,816 m ²	185-250 kWh/m ² simple average 218	Roof: 1.37 Outside walls: 0.9 Windows: 0.435 Doors: 0.385 Floor: 2.7
1993-1999 Bricks, concrete, panels	149 pcs 36,754 m ²	115-155 kWh/m ² simple average: 135	Roof: 4.76-4.17 Outside walls: 3.57- 1.67 Windows: 0.526 Doors: 0.5 Floor: 3.33
2000-2005 Bricks, concrete, panels	120 pcs 280,739 m ²	65-90 kWh/m ² simple average: 78	Roof: 5.0 Outside walls: 3.33 Windows: 0.526 Doors: 0.526 Floor: 3.33
2006 Bricks, concrete, panels	9 pcs 10,742 m ²	60-80 kWh/m ² simple average: 70	Roof: 5.0 Outside walls: 4.0 Windows: 0.625 Doors: 0.625 Floor: 3.33

PSF Lithuania estimates the energy saving potential for schools etc. built before 1993 to be: $(195 \text{ kWh/m}^2/\text{yr} - 100 \text{ kWh/m}^2/\text{yr}) * 9,344,816 \text{ m}^2 = 0.888 \text{ TWh/yr}$. The realistic energy saving potential is assumed to be 25% less because in practice not all RUE measures will be implemented during refurbishment: $0.888 \text{ TWh/yr} - 25\% = 0.666 \text{ TWh/yr}$.

Typical energy source is: Natural gas, oil, wood and district heating.

Table 3.1.7: Hospitals.

Year of erection	No Floorage	Energy consumption	Thermal resistance parameters m ² k/W
Before 1993 Bricks, concrete, panels	1,688 pcs 2,449,804 m ²	185-250 kWh/m ² simple average 218	Roof: 1.37 Outside walls: 0.9 Windows: 0.435 Doors: 0.385 Floor: 2.7
1993-1999 Bricks, concrete, panels	75 pcs 162,100 m ²	115-155 kWh/m ² simple average: 135	Roof: 4.76-4.17 Outside walls: 3.57- 1.67 Windows: 0.526 Doors: 0.5 Floor: 3.33
2000-2005 Bricks, concrete, panels	60 pcs 101,371 m ²	65-90 kWh/m ² simple average: 78	Roof: 5.0 Outside walls: 3.33 Windows: 0.526 Doors: 0.526 Floor: 3.33
2006 Bricks, concrete, panels	5 pcs 21,244 m ²	60-80 kWh/m ² simple average: 70	Roof: 5.0 Outside walls: 4.0 Windows: 0.625

Doors: 0.625
Floor: 3.33

PSF Lithuania estimates the energy saving potential (reaching 100 kWh/m²/yr): (195 kWh/m²/yr – 100 kWh/m²/yr) * 24,498,804 = 0.233 TWh/yr. A more realistic potential 25% less is assumed because in practice not all RUE measures will be implemented during refurbishment resulting in a potential of 0.175 TWh/yr.

Table 3.1.8: Hotels, supermarkets, utility centres.

Age	Extent	Energy consumption	Thermal resistance parameters m ² k/W
Before 1993 Bricks, concrete, panels	12,704 pcs 5,046,860 m ²	185-250 kWh/m ² simple average 218	Roof: 1.37 Outside walls: 0.9 Windows: 0.435 Doors: 0.385 Floor: 2.7
1993-1999 Bricks, concrete, panels	1,583 pcs 790,240 m ²	115-155 kWh/m ² simple average: 135	Roof: 4.76-4.17 Outside walls: 3.57- 1.67 Windows: 0.526 Doors: 0.5 Floor: 3.33
2000-2005 Bricks, concrete, panels	1,345 pcs 1,039,909 m ²	65-90 kWh/m ² simple average: 78	Roof: 5.0 Outside walls: 3.33 Windows: 0.526 Doors: 0.526 Floor: 3.33
2006 Bricks, concrete, panels	198 pcs 215,301 m ²	60-80 kWh/m ² simple average: 70	Roof: 5.0 Outside walls: 4.0 Windows: 0.625 Doors: 0.625 Floor: 3.33

For the older hotels, supermarkets etc. PSF Lithuania estimates an energy saving potential (reaching 100 kWh/m²/yr) to be: (195 kWh/m²/yr – 100 kWh/m²/yr) * 5,046,860 = 0.479 TWh/yr. A more realistic estimate is 25% lower because not all RUE measures will be implemented during refurbishment resulting in 0.359 TWh/yr.

Typical heat source is natural gas, oil, wood and district heating.

3.1.2.3 RUE measures

PSF Lithuania has suggested more than 20 options for RUE measures in the building sector:

- Option 1: For flat roof buildings: Putting extra thermal insulation. Thickness about 15-20 cm. Thermal resistance of refurbished roof should conform to requirements STR 2.05.01.2005. Roof: 5 m²k/W.
- Option 2: Installation of slope roof instead of flat roof. New slope roof with right thickness of thermal insulation to be built on flat roof together with one store apartment or without.
- Option 3: Enclosures adjoining with outside air (external walls). Putting thermal insulation of right thickness on external wall (about 15 cm). Thermal resistance of

refurbished wall should conform to requirements of standard STR 2.05.01:2005. Wall: 4 m²K/W

- Option 4: Floor on the ground. Insulating floor with thermal insulation of right thickness (10-15 cm). Thermal resistance of refurbished floor should conform to requirements of STR 2.05.01:2005. Floor: 3.33 m²k/W
- Option 5: Enclosure of not heated cellar or basement. Insulating the enclosure with thermal insulation (10-15 cm). Thermal resistance should conform to STR 2.05.01:2005 Floor 3.33 m²k/kW.
- Option 6: Window replacement with new ones with better thermal resistance.
- Option 7: Entrance doors: Replacement of the existing doors with new ones with better thermal resistance.
- Option 8: Heating system (central heating system): Installing thermostatic valves, balancing valves, replacement of radiators with new ones, installing heat cost allocators on each radiator.
- Option 9: Domestic hot water system: Installing the new modern heat substation or DHW (with plate heat exchanger and temperature control).
- Option 10: Ventilating system: Refurbishment of existing ventilation system. Generally it concerns public building.
- Option 11: Lightning: Replacement of lamps or fixtures.

Other options: Insulation of piping, ducts, tanks etc. Increase efficiency of burner/boiler. Increase COP of cooling system. Improvement of air handling unit. Outside air control. Heat recovery. Heat pumps. Improvement of control systems. Improvement of glazing/shading. During refurbishment of public buildings feasibility of reducing windows area could be considered.

3.1.3 Poland

In Poland the PSF will mainly perform activities in the Pomeranian province based in Gdansk. Pomeranian's area is 18,293 km², which is 5.6% of the area of Poland. The province is inhabited by almost 2.2 million people. The Pomeranian province's share of dwellings in Poland accounts to 5.2% in 2005 or 692,000.

Housing stock in Poland is relatively old – 85% of the buildings are more than 20 years old. 50% of the housing stock consists of multifamily houses.

Table 3.1.9: Ownership structure of Pomeranian dwellings (National Census 2002).

	Total no. of dwellings [1000]	Ownership share [%]							
		Private	Housing coop owners		Municipal	National Treasure	Company	Public building society	Other entities
			rented						
Total	658.9	49.5	22.8	8.9	13.6	2.6	2.0	0.4	0.2
Urban	488.3	36.0	30.4	11.7	17.2	2.5	1.5	0.5	0.2
Rural	170.6	88.4	1.1	0.9	3.1	2.7	3.4	0.1	0.3

To a large extent residential buildings in the Pomeranian province are old (erected before than 1989). The table and the figure below present the age structure of dwellings.

Table 3.1.10: The age structure of buildings in the Pomeranian Province (Central Statistical Office).

Amount of buildings	Year of construction						
	Until 1918	1918 - 1944	1944 - 1970	1971 - 1978	1979 - 1988	1989 - 2002	2002
227,035	26,204	45,760	43,171	21,271	32,980	41,208	16,440
	11.5%	20.1%	19.0%	9.3%	14.5%	18.1%	7.2%

Energy peak load and heat demand in residential building sector in the province are estimated to 4,150 MW and 52 PJ respectively. Shares of energy resources in building sector in the province is following: 70% - coal, 20% - natural gas, 5% - oil, 4% - biomass and 4% - electricity.

Table 3.1.11: Pomeranian energy saving potential - residential.

	Before 1944	1944-1978	1979-1988	1988-2002
Multi family buildings	240 - 380 KWh/m ² /y	240 - 380 KWh/m ² /y	120 - 240 KWh/m ² /y	90 - 120 KWh/m ² /y
pcs/m2	1,241,422	2,044,040	763,461	618,348
Poland	173,626,950	324,194,417	166,279,546	136,295,246
Pomeranian Region	174,343 11,169,361	133,461 15,521,697	112.164 8,267,085	93,020 8,738,640
Saving potential (average - 25%)	60 - 95 kWh/m ² /yr	60 - 95 kWh/m ² /yr	30 - 60 kWh/m ² /yr	23 - 30 kWh/m ² /yr
Pomeranian saving potential, estimated	650 GWh/yr	902 GWh/yr	279 GWh/yr	174 GWh/yr

According to Bape's information 25% of the energy saving potential has already been realised. Therefore the above estimate of saving potential is reduced by 25%.

Due to the age of the buildings and mild standards for building heat protection that were in force in the past, heat consumption in most of the buildings is high.

The figure below presents heat consumption per unit in kWh/m².

The multifamily buildings in Poland can be categorised in five categories by year of construction. The oldest buildings are mostly brick construction, while the newer buildings mostly are prefabricated concrete panel buildings. Depending of the age and the conditions of the residential buildings the technical saving potential is estimated to 20 – 50%.

The category public building covers three types of buildings: public administration, schools and hospitals.

The energy consumption and the average saving potential for Poland are shown in the table below.

3.1.3.1 Public buildings

Table 3.1.12: Public buildings in Poland.

	Public administration	Schools	Hospitals
Energy consumption	187 kWh/m ² /yr	92 kWh/m ² /yr	407 kWh/m ² /yr
Energy Saving potential (average)	37 kWh/m ² /yr (20%)	17 kWh/m ² /yr (18%)	94 kWh/m ² /yr (23%)

PSF Poland did not have further statistical data available on public buildings available. Therefore the total saving potential could not be estimated.

For hospitals in general extra insulation of external walls, exchange of windows, sometimes modernisation of heating and hot water supply installations and modernization of heating sources are most relevant.

For schools complex thermomodernization is relevant in combination with modernization of heat source. 20-60% energy savings are realistic.

Communities do invest in thermomodernization of schools either by using their own financial resources or combining thermo modernization credit with known resources. Some will get financial support EEA (grant up to 80%). However, the budget was too small to cover all applications.

For public administration buildings the same measures are relevant. A saving potential of 20-50% is estimated. Saving activities might also improve image of local governments.

3.1.3.2 RUE measures

FSP Poland has suggested the following options for RUE:

- Option 1: Extra insulation of external walls
- Option 2: Extra insulation of roofs
- Option 3: Extra insulation of floors above cellars
- Option 4: Modernization of heating installations
- Option 5: Modernization of hot tap water installations
- Option 6: Modernization of heating sources (replacement of coal fired boilers by gas or biomass fired boilers or connection to district heating)
- Option 7: Combinations of above mentioned
- Option 8: Installation of solar panels
- Option 9: Exchange of windows and improvement of natural ventilation
- Option 10: Heat recovery (rather limited solution as to high cost and technical difficulties)

For residential buildings most common measure is extra insulation of external walls, exchange of windows and sometimes modernization of heating and hot water supply installation and modernization of heating sources.

Common decision of tenants or their representatives has to be taken as to investment costs. Benefits are in addition to reduced heating costs, environmental impact, improved technical state of buildings and improved building aesthetic. Add hereto improved comfort and local employment.

In general savings of 20-50% are possible for residential buildings with an average of 35%.

3.2 Central Europe (East)

The central Europe region is in this report represented by Slovenia and Czech Republic.

3.2.1 Czech Republic

In the Czech Republic 10.2 million inhabitants are living in more than 3.8 million flats. Flats were constructed gradually in approximately 6.500 cities and villages. Approximately 25% of the energy consumption is for the heating.

Almost 1.2 million flats are situated in panel buildings constructed after 1950. Almost 70% of these flats were built in 1960s and 1970s.

Table 3.2.1: Apartments buildings, Czech Republic.

Time of construction	Number of flats
1959-1960	58,700
1961-1970	344,800
1971-1980	467,100
1981-1990	294,400
TOTAL	1,165,000

Table 3.2.2: Type of ownership for flats.

Type of ownership	Share
Private ownership	47%
Municipal rental housing	17%
Co-operative ownership	17%
Private ownership rental housing	12%
Other flats	7%
TOTAL	100%

Besides flats, municipalities, regions and state own many thousands other buildings, which are used for healthcare service, education, culture, sport, office work and others.

It can be said that the standard of housing in the Czech Republic is quite high. The fact that the country's more than one million prefabricated apartments are gradually being reconstructed is a positive trend.

Positive and dynamic progress in housing development can be seen in recent years. This has been catalyzed with improving economic situation of citizens and higher demands on living and housing.

The key factors for positive trends in housing development are (according to the Czech Statistical Office):

- Favourable situation on the mortgage market,
- Increasing number of loans connected to building saving,
- Support for young married couples to acquire housing,
- Change in VAT relevant to housing (an exception from the EU allowing payment of lower taxes in case of housing development can be applied only till 31 December 2007).

The highest number of housing units is being built in the surrounding of big cities, especially Prague and other localities in the Central Bohemian Region. Almost a half of new units is being built just in this region. The lowest number of units is being built in Liberec region and Karlovy Vary region. Especially around Prague, we can see a new phenomena of "satellite villages" composed with many new houses with inhabitants commuting daily to the capital city.

All apartments and homes are equipped with heat and running water. The average Czech salary is on the increase, allowing more and more people to invest in the construction of architecturally interesting and well-equipped homes and apartments.

The multifamily buildings in Czech Republic are categorised in five categories by year of construction. The buildings in the Czech Republic dated up to 1968 are brick construction, while the buildings dated up to 1982 are made of prefabricated concrete panel systems.

In all buildings a high energy saving potential still exists. A very positive step towards energy savings was the adoption of Act on Energy Management in 2000. One provision of the law was related to the obligation to prepare energy audits for the buildings with consumption higher than 700 GJ. This obligation and the increase of the energy price gave a significant impulse and interest in implementing energy efficiency measures in buildings in general.

Mainly building companies have taken advantage of this opportunity. They began to promote building insulation and window replacement. Many times projects were prepared without any analysis to show an expedience of the installations and payback period of the investments. Nevertheless most of the projects realised substantial reduction in energy consumption. The Czech state has supported these activities. In 2000, the State Fund of housing development was established under management of the Ministry of Regional Development. The financial support in better quality housing was almost 15 milliards CZK (i.e. more than 530 million EURO), including support in the field of energy savings (insulation etc.).

The technical saving potential for Residential buildings in Czech Republic is estimated to 50 %. Behind this potential is a total solution containing improvement of thermal isolation of walls, roof and lower parts of building, replacement of windows, reconstruction of heat exchanger or boiler

In the Czech Republic the degree days vary considerable, depending on landscape type. In the areas in the mountains of Bohemia and north part of Moravia there are 4157 degree days, in the Prague area annual number 3308 degree days is calculated from fifty-year average outside temperature and inner temperature 19⁰C for Prague.

Table 3.2.3: Czech Republic, energy saving potential, all in kWh/m²/year.

	1957-1961	1960-1968	1968-1975	1974-1982
Multi family buildings	163-205	245	245	206-245
Saving potential (50%)	82-102	122	122	103-122

3.2.1.1 Residential buildings

Average flat energy consumption is 21.7MWh/a. The Czech Republic has 3,827,678 flats - total consumption is 83,145,672 MWh/yr.

Buildings built up in sixties, seventies and eighties were mainly made of panel blocks with small thick of insulation (according to old standards). Energy audits describe the quality of

buildings and recommend suitable solution. These buildings need big reconstruction. New quality windows, thermal insulation thick 100mm and more on walls, reconstruction of heating system and completion with thermostatic valves are being made step by step.

Category:	Residential
Description:	Social housing is a very big group of flats (1/3) which are built in panel technology. It enables to improve them by similar technology. Improvements of roofs can be done by an additional insulation or by constructing new flats (in penthouses) with better insulated roof.
Energy consumption:	Rate A/V (Building Shape Factor) determines specific consumption which we need for comparison of calculated energy level of building.
Energy source: (E.g. nuclear, coal, oil, natural gas, wind, solar, etc.)	Social houses are heated mainly by district heating systems, local boilers for several buildings or their own boilers. Most of boilers use natural gas, a small number uses coal or oil. Big district heating boilers use coal and natural gas too.
Energy saving potential:	Energy savings potential is in: thermal insulation up to 30-40%, heating system 10-25%.
Uncovered demand for heating / cooling. (E.g.: low indoor temperature, high indoor temperature, other reason?) Please describe:	In our country we do not have problems with heating. Sources are overloaded and people get used to high indoor temperature. Cooling is not popular in social housing.
Comments:	This group of buildings is described very well and various methods of reconstruction and modernisation have been tested. This process continues successfully.

4 common types of standard apartment buildings are described:

Building type 1:	Building T 02B
Description:	Brick construction, wall thickness 375mm, flat roof, wooden windows with metal sealing
Number of buildings/total area:	Stocktaking is not done for the whole republic, but we guess 500 buildings.
Age:	1957 -1961
Energy consumption:	$E_v = 34,3 \text{ kWh/m}^3 \cdot \text{a}$, label E
Construction principle:	Buildings were built with use of classic technology of thirties of last century.
Comments:	These buildings have a good thermal quality, problems are in roof construction (leakage). They need maintenance very often. Water piping, electricity system and central heating system have been modernised.
Building type 2:	Building T 16

Description:	Concrete frame filled with bricks, outer wall have 450mm thickness, saddle roof, wooden windows with metal sealing
Number of buildings/total area:	Stocktaking is not done for the whole republic, but we guess 900 buildings.
Age:	1960 - 1968
Energy consumption:	$E_v = 43,6 \text{ kWh/m}^3 \cdot \text{a}$, label G
Construction principle:	This kind of construction was known from thirties and used for bigger buildings. Buildings of this type enabled to use some prefabricated elements.
Comments:	The quality of technology was not good. There were many thermal bridges which cause huge thermal losses.

Building type 3:	Building VVÚ ETA
Description:	This type of construction is open assembled pre-cast panel-system used for residential construction.
Number of buildings/total area:	Stocktaking is not done for the whole republic, but we guess 2500 buildings.
Age:	1968-1975
Energy consumption:	$E_v = 49,8 \text{ kWh/m}^3 \cdot \text{a}$, label G
Construction principle:	Pre-cast concrete panel blocks are filled with 50mm thick thermal insulation (polystyrene). All panels were prefabricated in special plants and transported to a construction site and assembled. Roofs are flat. Sanitary equipment, bath and WC were prefabricated.
Comments:	The standard of thermal insulation was softer than nowadays. Owners of these buildings modernised these buildings by (1) adding approx. 100mm thick thermal insulation (usually polystyrene) on the outer walls, (2) changing wooden windows for insulating ones (usually plastic), (3) improving their bath and WC etc.

Building type 4:	Larsen - Nielsen
Description:	This type of construction is open assembled pre-cast panel-system used for residential construction.
Number of buildings/total area:	Stocktaking is not done for the whole republic, but we guess 1800 buildings.
Age:	1974-1982
Energy consumption:	$E_v = 39,6 \text{ kWh/m}^3 \cdot \text{a}$, label F
Construction principle:	Pre-cast concrete panel blocks are filled with 60mm thick thermal insulation (polystyrene). All panels were prefabricated in special plants and transported to a construction site and assembled. Roofs are flat. Sanitary equipment, bath and WC were prefabricated.

Comments:	Thermal insulation of outer panel walls was thicker (60mm). Differences among various constructions were mainly in technological details because it was necessary to build up quicker and cheaper in regards on standards of the days.
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Experience with refurbishment of apartment buildings:

Category:	Residential
Type of measures:	Improvement of thermal insulation of walls, roof and lower parts of building, replacement of windows, reconstruction of heat exchanger or boiler
Description:	All options are common for municipalities and private owners. They realize that these problems originate in soft standards, bad quality of work and neglected maintenance.
Social conditions:	Most people themselves pay for the improvements. In municipal buildings people pay higher rent to pay back the investment.
Investments:	The sum of investment depends on size of building, number of options etc. Average price of new windows and glass-facade is about 7 000 CZK/m ² , ETICS about 1 300 CZK/m ² and roof insulating layers about 1 100 CZK/m ² .
Potential of savings:	Potential savings are about 50% per all named options and can be more.
Impact:	These options can influence the heating system. Boilers or exchangers become bigger than necessary. Efficiency of the boiler houses or exchangers has become worse. It claims new design and investment.
Description:	Heat and hot water consumption is turning down and the whole system has to be controlled better.
Social: (Employment/health etc.)	These improvements do not influence number of employment and health. People will pay less for the heat but they have to pay more for loan.
Comfort:	Standard of living is growing.
Actual savings:	It is very difficult to say how much they spare because prices of heat are different.
Comments:	Improvement of residential buildings is common. Energy Management Act No. 406/2006 Coll. adjusted conditions for dwellers and municipalities and they started to modernize step by step.

3.2.1.2 Public buildings

Category:	Hospitals
Description:	Hospitals utilize energy in wide scale – heating, hot water heating and various technologies. The main problem is to secure reliable supply of energy – from grid or own sources.
Energy consumption:	We can not define energy consumption for the hospital, but only for some technology – kitchen, lift, laundry, average value for a bed etc.
Energy source: (E.g. nuclear, coal, oil,	In the CZ sources of energy are: electricity grid, natural gas network, district heating, coal etc.

natural gas, wind, solar, etc.)	
Energy saving potential:	Energy savings potential is in system solution of demand side and supply side.
Uncovered demand for heating / cooling. (E.g.: low indoor temperature, high indoor temperature, other reason?) Please describe:	Problems of hospitals are in high indoor temperature, non appropriate ventilation and old energy system
Comments:	To improve energy management of hospitals it is necessary to start with design of complex solution. It enables to improve technology, low energy consumption, low energy losses, modernise hospital sources
<hr/>	
Category:	Schools
Description:	Schools have very similar scheme of utilisation. When we remove defects of construction then problems of energy management, lighting and technology of kitchen remain.
Energy consumption:	The main consumption is in heating. It can be from 35 – 200kWh/m ² . It depends on quality of the building.
Energy source: (E.g. nuclear, coal, oil, natural gas, wind, solar, etc.)	Electricity grid, natural gas, district heating. Some schools have their own demonstration solar panels to show to children how it works. It is not utilized for preparation of the whole volume of hot water.
Energy saving potential:	Building improvement, energy management, lighting improvement
Uncovered demand for heating / cooling. (E.g.: low indoor temperature, high indoor temperature, other reason?) Please describe:	Power from heat sources is usually not utilized well. There is a higher temperature in classrooms and corridors. Classroom illumination does not respect daily and artificial lighting.
Comments:	EPC method of financing has been very effective for improving energy consumption. Energy management of a heating system, improvements in control system and hydraulic balance bring savings which pay some investment and long-term service.
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Category:	Public administration
Description:	There are two big groups of administrative buildings. Old buildings - there is difficult to do thermal insulation on walls and replacement of windows, too. Newer buildings have good chance to be improved – insulation, heating system, ventilation etc. Public administration buildings have very similar working scheme to schools. Both categories differs in administrative equipment.
Energy consumption:	The main consumption is heating. It can be from 35 – 200kWh/m ² . It depends on quality of the building. Administrative building has higher heat gains from administrative equipment.
Energy source: (E.g. nuclear, coal, oil, natural gas, wind, solar, etc.)	Electricity grid, natural gas, district heating. Some administrative building wants to utilize flat vast roof to install PV cells.

Energy saving potential:	Energy management of heating and air conditioning.
Uncovered demand for heating / cooling. (E.g.: low indoor temperature, high indoor temperature, other reason?) Please describe:	All demands are fulfilled.
Comments:	Most of administrative buildings are new or after reconstruction. Designers have forgotten utilisation of solar panels and PV cells. They have aimed for attractive appearance of the building, faultless control system and high quality of indoor climate.

Category:	Hotels
Description:	This group of buildings is very progressive. The competition makes them to use solar panels for preparation of hot water, PV cells for illumination, collection of rain water for irrigation or as gray water for WC.
Energy consumption:	We can describe consumption of technology – kitchen, laundry, swimming pool etc. or average value for a bed but it depends if it is yearly or only season utilisation and what quality the hotel is.
Energy source: (E.g. nuclear, coal, oil, natural gas, wind, solar, etc.)	Electricity grid, natural gas, district heating.
Energy saving potential:	To be competitive they have to avoid losses. At lower classes hotels are problems with water at all. It can be good idea to use timed taps.
Uncovered demand for heating / cooling. (E.g.: low indoor temperature, high indoor temperature, other reason?) Please describe:	The hotel class dictates conditions. Basic conditions should be fulfilled everywhere without any comments.
Comments:	Good hotel should offer service at the highest level and guest should not recognise that he is limited. The role of a good designer is to find out the boundary.

Experiences with refurbishment of public buildings

Category:	Hospitals
Type of measures:	Improvement of thermal insulation of walls, roofs and lower parts of building, replacement of windows, reconstruction of heat exchanger or boiler, reconstruction of distillation and sterilization, change of production of steam and heat exchangers. Energy management
Description:	Problems with energy efficiency in a hospital is derived from bad building construction, production of steam, combination of DH system with hospital heating system, system of distillation and sterilisation, kitchen etc.
Social conditions:	Temperatures in rooms are at the standard level.
Investments:	Hospitals use their own budget for investment and some state and regional grants. Several hospitals used EPC method to finance

	services and to lower their own energy expenses.
Potential of savings:	The best way how to gain huge savings is separation of heating system from steam consumers like kitchen, laundry, distillation, sterilisation and humidification.
Impact:	Energy saving can pay the investment into energy equipment.
Description:	Some options in hospital are cheap and bring money back rather quickly, EPC method is interesting for hospitals because it enables to invest money into equipment and to do real and good energy service for contractor and sharing bigger savings
Social: (Employment/health etc.)	EPC courses that service organisation uses only a small number of employees than before. It enables to offer them another work in hospital.
Comfort:	Temperature comfort is higher. Rooms are not overheated or vice versa.
Actual savings:	It is difficult to say what savings will be when ...? Size and options installed are key actors to savings.
Comments:	Hospitals are very good case studies to EPC financing method of investment. Mostly hospitals have been built for many years without any energy concepts, they do not have money to invest, they do not have good engineers to operate their system etc.

Category:	Schools
Type of measures:	Building options, heating options, energy management, lighting options
Description:	The most important in schools is energy management. Time table of classes is different; Saturdays and Sundays are free and a school is not occupied. Heating system should be adjusted to the timetable of the school. Caretaker should have his own heating system when he lives in the school. Lighting is very important and proper illumination enables savings, too.
Social conditions:	Social conditions are the same for the whole time.
Investments:	Energy management is sophisticated instrument and very cheap. Lighting option depends on temporary illumination conditions.
Potential of savings:	Energy management can bring savings from 5 – 15%.
Impact:	Energy savings improve school budget.
Description:	Savings can be used for lighting investment.
Social: (Employment/health etc.)	Number of employees does not change. Better illumination of interior is healthier for children.
Comfort:	Illumination makes the comfort higher.
Actual savings:	Actual savings is difficult to predict. In our country there are many various types of schools from village schools to universities.
Comments:	Energy management is useful and proved option which can be done for the whole municipality and coordinated by energy manager

Category:	Public administration
Type of measures:	The most important in buildings such kind is energy management. Time tables of halls and rooms are different; Saturdays and Sundays

	are free and the building is not occupied. Heating system should be adjusted to the timetable of the building. Caretaker should have his own heating system when he lives in it. Lighting is very important and proper illumination enables savings, too. Good quality of ventilation, air conditioning, heating and hot water preparation give energy savings.
Description:	Meeting rooms and halls should have their possibility of independent system of controlling. Lighting is another way how to get savings. The main problem of public administration is a large number of various equipment – computers, printers, copy machines, refrigerators, electric kettles etc. It is recommended to buy such instrument in A level of label.
Social conditions:	Measures do not influence social conditions of employees
Investments:	Energy management is very cheap option. Technology investment – heating system, ventilating system or air conditioning are much expensive.
Potential of savings:	There are no regulation to appreciate savings without knowledge of the site
Impact:	All options causes better working space for clerks and visitors.
Description:	Right temperature in working places does better conditions for negotiation.
Social: (Employment/health etc.)	There are no changes of employees in the building. The building environment will be healthier – right temperature and humidity enough fresh air and good illumination.
Comfort:	Building has good environment and high quality of equipment - both arrange high comfort
Actual savings:	Actual savings depends on real conditions
Comments:	New administration buildings are called intelligent buildings. When we calculate their thermal losses we re admired that is not level E or better but F or worse. Of course the control system is on the highest level. These buildings can not be improved after constructing. It required an energy audit of the project to approve thermal quality of the building.

3.2.1.3. RUE measures

RUE measure option 1:	Refurbishment of roof
Description:	Many roofs need to be reconstructed – to add about 150 – 200 mm of thermal insulation and to create a new envelope (to install new layers).
RUE measure option 2:	Thicker insulation of walls
Description:	To improve the quality of thermal insulation of old panels by approx. 100 – 120 mm thick of thermal insulation is necessary. It enables to get rid of thermal bridges and to recover the surface.
RUE measure option 3:	Replacement of old windows
Description:	Old buildings have wooden windows which need to be refurbished – sealing, painting some craftsman work etc. These windows have lower quality of thermal insulation and higher rate of infiltration. New windows are better in both parameters.

RUE measure option 4:	Insulation of floors above non-heated areas
Description:	To improve living conditions is necessary to insulate floors or ceiling of non-heated areas.
RUE measure option 5:	Reconstruction of heating system
Description:	Design and replacement of an old non-functional control equipment with new one
RUE measure option 6:	Installation of thermostatic valves
Description:	Each radiator should have a possibility to be adjusted to various conditions
RUE measure option 7:	Hydraulic balance
Description:	Each radiator needs only a part of the whole quantity of heat. Hydraulic balancing enables to do that.
RUE measure option 8:	Change of preparation of hot water
Description:	Preparation of hot water was in distant heat exchanger. There were huge heat losses in piping. Replacement of four-pipe system for two-pipe system gives us a possibility to build up a new type of quick heat exchanger in the building.
RUE measure option 9:	Replacement of old hot water pipes and insulation of new ones
Description:	Old hot water pipes have often splits and then the supply of hot water has to be stopped. Replacement by new plastic pipes gives a chance to get safer delivery of hot water and lower heat losses using new insulation.
RUE measure option 10:	Improvement of building lighting
Description:	Compact FCL are often used in dark places. Using of sensors which react on move and switch on the light for a half of minute.
RUE measure option 11:	Installation of solar panels for preparation of hot water on the roof
Description:	Flat roofs are very convenient to install solar panels for preparation of hot water. In combination of an accumulator in the place with a boiler or heat exchanger we can prepare enough water without heat from boiler.
RUE measure option 12:	Heat pump installation
Description:	Waste water flows off a building and contains enough heat. This heat can be used for hot water preparation.
RUE measure option 13	Solar PV cells
Description:	Big panel building with flat roof has a good opportunity to install PV cells. Electricity can be sold out to electricity grid.

Comments:	Some of proposed options (1-10) are usually being done during modernisation or reconstruction of building. Options (11-13) are waiting for an ecologically thinking investor. Investments in old buildings are much more expensive for RES than in new ones. Local government and private owners concentrate on improvement of quality of buildings and energy savings more than on RES. Low energy and passive houses utilize RES and other possibilities like recuperation of air from house etc.
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3.2.2 Slovenia

3.2.2.1 Residential buildings

The multifamily buildings in Slovenia is categorised in five categories by year of construction. The oldest buildings are mostly brick or modular brick construction, while the newer buildings mostly are prefabricated concrete panel buildings. The technical saving potential for Residential buildings in Slovenia is estimated to approx. 60 %, while the economically realistic potential is estimated to 30%.

Table 3.2.2.1: Residential buildings.

Year of construction	1952-1970	1971-1980	1981-1990	1991-2001	2002-2005
Quantity, no	49,031	51,192	53,641	40,602	19,624
Floorage, m ²	11,957,503	16,449,000	15,908,000	10,061,556	3,507,140
Multi family buildings	180-240 kWh/m ² /y	140-200 kWh/m ² /y	120-160 kWh/m ² /y	80-130 kWh/m ² /y	40-100 kWh/m ² /y
Construction	Mostly brick and modular brick blocks. Gradual increase of concrete construction. Poor thermal insulation	Many concrete constructions, not many panel buildings. Better window quality.	Mostly massive construction, but also prefabricated. First thermal insulation requirements	Many prefabricated buildings, good thermal insulation, efficient windows	Massive and lightweight construction with high thermal insulation and low energy standards.
Saving potential (30%), kWh/m ² /y	54-72	42-60	36-48	24-39	12-30

3.2.2.2 Public buildings

The following tables show the energy consumption in public buildings in Slovenia such as administrative buildings, schools and hospitals. As expected the hospitals are the building type with the highest energy consumption. The economically realistic saving potential is estimated to 30% - especially for the older buildings, which were constructed with regard to energy savings.

Table 3.2.2.2: Administrative buildings.

Year of construction	1952-1970	1971-1980	1981-1990	1991-2001	2002-2005
Quantity	335	218	121	857	1,249
Floorage, m ²	380,413	312,000	151,287	326,189	715,695
Multi-family buildings, kWh/m ² /y	150-250	100-180	85-140	70-120	40-100
Construction		Many concrete constructions, not many panel buildings. Better window quality.	Mostly massive construction, but also prefabricated. More glass. First thermal insulation requirements	Mostly massive construction, but also prefabricated. More glass. First thermal insulation requirements	Various, contemporary. High insulation standard
Saving potential (30%), kWh/m ² /y	50-72	30-60	26-42	?	?

Table 3.2.2.3: Educational/cultural buildings.

Year of construction	1952-1980	1981-2005
Quantity, no	981	2,006
Floorage, m ²	1,410,808	1,401,901
Energy consumption, multi-family buildings, kWh/m ² /y	250-350	180-250
Construction	Mostly massive construction (brick, modular brick block, concrete. No or low thermal insulation	As before, plus prefabricated lightweight buildings. Increase in energy efficiency
Saving potential (30%), kWh/m ² /y	75-105	54-75

Table 3.2.2.4: Hospitals.

Year of construction	1952-1980	1981-2005
Quantity, no	415	733
Floorage, m ²	869,373	569,203
Energy consumption, multi-family buildings, kWh/m ² /y	400-550	280-350
Construction	Mostly massive construction (brick, modular brick block, concrete	As before, plus prefabricated lightweight buildings. Increase in energy efficiency
Saving potential (30%), kWh/m ² /y	120-165	84-105

Table 3.2.2.5: Savings potential for public buildings in total.

Building type	Public administration	Schools	Hospitals
Energy consumption, kWh/m ² /year	40-180	180-350	407
Quantity, no	335		
Energy Saving potential (30%), kWh/m ² /year	12-54	54-105	122

3.2.2.3 RUE measures

The PSF in Slovenia has suggested the following RUE measures for the buildings:

- Option 1: Draught sealing of windows. Included in the first subsidy schemes by the state in mid-1990. Simple and non-expensive measure, some care needed regarding proper ventilation afterwards.
- Option 2: Insulation of floors in unheated lots. Included in the first subsidy schemes in mid 1990. Usually DIY process, 10-20 cm of mineral wool insulation, payback period 2-3 years.
- Option 3: Fine tuning of boilers, thermostat valves on radiators. Fine tuning included in the first subsidy schemes in mid 1990. Simple and quick measure, effect depending on the initial state.
- Option 4: Replacement of windows/glazing. One of the most popular subsidy schemes in late 1990. One of the positive effects of the scheme: Filtering of the market, introduction of reliable EE products. Instructions for tenants needed regarding ventilation.
- Option 5: Façade insulation. Loans possible by the EKO fund of Slovenia. Feasible and with an acceptable payback period when the façade already in need of repair. Substantial effect.
- Option 6: Roof insulation. Need to involve expertise, especially with flat roofs.
- Option 7: Unheated basement ceiling insulation. Not necessary and optimal solution, if influence of remaining thermal bridges too big. Usually DIY process, 10-20 cm of mineral wool or polystyrene insulation, short payback period.
- Option 8: Upgrade/replacement of heating system. Possibility of subsidies and loans. Project and detailed calculations needed. Best if combined with envelope insulation.
- Option 9: mechanical ventilation with heat recovery. Contemporary solution, still used only seldom. Important effect on indoor comfort highly eliminates risk of condensation and mould, suitable esp. in renovation of social housing.
- Option 10: Use of RES: Solar collector for DHW etc. Supported and promoted at official level. DIY solar collector also very popular, teams supervised by experts involved.

3.3 Southern Europe

3.3.1 Greece/Crete

The overall saving potential for residential buildings in Greece is depending of the age and the conditions of the buildings. As seen in the table bellow the geographical location of the buildings also have significance for energy consumption. The maximum saving potential is estimated to be around 45%, while average potential for residential buildings are 18%.

In the ClearSupport project Greece is represented by TEI, Crete, belonging to the southern part of Greece. In contradiction to the northern countries there are in Crete no massive developments of standardised apartment buildings in the suburbs. For Crete there are not as detailed data available as for the more northern countries. As for the buildings sector the problems are also of a different nature. The winter is short, but some heating is needed. For the long summer period the energy need is more related to cooling and electricity/hot water. Solar panels are widely used for the hot water supply. Especially for the hotels this is a relevant option, but also for hospitals, schools and administrative buildings. Design outdoor temperatures for winter is 0-5 degrees C and for summer 32.5-35 degrees C. Number of degree days is approx 870 with basis 18 degrees, for Heraklion it is 125 for temperature basis 25⁰ C. This is in great contrast to the northern countries.

3.3.1.1 Residential buildings

In Greece there exist only two district heating networks in cities in the northern part. For Crete it is questionable if district heating is generally feasible. However the combinations of a central heating boiler with local fuel (olive kernel residue) with solar panels are being investigated. So far analyses in this area are promising.

Table 3.3.1: Energy saving potential, residential buildings, Greece.

Part of Greece	A (South)	B (Central)	C (North)
Residential buildings, kWh/m ² /y	66-188	140-200	156-375
Energy Saving potential (average), kWh/m ² /y	12-34 (18%)	25-36 (18%)	28-68 (18%)

3.3.1.2 Public buildings

The overall saving potential for public buildings in Greece is depending of the age and the conditions of the buildings. The maximum energy saving potential for public administration buildings are estimated to be around 33 %, while average potential for public administration buildings are 20 %. For schools the average saving potential is 19 %, while the maximum potential is 42 %. For hospitals the average saving potential is 23 %, while the maximum potential is 54 %.

Table 3.3.2: Energy saving potential, public buildings Greece.

Type of building	Public administration	Schools	Hospitals	Hotels
Energy consumption,	187	92	407	273

kWh/m ² /y					
Energy Saving potential (average), kWh/m ² /y		avg. 20- max.33% 37 KWh/m ² /y	avg. 19- max42% 17 KWh/m ² /y	avg. 23% - max 54% 94 KWh/m ² /y	avg. 28% - max 44% 76 KWh/m ² /y

3.3.1.3 RUE measures

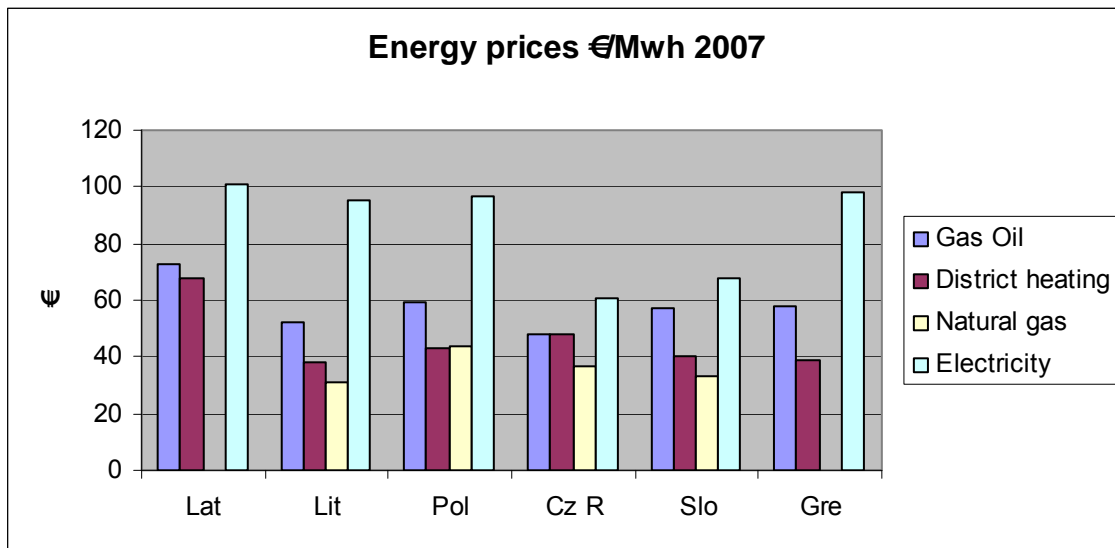
- Option 1: Conversion to slope rood. Build new slope rood instead of flat roof or put extra thermal insulation en existing slope rood (about 10-20cm).
- Option 2: Windows sealing by putting sealing strips or tapes
- Option 3: Installing the new modern heat substation or buildings boiler plant with automatic temperature control, depending on outside and room temperature
- Option 4: Refurbishment of lighting generally concerns public buildings only. RUE measures depend on specific case. It can be replacement of existing lamps with low energy lamps, for instance.
- Option 5: Combination of insulation of building envelope, replacement of incandescent lamps with compact fluorescent lamps, installation of solar system for hot water supply.
- Option 6: For hospitals: Replacement of incandescent lamps with compact fluorescent lamps, installation of BMS, improvement of control systems in HVAC system, improvement of piping insulation.
- Option 7: For schools: Insulation of building envelope, replacement of incandescent lamps with compact fluorescent lamps, optimization of burner/boiler operation.
- Option 8: For public administration buildings. Insulation of building envelope, replacement of incandescent lamps with compact fluorescent lamps, optimization of burner/boiler operation, improvement of control systems in HVAC system.
- Option 9: For hotels: Insulation of building envelope, replacement of incandescent lamps with compact fluorescent lamps, optimization of burner/boiler operations, improvement of control systems in HVAC systems, installation of BMS, installation of solar system for hot water supply, improvement of piping insulation.

4. Energy prices

The energy prices differ from country to country and from fuel to fuel. As shown in figure 10.3.1. Please note that for all countries electricity is by far the most expensive energy for heating. District heating and natural gas is competing and gas oil is also an expensive alternative in most cases.

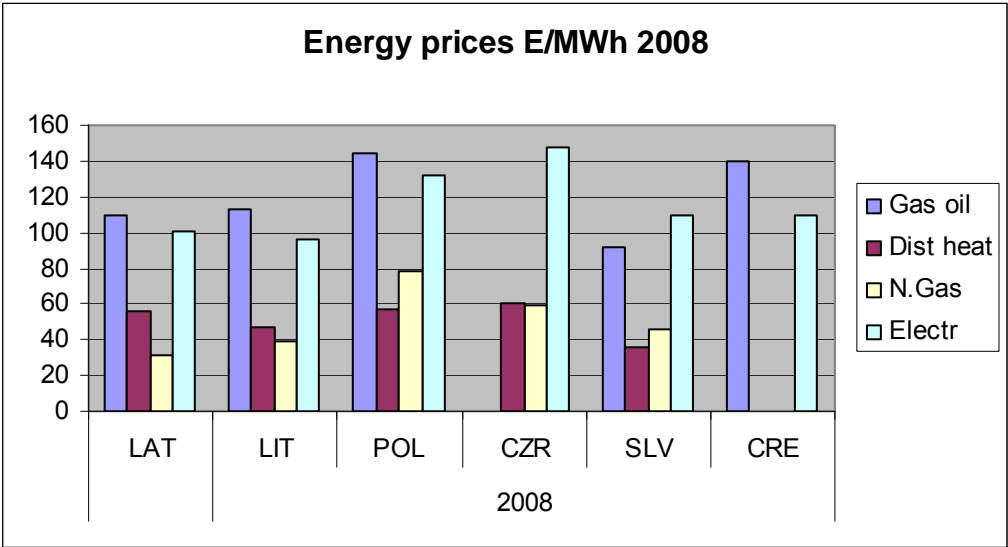
The prices illustrated in figure 2.3.1 were collected from the member states in spring 2007 due to the sharp increases in especially oil prices updates on the prices were made in May 2008. These prices are illustrated in figure 2.3.1.

Figure 4.1: Energy prices in ClearSupport countries 2007



The energy prices have an important influence on the economics of refurbishment measures. Especially the high electricity prices favour the different measures. In Section 7.4 the effect of the different heat sources on selected insulation measures clearly illustrates this. In general high energy prices favours the economics of saving measures because the costs saved are higher.

Figure 4.2 Energy prices in ClearSupport countries 2008



Please note how the prices for gas oil have increased while district heating and natural gas have a moderate development. This is mostly due to the fact that the impact of oil prices on these fuels has a rather long reaction time.

5. RUE initiatives

In this chapter are the RUE initiatives listed in different groups related to the type of measure. The options are mentioned to give an overview on available measures. In section 7.4 the economics of the different measures are analysed. This section gives only a short overview on most relevant measures. In the report 4.4 the different measures are described in detail with specific characteristics.

Thermal insulation

Type of measure	Description
Facade insulation	
Insulation - sloped roof	Build new slope roof instead of flat roof or put extra thermal insulation on existing slope roof (about 15-20 cm)
Insulation - flat roof	Putting extra thermal insulation. Thickness about 15-20 cm
Insulation of floor	
Consider	New apartments on top floor

Windows/doors

Type of measure	Description
Windows replacement	Replacement of windows with new ones with better thermal resistance
Sealing of windows	Windows sealing by putting sealing strips or tapes
Entrance doors	Replacement the existing doors with new ones with better thermal resistance

Heating Systems

Type of measure	Description
Optimization of heating system	
Replacement of heating system	Connection to district heating or new and effective boiler on cheap/renewable fuel
Thermostat valves	
Insulation of piping, ducts, tanks etc	
Increase of efficiency of burner / boiler	Renovation and installation of flue gas control
Heat pumps installation	Effective to replace electric warmers

Cooling systems

Type of measure	Description
Mechanical ventilation with heat recovery	
Increase of COP of cooling system	
Improvement of air handling unit	
Outside air control	
passive-heating and cooling	

Lightning

Type of measure	Description
Replacement of lamps or fixtures	Replace incandescent lamps with compact fluorescent
Photo controls	Switch light on/off

6. Cost of RUE initiatives

In this chapter the cost of the RUE initiatives described. The description is divided into Residential buildings and Public buildings. The Residential building category will mainly focus on multi family building, while the public building category contains following building types: Public administration, schools and Hospitals. The measures will for most part be the same in the two building categories, but the investment cost and the savings potentials will differ. Information on investment costs are not available for all PSF but for the analysis of the different measures in section 7.4 estimated costs are used.

6.1 Residential buildings

Table 6.1 Investments for insulation in residential buildings

RUE	Lat	Lit	Pol	CzR	Slo	Gre
Building insulation	€/m ²	€/m ²	€/m ²	€/m ²	€/m ²	€/m ²
Facade insulation	54	41,2		52	30-50	50-70
Roof insulation - sloped	35,6	31,53		44 ²		45
Roof insulation - flat	28	16,93		44 ²		35
Insulation of floor	6	10,48				25
Enclosure of adjoining	6	10,48				22

M² is defined as useful floor area

Table 6.2 Investments for insulation in residential buildings

RUE	Lat	Lit	Pol	CzR	Slo	Gre
Windows	€/m ²	€/m ²	€/m ²	€/m ²	€/m ²	€/m ²
Windows replacement	42,7	30,3		279 ²	130-250	350-500
Sealing of windows	1,7	0,12				0,7
Entrance doors	28,5	3,58				450-500

2) For CzR unit is per m² façade etc.

6.2 Public buildings

Table 6.3 Investments for Schools

RUE	Lat	Lit	Pol	CzR	Slo	Gre
Schools, building insulation	€/m ²	€/m ²	€/m ²	€/m ²	€/m ²	€/m ²
Facade insulation	54	36,27			30-50	
Roof insulation - sloped	35,6	60,8				
Roof insulation - flat	28	32,61				
Insulation of floor	6	18,22				
Enclosure of adjoining						

Table 6.4 Investments for windows and doors

RUE	Lat	Lit	Pol	CzR	Slo	Gre
Windows and doors	€/m ²	€/m ²	€/m ²	€/m ²	€/m ²	€/m ²
Windows replacement	71,1	54,5				
Sealing of windows	1,7	0,42				
Entrance doors	42,7	4,34				

6.3 Eurima study

EURIMA is the European Association of Insulation Manufacturers and represents the interests of all major mineral wool producers throughout Europe. Eurima published a study on the savings and economics for different measures for building rehabilitation "Cost-Effective Climate Protection in the EU building stock. With due respect to the study a few of the conclusions are brought here because the areas covered are close to the subject of this report.

The study also operates with 3 climatic zones: Cold: (Finland, Sweden. Moderate (Middle Europe) and Warm: Southern Europe.

The costs involved include both materials and installation. A value expressing cost of saving one tonne of CO₂ is also included in the study.

Effects of thermal insulation of wall are illustrated with different techniques. In a thermal composite system the material is attached to the wall and coated with a final layer. The method is widely employed in retrofit projects in central Europe. Also tested is a cladding with air circulation consisting of insulation material, an air gap of approx 3 cm and a waterproof layer. Wood covered external insulation is commonly used in the northern European countries.

The study operates with two types of realisation. Coupled realisation means that investments are done as part of a general renovation. Independent realisation is an investment done independently from other measures. It is clear from the results that when a general refurbishment of a building is considered then it is the right time to implement energy saving measures, which at such time will have a much better economical benefit.

The main results are summarised as such:

Table 6.3.1

Investment in façade, external insulation		Cold zone	Moderate zone	Warm zone
U-value before retrofit	W/m ² K	0,50	1,5	2,6
U-value after retrofit	W/m ² K	0,17	0,38	0,48
Total investment costs	Eur/m ²	152	92	70
Coupled investment	Eur/m ²	77	42	32
Cost saved energy independent	Ecent/kWh	14,6	0,2	1,3
Cost saved energy coupled	Ecent/kWh	3,5	-3,0	-3,4
Pay back independent	years	50	18	13
Pay back coupled	years	25	8	6

(Source: Eurima report)

Table 6.3.2

Investment in façade, cavity insulation		Cold zone	Moderate zone	Warm zone
U-value before retrofit	W/m ² K	0,50	1,5	2,6
U-value after retrofit	W/m ² K	0,17	0,38	0,48
Total investment costs	Eur/m ²	41	21	17
Cost saved energy independent	Ecent/kWh	-1,5	-4,3	-4,2
Pay back independent	years	14	4	3

(Source: Eurima report)

Table 6.3.3

Investment in façade, interior insulation		Cold zone	Moderate zone	Warm zone
		(uncommon)		
U-value before retrofit	W/m ² K		1,5	2,6
U-value after retrofit	W/m ² K		0,38	0,48
Total investment costs	Eur/m ²		32	23
Cost saved energy independent	Ecent/kWh		-3,6	-3,9
Pay back independent	years		6	4

(Source: Eurima report)

Table 6.3.4

Investment in pitched roof, insulation		Cold zone	Moderate zone	Warm zone
U-value before retrofit	W/m ² K	0,5	1,5	3,4
U-value after retrofit	W/m ² K	0,13	0,23	0,43
Total investment costs	Eur/m ²	46	25	16
Cost saved energy independent	Ecent/kWh	-1,5	-4,2	-4,5
Pay back independent	years	14	4	2

(Source: Eurima report)

Table 6.3.5

Investment in cellar ceiling, insulation		Cold zone	Moderate zone	Warm zone
U-value before retrofit	W/m ² K	0,5	1,2	3,4
U-value after retrofit	W/m ² K	0,17	0,41	0,48
Total investment costs	Eur/m ²	44	22	18
Cost saved energy independent	Ecent/kWh	4,4	-1,8	-3,0
Pay back independent	years	27	12	7

(Source: Eurima report)

Table 6.3.6

Investment in windows, replacement		Cold zone	Moderate zone	Warm zone
U-value before retrofit	W/m ² K	3,0	3,5	4,2
U-value after retrofit	W/m ² K	1,33	1,68	2,71
Total investment costs	Eur/m ²	433	316	142
Coupled investment	Eur/m ²	133	116	60
Cost saved energy independent	Ecent/kWh	4,9	6,9	6,0

Cost saved energy coupled	Ecent/kWh	-3,7	-1,1	-0,5
Pay back independent	years	29	38	37
Pay back coupled	years	8	14	16

Please note how the economy of a measure is improved, when it is made together with a general renovation.

6.4 ClearSupport analysis of saving measures

Based on the technical coefficients of the Eurima study ClearSupport has tested the economics of the different measures applying energy prices and investment cost related to the participating countries and the climate parameters. The calculations are carried out for North (Latvia, Lithuania, Poland), Central (Czech R, Slovenia) and South (Crete). The degree days used is average values for each region: 3800, 3102 and 870. For energy prices the values from section 3 is used. The prices are those collected in 2007 and do not reflect the latest increases in energy prices, as is the case in section 6.5. Investments were originally prices related to Western European countries. Based on studies on difference in salary (the new member states salaries are generally 2,5 times lower than for EU 15. The investment costs are reduced accordingly for North and Central, but not for South. Reduction is assumed to be approx 38% because the salary part of the investment is assumed to be 2/3 of the total investment.

On the basis of these inputs the simple payback of the investments for the different measures are calculated. Please note that the pay back time is calculated for prices for different energy sources: Gas oil, district heating, Natural gas and electricity. In some cases the investment is defined as additional investment being done together with a general renovation. In these cases the investments are stated as additional. Other investments are stand alone.

Please note that the effect of some of the measures seems to increase in Central and South. This is due to the rationale that in general buildings in the North are originally built with more consideration to climate before the retrofit. Therefore there is supposed to be a lower building standard related to climate more southern, and therefore again there is a saving potential to be captured.

In some cases no investment and results are mentioned this is because the measure is rarely used in the area concerned.

Table 6.4.1 Facade external insulation

	North	Central	South
Investment Eur/m2	94	57	70
Investment Eur/m2 add	48	26	32
.Pay back (gas oil)	51	13	23
Pay back (district heating)	62	16	
Pay back (natural gas)	54	20	
Pay back (electricity)	32	11	23
Pay back additionally (gas oil)	26	6	11
Pay back add (district heating)	32	7	
Pay back add (natural gas)	27	9	
Pay back add (electricity)	16	5	7

Please note that for all the pay back is improved considerable when insulation is done in connection with a general renovation. Please also note how the pay back varies according to the fuel type. Especially for electricity pay back is lower due to the high prices.

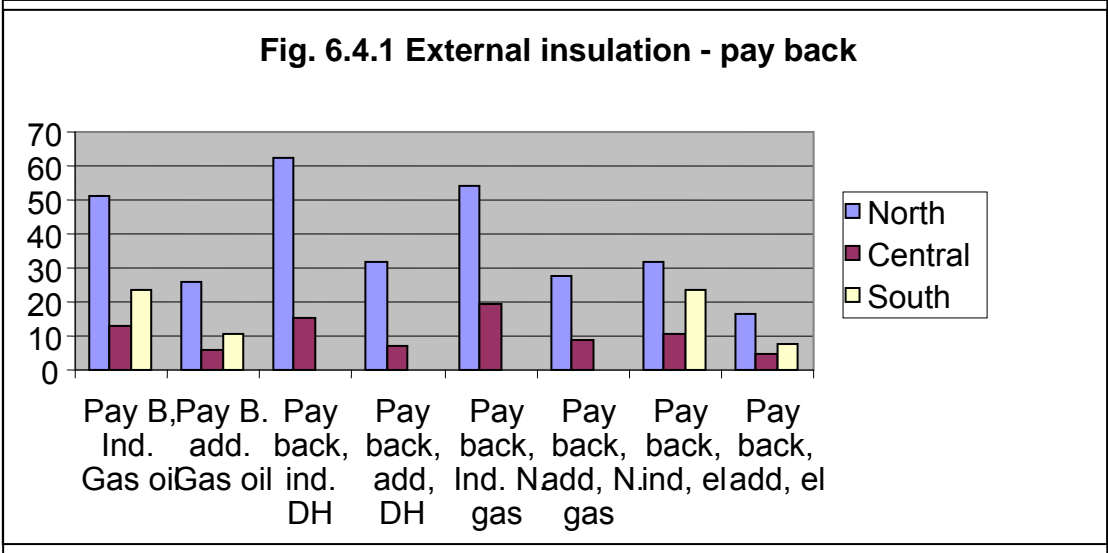


Table 6.4.2 Facade cavity insulation

	North	Central	South
Investment Eur/m ²	25	13	17
Pay back (gas oil)	14	3	6
Pay back (district heating)	17	4	
Pay back (natural gas)	15	4	
Pay back (electricity)	9	2	4

Please note the surprisingly short pay back in the Central and South areas.

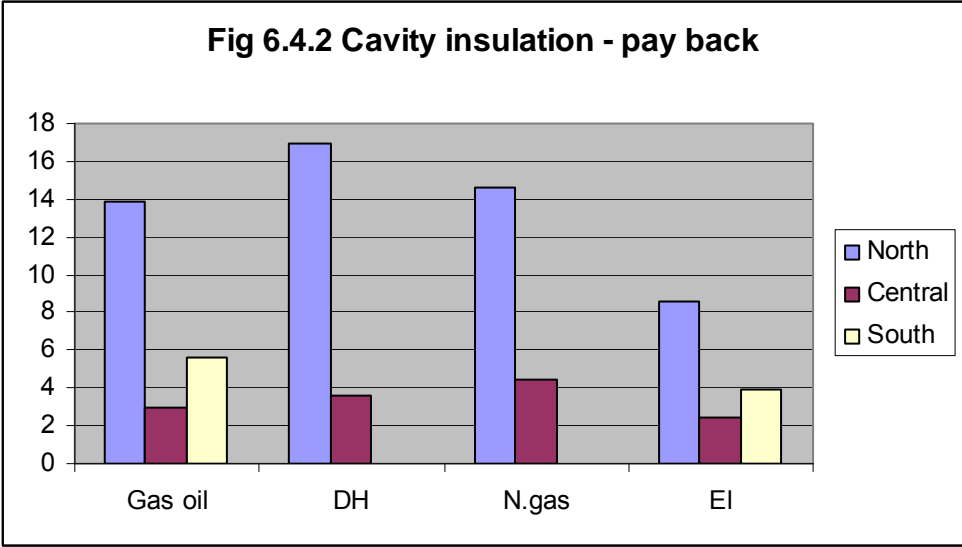


Table 6.4.3 Interior insulation (OBS. condensing problems might arise)

	North	Central	South
Investment Eur/m2	20	23	
.Pay back (gas oil)		4	8
Pay back (district heating)		5	
Pay back (natural gas)		7	
Pay back (electricity)		4	5

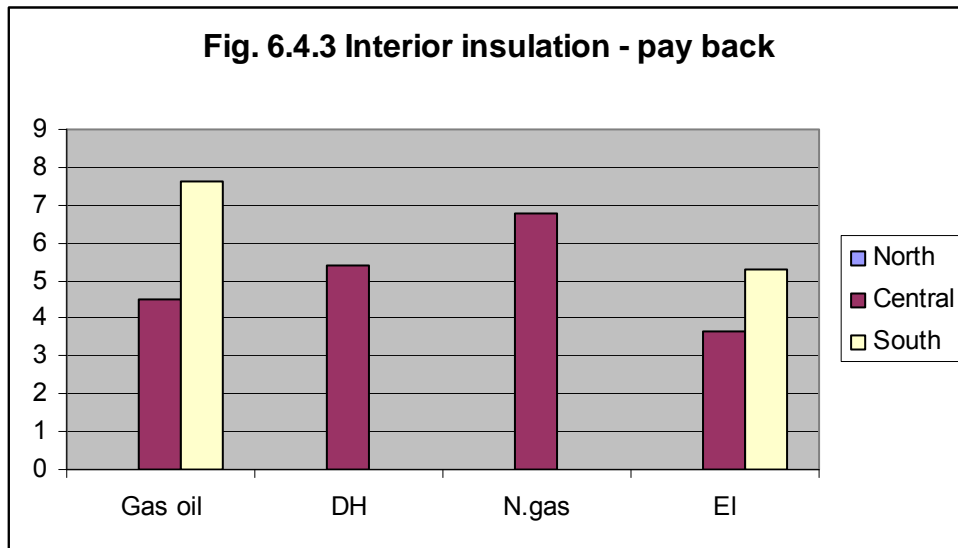


Table 6.4.4 Roof insulation. Pitched

Roof insulation, Pitched	North	Central	South
Investment Eur/m2	29	16	16
.Pay back (gas oil)	14	3	4
Pay back (district heating)	17	4	
Pay back (natural gas)	15	5	
Pay back (electricity)	9	3	3

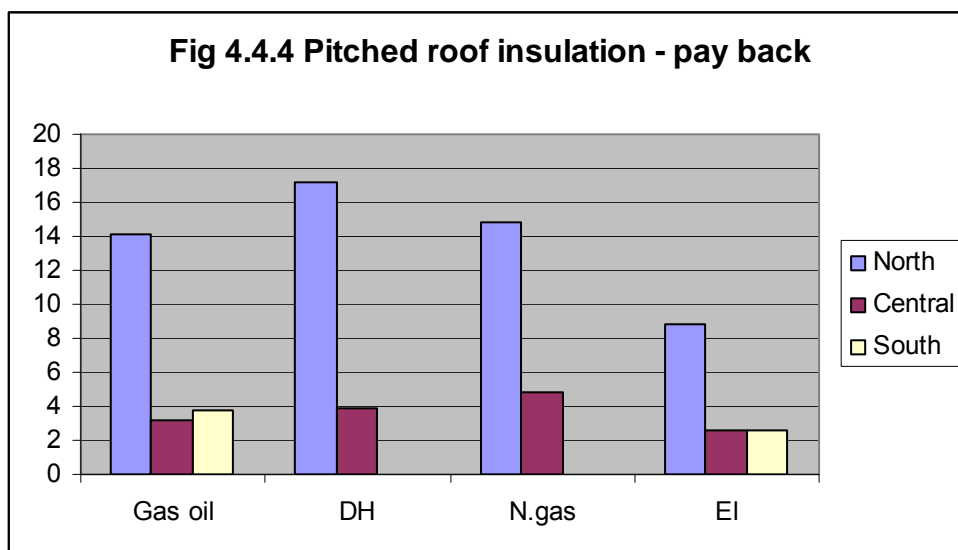


Table 6.4.5 Cellar ceiling insulation

	North	Central	South
Investment Eur/m ²	27	7,5	18
.Pay back (gas oil)	15	2	4
Pay back (district heating)	18	3	
Pay back (natural gas)	15	4	
Pay back (electricity)	9	2	3

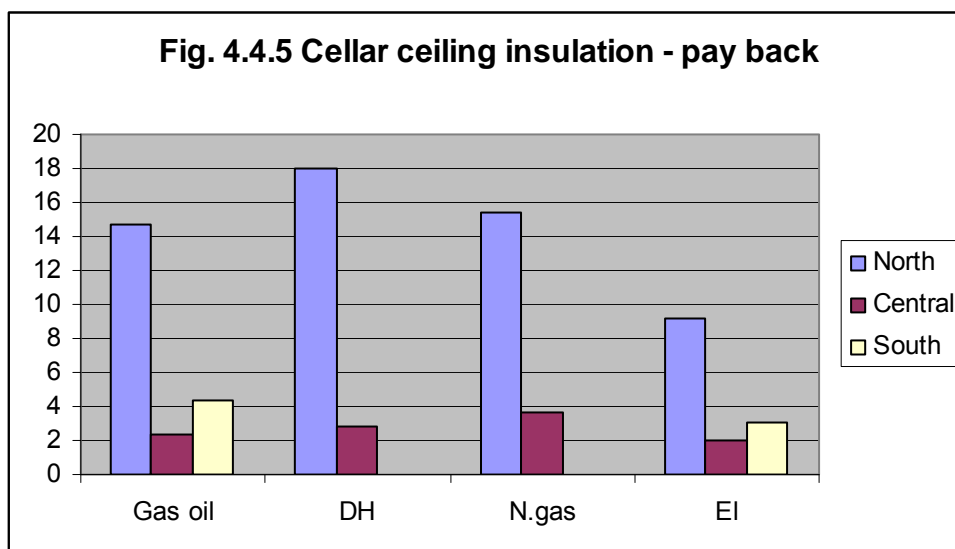
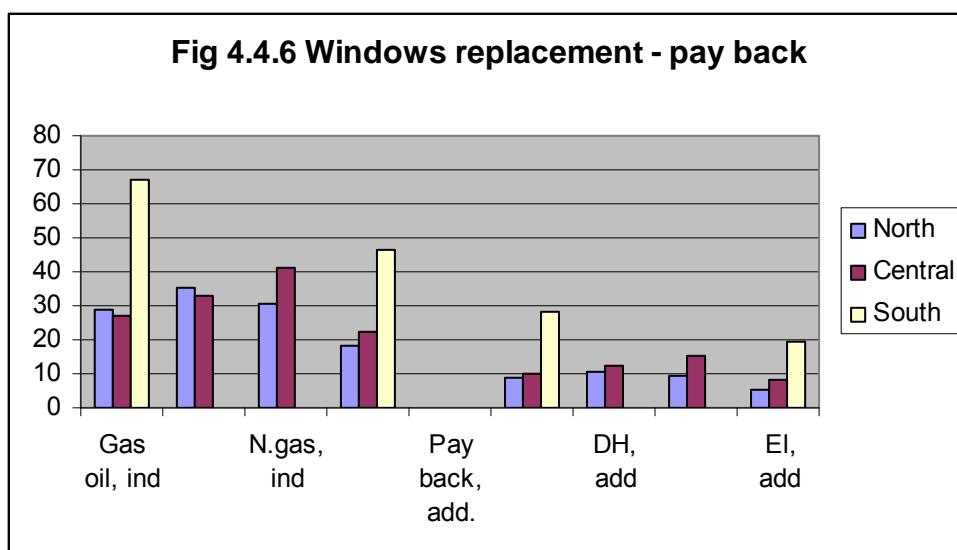


Table 6.46 windows replacement

	North	Central	South
Investment Eur/m ²	268	196	142
Investment Eur/m ² add	82	72	60
.Pay back (gas oil)	29	27	67
Pay back (district heating)	35	33	
Pay back (natural gas)	30	41	
Pay back (electricity)	18	22	47
Pay back additionally (gas oil)	9	10	28
Pay back add (district heating)	11	12	
Pay back add (natural gas)	9	15	
Pay back add (electricity)	5	8	20



For the cases where additional investments are made it is clear that the pay back time is considerably lower (=better). It might also be interesting to note that even in warmer climate conditions there are gains due to the presumed lower energy standard of the older buildings compared to more Northern countries.

It is also clear how much the economical saving potential depends on the price of the energy supply. Not surprisingly the cases with electricity bring most benefit. In many countries it is therefore a policy to avoid heating with electricity. Both from economical and environmental reasons (the efficiency is low) but also because heating with electricity put a load on the electricity supply capacity, which is limited in some countries.

Please also note that these calculations are done based on technical coefficients from the Eurima study and adjusted to the conditions in the ClearSupport countries. These adjustments can be discussed, but in general the results give a useful picture on the effects and potential of different measures.

6.5 Examples on improving building envelope: Latvia and Czech R.

Using the methodology from section 6.4 two examples on improvement of the building envelope has been made for Latvia and Czech Republic respectively.

The energy prices are the same as in section 4 for 2008. Oil prices have been sharply increasing while prices for district heating and natural gas have increased with a slower rate. This influences the economics of the tested insulation methods, because higher prices imply a better economy of the single measures.

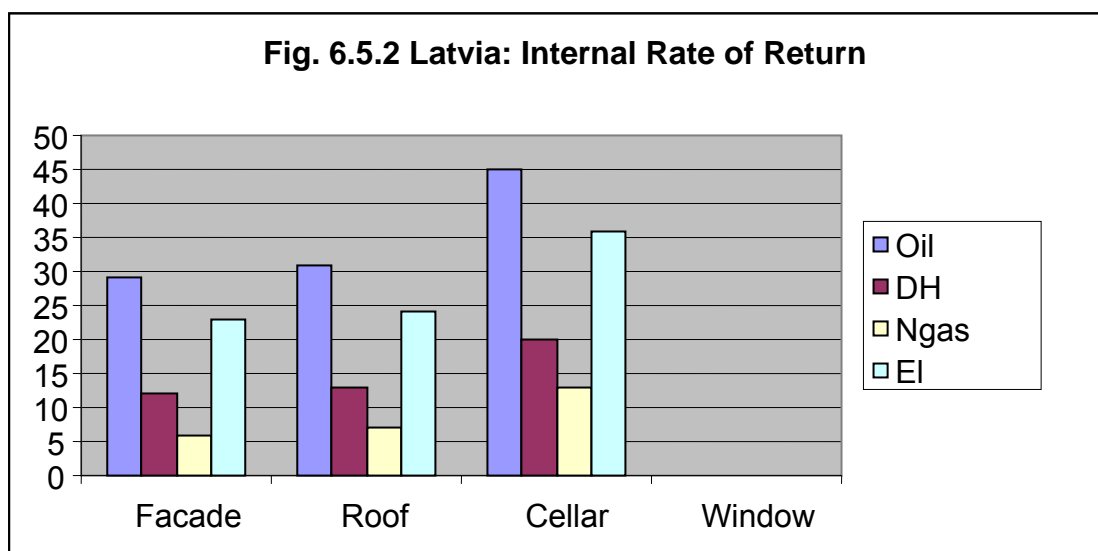
Values for savings and investment costs related to the tested insulation measures have been estimated by the PSF's according to the following table:

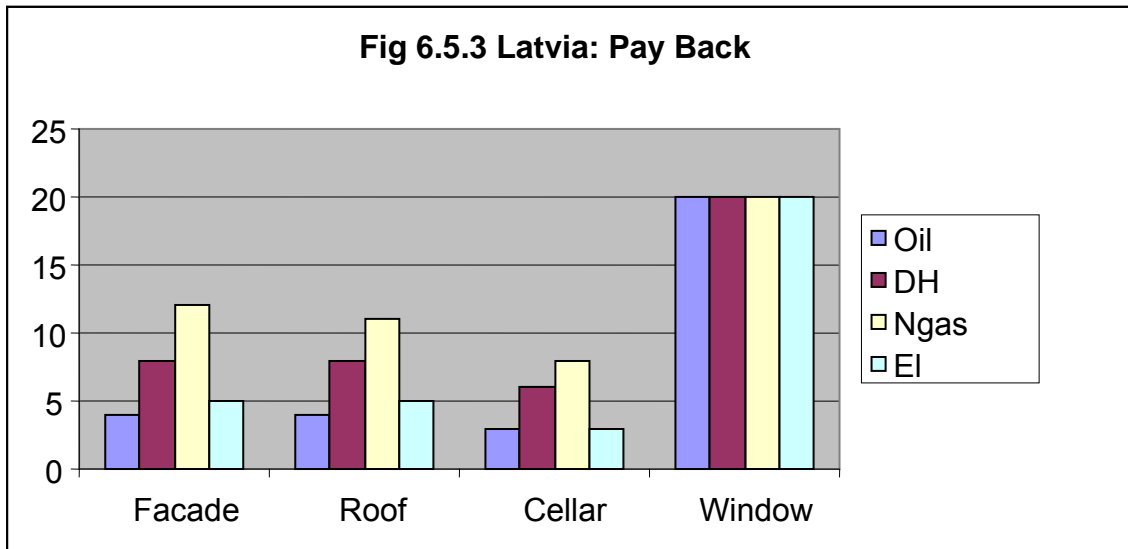
Table 6.5.1

Savings and investments (MWH - Euro/m ²)		
External wall insulation	Latvia	CZ
u-before	1,48	0,95
u-after	0,35	0,38

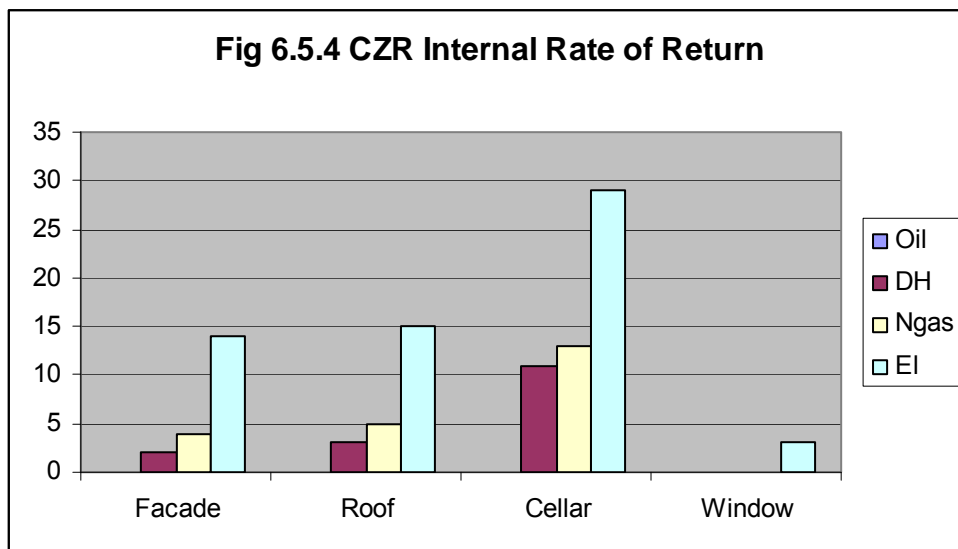
Saved MWh	0,112738	0,048605
Investment	55	56
Roof insulation		
u-before	1	0,8
u-after	0,2	0,24
Saved MWh	0,079814	0,047752
Investment	36	52
Cellar insulation		
u-before	1,17	1,2
u-after	0,25	0,45
Saved MWh	0,091787	0,063954
Investment	28	36
Windows		
u-before	2,56	2,9
u-after	2,2	1,7
Saved MWh	0,035916	0,102326
Investment	145	270
Degree days	4157	3553

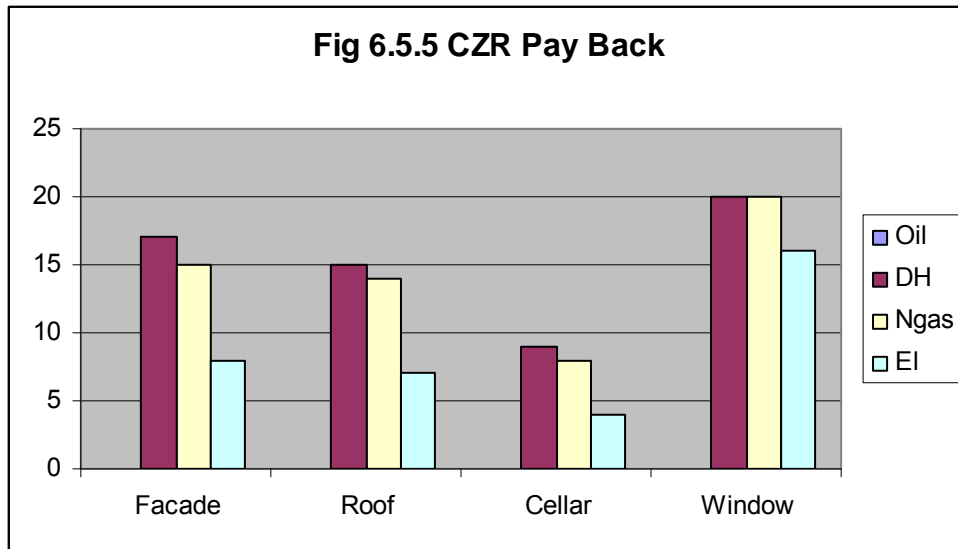
Based on these values the economics of the investment are analysed. Internal rate of return and pay back time is calculated.





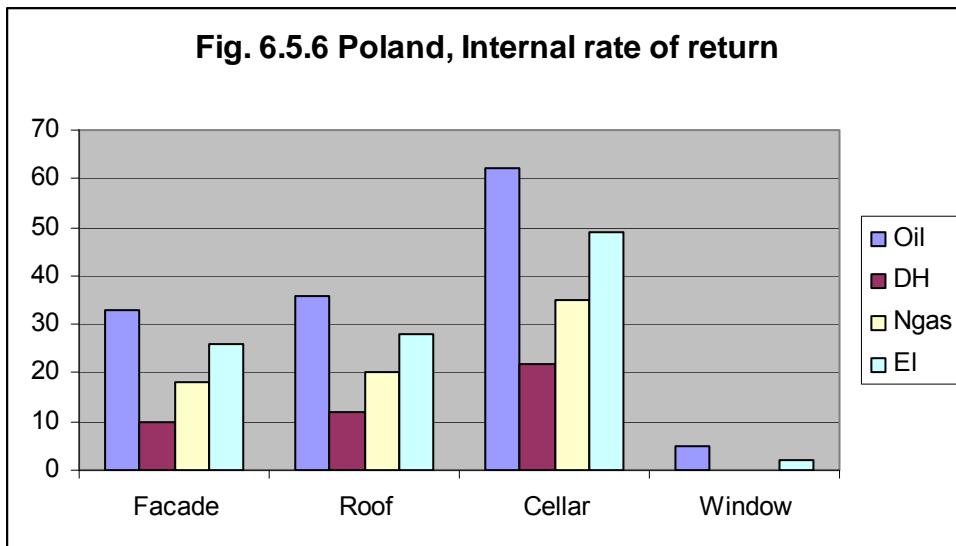
It is clear that all investments except for windows have reasonable economical results. Especially the result for insulation to cellars seems to be advantageous. Regarding the windows the result will be much better if replacement is done in connection with a major rehabilitation, such as illustrated in section 6.4. It is also clear from the above that investments done in building supplied with oil and electricity has a better economy than those with district heating and natural gas, for which the savings is valued lower due to lower prices. It must however, be expected that in the longer term the prices will also be influenced by the higher oil prices at the world market. Nevertheless the results illustrate indirectly the advantages of these two supply sources.

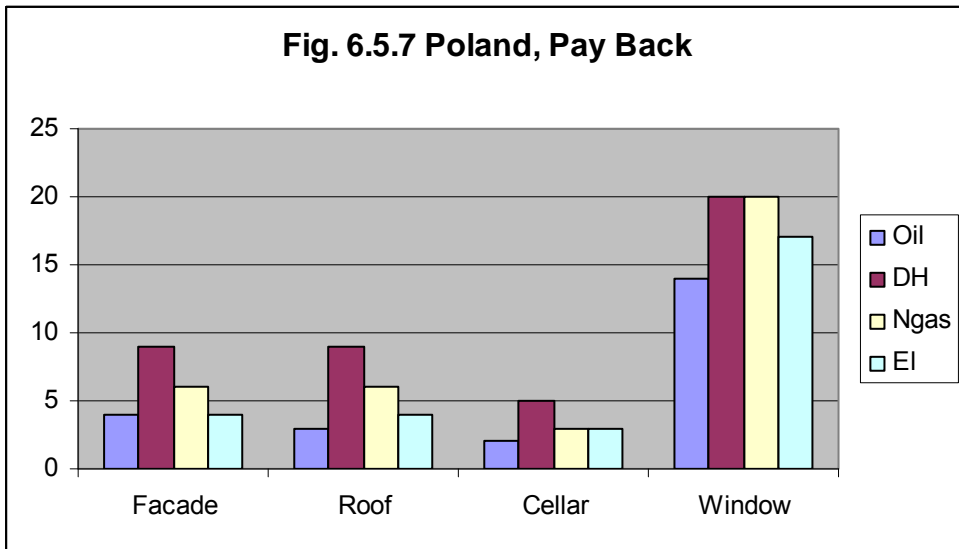




For Czech Republic the results have the same tendencies as for Latvia, but the economic results are not as advantageous. This could be due to the fact that the climate in CZR is milder than in Latvia resulting in less energy savings compared to the investment. Energy prices are at the same level. For CZR oil prices are not used because this is not commonly used in apartment buildings.

The results of these calculations illustrate the economics of common improvements of the building envelope. As was the case with the Eurima analysis and the ClearSupport analysis using the same methodology in section 6.3 and 6.4





The results from Poland are quite similar to those of Latvia except for the examples fuelled with natural gas and district heating. Here the results for Poland (Pomerania) are better because of the higher energy prices.

7. Comparison on building energy standards

7.1 Germany

Table 0.1: New residential buildings, Germany.

		EnEV 2007 ¹		KfW 40 ²
		Buildings with internal temperature $\geq 19^{\circ}\text{C}$	Buildings with internal temperature between $12-19^{\circ}\text{C}$	
		Max. thermal transmission coefficient (U_{max})		
Walls (ext.)	general	0.45	0.75	Compliance with two criteria required: - annual demand for primary energy $\leq 40 \text{ kWh/m}^2$ - specific loss of transmission heat at least 45% lower than ENEV-standard
Windows	ext. windows	1.7-2.0 ³	2.8	
	glass doors, etc.	-	-	
	glazing	-	-	
	curtain wall	1.9-2.3 ³	3.0	
Roof	ceilings, house tops, droops	0.3	0.4	
	flat roofs	0.25	0.4	
Bottom against ground	Ceilings and walls adja-cent to unheated rooms or soil	0.5	no standard	

¹ In addition to mentioned U-values, EnEV also specifies legal requirements with regard to primary energy demand p.a. (maximum caps on primary energy demand in relation to floor space, values must comply with volume specific standards for transmission heat loss).

² Voluntary support programme of KfW, selection criteria of support are standards set in EnEV

³ Higher value in the case of special glazing.

Table 0.2: Existing residential buildings, Germany.

		EnEV 2007		KfW 40
		Buildings with internal temperature $\geq 19^{\circ}\text{C}$	Buildings with internal temperature between $12-19^{\circ}\text{C}$	
		Max. thermal transmission coefficient (U_{max})		
Walls (ext.)	general	0.45	0.75	Compliance with two criteria required: - annual demand for primary energy $\leq 40 \text{ kWh/m}^2$ - specific loss of transmission heat at least 45% lower than ENEV-standard
	slabs, insulation layer, exterior plaster	0.35	0.75	
Windows	ext. windows and glass doors, etc.	1.7-2.0 ⁴	2.8	
	glazing	1.5-1.6 ⁵	no standard	
	curtain wall	1.9-2.3 ⁴	3.0	
Roof	ceilings, house tops, droops	0.3	0.4	
	flat roofs	0.25	0.4	
Bottom against ground	Ceilings and walls adjacent to unheated rooms or soil	0.4-0.5 ³⁶	no standard	

⁴ Higher value in the case of special glazing.

⁵ Higher value in the case of special glazing, both values in the case of substitution

⁶ Lower value in the case of refurbishing exterior slabs, insulation against humidity and ceiling installations, higher value for inside insulations at walls, superstructural measures on the floor, further insulation measures.

7.2 Denmark

Establishment of residential buildings	Denmark ¹⁾ (U=W/m ² K)
Walls	0,40
Windows	2,00 ²⁾
Roof	0,25
Bottom against ground	0,30

*: No demand on separate U-values but on total energy demand, (called energy framework)
U-values can reach target under standard conditions of a multifamily building

1) from 01.01.2006 2) from 01.01.2008

Refurbishment of residential buildings	Denmark ¹⁾ (U=W/m ² K)
Walls	0,20
Windows	1,5
Roof	0,15
Bottom against ground	0,15

7.3 Latvia

Establishment of residential buildings	Latvia ⁴⁾
Walls	0,35-0,40
Windows	2,2
Roof	0,2
Bottom against ground	0,25

4)from 01.01.2003 new in progress

Refurbishment of residential buildings	Latvia
Walls	0,35-0,40
Windows	2,2
Roof	0,2
Bottom against ground	0,25

7.4 Lithuania

Establishment of residential buildings	Lithuania ³⁾ U(normative)
Walls	0,20
Windows	1,60
Roof	0,16
Bottom against ground	0,25

3) from 04.01.2006

Refurbishment of residential buildings	Lithuania ³⁾ U(justifiable)
Walls	0,30
Windows	0,19
Roof	0,25
Bottom against ground	0,35

7.5 Poland

Establishment of residential buildings	Poland ⁵⁾ U - draft
Walls	0,30-0,40
Windows	1,7-1,9
Roof	0,25
Bottom against ground	-

5) draft, in force 01.01.2008?

Refurbishment of residential buildings	Poland ⁵⁾
Walls	0,30-0,40
Windows	1,7-1,9
Roof	0,25
Bottom against ground	-

Latvia, Lithuania and Poland source is BEEN project.

7.6 Greece/Crete

Establishment of residential buildings	Greece/Crete
Walls	0,7
Windows	2,3 – 5,8
Roof	0,5
Bottom against ground	0,7-3,0

Refurbishment of residential buildings	Greece/Crete
Walls	0,7
Windows	2,3 – 5,8
Roof	0,5
Bottom against ground	0,7-3,0

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