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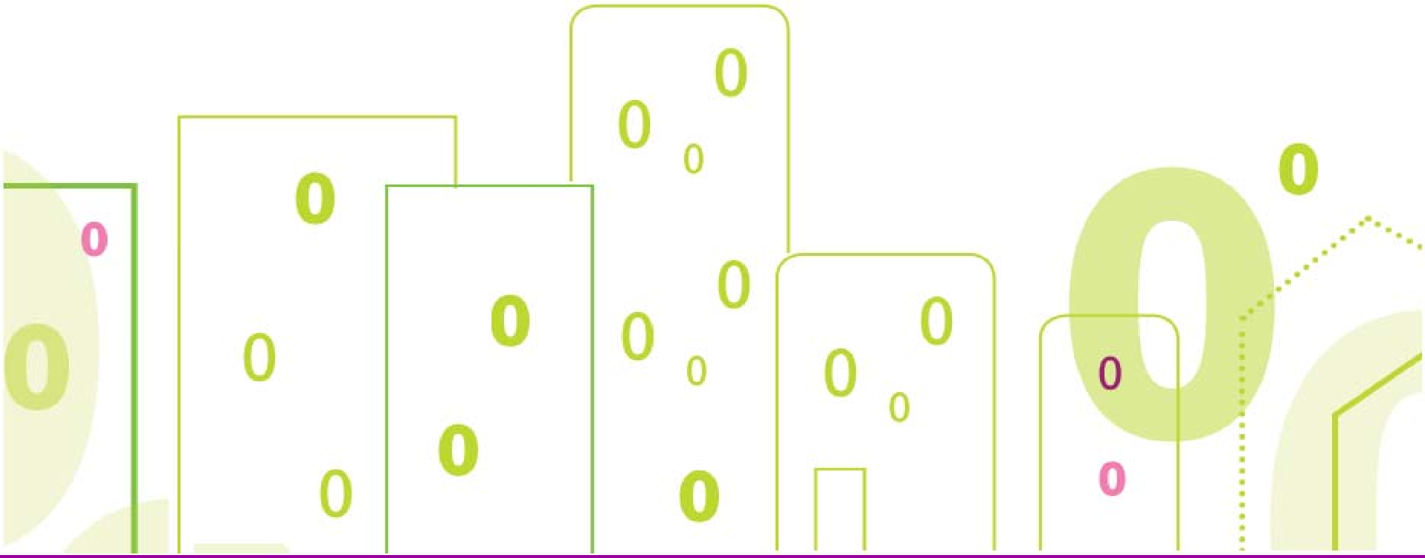
The nearly-Zero Energy Challenge in Divided and Cooperative Ownership

Cost-effectiveness in Divided and Cooperative Ownership in practice



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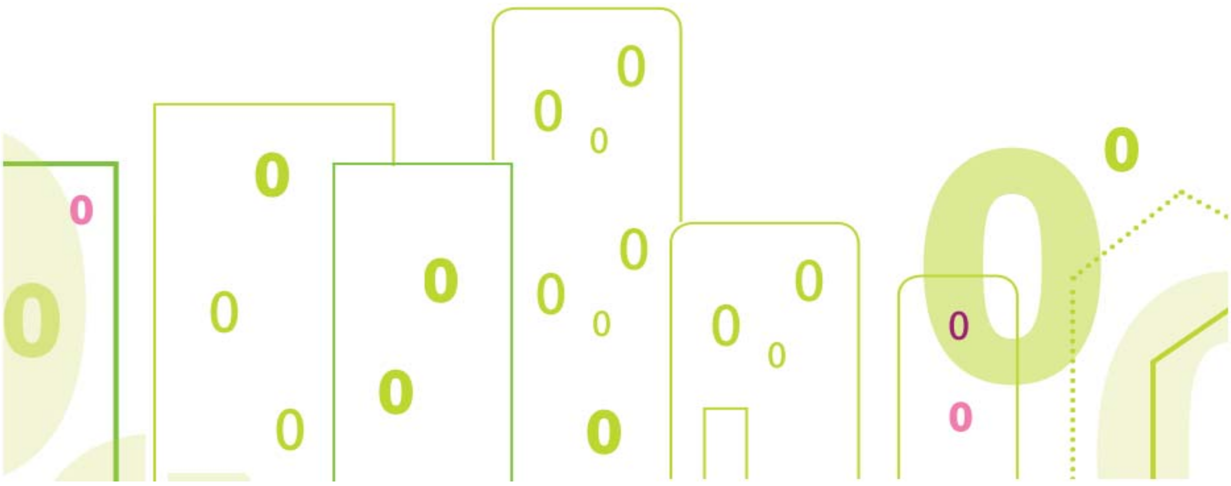

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Contents

1 Introduction

Scope of this document is to provide a clear idea of the cost effectiveness of low energy and nearly zero energy buildings in divided and cooperative property. The study is based on the direct experience of low energy buildings constructed in Bulgaria, Estonia and Italy, including both new constructions and refurbishments projects.

To assess where a building project (renovation or new built) is more or less cost effective, there are different aspects, which should be considered and analysed. We have identified 3 of them, which in our opinion should all be taken in good consideration whenever assessing the economical feasibility of the project:

- Investment costs vs. running costs balance: will the savings on energy costs pay back for the investment?
- Increased market value of the property: does energy efficiency add value to the property?
- Improved comfort (user satisfaction): do energy efficient renovations provide a better comfort?

For this analysis it has been of vital importance the support gathered from the housing managers, real estate agents and from the people who live in the selected buildings and has provided useful information for our investigation.

The second and final version of this document includes:

- Chapter 2: Integration of new data and analysis
- Chapter 3: Integration of new data and analysis
- Chapter 4: Results from the user satisfaction survey
- Conclusions: Updated conclusions

The projects that have been analysed to support this study are:

Country	Name of the project (with link to PH)	Investment vs. running costs	Property value	User satisfaction
Bulgaria	B1 Energy refurbishment of 13 dwellings in Zaharna Fabrika block 11, Sofia	Y	Y	Y
Bulgaria	B2 Energy refurbishment of 17 dwellings in Prof. Giovanni Gorini Street 2, Sofia	Y	Y	Y
Bulgaria	B3 Energy refurbishment of 21 dwellings in Boulevard Madrid 11, Sofia	Y	Y	N
Estonia	E1 Energy refurbishment of 18 dwellings in Rõõmu str 12, Tartu	Y	Y	Y
Estonia	E2 Energy refurbishment of 32 dwellings in Tartu str 33, Võru	Y	Y	N
Estonia	E3 Energy refurbishment of 60 dwellings in Tuleviku str 10, Rakvere, Estonia	Y	Y	N
Estonia	E4 Energy refurbishment of 40 dwellings in Võidu str 42, Rakvere	Y	N	N
Estonia	E5 Energy refurbishment of 30 dwellings in Õismäe str 11, Tallinn	Y	Y	Y
Italy	I1 New construction of 142 dwellings in Bazzana Inferiore, Assago	Y	Y	N
Italy	I2 Energy refurbishment of 131 dwellings and new construction of 45 dwellings in Via Caldera, Milano	Y	Y	Y
Italy	I3 Energy refurbishment of 38 dwellings in Via dei Querci, Florence	Y	Y	Y
Italy	I4 New construction of 84 dwellings in Largo Aldo Capitini, Sesto Fiorentino	Y	Y	N
Italy	I5 New construction of 16 dwellings in Via Martiri Palestinesi, Cinisello Balsamo	Y	Y	N

2 Case studies: Investment costs vs. running costs

Financial feasibility analyses are never simple. Especially when they concern building construction or renovation projects, where there are so many aspect to consider and a growing number of possible options to evaluate.

The simplest analysis is the calculation of the "*simple pay back time*", meaning after how many years the *savings* deriving from smaller running costs after renovation will overcome the *investment* done for the renovation. But also in this case, it has to be defined what is the investment. One way to look at the question is to consider investment the entire cost of the energy related measures. This way deep renovation projects which include also action on the building envelope (addition of insulation on walls or roof, changing the windows…), will turn out having very high investment costs, and will require typically pay back time over 20 years, possibly even 40 years.

Another way to look at the question is considering only the extra cost for the added energy efficiency: the old windows have to be changed because are 40 years old, installing new, energy efficient, windows, costs *100*. New non-energy efficient windows would cost *80*, so the extra costs for choosing a good, energy efficient product instead of one with the same "efficiency" has the old one, is only *20* (1/5) of the total investment. In this case the payback time would also be 1/5, using the example above, 4 to 8 years compared to the previous 20-40. It is a completely different scenario.

The analysis done in this chapter will identify for each study case:

Investment costs:

- $\mathbf{I_r}$ total investment done for the renovation (all measures adopted)
- $\mathbf{I_{ee,brutto}}$ total cost of only the measures, which have an effect on: space and water heating energy, cooling energy, and building services electricity.
- $\mathbf{I_{ee,netto}}$ of each energy efficiency measure, only extra costs directly responsible for improving the energy efficiency will be taken in consideration

Normally $\mathbf{I_r >= I_{ee,brutto} > I_{ee,netto}}$

Running costs:

Savings on energy running costs must be calculated. This is simply the difference between the cost of the energy service, which includes energy, but also the maintenance of the generator and other systems (for example ventilation systems) and other new part of the buildings which after the renovation require more maintenance than before, limited to those things that have an effect on the energy consumption of the building.

New built projects.

For new built projects, the analysis is more complicate, as the analysis will compare a new very low energy building with a similar building constructed according to the standard (at the time of construction). For new built projects, $\mathbf{I_r}$ is then the construction cost, $\mathbf{I_{ee,brutto}}$ and $\mathbf{I_{ee,netto}}$ are the same as for renovation projects. Energy running costs must be compared to those of a similar building, but just "standard" in terms of energy class. Housing managers have been asked to provide a valid estimate of the running costs (per m²) of buildings of the same type, but not as energy efficient as the case study.

The average life-time of the energy efficient measures will give an other useful information for analysing the economical feasibility of the projects.

For each study case, the following information will be provided:

> Name of the study case and location

> New Built (year of construction) or renovation (year of construction and year of retrofit)

> Energy efficient measures table:

Energy efficiency measure	I_r **[€]**	$I_{ee,brutto}$ **[€]**	$I_{ee,netto}$ **[€]**	**Life time [years]**
1	-			
2	-			
3	-			
4	-			
Total investment				
Running costs	**RC**			
Simple pay back time[1]	I_r**/RC**	$I_{ee,brutto}$**/RC**	$I_{ee,netto}$**/RC**	

> Comments: information of the source of data and eventually how they have been calculated.

[1] Simple pay back time on I_r s not calculated for new built projects, as it wouldn't be significant.

✓ 2.1 Bulgaria

The investment costs for energy renovation of the analyzed condominium buildings cover the basic energy efficiency measures such as energy renovation of the building envelope and replacement of window frames without additional measures such as replacement of the heating system, replacement of the major building installations, etc. This is due to the 1) level of available public funding from which 75% of project costs are subsidized and 2) the limited co-financing capacity of the apartment owners certain percentage of whom need to be financially backed up by the state even for the remaining 25% of the project costs.

The building renovation program consists predominantly of energy saving measures due to the strict requirements of the national renovation program with 75% of financial aid from EU structural funds and the limited financial co-financing involvement of apartment owners. No interventions in the building structure and/or major installations are eligible to be subsidized and therefore, only condominium buildings without problems in the building structure and major installations are selected to be rehabilitated within the framework of the pilot phase of the national renovation program.

Case Study: Energy refurbishment of 13 dwellings in Zaharna Fabrika block 11, Sofia

The case study is an energy renovation of a multi-apartment building located in Sofia.

Year of construction – 1946, year of retrofit – 2012

The building is a divided ownership type, operated as homeowners' association.

Energy efficiency measure	I_r [€]	$I_{ee,brutto}$ [€]	$I_{ee,netto}$ [€]	Life time [years]
1 Thermal insulation of external walls (100 mm), ground slab (120 mm) and roof (150 mm)		74 100	37 050	30
2 Replacement of all windows with PVC, double glazed (old U value 2.37 W/m^{2}K replaced with U value 1.70 W/m^{2}K)		15 600	3 200	30
3 Replacement of lighting installation in building common parts		800	400	15
4 Solar thermal installation for part of dwellings		8 200	8 200	20
Total		**98 700**	**48 850**	
Running costs (savings)		**3 250**	**3 250**	
Simple payback time (years)		**30**	**15**	**30**

Total extra cost: 98700 €.

Average life time (min): 30 years.

Savings estimated from running cost: 3250 €/year.

Comments

The achieved reduction in energy use increased from 52% to 58% due to the installation of solar collectors at a later stage. The achieved reduction in greenhouse gas emissions is 62t/y. The renovated building obtained energy certificate class B after the completion of the refurbishment project. The installation of solar thermal equipment requires some additional maintenance service costs over the time.

The calculation of $I_{ee\ netto}$ for the PVC double glazed windows is based on the following information: U value of 2.37 W/m^{2}K before the renovation, U value 1.70 W/m^{2}K after the renovation, area of replaced windows 130 m^2, 3100 degree days for 20^0 indoor temperature for Sofia, and MWh energy price of € 59.

Case Study: Energy refurbishment of 17 dwellings in Prof. Giovanni Gorini Street 2, Sofia

The case study is an energy renovation of a multi-apartment building located in Sofia.

Year of construction – 1939, year of renovation – 2011

The building is a divided ownership type, operated as homeowners' association.

Energy efficiency measure	I_r **[€]**	$I_{ee,brutto}$ **[€]**	$I_{ee,netto}$ **[€]**	**Life time [years]**
1 Thermal insulation of external walls (100 mm), ground slab (120 mm) and roof (150 mm)		56 300	28 150	30
2 Replacement of all windows with PVC, double glazed (old U value 2.32 W/m^{2}K replaced with U value 1.70 W/m^{2}K)		20 400	4 100	30
3 Replacement of lighting installation in building common parts		1 300	650	15
Total		**78 000**	**32 900**	
Running costs (savings)		**3 630**	**3 630**	
Simple payback time (years)		**21**	**9**	**30**

Total extra cost: 78000 €.

Average life time (min): 30 years.

Savings estimated from running cost: 3630 €/year.

Comments

The achieved reduction in energy use is 59%. The achieved reduction in greenhouse gas emissions is 45t/y. The renovated building obtained energy certificate class B after the completion of the refurbishment project.

The calculation of $I_{ee\ netto}$ for the PVC double glazed windows is based on the following information: U value of 2.32 W/m^{2}K before the renovation, U value 1.70 W/m^{2}K after the renovation, area of replaced windows 170 m^2, 3100 degree days for 20^0 indoor temperature for Sofia, and MWh energy price of € 62.

Case Study: Energy refurbishment of 21 dwellings in Boulevard Madrid 11, Sofia

The case study is an energy renovation of a multi-apartment building located in Sofia.

Year of construction – 1954, year of renovation – 2012.

The building is a divided ownership type, operated as homeowners' association.

Energy efficiency measure	I_r **[€]**	$I_{ee,brutto}$ **[€]**	$I_{ee,netto}$ **[€]**	**Life time [years]**
1 Thermal insulation of external walls (100 mm), ground slab (120 mm) and roof (150 mm)		81 600	40 800	30
2 Replacement of all windows with PVC, double glazed (old U value 2.25 W/m^{2}K replaced with U value 1.70 W/m^{2}K)		25 200	5 100	30
3 Replacement of lighting installation in building common parts		2 800	1 400	15
Total		**109 600**	**47 300**	
Running costs (savings)		**4 660**	**4 660**	
Simple payback time (years)		**24**	**10**	**30**

Total extra cost: 109600 €.

Average life time (min): 30 years.

Savings estimated from running cost: 4660 €/year.

Comments

The achieved reduction in energy use is 42%. The achieved reduction in greenhouse gas emissions is 193t/y. The renovated building obtained energy certificate class B after the completion of the refurbishment project.

The calculation of $I_{ee\ netto}$ for the PVC double glazed windows is based on the following information: U value of 2.25 W/m^{2}K before the renovation, U value 1.70 W/m^{2}K after the renovation, area of replaced windows 210 m^2, 3100 degree days for 20^0 indoor temperature for Sofia, and MWh energy price of € 64.

✓ 2.2 Estonia

Case Study E1: Energy refurbishment of 18 dwellings in Rõõmu str 12, Tartu

Renovation (year of construction 1975, year of retrofit 2012).

The case study refers to an energy retrofitting of a multi-family building located in Tartu.

The building is a divided ownership type, operated as association.

Energy efficiency measure	I_r **[€]**	$I_{ee,brutto}$ **[€]**	$I_{ee,netto}$ **[€]**	**Life time [years]**
1 Additional insulation for all external areas (roof 200 mm, walls, basement with 150 mm of insulation)		103 000	51 500	40
2 Replacement of all old windows (U value more than 2 replaced with U value less than 1,1)		2 000	1 000	30
3 Heating system renovation from one-pipe system to two-pipe system with thermostatic valves		45 000	11 250	40
4 Heat recovery ventilation system installation (room based system)		27 000	27 000	20
Total		**177 000**	**90 750**	
Running costs		**4 608**	**4 608**	
Simple pay back time		**38**	**20**	**30**

Comments

$I_{ee\ netto}$ for high standard windows are calculated as follows – the extra cost for those windows are 1000 EUR for all replaced 8 windows with area 20 m² and running cost for those 20 m² replaced windows are found as (U1-U2)*L (kW/K) *Dd*24/1000 (MWh).

L - area of windows, U - U value, Dd – degree days, (4000).

Saved energy price is taken as existing MWh price 64 EUR.

For full project

Total extra cost: 187 000 €.

Average life time: 30 years.

Savings estimated from running costs:

142 MWh in 2011 - 70 MWh in 2013 = 72 MWh*64 EUR MWh = 4608 €/year

Simple payback time: 40 years, because the energy costs are reasonable for consumers due to the fact that district heating system use wood chips as a base for energy and the wood price is the lowest possible source for district heating in Estonia.

The complex retrofitting means that it is not reasonable to divide the extra cost between different energy efficiency measures as retrofitting in complex way allows saving from different organizational aspects and therefore the division between different measures would not describe the actual costs.

SPBP (simple payback time) is calculated by dividing investment cost with saved energy cost.

Saved energy is calculated with comparison of 2011 and 2013 years. The achieved saving is 51%. The autumn of 2013 was extraordinary warm. For more detailed calculation the degree days should be used for comparison.

Investment cost for heated m^2 was 152 EUR. Even if the savings are remarkable, the energy price is low compared with the investment price and this makes the payback period long.

Updates December 2014

During the period from 2012, when the complex renovation was done, till 2014 the energy consumption for space heating drops from 151 kWh/m² to 66 kWh/m², means 56%. Saved energy cost 6 680 EUR for heated area 1 228 m², which makes the payback time shorter than planned.

Case Study E2: Energy refurbishment of 32 dwellings in Tartu str 33, Võru

Renovation (year of construction 1963, year of retrofit 2012).

The case study refers to an energy retrofitting of a multi-family building located in Võru.

The building is a divided ownership type, operated as association.

Energy efficiency measure	I_r [€]	$I_{ee,brutto}$ [€]	$I_{ee,netto}$ [€]	Life time [years]
1 Additional insulation for all external areas (roof 200 mm, walls, basement with 150 mm of insulation)		82 225	41 113	40
2 Replacement of all old windows (U value more than 2 replaced with U value less than 1,1)		4 000	2 000	30
3 Heating system renovation from one-pipe system to two-pipe system with thermostatic valves.		50 000	12 500	30
4 Heat recovery ventilation system installation (room based system)		44 000	44 000	20

Total	**180 225**	**99 613**	
Running costs	**4 818**	**4 818**	
Simple payback time	**37**	**21**	**30**

Comments

$I_{ee\ netto}$ for high standard windows are calculated as follows – the extra cost for those windows are 2000 EUR for all replaced 14 windows with area 31 m² and running cost for those 31 m² replaced windows are found as (U1-U2)*L (kW/K) *Dd*24/1000 (MWh).

L - area of windows, U - U value, Dd – degree days, (4000).

Saved energy price is taken as existing MWh price 66 EUR.

For full project

Total extra cost: 180 225 €.

Average life time: 30 years.

Savings estimated from running costs:

Heating 182 MWh in 2011 - 109 MWh in 2013 = saved 73 MWh*66 EUR MWh = 4 818 €/year

Simple payback time: 37 years, the reason is the reasonable energy price 66 EUR MWh for end users.

The complex retrofitting means that it is not reasonable to divide the extra cost between different energy efficiency measures as retrofitting in complex way allows to save from different organizational aspects and therefore the division between different measures would not describe the actual costs.

Energy price is 66 EUR MWh.

SPBP is calculated by dividing investment cost with saved energy cost .

Saved energy is calculated with comparison of 2011 and 2013 years. The achieved saving in space heating is 40%.

Investment costs for heated m^2 were 115 EUR. Even if the savings are remarkable, the energy price is low compared with the investment price and this makes the payback period long (that is still reasonable in Estonian context).

Updates December 2014

New ventilation system had some difficulties for users, because there is a need for the heat exchanger to “charge” the heat accumulation part of the exchanger, but for some users this was not understood. If the water heating system battery is regulated with thermostatic valve on low position (+16 C) then the exchanger does not have the heat to charge the exchanger and inlet air will not warm on comfortable level and users feel could (+8 C) air inlet. Radiators should be regulated on +21 C and ventilation heat exchangers should run permanently, then the heat exchanger will charge and those problems are solved.

During the period from 2012, when the complex renovation was done, till 2014 the energy consumption for space heating drops from 140 kWh/m² to 57 kWh/m², means 59%, saved energy cost 8 573 EUR for heated area 1565 m², which makes the payback time shorter than planned.

Case Study E3: Energy refurbishment of 60 dwellings in Tuleviku str 10, Rakvere

Renovation (year of construction 1977, year of retrofit 2012).

The case study refers to an energy retrofitting of a multi-family building located in Rakvere.

The building is a divided ownership type, operated as association.

Energy efficiency measure	I_r [€]	$I_{ee,brutto}$ [€]	$I_{ee,netto}$ [€]	Life time [years]
1 Additional insulation for all external areas (roof 200 mm, walls, basement with 150 mm of insulation)		368 000	184 000	40
2 Replacement of all old windows (U value more than 2 replaced with U value less than 1,1)		24 000	10 000	30
3 Heating system renovation from one-pipe system to two-pipe system with thermostatic valves.		150 000	37 500	30
4 Heat recovery ventilation system installation (room based system)		110 000	110 000	20
Total		**652 000**	**341 500**	
Running costs		**25 370**	**25 370**	
Simple pay back time		**26**	**13**	**30**

Comments

$I_{ee\ netto}$ for high standard windows are calculated as follows – the extra cost for those windows are 10 000 EUR for all replaced 54 windows with area 130 m² and running cost for those 130 m² replaced windows are found as (U1-U2)*L (kW/K) *Dd*24/1000 (MWh)=12,4 MWh * 86 = 1073 EUR.

L - area of windows, U - U value, Dd – degree days, (4000).

Saved energy price is taken as existing MWh price 86 EUR.

For full project

Total extra cost: 652 000 €.

Average life time: 30 years.

Savings estimated from running costs:

saved energy cost 610 MWh in 2011 - 315 MWh in 2013 = 295 MWh*86 EUR MWh = 25 370 €/year

Simple payback time: 26 years.

The complex retrofitting means that it is not reasonable to divide the extra cost between different energy efficiency measures as retrofitting in complex way allows saving from different organizational aspects and therefore the division between different measures would not describe the actual costs.

SPBP is calculated by dividing investment cost with saved energy cost.

Saved energy is calculated with comparison of 2011 and 2013 years. The achieved savings are 50%. The autumn of 2013 was extraordinary warm. For more detailed calculation the degree days should be used for comparison.

Investment costs for heated m^2 were 165 EUR. Even if the savings are remarkable, the energy price is low compared with the investment price and this makes the payback period long.

Updates December 2014

During the period from 2012, when the complex renovation was done, till 2014 the energy consumption for space heating drops from 146 kWh/m² to 59 kWh/m², means 59%. Saved energy cost for this period is 29 538 EUR for heated area 3 948 m², which makes the payback time shorter than planned.

Case Study E4: Energy refurbishment of 40 dwellings in Võidu str 42, Rakvere

Renovation (year of construction 1989, year of retrofit 2012).

The case study refers to an energy retrofitting of a multi-family buildings located in Rakvere.

The building is a divided ownership type, operated as association.

Energy efficiency measure	I_r [€]	$I_{ee,brutto}$ [€]	$I_{ee,netto}$ [€]	Life time [years]
1 Additional insulation for all external areas (roof 200 mm, walls, fundament with 150 mm of insulation)		131 000	65 500	40
2 Replacement of all old windows (U value more than 2 replaced with U value less than 1,1)		12 000	7 000	30
3 One-pipe heating system was replaced by two-pipe system with thermostatic valves.		65 000	16 250	40
4 Heat recovery ventilation system installation (heat pump for using exhaust air heat to produce heat for hot tap and heating system)		86 000	86 000	20

Total	**294 000**	**174 750**	
Running costs	**13 700**	**13 700**	
Simple pay back time	**21**	**13**	**30**

Comments

$I_{ee\ netto}$ for high standard windows are calculated as follows – the extra cost for those windows are 7 000 EUR for all replaced 48 windows with area 85 m^2 and running cost for those 85 m^2 replaced windows are found as (U1-U2)*L (kW/K) *Dd*24/1000 (MWh)= 8 MWh * 86 = 702 EUR.

L - area of windows, U - U value, Dd – degree days, (4000).

Saved energy price is taken as existing MWh price 86 EUR.

For full project

Total extra cost: 294 000 €.

Average life time: 30 years.

Savings estimated from running costs:

Saved energy cost 289 MWh_h and 2 MWh_{el} in 2011 and 86 MWh_h and 31 MWh_{el} in 2013. Cost for the saved energy = 203 MWh_h*86 EUR MWh - 29 MWh_{el} *130 EUR= 13 700 EUR/year.

Simple payback time: 21 years.

The complex retrofitting means that it is not reasonable to divide the extra cost between different energy efficiency measures as retrofitting in complex way allows to save from different organizational aspects and therefore the division between different measures would not describe the actual costs

District heating energy price is 86 EUR MWh, electricity price is 130 EUR MWh

SPBP is calculated by dividing investment cost with saved energy cost

Saved energy is calculated with comparison of 2011 and 2013 years. The achieved savings are 60%.

Investment costs for heated m^2 were 211 EUR.

Updates December 2014

For the new ventilation and heating system the inlet air was designed to take on the top of radiators and this gives possibility to close the inlet air channels by the users and some persons did it. This caused the problem for the heat pump feeding system and there were not as much exhausted warm air as was designed and this meant that the heat pump was not able to produce hot water as much as was designed. During the period from 2012, when the complex renovation was done, till 2014 the energy consumption for space heating drops from 176 kWh/m^2 to 59 kWh/m^2, means 66%. Saved energy cost 13 986 EUR for heated area 1 390 m^2, which makes the payback time shorter than planned.

Case Study E5: Energy refurbishment of 30 dwellings in Õismäe str 11, Tallinn

Renovation (year of construction 1975, year of retrofit 2011).

The case study refers to an energy retrofitting of a multi-family buildings located in Tallinn.

The building is a divided ownership type, operated as association.

Energy efficiency measure	I_r **[€]**	$I_{ee,brutto}$ **[€]**	$I_{ee,netto}$ **[€]**	**Life time [years]**
1 Additional insulation for all external areas (roof 200 mm, walls, fundament with 150 mm of insulation)		70 000	35 000	40
2. Replacement of all old windows (U value more than 2 replaced with U value less than 1,1) Glazing of balconies		9 000	4 000	30 30
3 Sun panels for hot tap water		26 000	26 000	25
4 Heat recovery ventilation system installation (room based system)		45 000	45 000	20
Total		**150 000**	**110 000**	
Running costs		**4 774**	**4 774**	
Simple pay back time		**31**	**23**	**30**

Comments

$I_{ee\ netto}$ for high standard windows are calculated as follows – the extra cost for those windows are 4 000 EUR for all replaced 48 windows with area 60 m² and running cost for those 60 m² replaced windows are found as (U1-U2)*L (kW/K) *Dd*24/1000 (MWh)= 6 MWh * 77 = 444 EUR.

L - area of windows, U - U value, Dd – degree days, (4000).

Saved energy price is taken as existing MWh price 77 EUR.

For full project

Total extra cost: 154 000 €.

Average life time: 30 years.

Savings estimated from running costs:

Used heat 176 MWh in 2010 - 114 MWh in 2012 = saved 62 MWh*77 EUR MWh = 4 774 €/year.

Simple payback time: 32 years.

The complex retrofitting means that it is not reasonable to divide the extra cost between different energy efficiency measures as retrofitting in complex way allows to save from different organizational aspects and therefore the division between different measures would not describe the actual costs. Thermostatic valves were installed earlier (2008).

District heating energy price is 77 EUR MWh.

SPBP is calculated by dividing investment cost with saved energy cost.

Saved energy is calculated with comparison of 2010 and 2012 years. The achieved saving 35%.

Investment costs for heated m^2 were 102 EUR.

Updates December 2014

The solar panels for hot tap water brings into the house energy balance positive renewable energy. During the period from 2010, and after the complex renovation was done in 2012, till 2014 the energy consumption for space heating drops from 94 kWh/m^2 to 47 kWh/m^2, means 50%. Saved energy cost 5 482 EUR for heated area 1 515 m^2, which makes the payback time shorter than planned.

✓ 2.3 Italy

In January 2014, Finabita collected the experiences from test cases about the extra-costs both for new buildings and retrofitted.

Case Study I1: New construction of 142 dwellings in Bazzana Inferiore, Assago

New Built (2013).

Divided ownership.

Energy efficiency measure	I_r [€]	$I_{ee,brutto}$ [€]	$I_{ee,netto}$ [€]	Life time [years]
Thermal insulation	-	760 000	100 000	30
Windows	-	1 600 000	460 000	30
PV System	-	60 000	60 000	20
Mechanical Ventilation with Heat Recovery	-	360 000	360 000	20
Heating Pumps	-	60 000	60 000	20
Total	**40 800 000**	**2 840 000**	**1 040 000**	
Running costs (savings estimated)	**47 121**	**47 121**	**47 121**	
Simple payback time		60	22	**24**

Comments

This intervention consists of 142 apartments distributed in four buildings. They have been classified in energy class "A+" according to the regulations of the Lombardy Region, with an energy requirement for heating (EPh) of less than 14 kWh/m2 per year. The annual savings was estimated considering that the minimum energy standard currently in force is roughly equal to 60 kWh/m^2 per year (4 times greater).

As we can deduce from the Table, the total costs for energy measures are equal to 2.840.000,00 €, but the extra-costs for improving energy efficiency from a "standard" energy class building to a A+ class building are equal to 1.040.000,00 € and represent the 3% of the Total investment costs.

Concerning the extra costs for energy measures, we can see from the Table that the costs for:

- PV system
- Mechanical ventilation with Heat Recovery
- Heating Pumps

are 100% composed by extra-costs.

Concerning the extra -cost for the heating pump, we must say that it allows the building to get the A+ class energy performance: heat pump systems are a viable alternative to traditional combustion heater, currently they represent one of the most efficient and effective system for the air conditioning in the annual cycle and are able to contribute to the achievement of the 20-20-20 targets for reducing energy consumption, reducing greenhouse gas emissions and increasing the use of renewable sources: heat pumps allow savings from 40-60% of primary energy, with equal reduction of CO_2 and employ for their operation about 75% of renewable energy.

In fact, in the calculation of the cost savings, the contribution of PV system to power the heat pump in the summer should be considered, as it reduces the off takes of energy from the grid by exploiting the self-consumption.

According to Regional law, new buildings must respect energy minimum requirements, which are less restrictive than an A+ class. Nevertheless, the SHO decided to build in energy class A+ for several reasons:

- Marketing aspects: potential buyers are interested in “energy saving” dwellings, therefore an A+ class energy certificate gives an added value to the building itself and constitutes a “marketing lever”.
- Promotional, since Cascina Bazzana was built in an area which is not traditionally "competence" of the SH company, therefore it could represent a good example of its construction activity, even if this type of construction implies extra costs for high quality energy efficiency measures. Nevertheless, the cooperative decided to reduce the economical expected margin (consider that the buildings belong to subsidized housing and people will buy at a fixed price per m^2).

Update December 2014:

Finabita has contacted the technicians responsible of the project in December 2014 and asked them some updates regarding energy savings . The dwellings started to be occupied in November/December 2013. The SH company is not yet able to quantify the potential savings of this building comparing to a traditional building, since the first year of operation has not been completed yet . In addition, the energy supplier does not read the meters regularly, hence the bills received by the SH company are not in line with the actual production. The annual savings was estimated comparing the minimum energy standard currently in force (60 kWh/m^2 per year) with that of the building (14 kWh/ m^2 per year).

Case Study I2: Energy refurbishment of 131 dwellings and new construction of 45 dwellings in Via Caldera, Milano

Renovation (construction:1909-1960, renovation: 2014).

Cooperative ownership.

Energy efficient measures table:

Energy efficiency measure	I_r **[€]**	$I_{ee,brutto}$ **[€]**	$I_{ee,netto}$ **[€]**	**Life time [years]**
Thermal insulation of roof	-	650 934	150 768	**30**

New PVC Windows	-	284 000	65 150	30
Installation of 3 gas condensation boilers	-	220 000	220 000	20
Installation of a metering system and thermostatic valves	-	189 000	0	20
Thermal solar system	-	126 000	0	20
Total	**2 809 000**	**1 469 934**	**435 918**	
Running costs	**39 546**	**39 546**	**39 546**	
Simple pay- back time	71	33	11	**24**

Comments:

In this case study, the extrapolation of the only costs for energy retrofitting is quite complicated without taking into account that,in cooperative property, retrofitting means not only improving energy efficiency measures but also taking action on ancient and degraded elements of both system and structural: these costs are much more financially important and affect more on the SH company decisions than the mere extra-costs for energy efficiency measures.

Let's look at the Energy efficiency measures Table and go through every energy measure.

Regarding the replacement of the roof, we must say that anyway the roof would need to be replaced. As for the total costs of this energy measure, the renovation of the roof includes many operations, since the SH company improved a lot the quality of the roof: removal and disposal of existing coverage (only the the main warping was kept), extention of the flaps in order to cover balconies, new gutters, downspouts and plumbing. Finally, they put new insulation. The whole packet costs € 576.934,00. Then, we must consider the scaffolding, which cost € 74.000,00. So the total costs for this measure are equal to 650.934,00. As for the extra -costs, they have been derived from the total energy measure cost deducting the costs for: scaffolding, demolition of the existing roof, new wooden framework, planking, flashings, eaves, chimneys, vapor barrier, downspouts,. During the roof remaking, the SH company has decided to improve thermal insulation, so they have remade the frame and the planking roof, as in the case of a traditional roof, then an insulation sandwich panel finish was applied in place of the existing tiles. Consequently, we can affirm that the only extra-cost consists in the insulation panel, which is equal to 150.768,00

As for the windows, the total cost for the windows installation is equal to € 284.000,00, including the disposal of the existing windows, As for the calculation of the extra- cost, the SH company estimated the cost difference between the real high performant window and hypothetical traditional type, difference which is about € 150 per window, therefore the total extra cost for windows is around € 65.150,00 (433 windows).

With regard to the installation of boilers, the cost is inclusive of central system, heat exchangers, combustion analyzers, manifolds, twin pumps, circuits, expansion vessels, probes, chimneys. It is considered as extra-cost because it would not need to be replaced, since the boilers were not very old (10 years), but the substitution was made in anticipation of the elimination of the individual butane - fueled water heaters.

Other two energy efficient measures must be analyzed, they are those relating to the installation of the thermostatic valves and heat cost allocators and the installation of the solar thermal system. The installation of heat cost allocators will enable the SH company a precise monitoring of the consumption and therefore can be considered undoubtedly a measure of reducing energy consumption. These elements, however, are required by regional energy legislation, which also requires the installation of solar thermal system in the event of redevelopment of the building, consequently those expenses may not even be considered extra -costs but they should anyway be included in the total energy measures costs.

Therefore, excluding the costs due to the solar thermal system and installation of thermostatic valves / heat cost allocators, the total costs for energy measures amount to 1.469.934,00 €, while the extra-costs amount to € 435.918,00, and the total expenditure of the intervention amounted to € 2.809.000,00. In this case, extra-costs are around 16% of the total investments.

The work was contracted and began in June 2013, expected to be completed in October 2014, so currently there is no information about the energy savings achieved: updates will be available after the monitoring of the first year.

Updates December 2014

While the windows replacements has ended in 2013, the works of roof insulation, new armored doors and new gas centralized boiler have been just ended in September 2014, so the savings for the current winter will be measured in the coming months (April 2015). Nevertheless, the building consumption has been monitored by web panel HIVE. The comparison between winter 2012/2013 and winter 2013/2014 shows that there are very significant savings of about 36%. Savings have been corrected on the basis of the degree-days recorded last winter season, since it was milder that the previous one (-13.9%). Despite the normalization, heating savings are around 27%. This result is due to the replacement of all windows, which occurred during 2013. In order to have some economic results, Finabita estimated economic savings, considering that the starting situation was characterized by an energy performance of around 200 kWh/m$^{2:}$ savings are estimated in about 39.500 € per year. The SH company expects a further improvement after the renovation of condensation boiler and the installation of thermostatic valves and energy meters in every flat.

Case Study I3: Energy refurbishment of 38 dwellings in Via dei Querci, Florence

Renovation (year of construction: 1970 and year of retrofit: 2011).

Divided Ownership.

Energy efficient measures table:

Energy efficiency measure	I_r **[€]**	$I_{ee,brutto}$ **[€]**	$I_{ee,netto}$ **[€]**	**Life time [years]**
Thermal insulation of the façades	-	361 000	39 000	**40**

Boiler replacement The work included the renovation of all the accessories; new exhausted fumes duct in stainless steel; new electric system in the heater room	-	25 000	25 000	20
Other services (selection of the supplier, supervision of the retrofitting works, assistance provision to the flat owners to access financial subsides, energy certification after the renovation)	-	43 000	43 000	-
Total	**468 000**	**429 000**	**107 000**	
Running costs	**9 200**	**9 200**	**9 200**	
Simple payback time	50	**47**	**12**	**30**

Comments

This study case is interesting since it represent an example of application of Energy Performance Contract by a Social Housing company.

Social Housing companies made an energy assessment based on the heating consumption data and following the prescription of national regulation. The assessment included proposals for energy retrofit of the building, which was in need of maintenance work of the façades. The total cost for this maintenance work was equal to € 361.000,00.

The SH company has proposed to add extra energy retrofitting measures to those already planned for the façades, with the following methodology:

- the SH company makes the tender specifications, which include:
  - the thermal insulation of walls with external cladding
  - the substitution of the existing gas boiler with a new, energy efficient one.

  The costs related to those two have been considered as extra-costs

- the SH technicians provide technical/administrative services: selection of the supplier, supervision of retrofitting works, assistance provision to the flat owners to access financial subsides.

These services are considered as an extra-cost, and they are equal to 107.000,00 €.

Then, the SH company finances the extra- costs for the energy retrofit measures, as an ESCO, so the technicians estimated energy savings basing on the results of the building energy audit, accounting for 20-22 %, with reference to the gas consumption for the past two years prior to the intervention. This datum is set in the Energy Performance contract signed between the SH company and the condominium, and it corresponds to 46.000 gas mc/year.

It is possible to envisage an annual economic saving of approximately 9.200 €, with a payback period which stood at 12 years, considerably less than the average life times of the boiler and of the façades.

Concerning the Energy Performance Contract:

If the fuel savings will be greater than 20%, the payback will be shorter and the condominium will begin to enjoy the savings directly before the end of the twelfth year. In the meantime, flat owners keep paying for energy as in 2010: 46.000 mc natural gas/ year.

The energy savings, that means the difference between the actual consumption and 46.000 mc and the average gas consumption for the past two years prior to the intervention are measured through periodic monitoring and is billed by the SH company to the condominium. The savings will be always considered in terms of energy savings (gas mc) and not in terms of economic savings, because the gas tariff varies quarterly.

The flat owner doesn't have extra costs for the energy retrofit, but will benefit of better comfort from the beginning and of lower energy costs after the extra investment has been repaid.

The extra-costs represent about the 22% of the investment.

Update December 2014:

During the first heating season, due to some shortcomings in the management of central heat and a general misuse of the central itself, the gas savings was only 14,70% compared to pre-intervention, while in the second year was of 22,50%, and in the third year (October 2014) they are around 25%.

Case Study I4: New construction of 84 dwellings in Largo Aldo Capitini, Sesto Fiorentino

The intervention consists in 84 dwellings placed in Sesto Fiorentino, Tuscany.

It is a New Built type (2010).

Energy efficient measures table:

Energy efficiency measure	I_r [€]	$I_{ee,gross}$ [€]	$I_{ee,netto}$ [€]	Life time [years]
Thermal insulation	-	207 000	207 000	**30**
Trigeneration	-	80 000	0	**15**
Total	**10 350 000**	**287 000**	**207 000**	
Running costs	**20 002**	**20 002**	**20 002**	
Simple payback time		**14**	**10**	**27,5**

Comments:

The total cost of the intervention is 10.350.000,00 € (1500 € per m^2).

Regarding the thermal insulation, since the project was designed when minimum requirements for energy efficiency were really very scarce, the cost for the insulation is totally an extra-cost. The extra-cost for insulation represents about the 2% of the overall costs.

Regarding the tri-generation system, the SH company bought on its own only the DH substations whose cost is comparable to a traditional boiler, while remaining works were incurred by the energy provider. So, the cost is equal to the costs of the 2 DH substations, while the extra-cost is equal to zero. .So, the total cost for energy measures are 287.000,00 €, while the extra-costs are 207.000,00 €.

Concerning the estimated energy savings, the SH company thinks that is more interesting to speak in terms of energy savings than in terms of money savings. Nevertheless, in order to economically quantify the energy savings, the SH company told us that, during the designing phase, it was assumed an average savings per unit of heating costs amounted to about 30%. This saving is now largely confirmed by the monitoring that have been made since the year 2011, which recorded average savings even higher. The SH company has estimated an expenditure for the conduct of the heating and DHW production per unit equal to € 580 against € 850 in case the building had been built according to traditional criteria: this money saving, hence the value of € 20.000/year.

Updates December 2014:

The monitoring for the period 2013-2014 points out energy savings of around 40%, since the building is now almost completely inhabited. Residents pay a fixed price for the energy supply service, which includes the running costs (energy consumption for heating / cooling and system maintenance). This implies that energy savings of 40% does not mean an expenditure reduction of 40%. However, annual average costs for the energy supply service are in line with those expected: energy costs are lower than standard building ones by about 10-20%.

The experience thus far conducted reveals still positive, although complex.

The SH company give also some Lessons Learnt:

- this technology (centralized tri-generation System) works well if all the dwellings are occupied, the partial use of the system can cause problems in the energy performance of the system;
- since the system is very innovative, some management difficulties have occurred due to the inexperience of the company in charge of the energy supply service;
- households in general are not well disposed towards centralized systems, as they can't directly regulate the temperature in the accommodation, and this trend was also replicated in this case. In the future SH company will work for a greater involvement of the residents on this front in the preliminary stages through information and an adequate training.
- DHW production: according to the SH company, should be paid attention to circulation, which, as in the case in question, undertakes to keep the water temperature 24 hours. Now the peak usage of the DHW can be foreseen, and this should be considered in future projects . Due to the managerial difficulties incurred, SH company thinks it would be preferable to individual solution for the production of DHW leaving to each household choices of use: probably it would cheaper, surely easier to manage.

Case Study I5: New construction of 16 dwellings in Via Martiri Palestinesi, Cinisello Balsamo

New Built (2014).

Energy efficient measures table:

Energy efficiency measure	I_r [€]	$I_{ee,brutto}$ [€]	$I_{ee,netto}$ [€]	Life time [years]
Thermal insulation	-	141 000	0	30
Windows	-	96 000	20 000	30
PV System	-	10 271	0	20
Mechanical Ventilation with Heat Recovery System	-	45 000	45 000	10
Total	**2 720 000**	**292 271**	**65 000**	
Running costs	**3 200**	**3 200**	**3 200**	
Simple pay- back time		91	20	**22**

Comments:

Referring to the energy measures :

- "Thermal insulation", there is no extra-cost since the thickness of the coat is the same as a traditional system.
- "PV systems", there is no extra-cost since the peak power corresponds to the minimum required by regional law.
- The cost of Mechanical Ventilation with Heat Recovery System is fully an extra-cost, since it would not have been installed in a energy "standard" building.

Update December 2014:

The building is now in construction phase. Construction works have started in August 2014 and will end in March 2015. In October, Finabita staff has participated to a visit to the building site: the structure was completed and technological systems were going to be installed. Nevertheless, in order to give an estimation of paybacks, Finabita and the SH company have tried to calculate economical savings of a "A-class" energy building with reference to a "B-class" one.

Running costs are estimated considering that a new building will be classified in A class according with CasaClima methodology, so the index for the Energy performance of the heating (EPh) building will be inferior to 20 kWh/m^2, while a traditional building would be classified in class B, that means EPh is inferior to 40 kWh/m^2. Supposing to consider a 100-square meters-flat as reference, the cost for heating change depending from the Energy class, as follows:

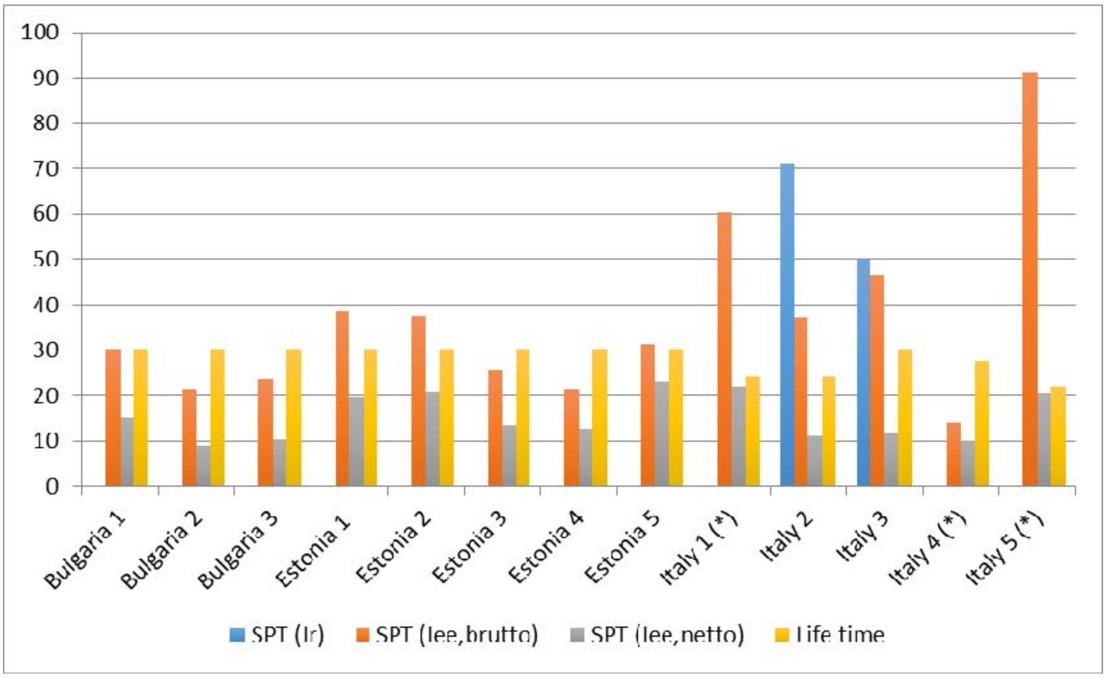
In A class, heating cost would amount to about € 250,00/year

In B class, heating cost would amount to about € 450,00/year

Therefore, the savings could be estimated in 3200 €/year.

Furthermore, in this particular case, a simple economic evaluation of the pay-back time is not suitable, since this building will be constructed through pre-fabricated wood elements, a new technique that differs from the local traditional one: this technique will reduce considerably yard times (from 1 year to 6 months) and, consequently, the overall costs of construction, despite the presence of high performance windows and installation of mechanical ventilation.

✓ 2.4 Summary of results in the 3 Countries



(*) new built project

The analysis conducted in the 3 countries shows that energy renovation which involves also thermal insulation of the building envelope, generally doesn't pay for itself (simple pay back time > than time of the renewed building components). But the results is significantly different if the energy renovation is done at the right time: when the building is in need of renovation, choosing solution with a significantly better energy efficiency than the former, will pay itself back in less than half the time od the components life span. This conclusion is rather obvious, but it is also often neglected.

For Bulgaria's and Estonia's case studies, I_r (which is the cost of the entire renovation) is basically the same as $I_{ee,brutto}$ (which is the cost of the only energy efficiency measures), as only renovation works which affect energy efficiency are generally done. For new built projects, I_r (which is the total construction cost) is not relevant, because is far too big compared to savings. For these reasons we can't say much about total renovation costs in relation to energy savings.

For new built projects, the only analysis which makes sense is the comparison of extra costs for energy efficiency measures ($I_{ee,netto}$) compared to minimum requirement and the expected savings. From the 3 Italian cases, we observe that in terms of economical feasibility it is convenient to build with energy standards, which are better than the minimum requirements. It is difficult to generalize this finding, as the minimum requirements are different in the EU countries and also get more demanding all the time. We also have to keep in mind that technology improves all the time and costs decrease consequently, while on the other side energy costs are very volatile in the short period.

3 Case studies: Increased market value of the property

Another aspect, which should be kept in consideration, is the augmentation of the property value. When a deep renovation is done on a building, the property value of it normally increases significantly. In this perspective, deep renovation projects should not be seen only as costs, but instead as investments, which will return their value when an apartment should be rented or sold. Of course it is difficult to assess how much of the increased market value after the renovation is due to the energy efficiency measures only, and what is due to the better condition of the building in general. For this reason it is good to compare total increase of the property value with the 3 different investment costs reported in chapter 2: Total cost of the renovation (I_r), Total cost of the energy efficiency measures only ($I_{ee,brutto}$), share of the energy efficiency measures costs due to the increased energy efficiency ($I_{ee,netto}$).

In case of new built projects, the housing managers will be asked to compare the property value of the new very-low energy building with a similar one which satisfy only the minimum energy requirements.

This chapter provides:

> A definition of property value in each County.

> For each study case, an estimate of the property value before and after the renovation, estimated by the housing manager or real estate expert.

For each case study, the following information are provided:

- name of the casestudy, location
- property value before the deep renovation €
- property value after the deep renovation €
- increase of the property value €
- investment costs: I_r, $I_{ee,brutto}$, $I_{ee,netto}$ € (as from chapter 2)

3.1 Bulgaria

The notion building managers is not relevant for the Bulgarian case because 97.3% of the housing stock is privately owned and very few entire buildings with municipal social rentals are with the characteristics of shelter housing for marginal social groups. Therefore, the selected case studies are multi-story apartment buildings renovated within the framework of the first pilot phase of the National Program „Energy Renovation of Bulgarian Homes“. In January 2014, CAC asked experts in real estate market valuation to provide an estimation of the added value of renovated condominium buildings.

Case Study B1: Energy refurbishment of 13 dwellings in Zaharna Fabrika block 11, Sofia

- Renovation (year of construction – 1946, and year of retrofit – 2012).
- Property value estimate without the energy measures (at the beginning of 2012) – 420 €/m^2 built up area. Since this is a condominium building the property value is estimated on the basis of a free market valuation.
- Property value estimate with the energy measures (at the end of 2014) – 530 €/m^2 built up area.
- Difference – 110 €/m^2 built up area, which means an increase of 26,2%.
- The total building market value was increased to 560 000 €. Difference is 147 000 €
- Investment extra costs (energy efficiency measures) – € 98 700 (as from chapter 2).
    - I_{tot} = *about same as* $I_{ee,\ brutto}$
    - $I_{ee,\ brutto}$ = 98 700 EUR
    - $I_{ee,\ netto}$ = 48 850 EUR

Case Study B2: Energy refurbishment of 17 dwellings in Prof. Giovanni Gorini Street 2, Sofia

- Renovation (year of construction – 1939, and year of retrofit – 2011)
- Property value estimate without the energy measures (at the beginning of 2011) – 510 €/m^2 built up area. Since this is a condominium building the property value is estimated on the basis of a free market valuation.
- Property value estimate with the energy measures (at the end of 2014) – 600 €/m2 built up area.
- Difference – 90 €/m^2 built up area, which means an increase of 17,64%
- The total building market value was increased to 920 000 €. Difference is 162 000 €
- Investment extra costs (energy efficiency measures) – € 78 000 (as from chapter 2).
    - I_{tot} = *about same as* $I_{ee,\ brutto}$
    - $I_{ee,\ brutto}$ = 78 000 EUR
    - $I_{ee,\ netto}$ = 32 900 EUR

Comments: This case study is with better location in comparison with the previous. Therefore, the potential for growth of the market price was lower. In addition, the initial general condition of the building before the energy renovation was better due to the higher level of building maintenance.

Case Study B3: Energy refurbishment of 21 dwellings in Boulevard Madrid 11, Sofia

- Renovation (year of construction – 1954, and year of retrofit – 2012).
- Property value estimate without the energy measures (at the beginning of 2012) – 500 €/m^2 built up area. Since this is a condominium building the property value is estimated on the basis of a free market valuation.
- Property value estimate with the energy measures (at the end of 2014) – 590 €/m^2 built up area.
- Difference – 90 €/m^2 built up area, which means an increase of 18%.
- The total building market value was increased to 1 080 000 €. Difference is 194 000 €
- Investment extra costs (energy efficiency measures) – € 109 600 (as from chapter 2).
    - I_{tot} = *about same as* $I_{ee,\ brutto}$
    - $I_{ee,\ brutto}$ = 109 600 EUR
    - $I_{ee,\ netto}$ = 47 300 EUR

✓ 3.2 Estonia

Due to the high privatization rate in Estonia, where about 96% of the dwelling stock is currently in private ownership, large part of population are owners of their dwellings and live in apartment associations organized in housing associations. Social rental housing in Estonia currently represents only about 1-2% of the total housing stock. All selected case studies in Estonia are buildings in divided ownership operated as associations. Therefore there are no building managers in these buildings, who could deal with selling the apartments. All real estate transactions in these buildings are made by apartment owners themselves in the free real estate market without fixed price.

As all the selected case studies are buildings which had owners/tenants already living there before the renovation, there has not been many changes in the ownership during or after the renovation process, that would give us comparable information about the change in the property price of renovated buildings. Therefore, the property value of the case studies is estimated on the basis of a free market valuation.

As the estimation of a property value is quite a complex topic in Estonia and there are different criteria for the evaluation, the most commonly used by the experts is based on the estimate of the property market value.

This assessment is determined by comparing the property in question, and other units in the area with the same characteristics (period of construction, finish, type of construction, etc..): the comparison yields an average price per square meter of commercial surface.

EKYL contacted some real estate agencies in cities of Tallinn, Tartu, Rakvere and Võru, where the buildings (case studies) are situated and asked for the property prices in similar buildings as the case studies. As owners sell their apartment usually with the help of real estate agency services, the data from the agencies should be the most accurate.

According to estimations, the maximum increase in property value is 15-20% after renovations in cities like Tallinn or Tartu. In smaller towns like Rakvere or Võru, the increase is lower due to the market situation as these towns are less attractive regions in the real estate market. So, we may find many different aspects that actually have influence on the property value in addition to the fact if the building is refurbished or not. Therefore the renovation with same energy savings does not affect the property value in the same amount in different regions.

Subsequently, calculations of one case study in each region are presented. As there are no fixed property prices in apartment associations, the next calculations has been done with one possible property value estimation in each region in the buildings similar to the case studies.

Case Study E1 : Energy refurbishment of 18 dwellings in Rõõmu str 12, Tartu, Estonia

- Renovation (year of construction 1975 and year of retrofit 2012).
- Property value estimate without the energy measures (at the end of 2013) – 950 €/m^2.
- Property value at the end of 2014 1050 €/m^2
- Difference – 100 €/m^2, which means an increase of 10%.
- The total building market value was increased 149 900 €.
- Investment extra costs (energy efficiency measures) – 187 000 € (as from chapter 2).
  - I_{tot} = *about same as* $I_{ee, brutto}$
  - $I_{ee, brutto}$ = 187 000 EUR
  - $I_{ee, netto}$ = 90 750 EUR
- New comments: If the property market allows to sell the apartment with higher price then the investment is covered with property value about 0,8 times.

Case Study E2: Energy refurbishment of 32 dwellings in Tartu str 33, Võru, Estonia

- Renovation (year of construction 1963 and year of retrofit 2012).
- Property value estimate without the energy measures (at the end of 2013) – 430 €/m^2.
- Property value at the end of 2014 - 500 €/m2
- Difference – 70 €/m^2, which means an increase of 14%.
- The total building market value was increased 116 130 €.
- Investment extra costs (energy efficiency measures) – 180 225 € (as from chapter 2).
  - I_{tot} = *about same as* $I_{ee, brutto}$
  - $I_{ee, brutto}$ = 180 225 EUR

  - $I_{ee,\ netto}$ = 99 613 EUR

- New comments: If the property market allows to sell the apartment with higher price then the investment is covered with property value about 0,6 times.

Case Study E3: Energy refurbishment of 60 dwellings in Tuleviku str 10, Rakvere, Estonia

- Renovation (year of construction 1977 and year of retrofit 2012).
- Property value estimate without the energy measures (at the end of 2013) – 430 €/m^2.
- Property value estimate with the energy measures (at the end of 2014) – 510 €/m^2.
- Difference – 80 €/m^2, which means an increase of 15%.
- The total building market value was increased 351 920 €.
- Investment extra costs (energy efficiency measures) – 652 000 € (as from chapter 2).
  - I_{tot} = *about same as* $I_{ee,\ brutto}$
  - $I_{ee,\ brutto}$ = 652 000 EUR
  - $I_{ee,\ netto}$ = 341 500 EUR
- New comments: If the property market allows to sell the appartement with higer price then the investment is covered with property value about 0,5 times.

Case Study E5: Energy refurbishment of 30 dwellings in Õismäe str 11, Tallinn, Estonia

- Renovation (year of construction 1975 and year of retrofit 2011)
- Property value estimate without the energy measures (at the end of 2013) – 1100 €/m^2
- Property value at the end of 2014 - 1250 EUR/m^2
- Difference – 150 €/m^2, which means an increase of 12%
- The total building market value was increased 295 350 €.
- Investment extra costs (energy efficiency measures) – 154 000 € (as from chapter 2).
  - I_{tot} = *about same as* $I_{ee,\ brutto}$
  - $I_{ee,\ brutto}$ = 154 000 EUR
  - $I_{ee,\ netto}$ = 110 000 EUR
- New comments: If the property market allows to sell the apartment with higher price then the investment is covered with property value about 1,9 times.
- The property market in Tallinn shows, that complex renovation investment is covered with the higher property value.

✓ 3.3 Italy

In January 2014, Finabita has contacted some Housing Manager experts and asked them to provide an estimation of the added value of nZEB (both new or retrofitted), considering the property values both before and after the energy renovation.

In Italy, the estimation of a property value is quite a complex topic, since there are different criteria for the evaluation, whose the most commonly used by the experts is based on the estimate of the property market value.

This assessment is determined by comparing the property in question, and other units in the area with the same characteristics (period of construction, finish, type of construction, etc..): the comparison yields an average price per square meter of commercial surface.

The commercial surface includes the bulk of the inhabited part (including the walls), the area of the balconies, terraces, gardens of any: for the calculation of this size, you can refer to UNI 10750, which provides the percentage of each element in conformity.

The other variables that characterize the unit price are: the exposure (daylight and noise from busy roads), the state of maintenance, the position with respect to the plans of the building, and so on.

Case Study I1: New construction of 142 dwellings in Bazzana Inferiore, Assago, Italy

- New Built (2013).
- Even if the buildings belong to subsidized housing and people will buy at a fixed price per m^2 independently from the energy certification class, the SH company staff provided us with an estimation of the local market value both for a C class dwelling (that means without energy measures), which is equal to 2.820,00 €/m^2 and a A+ one (with energy measures), which is equal to 3.000,00 €/m^2.
- Hence, we can establish that the building market value increase is equal to 180 €/m^2, and the total increase is equal to 2.074.860,00 €.
- The investment costs are (from chapter 2):
  - I_{tot} = 40.800.000,00 €
  - $I_{ee, brutto}$ = 2.840.000,00 €
  - $I_{ee, netto}$ =1.040.000,00 €

Case Study I2: Energy refurbishment of 131 dwellings and new construction of 45 dwellings in Via Caldera, Milano, Italy

- Renovation (construction:1909-1960, renovation: July 2013-October 2014).

- The property value estimate without the energy measures is equal to € 8.077.239,00, about € 851,78 €/m^2 which is far below the average property values in the surrounding area, because of the "old" age of the building.
- At the end of the deep renovation, the technological value of the property can be settled in the range between € 1.250,00 and € 1.650,00 per square meter depending on the interior accommodations. The SH company considers an average property estimate value of about 1400,00 /m^2, totally € 12.275.920,00.
- Increase of value is equal to € 4.198.681,00. The increase is high since the building, before renovation, was in bad shape and consequently the market value before renovation was very low.
- We must say that the retrofitting an "ancient" building implies high costs that often financially affect more that the energy renovation ones.. The investment costs are (from chapter 2):
    - I_{tot} = 2.809.000,00 €
    - $I_{ee,\ brutto}$ = 1.469.934,00 €
    - $I_{ee,\ netto}$ = 435.918,00 €

Case Study I3: Energy refurbishment of 38 dwellings in Via dei Querci, Florence, Italy

- Renovation (year of construction: 1970 and year of retrofit: 2011).
    - property value estimate without the energy efficiency measures amounts to 2.400,00 €/m^2.
    - The SH estimated that the market value increased in 11/12% approximately, so the new property value is equal to 2.680,00 €/m^2.
    - Considering a total surface equal to 3.000 m^2, the total increase is about € 828.000,00
- The investment costs are (from chapter 2):
    - I_{tot} = 468.000,00 €
    - $I_{ee,\ brutto}$ = 468.000,00 €
    - $I_{ee,\ netto}$ = 107.000,00 €

Case Study I4: New construction of 84 dwellings in Largo Aldo Capitini, Sesto Fiorentino, Italy

- It is a New Built type (2010).
- Property value estimate without the energy measures € 2.700,00/m^2
- Property value estimate with the energy measures € 2.950,00/m^2 .
- Considering a total commercial surface equal to 6900 m^2, the total increase is € 1.725.000,00.
- The investment costs are (from chapter 2):
    - I_{tot} = 10.350.000,00 €
    - $I_{ee,\ brutto}$= 287.000,00 €

- $I_{ee,\ netto}$ = 207.000,00 €

Case Study I5: New construction of 16 dwellings in Via Martiri Palestinesi, Cinisello Balsamo, Italy

- New Built (2015).
- The intervention is in subsidized housing, so the local cost can't exceed 2.400,00 €/m^2. In a free market, the local property value for a traditional residential building can be estimated around 3.000,00 €/m^2.
- According to SH company, the real estate market is in an instable phase, hence it becomes difficult to give an estimate: generally speaking, the market value for a very high efficient house may be increased by at least 10%, so property value estimate with the energy measures could be estimated in 3.300,00 €/m^2.
- Total increase € 360.000,00.
- The investment done buildings are (from chapter 2):
    - I_{tot} = 2.720.000,00 €
    - $I_{ee,\ brutto}$ = 292.271,00 €
    - $I_{ee,\ netto}$ = 65.000,00 €

✓ 3.4 Summary of results in the 3 Countries

From the analysis of the results, we can observe that:

- In Bulgaria (all cases are in Sofia), the increase of property value is about double that the cost of the energy efficiency measures (and total renovation cost is about the same as energy efficient measures)
- In Estonia, the increase of property value is smaller that the cost of the energy efficiency measures (and total renovation cost is about the same as energy efficient measures), but bigger than the extra costs for making an energy renovation instead of a conservative renovation
- In Tallinn, the property value increase is largely greater than the renovation costs, a similar situation verified also in Sofia. So there might be a difference in the benefit given by energy renovation in large cities and smaller centres.
- Also in the 2 renovation cases in Italy, the increase of property value is about double than investment costs. The developments are in Milan and Florence, which would confirm what stated at the point above.
- For the 3 (Italians) new-built projects, conclusions are more difficult because are based on estimates. In all cases the housing managers believe that the property value of the buildings is considerably bigger than the extra costs for making a very low energy building instead of one in line with the minimum requirements.

4 Case studies: Users satisfaction survey

Note: this chapter has been completed in version2- Final of the document. It has been decided to limit the survey to 2 renovation projects per Country, 6 projects in total. New built projects have not been considered because the comparison with the previous accommodation of each household would have been to complicate and would have required a larger size of the sample to be significant.

Experience shows that after a deep renovation, which includes the insulation of the building envelope, the average temperature in winter inside the apartments is often higher, providing a better comfort for the residents, for example because before it was too expensive to keep the temperature to an adequate level. When this happens only part of the potential energy saving is actually achieved

The positive “side-effects” on indoor comfort after a deep energy renovation goes over the increased internal temperature in winter: positive effects can be registered also in terms of better indoor air quality, better noise insulation from the outside, better conditions (lower temperatures) also in summer, and eventually also a better hot water supply (in case this was also renovated). But not always, of course, in some cases after the renovation, the inhabitants experience worse comfort parameters.

A quantification of the changed comfort before and after the renovation would have required a monitoring activity of comfort parameters over an extended period of time, which would have gone far beyond the objectives and means of this study. In alternative, a qualitative approach based on the feedback provided by users. A simple “user satisfaction” questionnaire has been proposed to the households living in the selected buildings. Answers are simply marks from 1 to 5, 3 no difference, 5 much better, 1 much worst, asking the family to make a comparison with the situation before the renovation. The proposed questions were intentionally easy in order to gather an as large feedback as possible, and were divided in 3 groups: comfort in winter, comfort in summer, quality of the domestic hot water service. This is the complete list of questions:

--- Winter ----

1 Do you think that your apartment is now more or less comfortable during the cold season?

And in particular:

1.1 The temperature inside is on average:

1.2 The air quality is:

1.3 The noise insulation is:

--- Summer ---

2 Do you think that your apartment is now more or less comfortable during the hot season?

And in particular:

2.1 The temperature inside is on average:

2.2 The air quality is:

2.3 The noise insulation is:

--- Hot water ---

3 Do you think that the hot water is overall better or worse after the renovation?

And in particular:

3.1 The temperature of the hot water is:

3.2 The waiting time is:

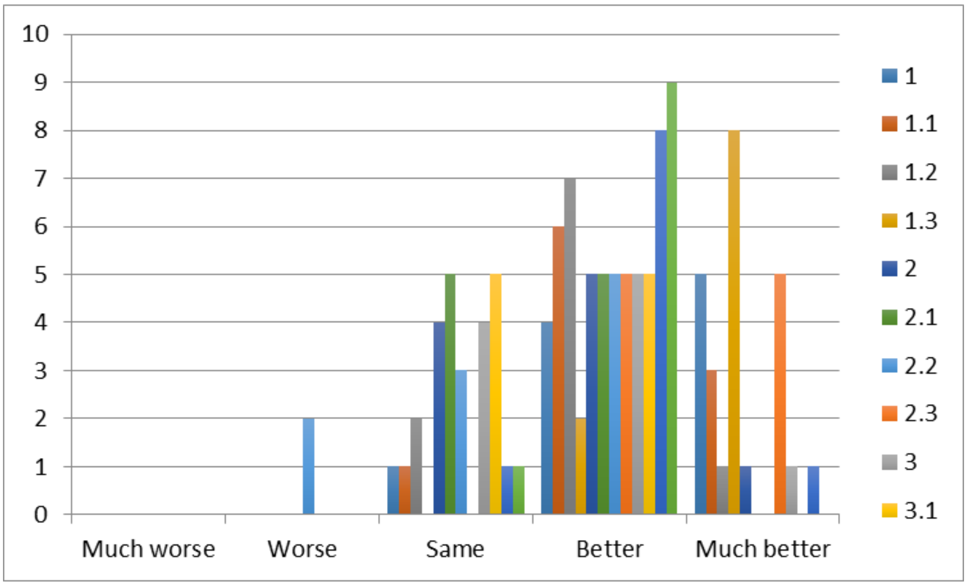
3.3 The availability is:

We aimed to achieve at least 75% of questionnaires return rate. While in practice 69% of the questionnaires have been returned on average.

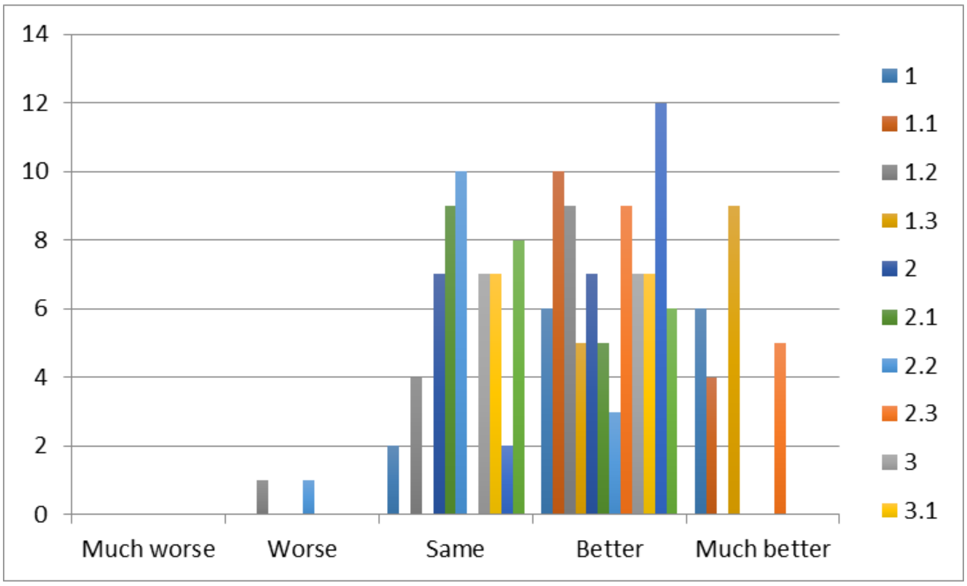
✓ **4.1 Bulgaria**

The Questionnaire was submitted to two Case studies dealing with energy retrofitting of multi-apartment buildings:

Energy refurbishment of 13 dwellings in Zaharna Fabrika block 11, Sofia



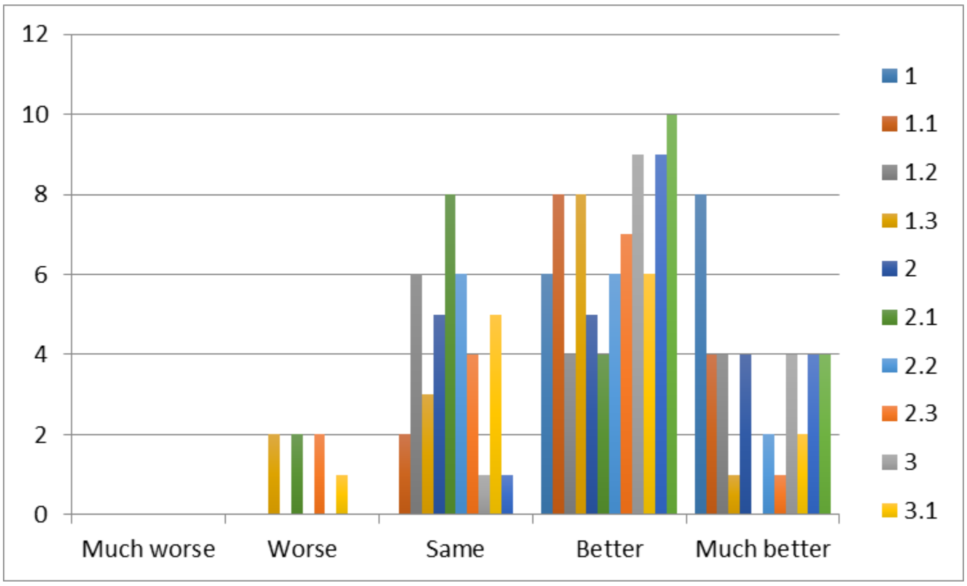
Energy Refurbishment of 17 dwellings in Prof. Giovanni Gorini Street 2, Sofia



✓ **4.2 Estonia**

The Questionnaire was submitted to two Case studies dealing with energy retrofitting of multi-apartment buildings:

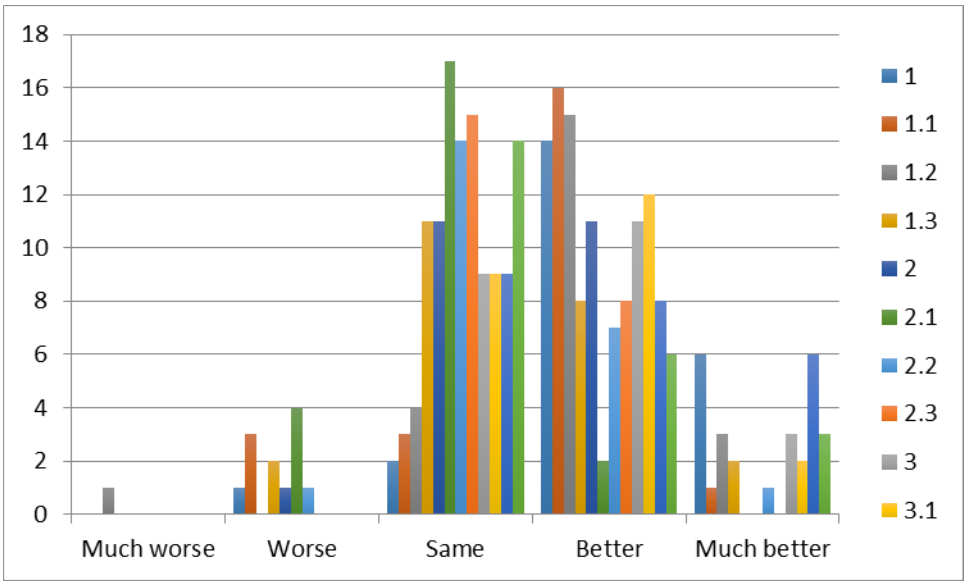
Energy refurbishment of 18 dwellings in Rõõmu str 12, Tartu



Question 1: it was difficult for tenants to answer, as one part of the renovation was installation of thermo regulators and everyone can choose higher/lower temperature now, how she/he likes. Finally we decided to mark better/higher in this case, basically because they can choose higher if they want

Question 1.1: as before renovation some apartments were overheated, they probably have lower temperature now, which is still better for them now

Energy refurbishment of 30 dwellings in Õismäe str 11, Tallinn



Question 1: it was difficult for tenants to answer, as one part of the renovation was installation of thermo regulators and everyone can choose higher/lower temperature now, how she/he likes. Finally we decided to mark better/higher in this case, basically because they can choose higher if they want

Question 1.1: as before renovation some apartments were overheated, they probably have lower temperature now, which is still better for them now

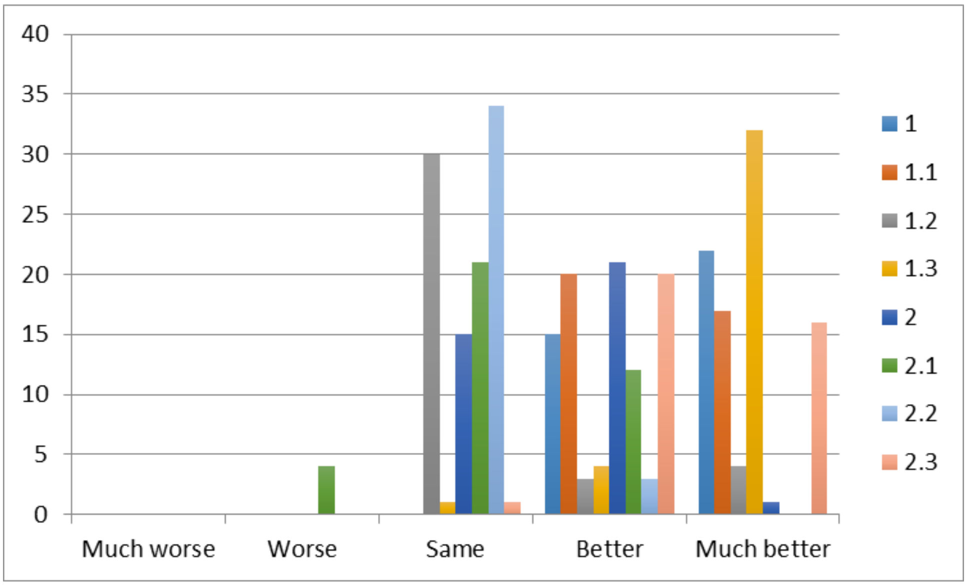
Question 3 (only from Õismäe 11): There wasn't problems with hot water before the renovation, so we may say that the situation with water is the same as we didn't need improvement in this

✓ **4.3 Italy**

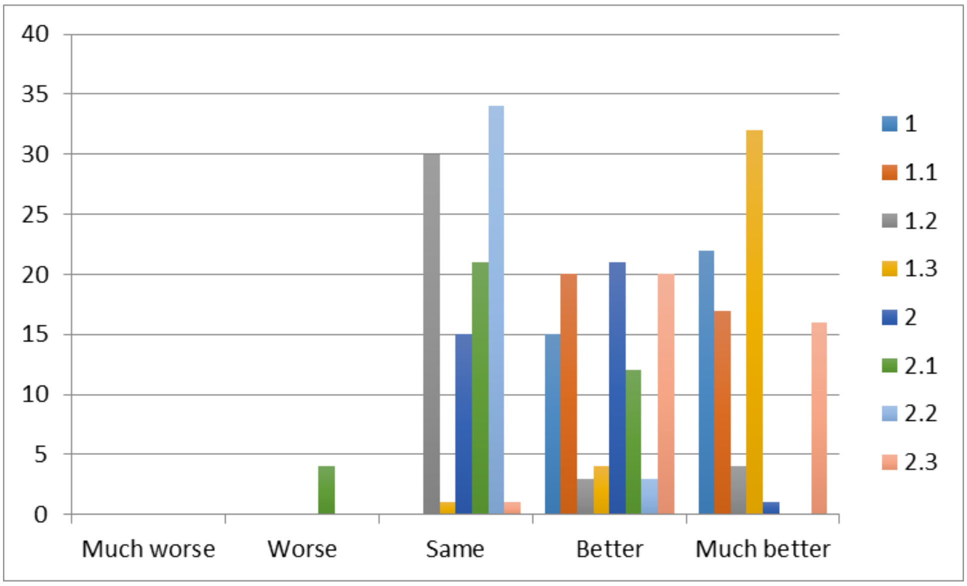
The Questionnaire was submitted to two Case studies dealing with Energy renovation of buildings:

Energy refurbishment of 131 dwellings and new construction of 45 dwellings in Via Caldera, Milano.

In this case, part 3 referring to DHW was not delivered to tenants since the concerning renovation works have not been yet finished.



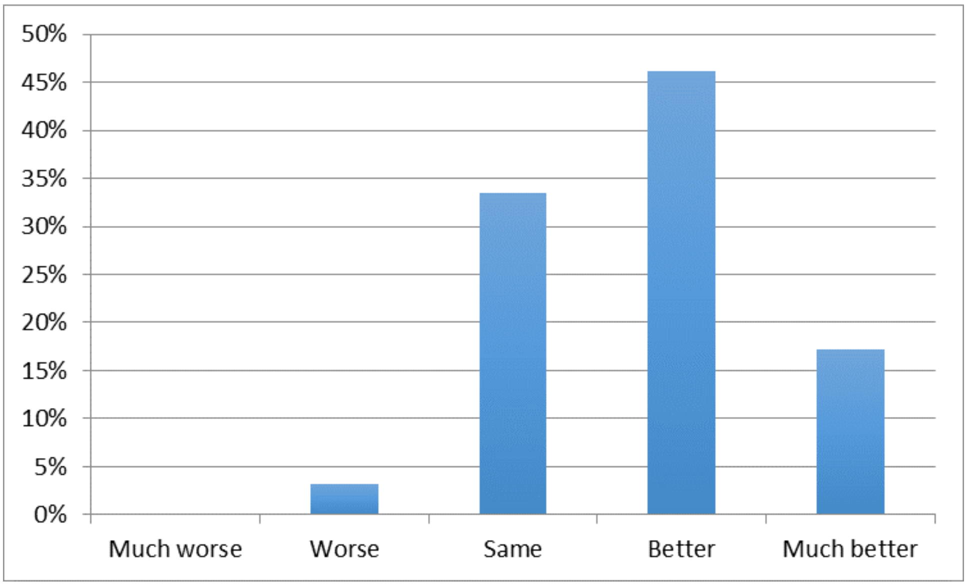
Case Study: Energy refurbishment of 38 dwellings in Via dei Querci, Florence:



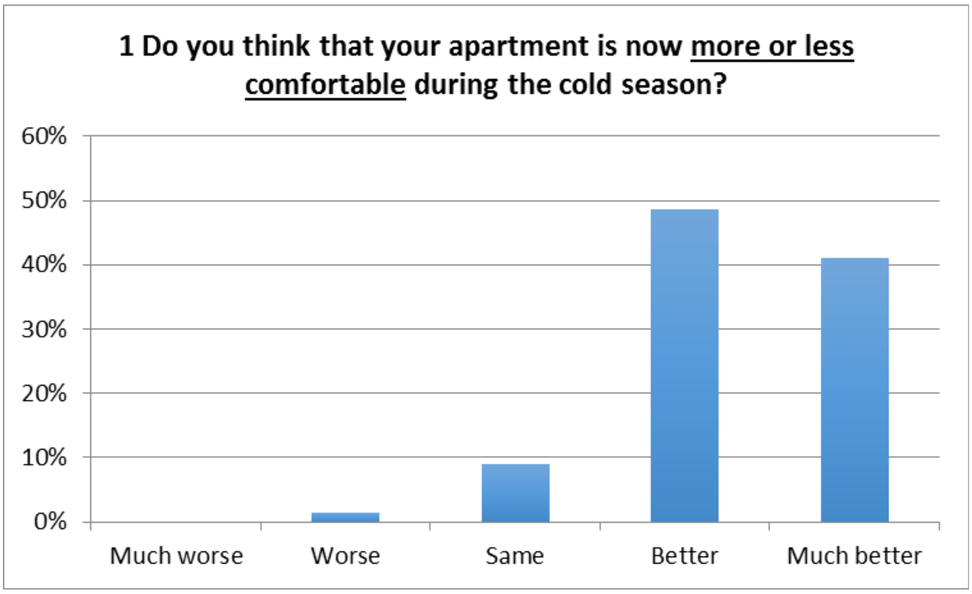
✓ **4.4 Summary of results in the 3 Countries**

Summarising the results in all Case studies, for all questions and than for the “main” questions about comfort in winter/ summer and quality of the hot water service, we find the following results:

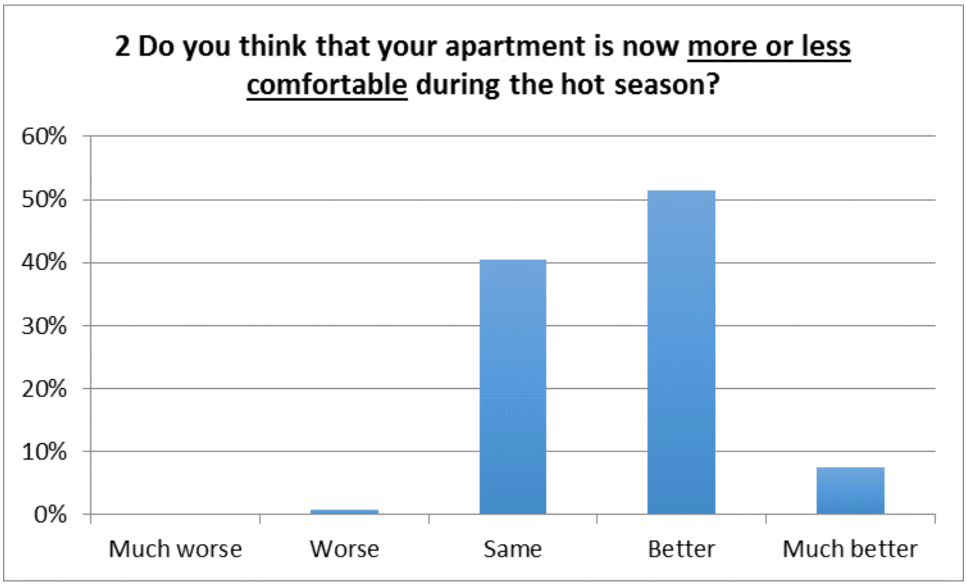
All questions:



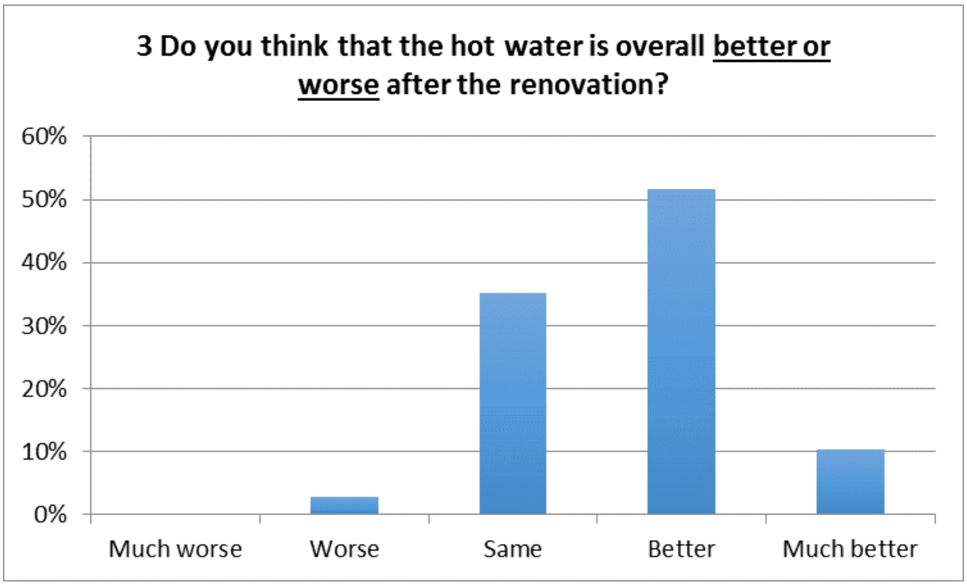
Question 1:



Question 2:



Question 3:



The data gathered in the 6 case studies show clearly that, according to the people living in the buildings, the comfort and quality of service improved significantly after the renovation works. This is particularly true for the comfort during the cold season, which generally was the primary object of the renovations: About 90% of the people interviewed say that the comfort in winter is *better* or *much better* after the renovation. Also for the quality of the hot water service, register 60% of *better* or *much better.*

Interesting to observe that also the summer comfort, which generally was not a direct object of the renovation, finds about 60% of *better* or *much better* votes. Some professionals still believe that the improvement of the thermal insulation of a building causes a worse comfort in summer. According to the results of all 6 case studies, the comfort improves also in summer after renovation.

5 Conclusions

This is an extensive report based on the research work conducted by the project partners CAC (Bulgaria), EKYL (Estonia) and Finabita (Italy), which have been investigating different aspects of economical feasibility of deep energy renovation and construction of nearly zero energy buildings in the divided and cooperative property context.

Once again we remark that at the time of the projects, the concept of nearly zero energy building was not yet been translated into a practical standard, especially for renovation projects. For this reason we prefer to define the projects “low energy building”, rather than “nearly zero”.

At the end of each chapter of this report there is a summary of results and observations with detailed analysis. The number of project considered is limited, 13, so further and more scientific study should be done. But here the main points which emerged from the work:

- Timing for energy renovation is crucial: pay back time for deep renovation of building components which *actually* need to be renovated is about 50% of the expected lifetime of the renewed components, making an *energy* renovation more convenient than a *conservative* renovation. Too high subsidizes could alter this relation, making economically convenient to renovate building components which have not yet entirely exhausted their lifetime.

- The research on the augmentation of the property value gave surprising results, as in many cases the value of the property after the renovation/ new construction compared to the basic energy standard building, shows that the increase of the property value is almost equal, or bigger, than the money invested for the energy measures. This is particularly true for properties in larger cities, less for projects in smaller centres. In any case the increase of property value is always (much) bigger than the extra cost for making an *energy* renovation instead of a *conservative* one. Instead of costs, it would be more correct to talk about investment when referring to energy renovation of buildings.

- User satisfaction questionnaire show that 90% of the users think that in winter comfort is better or much better after renovation. Thermal insulation was generally the main target of the renovation. 60% of the users think that summer comfort and domestic hot water service are also better or much better after renovation. While only less than 2% (in the worse case) of the users express a negative opinion about comfort of the building after the renovation. Also noise insulation is a positive “side” effect of the renovation, which is highly appreciated by the users

- It is not so easy to state that part of the potential energy savings for space heating are spent for a higher internal temperature: for example in some Estonian cases with central heating, previous the energy renovation the heat distribution was unbalanced, leading to high temperatures in some apartments.

- Detailed information on energy consumptions of the selected buildings (in Estonia and Italy), can be accessed via the energy tracking database: http://panel.hiveproject.net.

In conclusion, this report show rather clearly that expected saving on energy bills should not be the only parameter toward which economical feasibility, and also cost optimality, should be measured. There are other parameters, such as the actual need for renovation, the expected increase in property value and the benefits in terms of indoor comfort, which should be considered and appreciated in the evaluation.

On these topics it is advisable in our opinion to carry on further research.

For further information, please visit www.powerhouseeurope.eu

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