Programme of actions towards Factor 4 in existing social housings in Europe

Deliverable 7

Potential energy savings for some representative buildings by using only the ecological objective of a LCEC analysis

December 2007

Part 3 Italian case studies

www.suden.org/Factor4

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Project partly funded by the

EUROPEAN COMMISSION – Intelligent Energy Executive Agency

Grant agreement EIE/05/076/S12.419636

Intelligent Energy Europe

REMINDER UPON THE FACTOR 4 PROJECT

The Factor 4 project follows the Sustainable Development World Strategy worked out in Johannesburg in 2002 and aims at working out:

- an operational tool (the SEC or Sustainable Energy Cost model) for a long term management of the building stock of a social owner in the one hand,
- and at recommendations for all the actors concerned, illustrated by demonstration actions on the other hand.

Factor 4 deals with existing social housing buildings which will still be there in 2030-2050 for improving their energy efficiency by a minimum of 30 % in a short term and more in a long term and using renewable energy, in order to participate to the reduction of greenhouse effect gas (GEG) emission by a factor 4 before 2050.

EXPECTED AND/OR ACHIEVED RESULTS

The key products, with their use and impacts, generated by - or expected from - our project are

- **A Factor 4 model for social owners** with adapted versions for at least 3 countries (Denmark, France, Germany and Italy), easy to use and directly usable by social owners themselves **for the optimization of the retrofitting works.**

  As the Factor 4 model allows to work out various scenarii, it will help to get an idea of what would be the best strategy for the building stock or for some specific buildings.

  This Factor 4 model will be also an economic tool to be used with the Energy Performance Building diagnosis (which is only a technical diagnosis according to the European Directive).

  In regeneration projects at the neighbourhood scale such as in URBACT or in national programmes (ANRU in France, NRU in UK, Contratti di quartieri in Italy…), **the Factor 4 model will be also a decision aid tool for selecting the buildings to be demolished or to be hardly (or softly) renovated.** This decision aid tool will be usable by social owners themselves but also by their financial partners or by local authorities as regarding buildings from various social owners.

  At the building scale the Factor 4 model will complete the technical diagnosis with economical data.

  At least, this Factor 4 model should be also a way towards the integration of energy in the (strategic) management plan of social owners' building stocks.
- **Recommendations for social owners, local authorities, public administration and banks as regarding energy savings in social housing towards a factor 4**
- Demonstration case studies in order to be as operational as possible. Tests will be done upon the building stock of the Factor 4 partners showing how the Factor 4 model can be used and which results can be expected.

REMINDER UPON THE FIRST AVAILABLE DELIVERABLES

- Deliverable 3 : Typological analysis and energy diagnosis for the "2050 buildings", November 2006

- Deliverable 4: "The typology of buildings which will still be in use in 2050, the estimation of greenhouse effect gas (GEG) emissions from the social housing building stock and the selection of criteria for choosing the cases studies", March 2007

The part about France has been translated in French (by SUDEN and La Calade): « Typologie des bâtiments qui seront encore en usage en 2050 en France, estimation des émissions de gaz à effet de serre du parc social et critères de sélection des études de cas », Décembre 2006

- Deliverable 5: "A life cycle energy costing model for existing social housings in Europe**",** June 2007

- Deliverable 6: "The Efficient Energy Technologies dealt with in the Factor 4 or SEC models"

- **Deliverable 7: "**Potential energy for some representative buildings by using only the ecological objective of a LCEC analysis", June 2007

and deliverables in national languages:

- **Deliverable 8**:

French: « Le modèle SEC (Sustainable Energy Cost) d'analyse en coût global partagé : un outil d'aide à la décision pour la réhabilitation énergétique des bâtiments de logements sociaux », Philippe Outrequin (La Calade) and Catherine Charlot-Valdieu (SUDEN), June 2007

Italian, Danish and German : the titles are not yet known

- **Deliverable 9**:

French: - Deliverable 9. « L'optimisation des programmes de réhabilitation grâce à une analyse en coût global énergétique avec le modèle SEC (Sustainable Energy Cost)», Philippe Outrequin (La Calade) and Catherine Charlot-Valdieu (SUDEN), June 2007

Italian, Danish and German: the titles are not yet known

PART 3. THE ITALIAN RESULTS

This is a synthetic table of the 10 Italian Case Studies.

1 – Case studies from the Italian partner ANCAB with the main criteria of the typology (deliverable 3)

Criteria		ANCAB
Number of case studies		**10**
Number of buildings		**11**
Number of dwellings		**474**
Number of livable square meters		**27 439**
Construction date - NUMBER OF BUILDINGS		
Before 1946		**3**
Between 1947 et 1976		**4**
Between 1977 and 1991		**2**
Since 1992		**1**
Climatic area - NUMBER OF BUILDINGS		
A		
B		
C		
D		
E		**10**
F		
Building size – NUMBER OF BUILDINGS		
3 - 4 dwellings		**0**
5 - 8 dwellings		**0**
9 - 15 dwellings		**1**
More than 16 dwellings		**9**
Heating systems - NUMBER OF BUILDINGS		
gas		**10**
electricity		**0**
coal		**0**
oil		**0**
other		**0**

In order:

- to be more representative as regarding the criteria from the typology worked out in the deliverable 3 (for climatic areas for example)
- to validate the model with more various case studies and
- to be sure that the model is usable by social owners them selves (and so takes into account the data available as well as the social owners'way of working),

associated partners joined the project and offered a larger overview of representative case studies.

These case studies from the associated partners are described in the next table:

Social owners criteria	**LA BENEFICA**	**DEGRADI**	**NIGUARDA**
Nb of case studies	4	5	1
Nb of buildings	5	5	1
Nb of dwellings	245	145	84
Livable m²	14 420	8 307	4 712
Construction date			
Before 1946	X	X	
Between 1947 et 1976		X	X
Between 1977 and 1991	X	X	
Since 1992	X		
Climatic area			
A			
B			
C			
D			
E	x	x	x
F			
G			
Building size			
3 - 4 dwellings			
5 - 8 dwellings			
9 - 15 dwellings	X		
More than 16 dwellings	x	x	x
Heating system			
gas	x	x	x
electricity			
coal			
oil			
other			

Three Selected case studies

Analysis of the 3 case studies: energy data refer to the situation before and after retrofitting works.

For this Deliverable 3 of the ten case studies have been selected and deeply analyzed. The case studies have been chosen because they are representative of three different ages of construction. This three typologies imply different style of building and therefore different needs of retrofitting.

These three case studies have been analyzed following two different strategies and objectives:

1) A Social Owners' Scenario: this first scenario has been named Social Owners' Scenario because it has been elaborated with a strict dialogue with the cooperatives' owners of the buildings
2) A Factor 4 Scenario: that is to say a scenario that aims at reaching a factor 4 reduction of GEG emission.

3.1. SOCIAL OWNERS' SCENARIO

This first scenario has been named Social Owners' Scenario because it has been elaborated with a strict dialogue with the cooperatives' owners of the buildings. The researchers have organized a workshop with all the managers to present the project, its aims, the Brea model and its functioning. After the phase of energy audit a first presentation of different retrofitting technologies has been done. The managers have discussed with researchers the problems of application in the specific context, the costs, the inhabitants opinions, the possibilities of financing.

The results presented in the following tables and graphs represent a scenario that can be called a "medium" or a "realizable" or "realistic" scenario. The main feature is that it is the outcome of a work of analysis of the possibilities presented and the real possibilities to realize the interventions. This means that cooperatives have chosen an hypothesis that seemed profitable for them in terms of savings on one side and economic investment on the other.

CASE STUDY N. 1 – COOP. DEGRADI – Via Zoia, 76 - Milano

Initial situation

Social owner name:	**DEGRADI**		**Energy source**	**Energy consumption in kWh/m²/year**		**CO_2 - kg/m²**
Operation name:	**-**			Final	Primary	
Number of buildings:	**1**	Heating	**METANO**	**68**	**161,7**	**40,4**
Number of units:	**40**	Sanitary hot water	**METANO**	**31,1**		
Construction date	**1986**	Electricity	-	**40**	-	**26**
Location of the building (and climatic area):	**E**	Total expense in €/m²				**26,3**
Number of liveable m²	**2730**	Total CO_2 in kg / m²				**66,4**
Number of stairs:	**3**					

Retrofitting works. Data below correspond to a medium intervention level, in particular to level " 3 " (see the second part of DEL 7) - This level is in a medium position in a range of 5 levels of interventions to improve the energy efficiency of residential housing.

Nature of works		**Cost of retrofitting works in €**	**Results AFTER Works**				
H9 H10 H11	Envelope insulation	-		**Energy source**	**Energy consumption (KWh/m²/yea)**		**CO_2 (kg /m²)**
-	Energy efficient windows	52.000					
-	Good distribution (heating system)	2.800					
W2	Solar panels for sanitary hot water production (and individual accounting)	92.000			Final	Primary	
H2 H16	Heating system regulation and accounting	18.000	Heating	**METANO**	**30,4**	**73,4**	**18,3**
EI	Efficient lighting	1500	Sanitary hot water	**METANO**	**4,9**		
-	Natural light use	5000	Electricity	**-**	32,8	**-**	**21,3**
W5a W5b	Savings in water consumption	11.200	**Total expense (€/m²)**	**15,9**			
-	Correct behaviour in using electricity, heating system and hot water	0	**Total CO_2 (kg/m²)**	**39,6**			
-	Dissemination on energy saving issue	2800	**Pay back period(years)**	**6,6**			
E7	Photovoltaic plant	-					
	Total cost	**184.300**					

RETROFITTING WORKS:

This building has an envelope with quite a good insulation factor, as it ranges from 0,37 to 0,65; also windows have a quite efficient value even if they would not respect much restrictive U factors of recent Italian law.

So the project proposes to make no intervention on the walls (the cooperative considers it too much expensive in this moment) and roof but to substitute windows; these windows go back to 1989 so they are not so old but they do not have a good performance; the new ones will be provided with a double glass with gas argon.

The building has a good system of shading, obtained through external curtains that can be regulated by inhabitants; such a simple shading system is now compulsory in Italy with the new laws regarding building efficiency; in fact due to a very hot climate in Italy there is a very high use of conditioning system, which is very expensive and it can be avoided, or at least reduced, through the use of external curtains.

The roof is almost flat and it is not visible from the street so it is possible to introduce a solar thermal plant for hot water production. Hot water plant is now individual so it is not so efficient; introducing a solar plant the whole plant will be renewed and made centralized. Also heating system is individual in this building so it is not so efficient, but is considered too expensive for the cooperative to change it, so there have been planned no works for heating system.

CASE STUDY N. 2 – COOP. DEGRADI – Via Zanzottera, 9 - Milano

Initial situation

Social owner name:	**DEGRADI**		**Energy source**	**Energy consumption in kWh/m²/year**		**CO_2 . kg/m²**
Operation name:	**-**			Final	Primary	
Number of buildings:	**1**	Heating	**METANO**	**113**	**162,2**	**40,6**
Number of units:	**24**	Sanitary hot water	**METANO**	**31,6**		
Construction date	**1951**	Electricity	-	**40**	-	**26**
Location of the building (and climatic area):	**E**	Total expense in €/m²				**26,4**
Number of liveable m²	**1362**	Total CO_2 in kg / m²				**66,6**
Number of stairs:	**1**					

Retrofitting works. Data below correspond to a medium intervention level, in particular to level " 3 " (see the second part of DEL 7) - This level is in a medium position in a range of 5 levels of interventions to improve the energy efficiency of residential housing.

Nature of works		**Cost of retrofitting works in €**	**Results AFTER Works**				
H9 H10 H11	Envelope insulation	68.800		**Energy source**	**Energy consumption (KWh/m²/yea)**		**CO_2 (kg /m²)**
-	Energy efficient windows	31.200					
-	Good distribution (heating system)	1.680					
W2	Solar panels for sanitary hot water production	52.800			Final	Primary	
H2 H16	Heating system regulation and accounting	10.800	Heating	**METANO**	**23,2**	**45,4**	**11,3**
EI	Efficient lighting	300	Sanitary hot water	**METANO**	**7,2**		
-	Natural light use	1500	Electricity	**-**	32,8	**-**	**21,3**
W5a W5b	Savings in water consumption	6.700	**Total expense (€/m²)**	**13,2**			
-	Correct behaviour in using electricity, heating system and hot water	0	**Total CO2 (kg/m²)**	**32,6**			
-	Dissemination on energy saving issue	1000	**Pay back period(years)**	**3,9**			
E7	Photovoltaic plant	-					
	Total cost	**174.700**					

RETROFITTING WORKS:

This building has an envelope with very low insulation factor, as it goes back to 1920 so its structure is made of brick and covered directly with plaster, with no insulation.

So the proposed project wants to improve insulation value by adding a insulating external layer on the walls, the roof and the floor toward the basement (coat) .

Also windows and the external doors (which are made of wood and are quite old) will be substituted with more efficient ones, provided with a double glass with gas argon.

Besides, as the roof has a good exposition looking towards south (the side looking over the yard), it is suggested to install a solar thermal plant for hot water production. Hot water plant is now individual so it is not so efficient: introducing a solar plant the whole plant will be renewed and made centralized, with individual regulation and accounting.

It is not necessary to change heating system as it is quite new (2001); it has a condensation heater (106%).

CASE STUDY N. 7 – COOP. LA BENEFICA – Via Turati - Milano

Initial situation

Social owner name:	**LA BENEFICA**		**Energy source**	**Energy consumption in kWh/m²/year**		**CO_2 - kg/m²**
Operation name:	**-**			Final	Primary	
Number of buildings:	**1**	Heating	**METANO**	**83**	**149,1**	**37,2**
Number of units:	**54**	Sanitary hot water	**METANO**	**31,1**		
Construction date	**1992**	Electricity	-	**40**	-	**26**
Location of the building (and climatic area):	**E**	Total expense in €/m²				**25,1**
Number of liveable m²	**4177**	Total CO_2 in kg / m²				**63,2**
Number of stairs:	**3**					

Retrofitting works. Data below correspond to a medium intervention level, in particular to level " 3 " (see the second part of DEL 7) - This level is in a medium position in a range of 5 levels of interventions to improve the energy efficiency of residential housing.

Nature of works		**Cost of retrofitting works €**	**Results AFTER Works**				
H9 H10 H11	Envelope insulation	-		**Energy source**	**Energy consumption (KWh/m²/yea)**		**CO_2 (kg /m²)**
-	Energy efficient windows	70.200					
-	Good distribution (heating system)	3.780					
W2	Solar panels for sanitary hot water production (and individual accounting)	124.200			Final	Primary	
H2 H16	Heating system regulation and accounting	24.300	Heating	**METANO**	**26,3**	**56,4**	**14,1**
EI	Efficient lighting	1800	Sanitary hot water	**METANO**	**4,9**		
-	Natural light use	8600	Electricity	**-**	22,6	**-**	**14,6**
W5a W5 b	Savings in water consumption	15.120	**Total expense (€/m²)**	**12,1**			
-	Correct behaviour in using electricity, heating system and hot water	0	**Total CO2 (kg/m²)**	**28,7**			
-	Dissemination on energy saving issue	2800	**Pay back period(years)**	**8,4**			
E7	Photovoltaic plant	297.000					
	Total cost	**547.800**					

RETROFITTING WORKS:

This building has quite good insulation factors (U values below 1) and in any case the Cooperative has expressed some doubts concerning an intervention on the envelope which would be too expensive in this moment; in fact the building has quite a new looking as plaster is in good conditions.

So the intervention regards the substitution of windows with more efficient ones and the installation of the solar plant for the production of hot water, along with a system of regulation and accounting of hot water for each dwelling. Such a system of regulation and accounting of individual consumption will be also installed in the existing heating system (centralized).

As shown in the photos these three buildings' roofs are made of asbestos cement so there is a dangerous element which should be removed. The project proposes to install a photovoltaic system, placed on the roof in substitution of asbestos elements; this kind of work will receive interesting public economic support due to both the installation of solar panels and to the elimination of dangerous materials.

Other works will regard the installation of efficient lighting systems, some devices for the reduction of water consumption, some brochures to people where the best methods to save energy and money are illustrated, finally simple works of redecorating inner surface walls with bright colour so as to exploit natural light.

3.2 – COMPARISON BETWEEN THE SITUATION BEFORE AND AFTER (*) RETROFITTING WORKS, CONSIDERING 5 DIFFERENT CHOICES OF INTERVENTION.

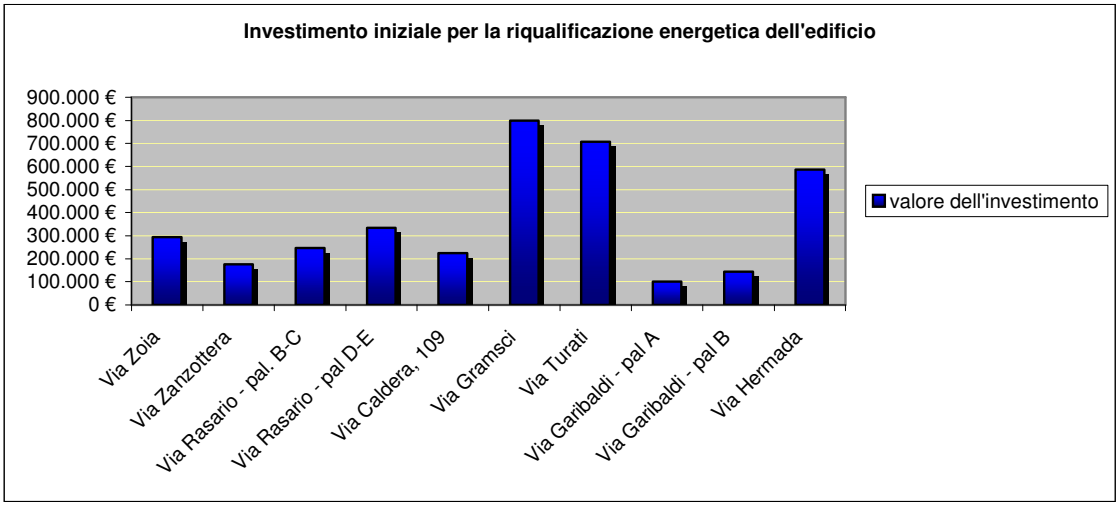
The results from the 10 Italian case studies are in the following table. Retrofitting works data correspond to a medium intervention level, in particular to level " 3 " (see 3.2) - This level is in a medium position in a range of 5 levels of interventions to improve the energy efficiency of residential housing.

							Before retrofitting works					After retrofitting works (level 3)					COST		
			Heating and sanitary hot water	Construction date	Dwelling number	Energy source	Primary energy for heating and sanitary hot water (*) (KWh/m^2)	Final energy needed for heating and sanitary hot water (*) (KWh/m^2)	Final energy needed for electricity (*) (KWh/m^2)	Energy labelling (***)	CO_2 emissions (**) (Kg/m^2)	Primary energy for heating and sanitary hot (*) water (KWh/m^2)	Final energy needed for heating and sanitary hot water (*) (KWh/m^2)	Final energy needed for electricity (*) (KWh/m^2)	Energy labelling (***)	CO_2 emissions (**) (Kg/m^2)	Investment cost (€) (complete retrofit works)	Investment cost (€) (only energetic retrofit works)	Net Present Value (NPV) (€)
Casi studio italiani	*Coop. BENEFICA*	*1*	**Via Zoia**	**1986**	40	metano	161,7	99,1	40	C	66,4	73	35,3	32,8	B	39,6	293.673	188.673	622.840
		2	**Via Zanzottera**	**1951**	18	metano	162,2	144,6	40	E	66,6	46,4	30,4	32,8	A	42,6	175.733	70.733	364.363
		3	**Via Rasario - pal. B-C**	**1955**	20	metano	311	211,1	40	G	103,7	121,7	52,5	32,8	B	45	246.579	91.579	489.359

		4	**Via Rasario - pal D-E**	**1961**	25	metano	247,1	187,1	40	G	87,7	106	46,5	32,8	B	40,8	333.672	178.672	532.719
		5	**Via Caldera, 109**	**1920**	81	metano	166,1	119,1	40	D	67,5	75,5	31	32,8	A	40,1	224.020	119.020	305.360
	Coop. DEGRADI	*6*	**Via Gramsci**	**1986**	68	metano	152,1	115,1	40	D	64	58,5	32	22,6	A	29,2	800.195	550.195	628.489
		7	**Via Turati**	**1992**	54	metano	149,1	114,1	40	D	63,2	56,4	31,2	22,6	A	28,7	706.850	465.850	874.484
		8	**Via Garibaldi - pal A**	**1920**	12	metano	152,1	115,1	40	D	64	70,7	35,7	32,8	B	38,9	100.480	35.480	168.281
		9	**Via Garibaldi - pal B**	**1920**	43	metano	159	121,1	40	D	65,7	74	38	32,8	B	39,8	143.301	38.301	179.464
	Coop. NIGUARDA	*10*	**Via Hermada**	**1952**	84	metano	110,1	90,1	40	C	53,5	46,4	29	34,2	A	120.748	586.488	531.488	306.000

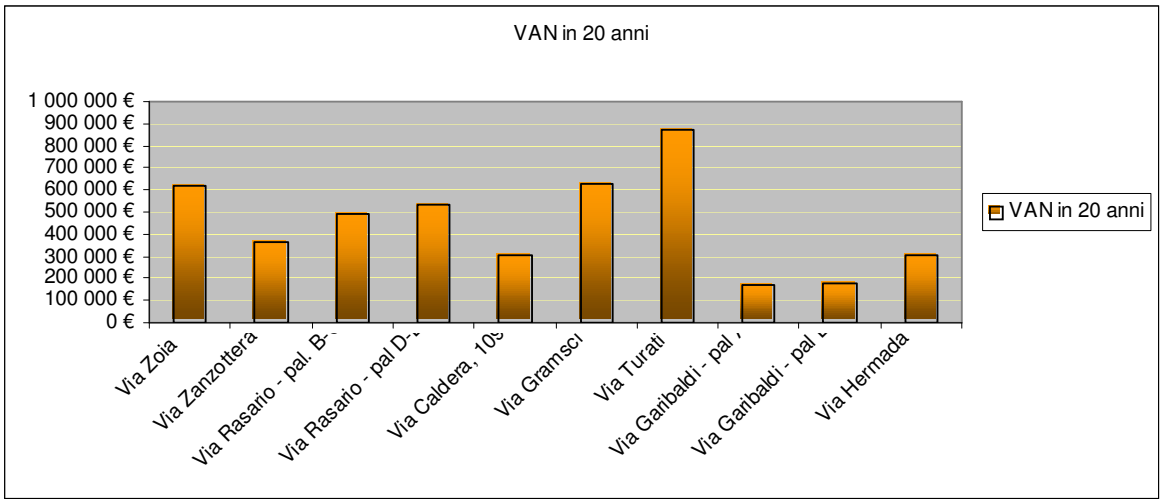
(*) regarding fossil fuels
(**) Value obtained using coefficients, not with BREA model
(***) Value obtained with BEST CLASS software, not with BREA model

Initial cost for energy retrofitting works



Source: ***AzzeroCO2 Srl***
The graphic has been elaborated with simple excel sheet
The case studies n. 6, 7 and 10 require a quite high initial cost for making retrofitting works

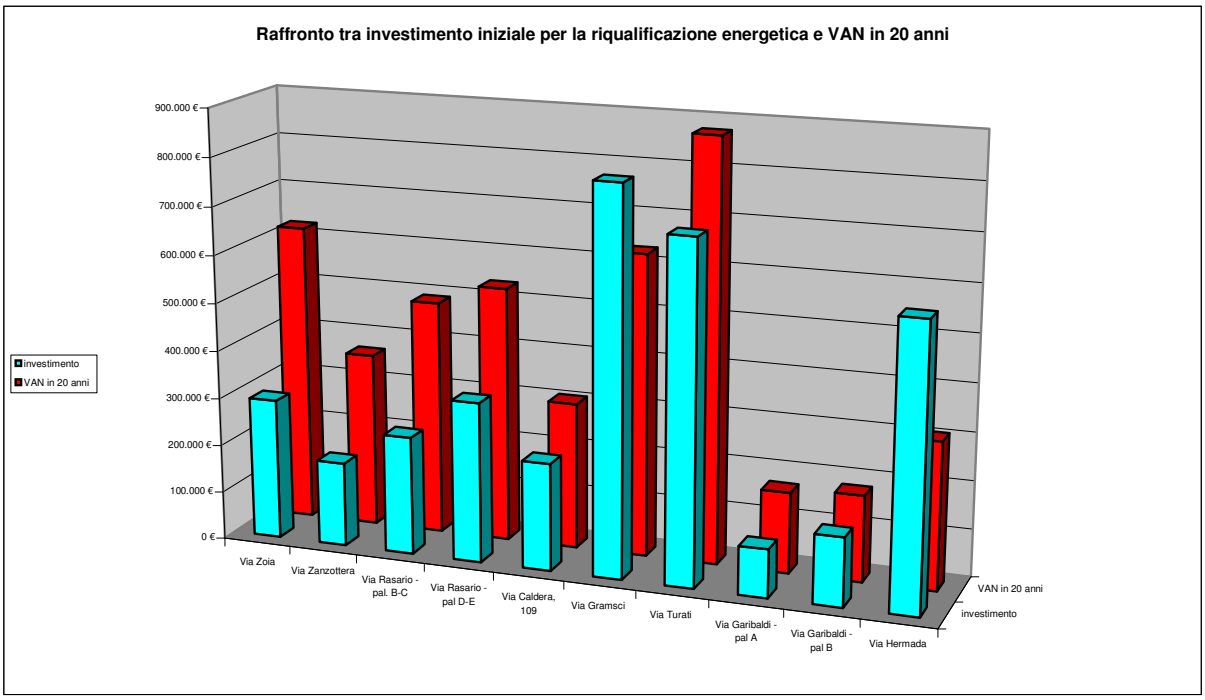
Net Present Value (NPV) (€)



Source: ***AzzeroCO2 Srl***
The graphic has been elaborated with simple excel sheet.

While for some case studies the NPT is quite proportional to the initial afford investment, for some others there is more difference. For a immediate comparison look at the following graphic.

Comparison between initial afford investment and Net Present Value.
The light blue columns indicate initial cost of investment for retrofit works, the red ones the Net Present Value after 20 years.



Source: ***AzzeroCO2 Srl***
The graphic has been elaborated with simple excel sheet.

The case studies n. 6, 7, via Gramsci and via Turati, which had high initial cost for investment for retrofitting works have a high Net Present Value; so the initial cost will be soon compensated through energy savings, and, after 20 years the economic gain ranges from 600.000 and 800.000 €. On the contrary the case study n. 10, via Hermada, has quite a low NPT; this is because the energy quality level of this building is already good, so energy improvements are not so evident. The case study n. 1, Via Zoia, with small initial cost will produce high energy savings so a high NPV: it would be a very good investment. As for the other case studies the NPV is quite proportional to the initial afford investment.

3.3 – COMPARISON BETWEEN THE SITUATION BEFORE AND AFTER RETROFITTING WORKS, CONSIDERING 5 DIFFERENT CHOICES OF INTERVENTION (ON 3 MORE REPRESENTATIVE CASE STUDIES SELECTED).

The choice of three case studies is based on analysis of their characteristics: actually they represent the three main typology of residential social building in Italy and belong to the three mail periods as it is pointed out in the following graphic:

Construction date - NUMBER OF BUILDINGS		
Between 1947 et 1976		***1951 – VIA ZANZOTTERA CASE STUDY N.2***
Between 1977 and 1991		***1986 – VIA ZOIA CASE STUDY N. 1***
Since 1992		***1992 – VIA TURATI CASE STUDY N. 7***

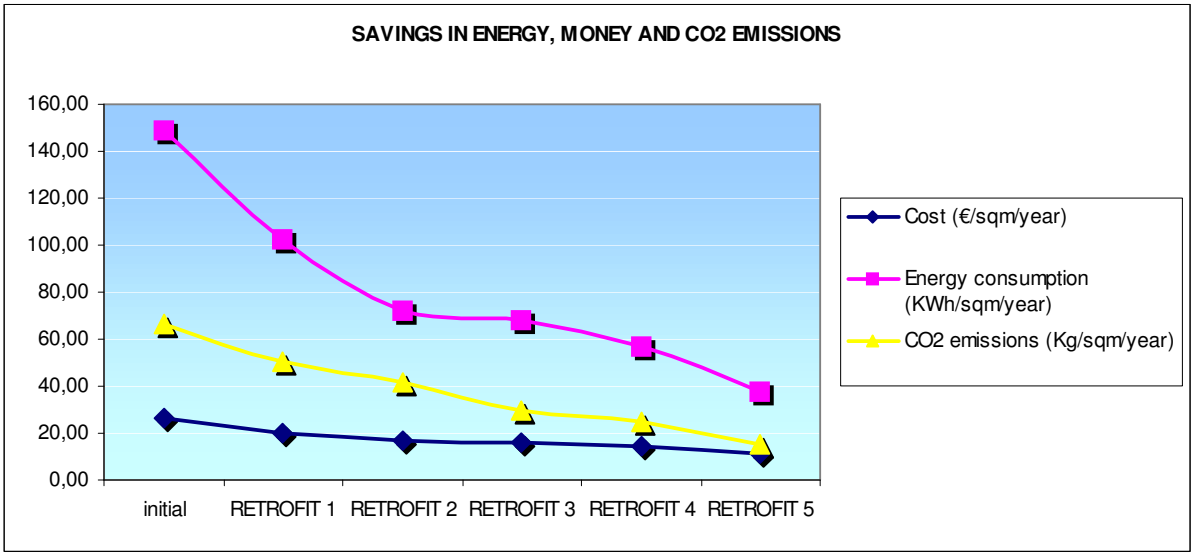
- CASE STUDY N. 1 - Via Zoia - COOP. LA BENEFICA
- CASE STUDY N. 2 - Via Zanzottera - COOP. LA BENEFICA
- CASE STUDY N. 7 - Via Turati - COOP. DEGRADI

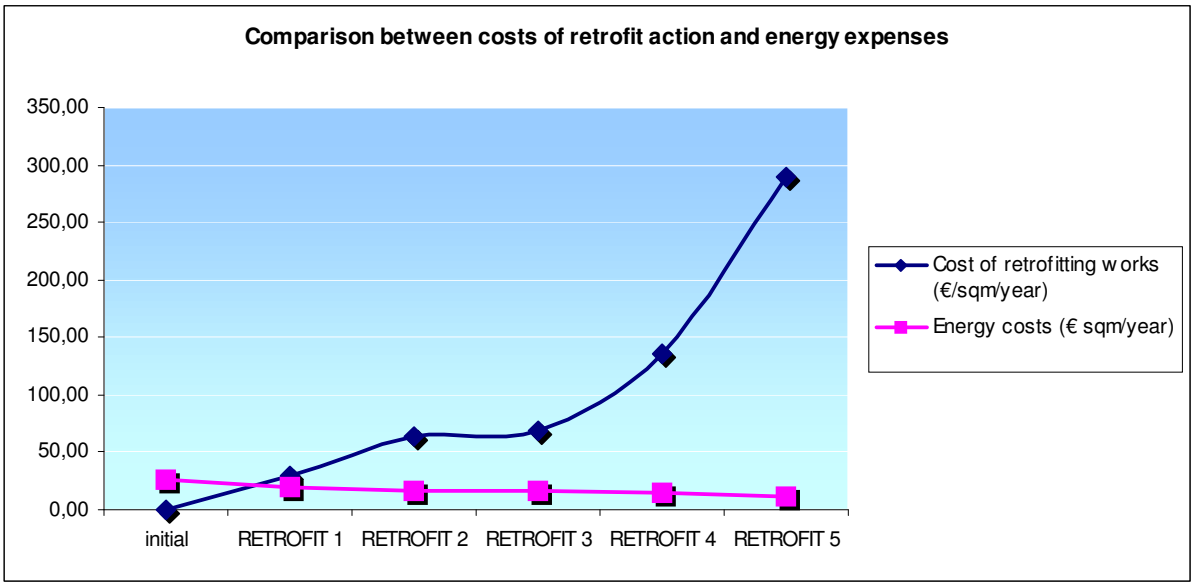
CASE STUDY N. 1 - Via Zoia - COOP. LA BENEFICA

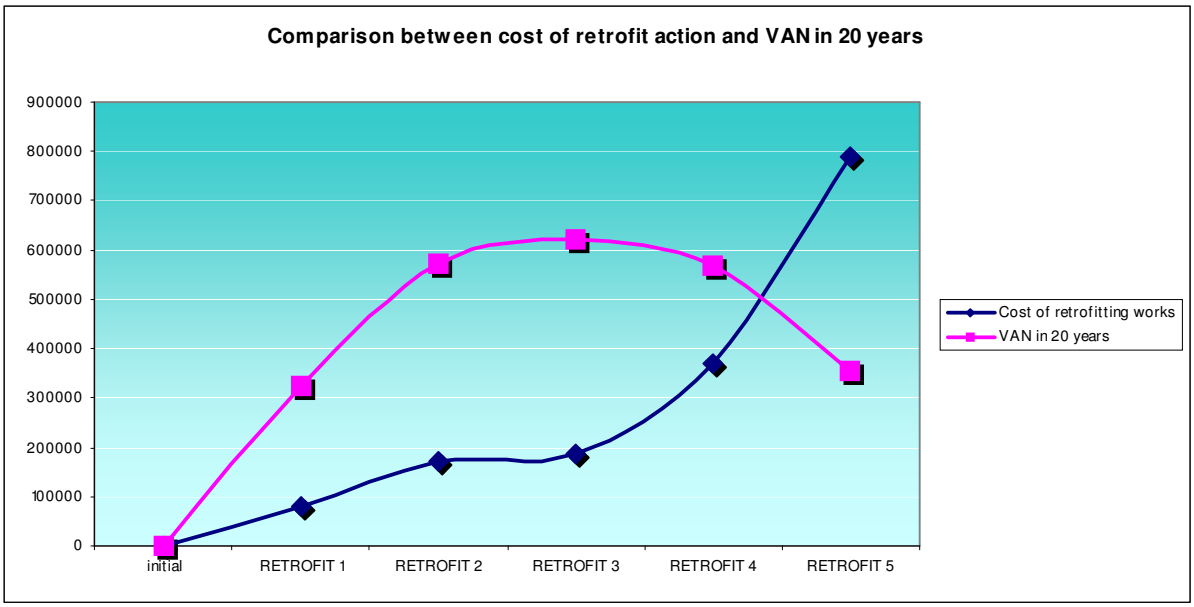
	Unit	Initial	RETROFIT 1	RETROFIT 2	RETROFIT 3	RETROFIT 4	RETROFIT 5
Primary energy (heating and hot water)	*kWh / m² a*	161,7	102,3	75,6	73,4	66,3	58,7
Final energy (heating and hot water)	*kWh / m² a*	99,1	63,4	37,5	35,1	29,2	22,4
Final energy (electricity)	*kWh / m² a*	40	38,8	34,8	32,8	27,6	15,4
Final energy (heating, hot water, electricity)	*kWh / m² a*	139,1	102,2	72,3	67,9	56,8	37,8
CO_2 emission (*)	*kg / m² a*	66,4	50,7	41,5	39,6	25,2	15,6
Residents charges	*€ / m² a*	26,3	20,19	16,73	15,97	14,17	10,91
Investment (**)	*€ / m² a*	0	29,73	62,99	69,11	135,05	288,89
Investment (**)	*€ / dwelling*	0	2029,325	4299,325	4716,825	9216,825	19716,825
Residents charges	*€ / dwelling*	2367	1378,15	1141,7	1090	966,775	744,3

(*) Value obtained using coefficients, not with BREA model
(**) Value refers to costs afforded for energy retrofit actions only

CASE STUDY N. 1 - Via Zoia - COOP. LA BENEFICA





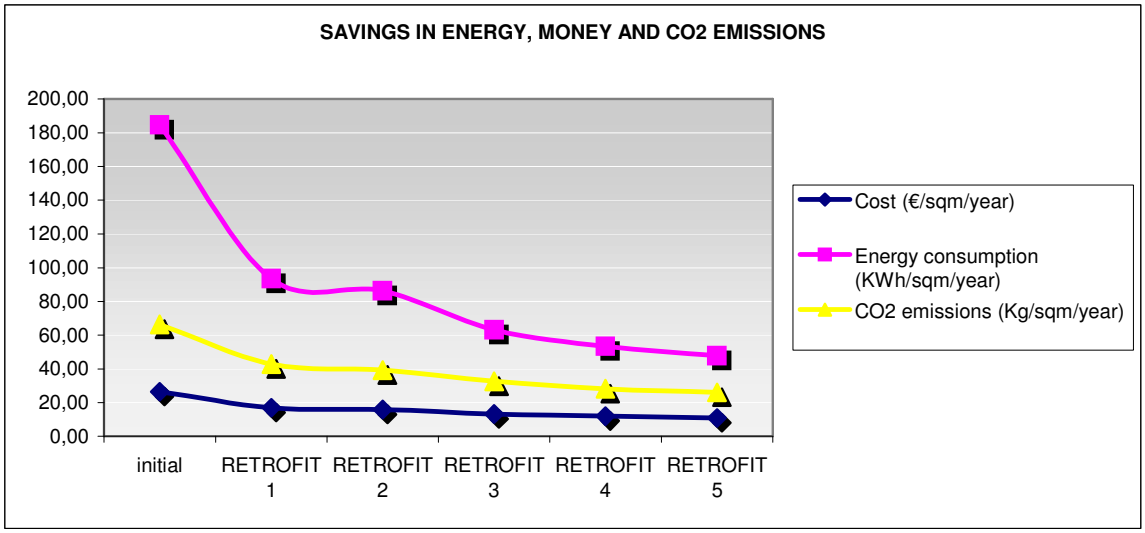


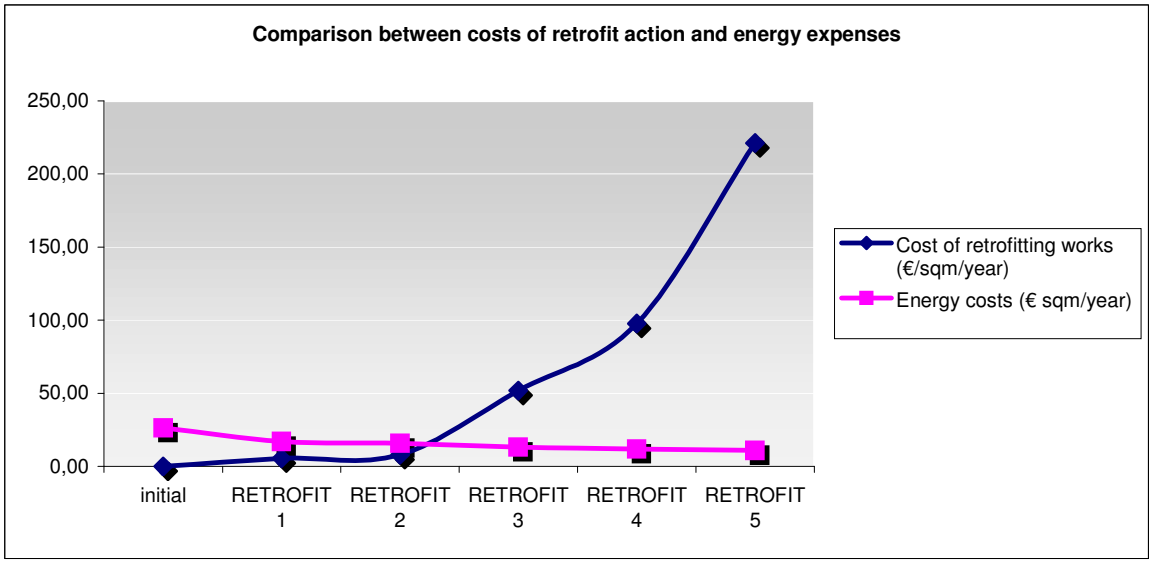
CASE STUDY N. 2 - Via Zanzottera - COOP. LA BENEFICA

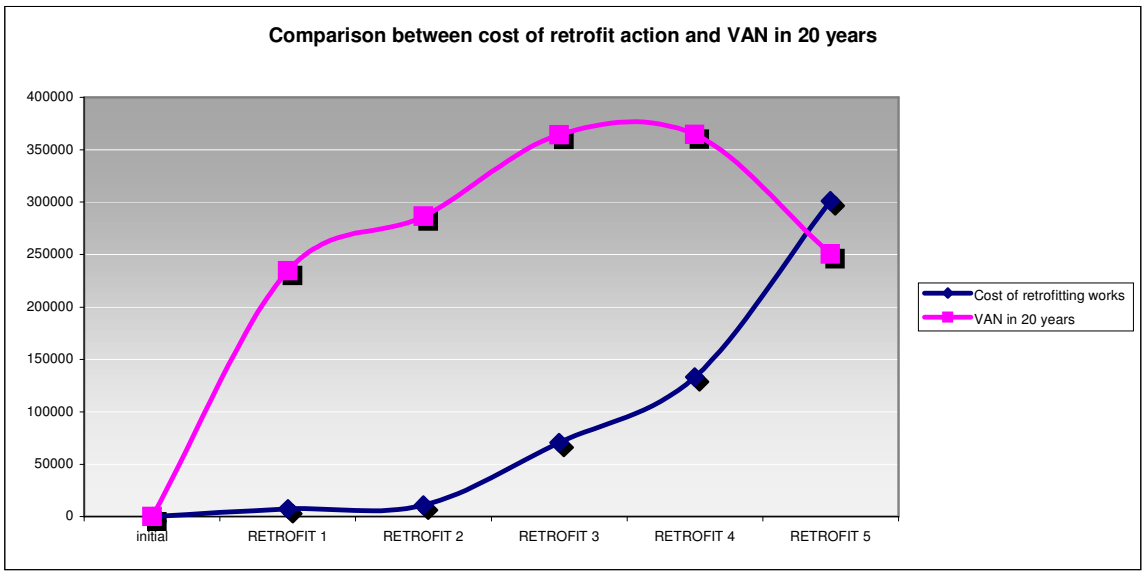
	Unit	initial	RETROFIT 1	RETROFIT 2	RETROFIT 3	RETROFIT 4	RETROFIT 5
Primary energy (heating and hot water)	*kWh / m² a*	162,2	68,8	66,7	45,4	40,8	37,6
Final energy (heating and hot water)	*kWh / m² a*	144,6	53,9	51,6	30,4	25,7	22,2
Final energy (electricity)	*kWh / m² a*	40	39,6	34,8	32,8	27,6	25,6
Final energy (heating, hot water, electricity)	*kWh / m² a*	184,6	93,5	86,4	63,2	53,3	47,8
CO_2 emission (*)	*kg / m² a*	66,6	42,9	39,22	32,6	28,1	26
Residents charges	*€ / m² a*	26,43	17,03	15,81	13,22	11,91	10,93
Investment (**)	*€ / m² a*	0	5,52	8,01	51,93	97,75	221,10
Investment (**)	*€ / dwelling*	0	313,04	454,71	2947,21	5547,21	12547,21
Residents charges	*€ / dwelling*	1500,00	966,67	897,08	750,00	675,83	620,21

(*) Value obtained using coefficients, not with BREA model
(**) Value refers to costs afforded for energy retrofit actions only

CASE STUDY N. 2 - Via Zanzottera - COOP. LA BENEFICA





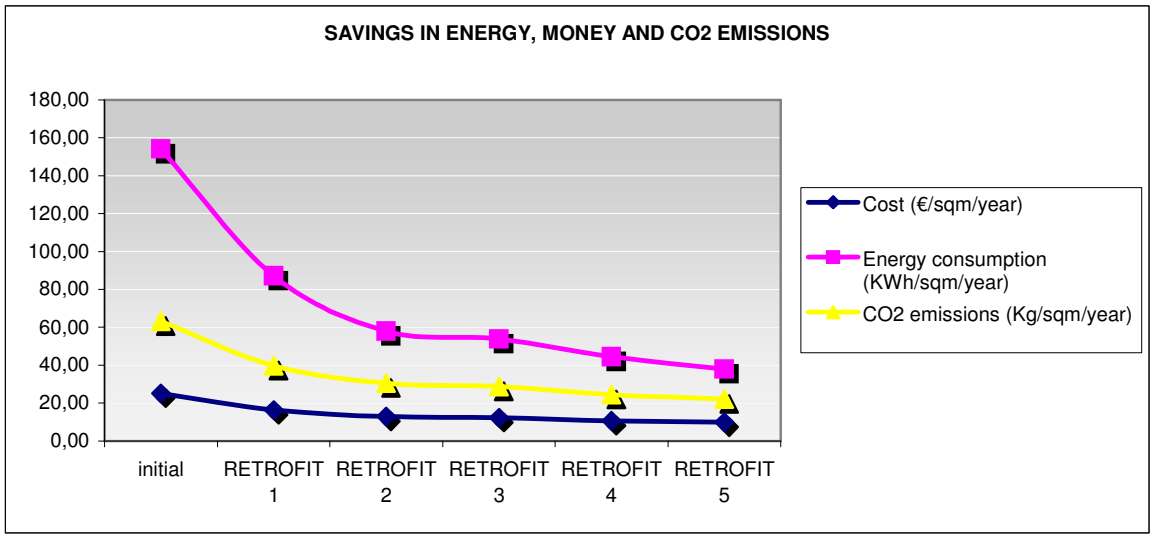


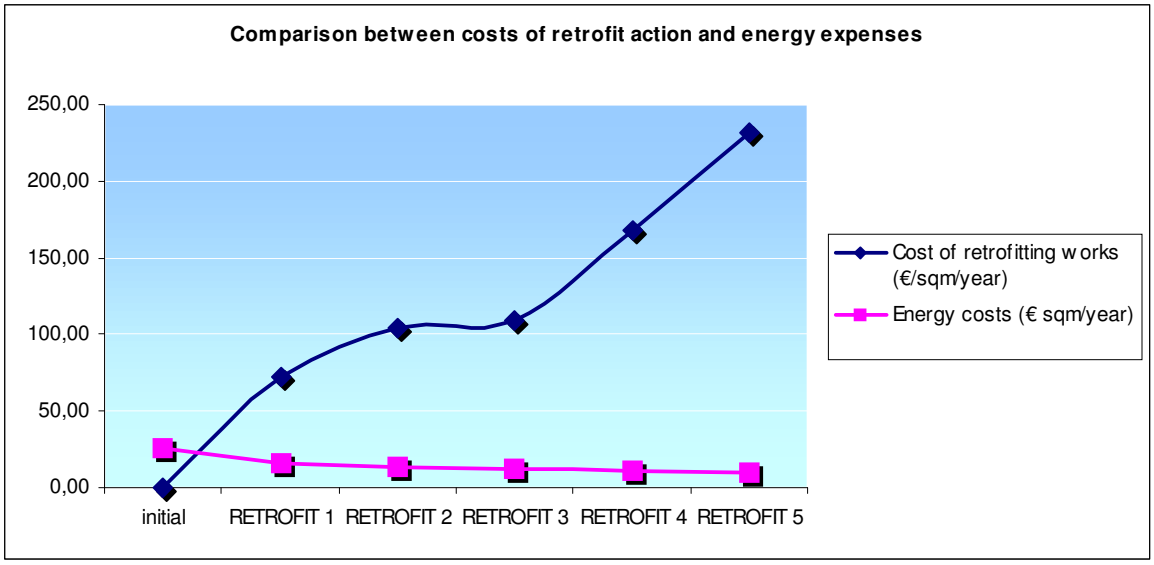
CASE STUDY N. 3 - Via Turati - COOP. DEGRADI

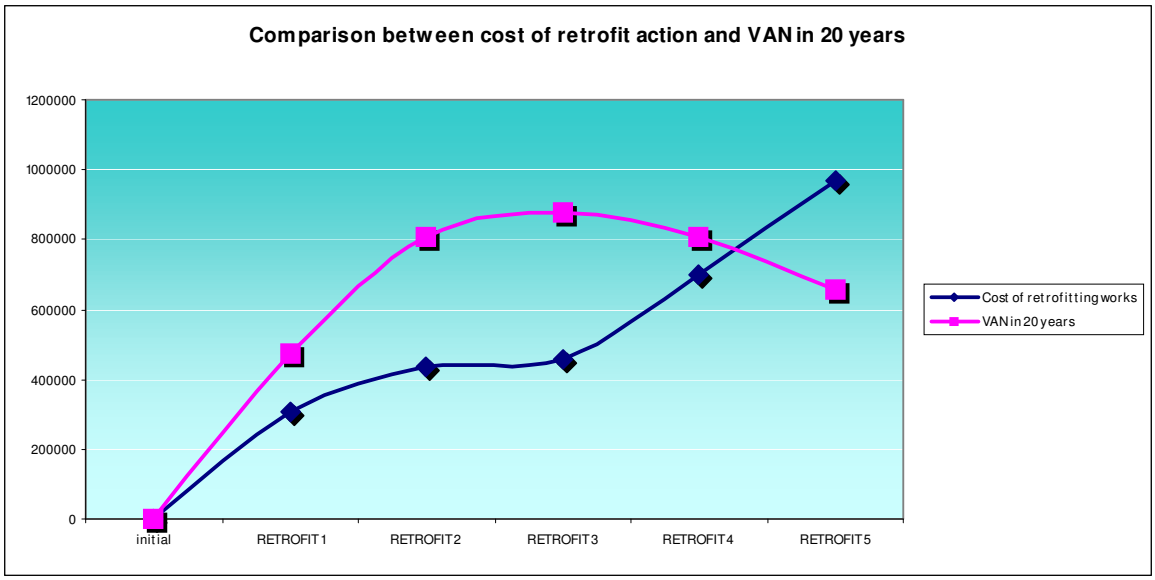
	Unit	initial	INTERVENTO TIPO 1	INTERVENTO TIPO 2	INTERVENTO TIPO 3	INTERVENTO TIPO 4	INTERVENTO TIPO 5
Primary energy (heating and hot water)	*kWh / m² a*	149,1	82,7	58,6	56,4	52,5	48,4
Final energy (heating and hot water)	*kWh / m² a*	114,1	57,8	33,4	31,2	27,1	22,5
Final energy (electricity)	*kWh / m² a*	40	29,4	24,6	22,6	17,4	15,4
Final energy (heating, hot water, electricity)	*kWh / m² a*	154,1	87,2	58	53,8	44,5	37,9
CO_2 emission (*)	*kg / m² a*	63,2	39,7	30,5	28,7	24,4	22
Residents charges	*€ / m² a*	25,12	16,30	12,92	12,17	10,68	9,85
Investment (**)	*€ / m² a*	0,00	72,86	104,03	109,37	167,55	232,19
Investment (**)	*€ / dwelling*	0,00	5635,74	8046,85	8460,19	12960,19	17960,19
Residents charges	*€ / dwelling*	1943,35	1260,46	999,67	941,07	825,98	762,04

(*) Value obtained using coefficients, not with BREA model
(**) Value refers to costs afforded for energy retrofit actions only

CASE STUDY N. 3 - Via Turati - COOP. DEGRADI







3.4. FACTOR 4 SCENARIO

This is the representation of the Factor 4 Scenario (that is to say a scenario that aims at reaching a factor 4 reduction of GEG emission). In order to reach this level some more interventions have been added: mainly the use photovoltaic plants. This could be named "demonstration scenario" useful to show which technologies need to be used to reach the factor 4, and which are the investment costs.

CASE STUDY 1 - zoia	Unit	initial	RETROFIT 1	RETROFIT 2	RETROFIT 3	RETROFIT 4	RETROFIT 5
Primary energy (heating and hot water)	*kWh / m² a*	161,7	102,3	75,6	73,4	66,3	58,7
Final energy (heating and hot water)	*kWh / m² a*	109,1	63,4	37,5	35,1	29,2	22,4
Final energy (electricity)	*kWh / m² a*	40	38,8	34,8	32,8	27,6	15,4
Final energy (heating and hot water and electricity)	*kWh / m² a*	149,1	102,2	72,3	67,9	56,8	37,8
CO_2 emission	*kg / m² a*	66,4	50,7	41,5	30	25,2	15,6
Residents charges *	*€ / m² a*	26,3	20,19	16,73	15,97	14,17	10,91
Investment	*€ / m² a*	0	29,73	62,99	69,11	135,05	288,89
Investment	*€ / dwelling*	0	2029,325	4299,325	4716,825	9216,825	19716,825
CO_2 emission	*tonn / dwelling*	5,97	3,45	2,82	2,04	1,71	1,06
Residents charges *	*€ / dwelling*	2367	1378,15	1141,7	1090	966,775	744,3
investimento		*0*	*81173*	*171973*	*188673*	*368673*	*788673*
costi gestione			*55126*	*45668*	*43600*	*38671*	*29772*

CASE STUDY 2 - zanzottera	Unit	initial	RETROFIT 1	RETROFIT 2	RETROFIT 3	RETROFIT 4	RETROFIT 5	RETROFIT 6
Primary energy (heating and hot water)	*kWh / m² a*	162,2	68,8	66,7	45,4	40,8	37,6	32,8
Final energy (heating and hot water)	*kWh / m² a*	144,6	53,9	51,6	30,4	25,7	22,2	21,2
Final energy (electricity)	*kWh / m² a*	40	39,6	34,8	32,8	27,6	25,6	13,9
Final energy (heating and hot water and electricity)	*kWh / m² a*	184,6	93,5	86,4	63,2	53,3	47,8	35,1
CO_2 emission	*kg / m² a*	66,4	42,9	39,22	32,6	28,1	26	16,8
Residents charges *	*€ / m² a*	26,43	17,03	15,81	13,22	11,91	10,93	7,96
Investment	*€ / m² a*	0	5,52	8,01	51,93	97,75	221,10	358,54
Investment	*€ / dwelling*	0	313,04	454,71	2947,21	5547,21	12547,21	20347,21
CO_2 emission	*tonn / dwelling*	3,72	2,40	2,20	1,83	1,57	1,46	0,94
Residents charges *	*€ / dwelling*	1500,00	966,67	897,08	750,00	675,83	620,21	451,58
investimento		*0*	*7513*	*10913*	*70733*	*133133*	*301133*	*488333*
costi gestione		*36000*	*23200*	*21530*	*18000*	*16220*	*14885*	*10838*

CASE STUDY 3 - turati	Unit	initial	RETROFIT 1	RETROFIT 2	RETROFIT 3	RETROFIT 4	RETROFIT 5	RETROFIT 6
Primary energy (heating and hot water)	*kWh / m² a*	149,1	82,7	58,6	56,4	52,5	48,4	48,4
Final energy (heating and hot water)	*kWh / m² a*	114,1	57,8	33,4	31,2	27,1	22,5	22,5
Final energy (electricity)	*kWh / m² a*	40	29,4	24,6	22,6	17,4	15,4	4,4
Final energy (heating and hot water and electricity)	*kWh / m² a*	154,1	87,2	58	53,8	44,5	37,9	26,9
CO_2 emission	*kg / m² a*	63,2	39,7	30,5	28,7	24,4	22	16,0
Residents charges *	*€ / m² a*	25,12	16,30	12,92	12,17	10,68	9,85	17,48
Investment	*€ / m² a*	0,00	72,86	104,03	109,37	167,55	232,19	551,10
Investment	*€ / dwelling*	0,00	5635,74	8046,85	8460,19	12960,19	17960,19	31275,00
CO_2 emission	*tonn / dwelling*	5,18	3,26	2,50	2,35	2,00	1,80	1,31
Residents charges *	*€ / dwelling*	1943,35	1260,46	999,67	941,07	825,98	762,04	991,71

investimento	*0*	*304330*	*434530*	*456850*	*699850*	*969850*	*750600*
costi gestione	*104941*	*68065*	*53982*	*50818*	*44603*	*41150*	*23801*

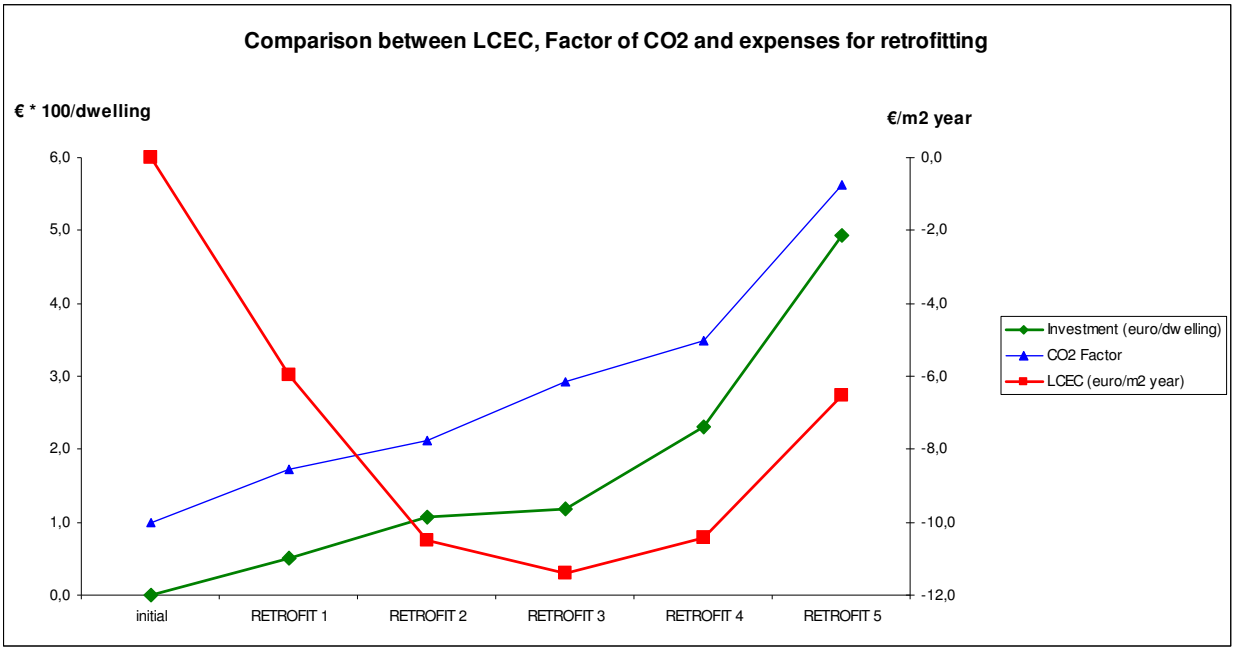
3.5 THE RESULTS OF THE LIFE CYCLE ENERGY COST ANALYSIS

Description of the model

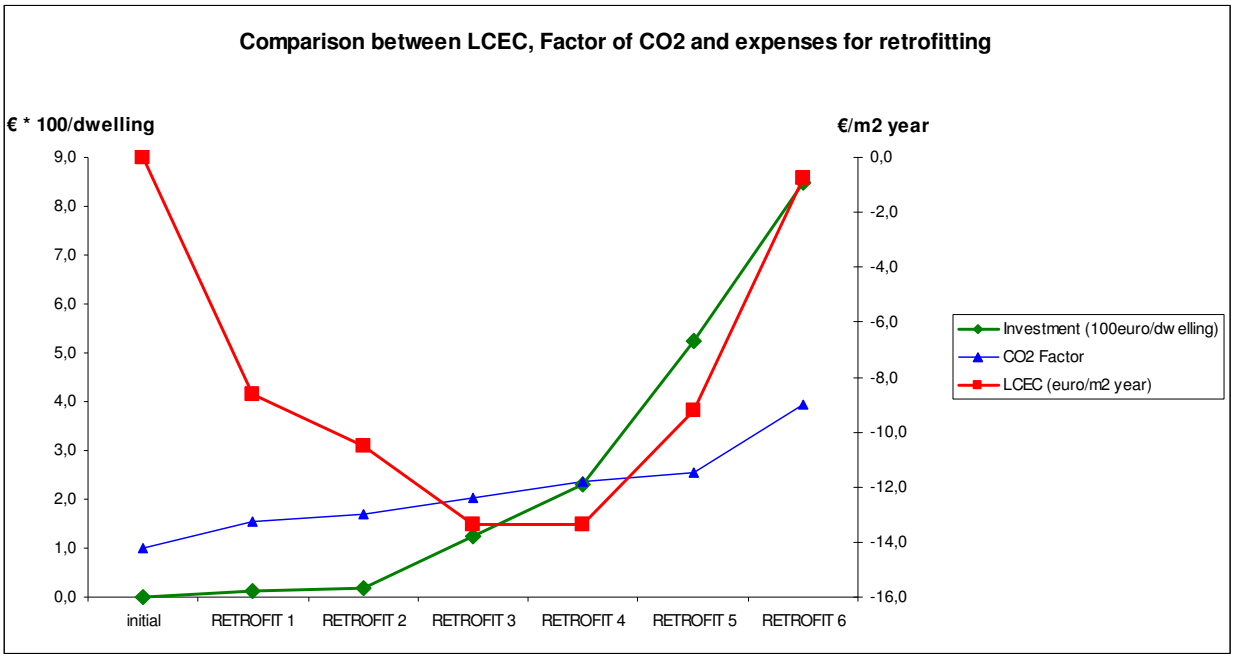
The Life Cycle Energy Costing (LCEC) is in the model the sum of the following items :

- the net present value of equipments and works, taking into account the life span of each equipment or component (= NPV),
- the evolution of maintenance and cleaning costs (=δM),
- the impact in terms of energy saving (= CE),
- the effect of energy price, the consequences of the hypothesis on the energy price increase (= δP).

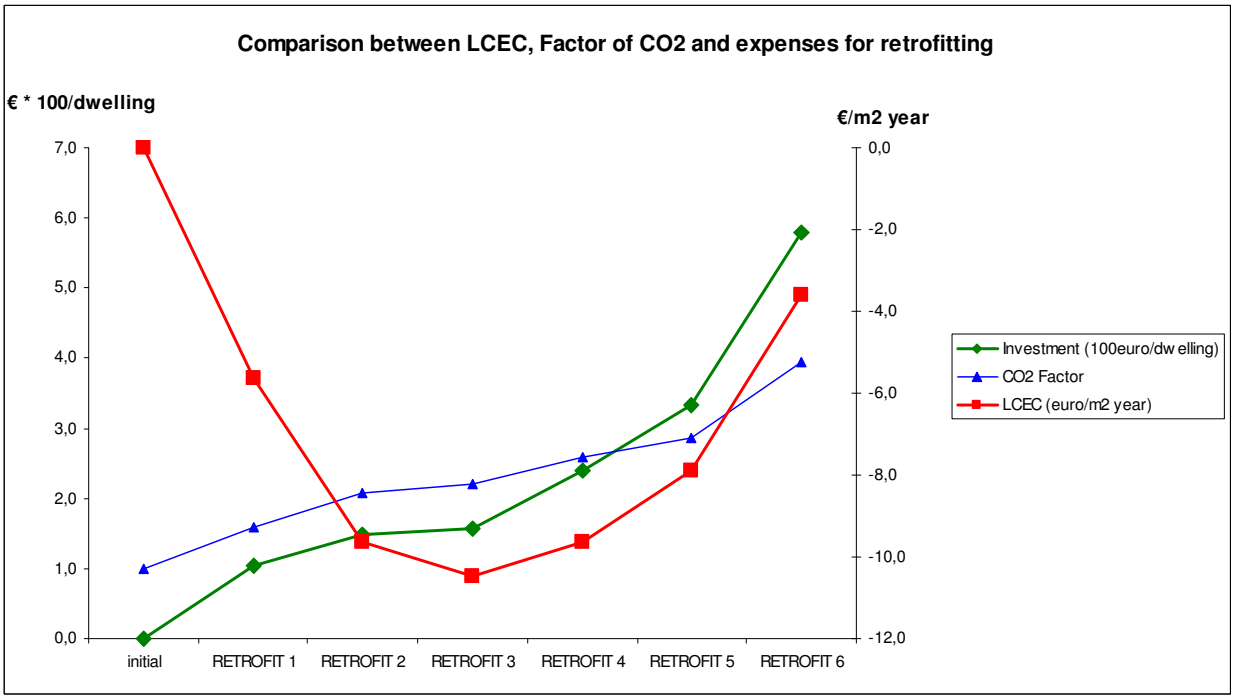
CASE STUDY 1 – Via Zoia



Case Study 2 - Via Zanzottera



Case Study 3 - Via Turati



3.6 NATIONAL ANALYSIS OF SOCIAL OWNERS' SCENARIO AND OF FACTOR 4 SCENARIO

The figures coming out from the three selected case studies, representative of different building typologies, have been multiplied for all the national building stock. The objective is just to have a first view of the National situation, comparing the two scenarios and giving an image of the whole national stock.

These data will have a deeper and more complex analysis in Del 10.

Social Owners' Scenario

	Number of dwellings		Primary energy - Social Owners' Scenario thousand KWh/mq				
Building type	Italian climatic areas		<1945	1946-1976	1977-1991	1992-2005	Total
3-4 family dwellings	A, B, C	before	85.294	350.234	352.111	50.574	838.213
		after	23.926	98.247	159.833	15.400	297.405
	D, E	before	328.980	909.983	670.349	184.462	2.093.774
		after	92.285	255.266	304.289	56.168	708.008
	F	before	3.990	11.969	8.620	3.754	28.332
		after	1.119	3.357	3.913	1.143	9.532
5-8 family dwellings	A, B, C	before	68.487	295.401	302.592	64.836	731.317
		after	19.212	82.865	137.355	19.742	259.174
	D, E	before	234.730	891.533	737.513	184.462	2.048.239
		after	65.846	250.091	334.777	56.168	706.882
	F	before	2.715	7.837	8.511	3.754	22.817
		after	762	2.199	3.863	1.143	7.966
9-15 family dwellings	A, B, C	before	47.446	309.071	302.384	72.337	731.238
		after	13.309	86.700	137.260	22.026	259.296
	D, E	before	158.042	1.004.605	747.812	235.904	2.146.362
		after	44.334	281.810	339.452	71.831	737.426
	F	before	1.566	7.881	8.085	3.911	21.443
		after	439	2.211	3.670	1.191	7.511
over 16 family dwellings	A, B, C	before	46.891	648.040	582.332	112.947	1.390.210
		after	13.154	181.787	264.336	34.392	493.669
	D, E	before	221.758	2.250.931	1.460.005	333.206	4.265.899
		after	62.207	631.426	662.736	101.459	1.457.828
	F	before	1.530	20.215	15.913	4.739	42.396
		after	429	5.671	7.223	1.443	14.766
Total							
		before	**1.201.429**	**6.707.698**	**5.196.227**	**1.254.886**	**14.360.240**
		after	**337.022**	**1.881.629**	**2.358.708**	**382.105**	**4.959.464**
Energy Saving			**864.406**	**4.826.069**	**2.837.519**	**872.781**	**9.400.776**

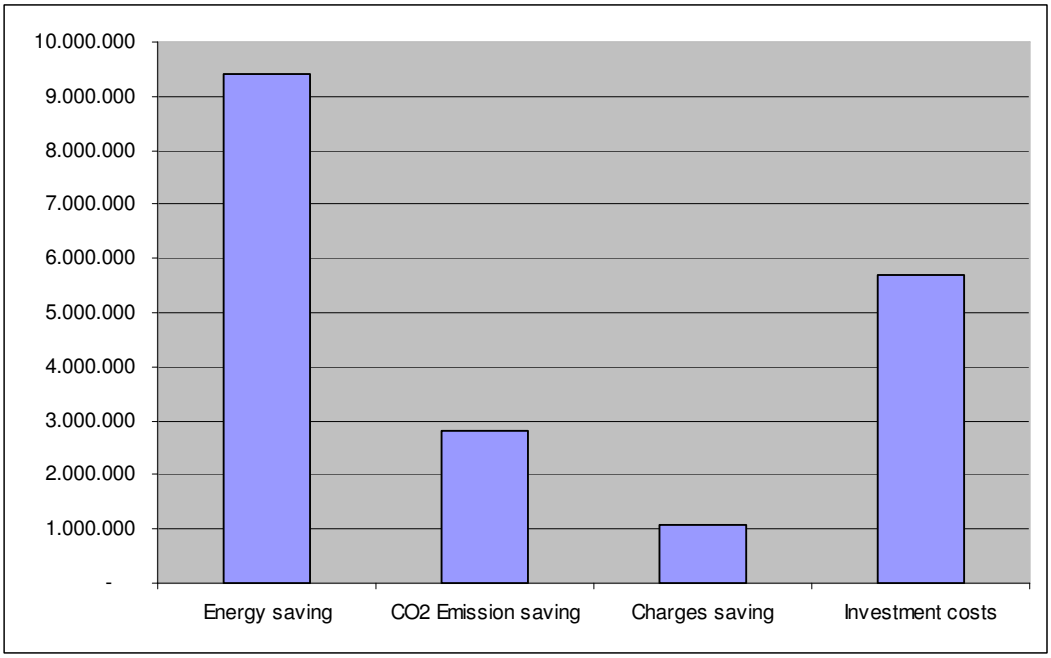
	Number of dwellings	CO2 Emission - Social Owners' scenario thousand Kg/mq					
Building type	Italian climatic areas		<1945	1946-1976	1977-1991	1992-2005	Total
3-4 family dwellings	A, B, C	before	34.917	143.376	144.590	21.437	344.319
		after	17.143	70.392	86.231	9.735	183.501
	D, E	before	134.675	372.521	275.270	78.189	860.655
		after	66.121	182.894	164.167	35.507	448.689
	F	before	1.633	4.900	3.540	1.591	11.664
		after	802	2.406	2.111	723	6.041
5-8 family dwellings	A, B, C	before	28.037	120.929	124.256	27.483	300.704
		after	13.765	59.372	74.104	12.480	159.721
	D, E	before	96.092	364.968	302.850	78.189	842.099
		after	47.178	179.186	180.616	35.507	442.486
	F	before	1.111	3.208	3.495	1.591	9.406
		after	546	1.575	2.084	723	4.928
9-15 family dwellings	A, B, C	before	19.423	126.525	124.170	30.662	300.780
		after	9.536	62.119	74.053	13.924	159.632
	D, E	before	64.698	411.256	307.079	99.994	883.027
		after	31.764	201.912	183.138	45.409	462.223
	F	before	641	3.226	3.320	1.658	8.845
		after	315	1.584	1.980	753	4.631
over 16 family dwellings	A, B, C	before	19.196	265.289	239.127	47.876	571.487
		after	9.424	130.247	142.612	21.741	304.025
	D, E	before	90.781	921.466	599.532	141.238	1.753.017
		after	44.570	452.407	357.552	64.138	918.667
	F	before	626	8.275	6.535	2.009	17.445
		after	307	4.063	3.897	912	9.180
Total							
		before	**491.830**	**2.745.938**	**2.133.763**	**531.917**	**5.903.448**
		after	**241.471**	**1.348.156**	**1.272.545**	**241.551**	**3.103.723**
Reduction CO2 Emissions			**250.359**	**1.397.782**	**861.218**	**290.366**	**2.799.725**

	Number of dwellings	Energy cahrges- social Owners Scenario thousand KWh/mq					
Building type	Italian climatic areas		<1945	1946-1976	1977-1991	1992-2005	Total
3-4 family dwellings	A, B, C	before	13.883	57.005	57.270	8.514	136.671
		after	6.941	28.502	34.623	4.104	74.171
	D, E	before	53.546	148.111	109.030	31.053	341.739
		after	26.773	74.055	65.916	14.970	181.713
	F	before	649	1.948	1.402	632	4.631
		after	325	974	848	305	2.451
5-8 family dwellings	A, B, C	before	11.147	48.080	49.216	10.915	119.358
		after	5.574	24.040	29.754	5.262	64.629
	D, E	before	38.205	145.108	119.954	31.053	334.320
		after	19.103	72.554	72.520	14.970	179.146
	F	before	442	1.276	1.384	632	3.734
		after	221	638	837	305	2.000
9-15 family dwellings	A, B, C	before	7.722	50.305	49.182	12.177	119.387
		after	3.861	25.152	29.734	5.870	64.618
	D, E	before	25.723	163.511	121.629	39.713	350.577
		after	12.862	81.756	73.533	19.144	187.294
	F	before	255	1.283	1.315	658	3.511
		after	127	641	795	317	1.881
over 16 family dwellings	A, B, C	before	7.632	105.476	94.715	19.014	226.837
		after	3.816	52.738	57.261	9.166	122.981
	D, E	before	36.094	366.366	237.465	56.093	696.018
		after	18.047	183.183	143.563	27.041	371.833
	F	before	249	3.290	2.588	798	6.925
		after	124	1.645	1.565	385	3.719
Total							
		before	**195.547**	**1.091.759**	**845.150**	**211.252**	**2.343.707**
		after	**97.773**	**545.879**	**510.946**	**101.838**	**1.256.437**
Energy Charges Saving			**97.773**	**545.879**	**334.204**	**109.413**	**1.087.270**

	Number of dwellings	Investment costs mq - Social Owners' Scenario in thousand €				
Building type	Italian climatic areas	<1945	1946-1976	1977-1991	1992-2005	Total
3-4 family dwellings	A, B, C	27.308	112.131	151.122	37.098	327.659
	D, E	105.326	291.340	287.707	135.309	819.683
	F	1.277	3.832	3.700	2.753	11.562
5-8 family dwellings	A, B, C	21.927	94.576	129.870	47.560	293.932
	D, E	75.151	285.434	316.533	135.309	812.427
	F	869	2.509	3.653	2.753	9.785
9-15 family dwellings	A, B, C	15.190	98.952	129.780	53.062	296.984
	D, E	50.599	321.634	320.953	173.044	866.230
	F	502	2.523	3.470	2.869	9.363
over 16 family dwellings	A, B, C	15.013	207.477	249.931	82.851	555.271
	D, E	70.998	720.659	626.619	244.418	1.662.694
	F	490	6.472	6.830	3.476	17.267
Total						
		384.650	**2.147.539**	**2.230.168**	**920.502**	**5.682.858**

Social Owners' SCENARIO (elaborated with Brea)

Energy saving	9.400.776	Kwh/mq /1000
CO_2 Emission saving	2.799.725	Kg/mq /1000
Charges saving	1.087.270	€mq/anno /1000
Investment costs	5.682.858	€ mq /1000



Factor 4 Scenario

	Number of dwellings	Primary energy - Scenario F4 thousand KWh/mq					
Building type	Italian climatic areas		<1945	1946-1976	1977-1991	1992-2005	Total
3-4 family dwellings	A, B, C	before	85.294	350.234	352.111	50.574	838.213
		after	17.248	70.824	127.823	16.417	232.312
	D, E	before	328.980	909.983	670.349	184.462	2.093.774
		after	66.526	184.016	243.349	59.879	553.770
	F	before	3.990	11.969	8.620	3.754	28.332
		after	807	2.420	2.580	1.218	7.026
5-8 family dwellings	A, B, C	before	68.487	295.401	302.592	64.836	731.317
		after	13.849	59.736	109.846	21.047	204.479
	D, E	before	234.730	891.533	737.513	184.462	2.048.239
		after	47.467	180.285	267.731	59.879	555.362
	F	before	2.715	7.837	8.511	3.754	22.817
		after	549	1.585	3.090	1.218	6.442
9-15 family dwellings	A, B, C	before	47.446	309.071	302.384	72.337	731.238
		after	9.594	62.500	109.771	23.482	205.347
	D, E	before	158.042	1.004.605	747.812	235.904	2.146.362
		after	31.959	203.151	271.469	76.578	583.157
	F	before	1.566	7.881	8.085	3.911	21.443
		after	317	1.594	2.935	1.270	6.115
over 16 family dwellings	A, B, C	before	46.891	648.040	582.332	112.947	1.390.210
		after	9.482	131.046	211.397	36.664	388.590
	D, E	before	221.758	2.250.931	1.460.005	333.206	4.265.899
		after	44.844	455.182	530.008	108.163	1.138.197
	F	before	1.530	20.215	15.913	4.739	42.396
		after	309	4.088	5.777	1.538	11.712
Total							
		before	**1.201.429**	**6.707.698**	**5.196.227**	**1.254.886**	**14.360.240**
		after	**242.952**	**1.356.427**	**1.885.774**	**407.354**	**3.892.508**
Energy Saving			**958.476**	**5.351.271**	**3.310.452**	**847.532**	**10.467.732**

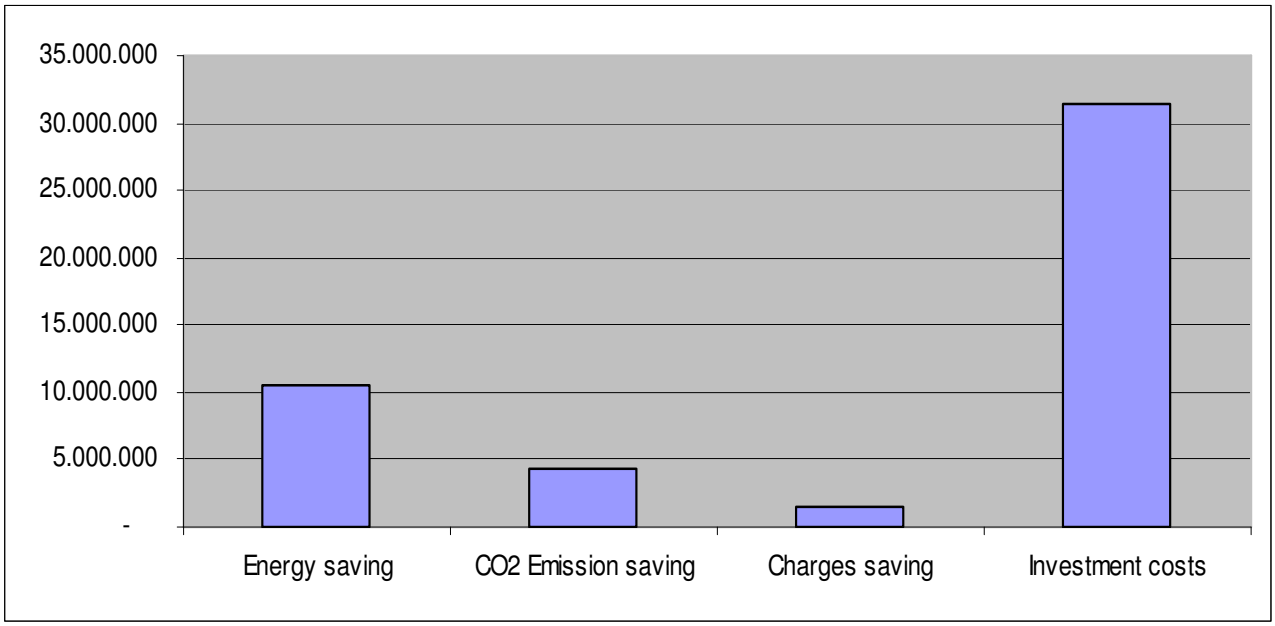
	Number of dwellings		CO2 Emission - Factor 4 scenario thousand Kg/mq				
Building type	Italian climatic areas		<1945	1946-1976	1977-1991	1992-2005	Total
3-4 family dwellings	A, B, C	before	34.917	143.376	144.590	21.437	344.319
		after	8.834	36.276	33.970	5.427	84.507
	D, E	before	134.675	372.521	275.270	78.189	860.655
		after	34.074	94.252	64.672	19.795	212.793
	F	before	1.633	4.900	3.540	1.591	11.664
		after	413	1.240	832	403	2.887
5-8 family dwellings	A, B, C	before	28.037	120.929	124.256	27.483	300.704
		after	7.094	30.596	29.193	6.958	73.840
	D, E	before	96.092	364.968	302.850	78.189	842.099
		after	24.312	92.341	71.152	19.795	207.600
	F	before	1.111	3.208	3.495	1.591	9.406
		after	281	812	821	403	2.317
9-15 family dwellings	A, B, C	before	19.423	126.525	124.170	30.662	300.780
		after	4.914	67.121	29.172	7.763	108.971
	D, E	before	64.698	411.256	307.079	99.994	883.027
		after	16.369	104.053	72.145	25.315	217.882
	F	before	641	3.226	3.320	1.658	8.845
		after	162	816	780	420	2.178
over 16 family dwellings	A, B, C	before	19.196	265.289	239.127	47.876	571.487
		after	4.857	67.121	56.180	12.120	140.279
	D, E	before	90.781	921.466	599.532	141.238	1.753.017
		after	22.969	233.142	140.854	35.756	432.721
	F	before	626	8.275	6.535	2.009	17.445
		after	158	2.094	1.535	508	4.296
Total		before	**491.830**	**2.745.938**	**2.133.763**	**531.917**	**5.903.448**
		after	**124.439**	**729.864**	**501.306**	**134.662**	**1.490.272**
Reduction CO2 Emissions			**367.391**	**2.016.074**	**1.632.457**	**397.254**	**4.413.176**

	Number of dwellings	Energy cahrges- Factor 4 Scenario thousand KWh/mq					
Building type	Italian climatic areas		<1945	1946-1976	1977-1991	1992-2005	Total
3-4 family dwellings	A, B, C	before	13.883	57.005	57.270	8.514	136.671
		after	4.186	17.188	23.757	5.929	51.060
	D, E	before	53.546	148.111	109.030	31.053	341.739
		after	34.074	44.658	45.229	21.626	145.587
	F	before	649	1.948	1.402	632	4.631
		after	196	587	582	440	1.805
5-8 family dwellings	A, B, C	before	11.147	48.080	49.216	10.915	119.358
		after	11.519	14.497	20.416	7.601	54.034
	D, E	before	38.205	145.108	119.954	31.053	334.320
		after	11.519	43.752	49.760	21.626	126.658
	F	before	442	1.276	1.384	632	3.734
		after	133	385	574	440	1.532
9-15 family dwellings	A, B, C	before	19.423	50.305	49.182	12.177	131.087
		after	2.328	15.168	20.402	8.481	46.379
	D, E	before	64.698	163.511	121.629	39.713	389.551
		after	7.756	49.301	50.455	27.657	135.169
	F	before	255	1.283	1.315	658	3.511
		after	77	387	545	459	1.468
over 16 family dwellings	A, B, C	before	7.632	105.476	94.715	19.014	226.837
		after	2.301	31.803	39.290	13.242	86.636
	D, E	before	36.094	366.366	237.465	56.093	696.018
		after	10.883	110.465	98.507	39.064	258.919
	F	before	249	3.290	2.588	798	6.925
		after	75	992	1.074	556	2.696
Total							
		before	**246.222**	**1.091.759**	**845.150**	**211.252**	**2.394.382**
		after	**85.048**	**329.182**	**350.593**	**147.119**	**911.942**
Energy Charges Saving			**161.174**	**762.577**	**494.557**	**64.133**	**1.482.441**

	Number of dwellings	Investment costs mq - Factor 4 Scenario in thousand €				
Building type	Italian climatic areas	<1945	1946-1976	1977-1991	1992-2005	Total
3-4 family dwellings	A, B, C	188.541	774.185	629.074	186.931	1.778.731
	D, E	727.205	2.011.500	1.197.631	681.805	4.618.141
	F	8.820	26.456	15.400	13.874	64.550
5-8 family dwellings	A, B, C	151.390	652.979	540.605	239.647	1.584.620
	D, E	518.866	1.970.717	1.317.627	681.805	4.489.015
	F	6.001	17.324	15.206	13.874	52.406
9-15 family dwellings	A, B, C	104.878	683.195	540.233	267.371	1.595.677
	D, E	349.349	2.220.659	1.336.026	871.942	4.777.976
	F	3.463	17.420	14.444	14.456	49.783
over 16 family dwellings	A, B, C	103.651	1.432.481	1.040.383	417.472	2.993.987
	D, E	490.191	4.975.639	2.608.415	1.231.588	9.305.834
	F	3.381	44.684	28.430	17.515	94.010
Total		**2.655.735**	**14.827.239**	**9.283.475**	**4.638.280**	**31.404.730**

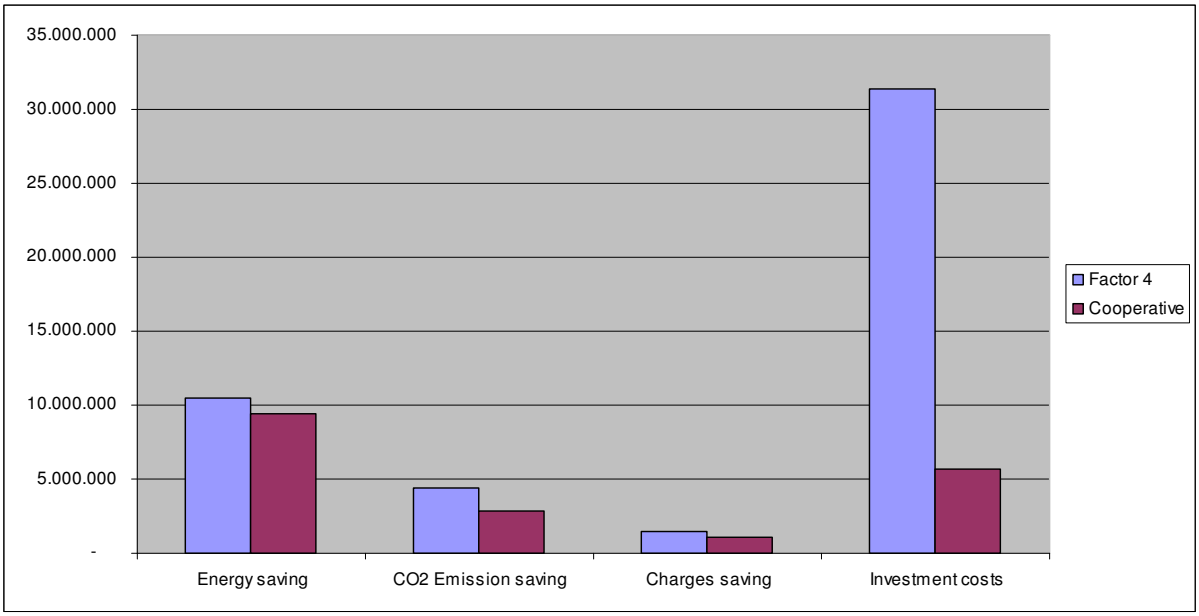
FACTOR 4 SCENARIO

Energy saving	10.467.732	Kwh/mq /1000
CO_2 Emission saving	4.413.176	Kg/mq /1000
Charges saving	1.482.441	€ mq/anno /1000
Investment costs	31.404.730	€ mq /1000

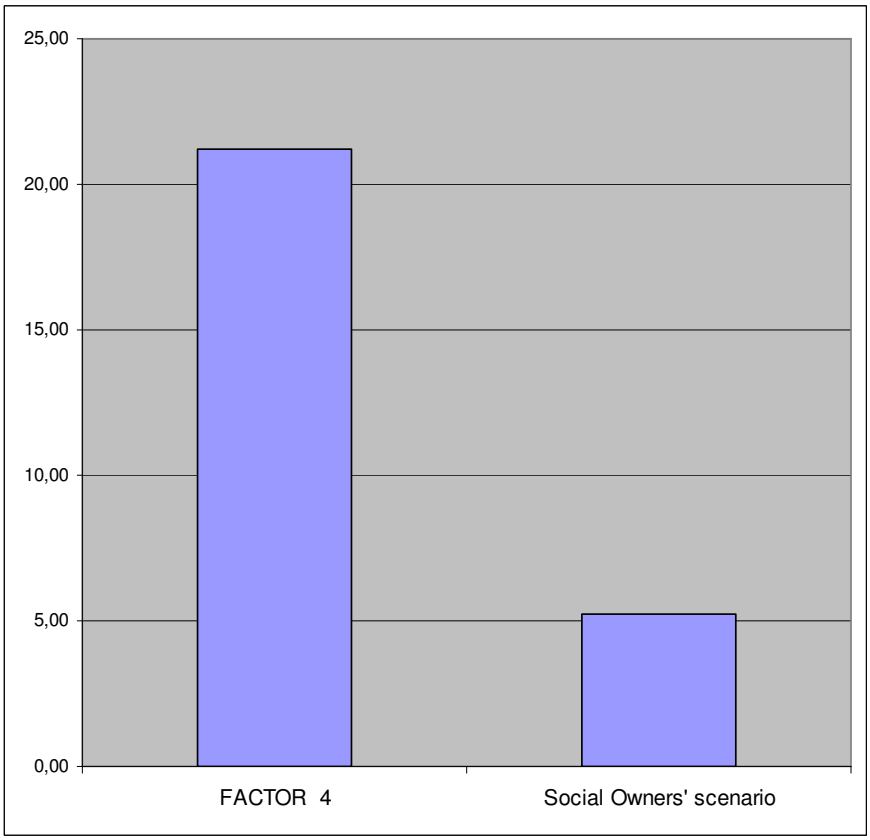


Comparison FACTOR 4 and Social Owners' SCENARIO

	FACTOR 4	*Social Owners*	
Energy saving	10.467.732	9.400.776	Kwh/mq /1000
CO_2 Emission saving	4.413.176	2.799.725	Kg/mq /1000
Charges saving	1.482.441	1.087.270	€mq/anno /1000
Investment costs	31.404.730	5.682.858	€ mq /1000



COMPARISON PAY BACK TIME BETWEEN F4 AND SOCIAL OWNERS' SCENARIO



	Years
FACTOR 4	21,18
Social Owners' scenario	5,23

Source: all the graphs and tables are Istat data, elaborated by Finabita

CONCLUSION

These simulations show that **it is necessary to think more in economic than in technical terms for setting win – win energy policies** (win for the users and win for the society).

Form the data it is easy to have a complete view of the efficacy of the interventions proposed in the case studies, considering for each intervention the cost of the investment, the saving in terms of CO2 emissions, and the development of LCEC (Life Cycle energy cost) which gives the measure of the profitability of the overall investment analyzed in the lifetime of the intervention.

The solutions that give immediate positive results under an economic point of view and of associated CO2 reduced emissions are clearly:

- envelope insulation especially walls, windows and roof have to be more performing
- the substitution of old heating systems with new and more efficient ones (the boiler have to be condensation boilers and the regulation has to be adapted in accordance).

It is interesting to notice that these kind of interventions and technologies in Italy at present, with the new financial regulations, receive a significant incentive.

There are also other interventions that seem to give good results:

- the isolation of the nets
- the augmented efficiency of lighting systems
- actions of the training of users
- awareness raising of users on their consumes by systems of independent management

The LCEC demonstrate that the factor 4 scenario is economically very heavy for all the interventions of retrofitting requested.

In fact as for the energy savings on the thermal use, the interventions against the envelope loss and on the plants seem to be convenient in the logic of LCEC.

On the contrary on the electric use side it is not possible to gain important savings unless with the use of solutions that "produce energy" as is the case of the photovoltaic plants.

But it is important to remind and underline that photovoltaic plants are not very efficient and that they are at present very expensive, even if they are financially supported by public incentives.