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

1st October 2007

Part 2: the French analysis

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Factor 4 – Deliverable 7

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REMINDER UPON THE FACTOR 4 PROJECT

THE FACTOR 4 OBJECTIVES

The Factor 4 project follows **the Sustainable Development World Strategy** and the **Kyoto protocol** and is focussed on social housing retrofitting (and especially on buildings which will still be in use in 2030-2050) for improving the energy efficiency of social housing buildings and the use of renewable energy, in order to participate to the reduction of greenhouse gas emission (GEG) by a factor 4 before 2050. The Factor 4 partners aim at being **real actors in the European strategy as regarding GEG**.

Its objective is to help social owners to optimise their retrofitting programmes for their whole building stocks and to set up strategies towards energy efficiency and the factor 4.

The Factor 4 partners think that a life cycle cost (LCC) approach can help to reach this objective and so it aims at:

- working out **a decision aid tool**, the Factor 4 model, **for optimising energy retrofitting programmes inside a sustainable development approach** (including a socioeconomic optimum)
    - **easy to be used by social owners themselves, both for each building retrofitting and for a long term assets' management** of their whole building stock,
    - facilitating the choice among energy efficient technologies (through the analysis of various scenarii)
    - improving the dialogue with all the social owners partners (and especially financial partners and tenants),
    - useful for setting up territorial social housing strategies towards a factor 4 (at the neighbourhood, city, regional or national scales),
    - which can also reduce energy precariousness, especially in the private sector.
- **recommendations** for all the actors concerned and especially for territorial strategies, illustrated by a barriers analysis and demonstration actions.

THE FACTOR 4 MAIN HYPOTHESIS

The Factor 4 project is focussing on solutions for optimizing retrofitting programmes of social housing towards a factor 4.

Reaching the factor 4 or reducing greenhouse effect gas emissions by a factor 4 means their division by 4: CO_2 emissions after retrofitting works must be 4 times lower than before works. The first question is upon how reaching these consumption levels for a factor 4 reduction of CO_2 emissions, with which technical and economical solutions.

The idea was to use a life cycle energy cost (LCEC) analysis. This LCEC analysis is an economic and financial complement of the usual technical analysis and it enables to integrate the EPBD in a sustainable development approach.

EXPECTED AND/OR ACHIEVED RESULTS

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

- **<u>A Factor 4 model</u> for optimising building retrofitting programmes of social owners** in at least 3 countries (Denmark, France and Italy), easy to use and directly usable by social owners themselves.

  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 SEC 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 representative buildings", 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 savings 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

- **Deliverable 9**:

French: « 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 : L'ottimizzazione dei programme di riabilitazione energetica attraverso un'analisi del Costo Globale energetico con il modello BREA (Building Retrofitting Efficiency Assessment Valutazione di interventi di efficienza energetica)

CHAPTER II. THE FRENCH RESULTS

1. THE OVERALL ANALYSIS AND THE FRENCH CASES STUDIES

1.1. The French cases studies as regarding the Factor 4 typology

The French case studies are summarised in the following table according to the criteria of the Factor 4 typology selected in the previous deliverables 3 and 4.

The selected French Factor 4 cases studies according to the Factor 4 typology

Social owners	**Moulins Habitat**	**OPHLM Arcueil Gentilly**	**CMH**	**OPAC 38**	**Maison Girondine**	**Maison du CIL UNILOGI**	**SAGECO**	**EFIDIS**	**OSICA**	**TOTAL**
Nb of case studies	11	2	3	2	3	3	3	3	2	**32**
Criteria										
Nb of buildings	63	2	3	2	2	7	12	68	9	**170**
Nb of dwellings	1 962	140	102	65	374	246	917	1 273	290	**5 439**
Living m²	132 100	7 033	13 241	3 923	23 041	16 417	55 704	95 550	17 703	**368 818**
Construction date and climatic area										
Before 1956		1	1	2			1			**5**
1956 - 1969	8	1	1			1	1	1	2	**10**
1970- 1974	3		1		2	2		2		**12**
1975 - 1989					1		1			**5**
1990 - 1999										**0**
Since 2000										**0**
Climatic area	H1	H1	H1	H1	H2	H1	H1	H1	H1	**29 H1 and 3 H2**
Building type										
Single-family houses					1					**1**
< 50 dwellings	9		2	2		2	2	3	1	**21**
50 up to 199 dwellings	2	2	1		1	1			1	**8**
> 200 dwellings					1		1			**2**
Type of energy for the heating system										
Gas (individual boiler)			1							1
Gas (collective boiler)	1	2	1		2	2	1	1	1	11
Fuel oil						1				1
District Heating	10		1		1		1	1	1	15
Electricity heating							1	1		2
Other				2						2

Number of stairs										
Collective		R+7; R+4	R+2, R+3, R+9	R+4	R+3 up to R+7, R+3	R+4	R+5,R+6, R+9	R+4; R+5; R+4	R+4; R+6	**170**
Single family housing					112		1			**113**

Source La Calade for Factor 4

These 32 cases studies deal with 170 buildings and 5 439 dwellings but are representative of more than 15 000 dwellings (as seen the deliverables 9).

1.2. The results of the energy analysis with the SEC model

These 32 cases studies have been studied with the SEC model during the first months of 2007.

The data on energy consumption and about the building characteristics have been collected in order to work out an energy balance before the retrofitting works. Then scenarii have been carried out and the main results are presented in the following table :

Results of the Factor 4 (energy and CO_2) analysis in France

Heating system and sanitary hot water Cases studies	Number of dwellings (multi family housing if not mentioned)	Primary energy consumption in heating and sanitary hot water	Final energy consumption before works Heating and sanitary hot water	Heating energy source	Final energy consumption after works Heating and sanitary hot water	Energy label	CO_2 Factor	CO_2 label	Investment cost per dwelling	Energy life cycle costing	
La Frileuse / Gentilly	60	230 kWh / m^2	207 kWh / m^2	Gas	185 kWh / m^2	D => D	1,1	E => E	660 €	Benefit	0,7 € / m^2 - an
La Vache Noire / Arcueil	1600	257 kWh / m^2	232 kWh / m^2	Gas	153 kWh / m^2	E => D	1,5	E => D	4 600 €	Benefit	4,6 € / m^2 - an
Vercors / Libourne	194	190 kWh / m^2	171 kWh / m^2	Gas	74 kWh / m^2	D => B	2,3	E => C	9 500 €	Benefit	1,2 € / m^2 - an
Verlaine / Cenon	212	229 kWh / m^2	169 kWh / m^2	District heating	78 kWh / m^2	D => C	2,1	E => D	10 300 €	Loss	2,4 € / m^2 - an
Maisons / Carbon-Blanc	112 maisons	376 kWh / m^2	339 kWh / m^2	Gas	174 kWh / m^2	F => D	1,9	F => E	6 200 €	Benefit	7,3 € / m^2 - an
ILM Centaure / Roubaix	132	242 kWh / m^2	179 kWh / m^2	District heating	91 kWh / m^2	E => C	1,9	E => D	9 800 €	Loss	1,0 € / m^2 - an
Canteleu / Lille	12	363 kWh / m^2	328 kWh / m^2	Gas	111 kWh / m^2	F => C	2,9	F => D	6 000 €	Benefit	14,6 € / m^2 - an
Joffre / Tourcoing	24	248 kWh / m^2	188 kWh / m^2	Gas	84 kWh / m^2	E => C	2,5	E => C	4 600 €	Benefit	3,1 € / m^2 - an
Leclerc / Bourgoin	25	382 kWh / m^2	377 kWh / m^2	Independant heating equipments => Central heating gas	140 kWh / m^2	F => D	2,1	F => D	19 800 €	Benefit	6,1 € / m^2 - an
Lucien Hussel / Bourgoin	40	240 kWh / m^2	233 kWh / m^2		209 kWh / m^2	E => E	1	E => E	5 500 €	Benefit	2,5 € / m^2 - an
Provence Roussillon Touraine / Château-Thierry	326	265 kWh / m^2	238 kWh / m^2	Gas	104 kWh / m^2	E => C	2,2	E => D	9 000 €	Benefit	6,4 € / m^2 - an
Hainaut / Château-Thierry	2016	224 kWh / m^2	201 kWh / m^2	Gas	97 kWh / m^2	D => C	2	E => D	7 300 €	Benefit	4,2 € / m^2 - an
Berry - Bretagne - Béarn / Château Thierry	2016	292 kWh / m^2	288 kWh / m^2	Fioul => Gas	115 kWh / m^2	E => C	3	G => D	8 400 €	Benefit	14,3 € / m^2 - an
Immeuble rue Dunois / Paris 13ème	76	270 kWh / m²	105 kWh / m^2	Electricity => Gas	86 kWh / m^2	E => C	0,8	C => D	3 600 €	Benefit	0,8 € / m^2 - an
Immeuble rue Beaugrenelle / Paris 15ème	183	295 kWh / m²	218 kWh / m^2	District heating	151 kWh / m^2	E => D	1,4	F => E	4 400 €	Benefit	0 € / m^2 - an

La Caravelle / Villeneuve la Garenne	1800	263 kWh / m²	236 kWh / m²	Gas	124 kWh / m²	E => C	1,8	E => D	5 000 €	Benefit	5,4 € / m² - an
Les Chaperons / Brie Comte Robert	206	453 kWh / m²	146 kWh / m²	Electricity => Gas	102 kWh / m²	F => C	0,9	D => D	9 300 €	Benefit	3,5 € / m² - an
Les Fleurs / Carrières sous Poissy	860	335 kWh / m²	250 kWh / m²	Gas	150 kWh / m²	F => D	1,4	E => D	5 400 €	Benefit	3,6 € / m² - an
La Montagne / Le Mée sur Seine	207	318 kWh / m²	241 kWh / m²	District heating => Gas	147 kWh / m²	E => D	1,8	F => D	5 600 €	Loss	4,4 € / m² - an
Valenton	210	240 kWh / m²	177 kWh / m²	Gas	177 kWh / m²	E => E	1	D => D	0 €	-	0 € / m² - an
Bonneuil	80	506 kWh / m²	380 kWh / m²	District heating	285 kWh / m²	G => F	1,3	G => G	4 100 €	Benefit	1,9 € / m² - an
Thonier BCD	109	253 kWh / m²	200 kWh / m²	District heating	111 kWh / m²	E => C	1,8	F => D	6 400 €	Benefit	1,1 € / m² - an
Thonier AEFG	120	264 kWh / m²	209 kWh / m²	District heating	120 kWh / m²	E => D	1,7	F => E	6 600 €	Benefit	1,1 € / m² - an
Champins HIK	48	312 kWh / m²	246 kWh / m²	District heating	158 kWh / m²	F => C	1,6	F => E	5 200 €	Benefit	1,6 € / m² - an
Champins AB	36	386 kWh / m²	305 kWh / m²	District heating	107 kWh / m²	E => C	2,8	G => D	8 400 €	Benefit	5,3 € / m² - an
Champins FG	48	311 kWh / m²	245 kWh / m²	District heating	115 kWh / m²	E => D	2,1	F => D	7 300 €	Benefit	2,6 € / m² - an
Nomazy KGJ	170	278 kWh / m²	219 kWh / m²	District heating	115 kWh / m²	E => C	1,9	F => D	6 600 €	Benefit	1,6 € / m² - an
Nomazy BDF	222	293 kWh / m²	231 kWh / m²	District heating	117 kWh / m²	E => C	1,9	F => E	7 700 €	Benefit	2,2 € / m² - an
Nomazy EIH	182	300 kWh / m²	237 kWh / m²	District heating	133 kWh / m²	E => D	1,8	F => E	8 000 €	Benefit	1,6 € / m² - an
Champmilan "A"	286	242 kWh / m²	191 kWh / m²	District heating	146 kWh / m²	E => D	1,3	F => E	3 500 €	Benefit	0,5 € / m² - an
Champmilan "R"	269	243 kWh / m²	192 kWh / m²	District heating	149 kWh / m²	E => D	1,3	F => E	3 500 €	Benefit	0,5 € / m² - an
Le Plessis	362	231 kWh / m²	208 kWh / m²	Gas	114 kWh / m²	E => C	1,8	E => D	7 400 €	Benefit	2,1 € / m² - an

Source La Calade for Factor 4

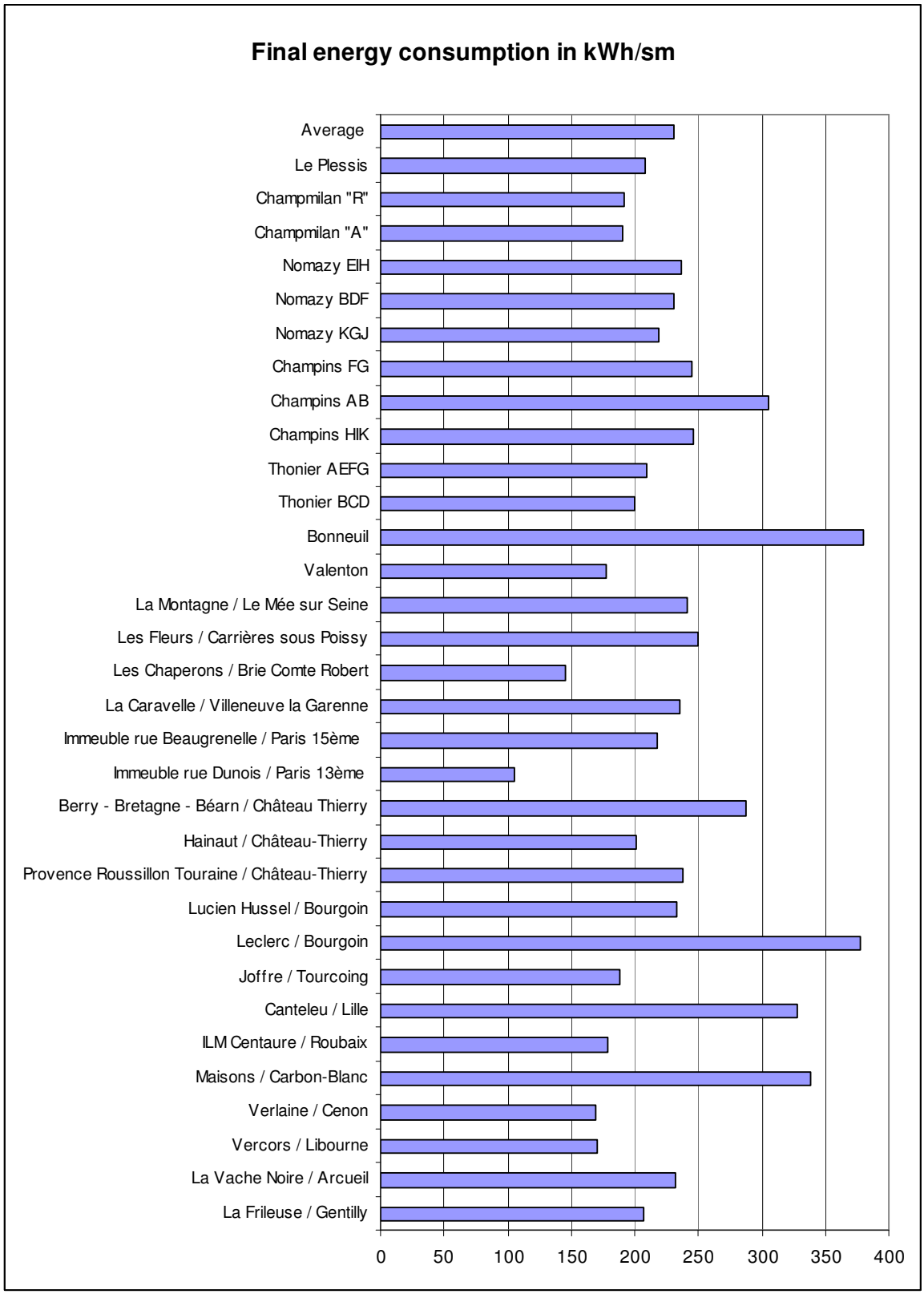
Each of these cases studies are described in French in the deliverable 9. The deliverable 9.1 shows the results of 11 cases studies in the same neighbourhood in order to get an optimised retrofitting scenario at the neighbourhood scale and the deliverable 9.2 gathers all the other cases studies[1].

First of all, we set up an overall synthesis from all the French cases studies and then we work out the Factor 4 scenario for some of them (in chapter 2).

The following graphics present the initial final energy consumption for heating and sanitary hot water for each French case study, then the final energy consumption after energy efficiency works.

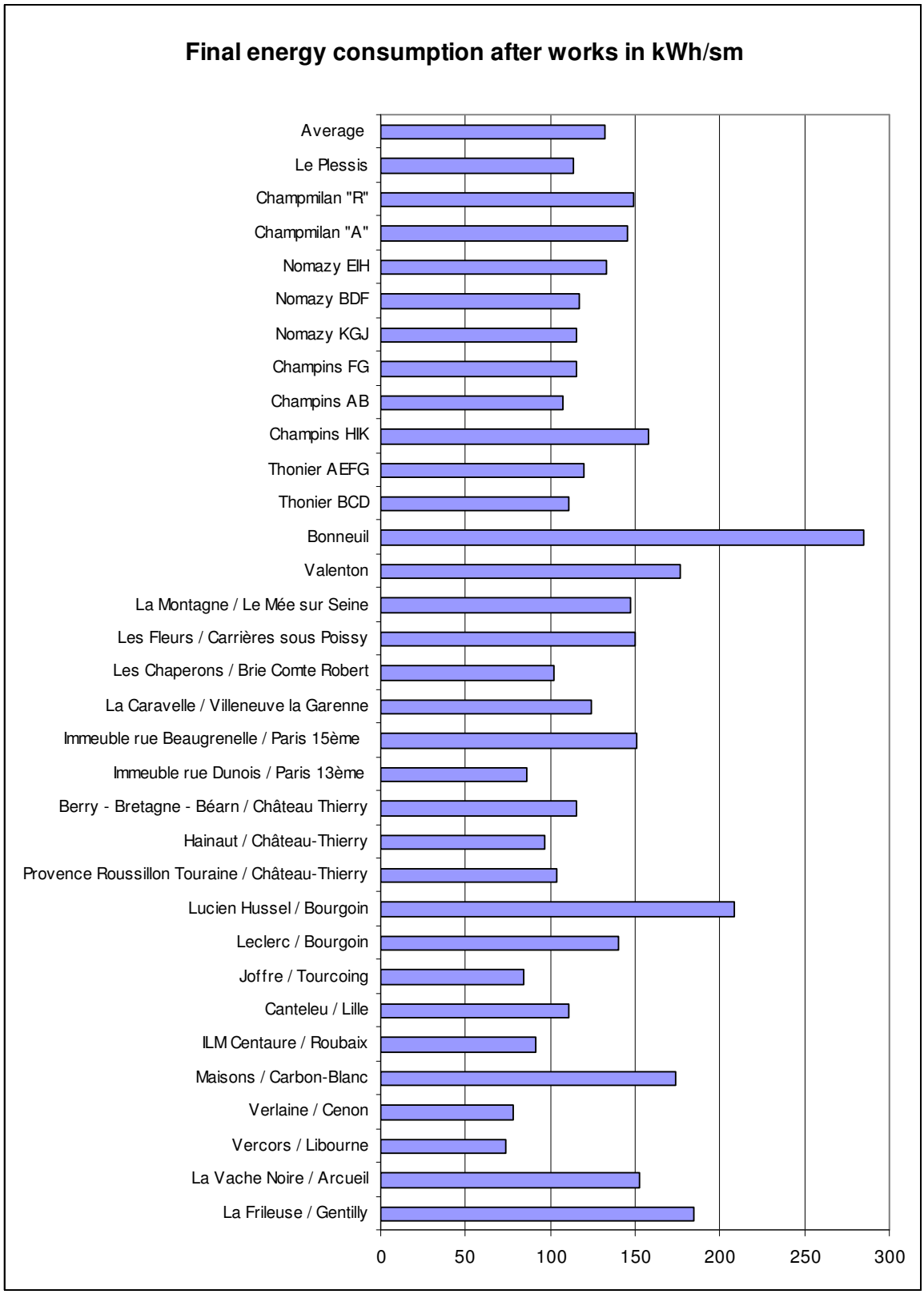
[1] Some of the cases studies are not described in this synthesis because they were finished or sent by the social owners after the writing of this synthesis

Final energy consumption before retrofitting works in the French cases studies



Source: La Calade for Factor 4

Final energy consumption after retrofitting works in the French cases studies



Source: La Calade for Factor 4

1.3. The average values analysis

The total sample, with all the cases studies, represents **more than 15 000 dwellings**.

The final energy consumption for heating and sanitary hot water before expected retrofitting works is equal to 231.5 kWh / m^2 (sometimes written as square meters: sm) and this is higher than the national average (171 kWh / m^2 for gas in the H1 climatic area, as mentioned in the deliverable 3, chapter 4.2. F. 3.g but the available data have sometimes hot water and sometimes not… so we should perhaps say between 180 and 190 in primary energy). This difference can be explained by the fact that these buildings had been chosen because they have to be retrofitted of buildings to be retrofitted.

The works (described by social owners themselves in the scenario they or their consultants have worked out)[2] represents as an average a cost of 6 400 € per dwelling.

The final energy consumption after retrofitting works would be 125 kWh / sm, i.e. an energy savings of 44 %.

The average CO_2 factor is only 1.9.

The energy labellings are improved as shown in the table below :

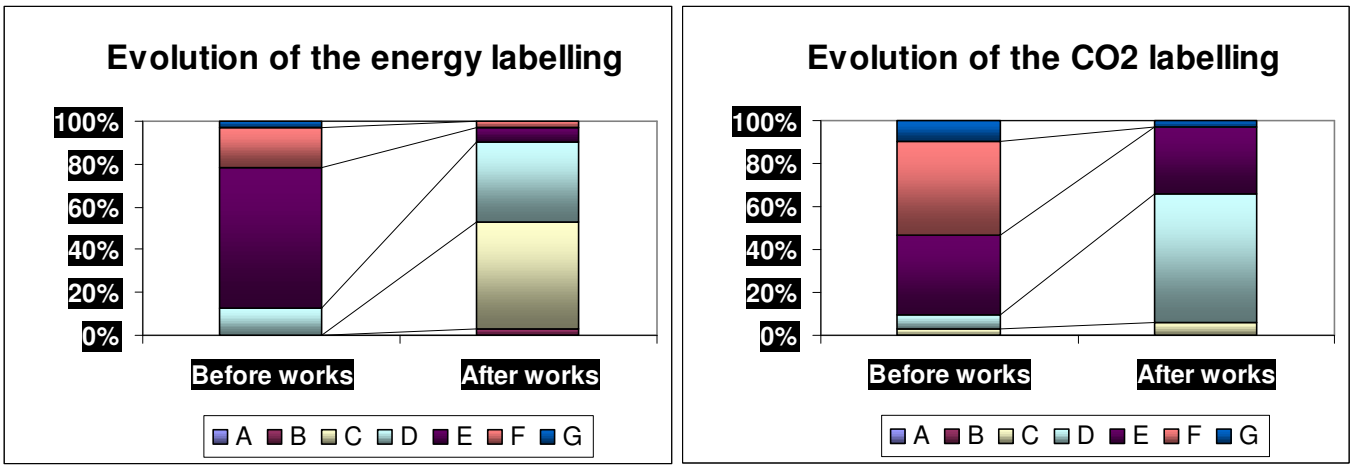
The French cases studies' energy and CO_2 labelling before and after retrofitting works

Energy Labelling			CO_2 labelling		
	Before works	After works		Before works	After works
A	0	0	A	0	0
B	0	1	B	0	0
C	0	16	C	1	2
D	4	12	D	2	19
E	21	2	E	12	10
F	6	1	F	14	0
G	1	0	G	3	1

Source La Calade for Factor 4

This can be illustrated with the following schema:

The French cases studies' energy and CO_2 labelling before and after retrofitting works



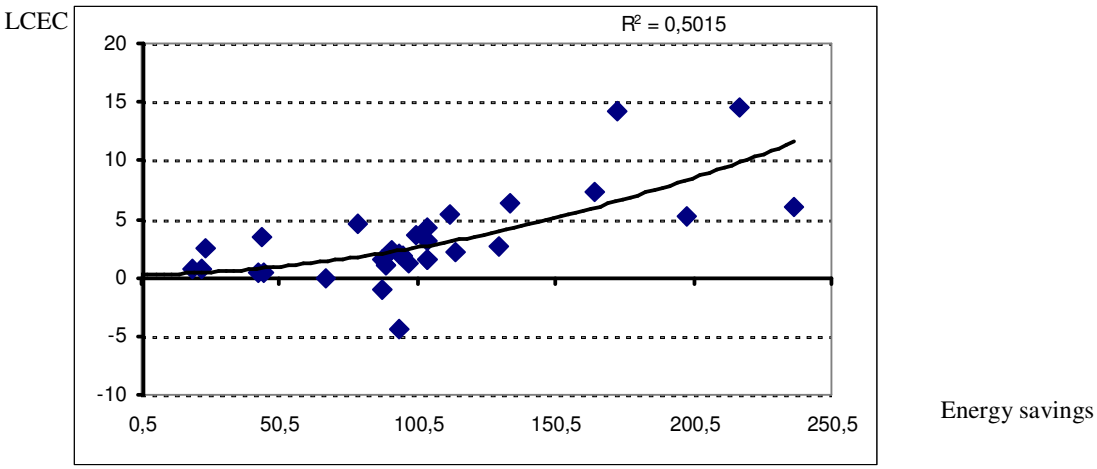
Source La Calade for Factor 4

[2] The retrofitted scenarii are not real retrofitted works but only scenarii given by social owners themselves and they can be considered as representative or usual works in France

These data analysis shows that there are **two interesting correlations.**

- **There is a positive correlation between the life cycle energy costing (LCEC) and the potential energy savings**: more we save energy and more we save money. We can think that there is a growing function which makes it more and more profitable to invest in energy savings, as shown in the following schema.

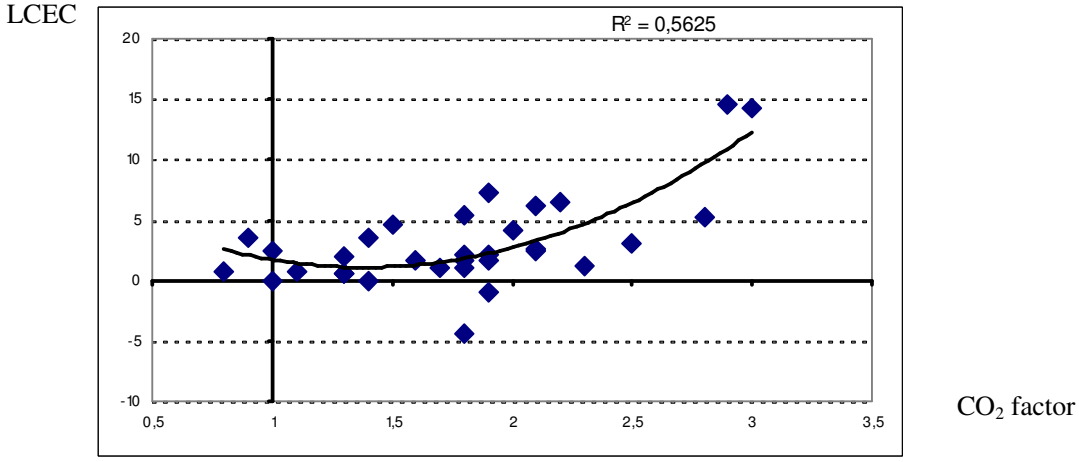
A good correlation between the expected energy savings and the LCEC (profitability)



Source: la Calade for Factor 4

- **The second correlation exists between the LCEC and the CO_2 factor**. It is the same positive correlation with a threshold from a CO_2 factor higher than 1.7.

A good corelation between the CO_2 factor and the LCEC

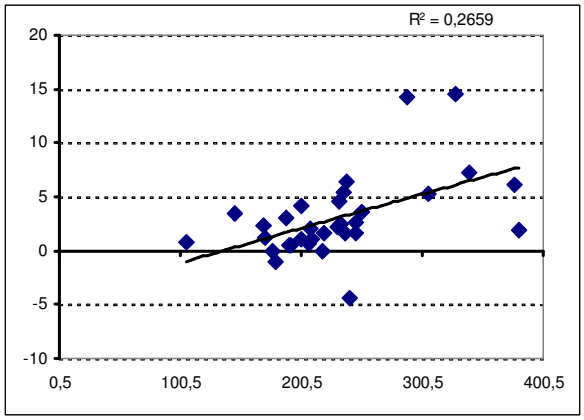


Source: la Calade for Factor 4

This last figure shows that the social owners (or their consultants) did not make any difference in working out the scenario if the initial energy consumption was high nor according to the CO_2 factor. So, **the scenarii given by French social owners (and explained in the deliverables 9) are representative ones, can be considered as business as usual in France**.

Not any correlation between the initial level of energy consumption and the profitalibility

LCEC



Initial level of energy consumption

Source: La Calade for Factor 4

1.4. The detailed values analysis

These scenarii were suggested or combined by the various social owners involved in the national Factor 4 working group (as associated Factor 4 partners). They represent a volontarist action to carry out energy savings but however without changing completely the decision habits.

The objective of these scenarii was not to reach the factor 4 (as done by the Danish partner) but **to show the conditions needed for reaching a high level of energy efficiency,** which overpasses the usual practices, but within the limits of investment capacities. **These scenarii can be presented as good usual energy practices.**

We can remark that only 50 % of the case studies reach the energy labelling "C" and that the average investment cost is 7 300 € per dwelling.

For this analysis, we will distinguish the cases studies with a first central heating system. The average investment cost of the cases studies with a central heating system where the energy labelling is "D" or "E" after retrofitting works is 4 600 € per dwelling.

The overinvestment would reach approximately 60 % in order to get the "C".level

The CO_2 factor is higher or equal to 2 only in ten cases, which demonstrates the difficulty to imagine how it is possible to reach the factor 4. We will remark that the "C" labelling is more difficult to reach for CO_2 than for energy. For CO_2, the "C" labelling is only reached in two cases studies in regards to 17 cases studies for the energy labelling !!

This can probably be explained by the need of using renewable energy for reaching a good level as regarding the CO_2 labelling.

We can also remark that the improvements are well distributed among the social owners. Otherwise that means that there is not any cultural difference among the social owners(associated) partners when defining energy savings projects or scenarii[3].

9 projects are more particularly profitable with a benefit issued from the LCEC analysis higher than 4 € / sm – year. **The benefits come from projects requiring an average investment of 8 300 € per dwelling, i.e. 30 % more than the sample average**.

[3] They worked as usual and did not tried to reach a high labelling and there was not any competition among them.

The average final energy consumption of these 9 projects reaches 283 kWh / sm, i.e. 20 % higher than the sample average. The projects number where the final energy consumption exceeds 235 kWh/ sm is 13 and 9 of them create profitable situations for the collectivity (society).

Among these 9 projects, 8 are finally heated with natural gas and only 1 with a district heating.

The impact of the energy price on the LCEC is obviously very important and explains this orientation.

Conclusion

The profitability is increasing with the expected energy savings and with the CO2 factor and so these 2 factors must (should) be carefully taken into account by social owners and their consultants. (This shows the full interest of the SEC model…).

In the following chapters we are presenting the Factor 4 scenarii worked out by La Calade in order to show how and what could be done for reaching the Factor 4 objective, which is an objective which has not been adopted yet by French social owners for various reasons (these reasons will be the topic of the further researchers in the Factor 4 project)**.**

2. THE CASE STUDY WITH LA VACHE NOIRE IN ARCUEIL, NEAR PARIS

In this second part of the results presentation, we present the initial energy consumption as we already did in the deliverable 9.2 and then La Calade tried to work out scenario reaching the Factor 4.

The first part of the analysis with is the energy analysis of the existing building is already described in French in the deliverable 9.2.

Source La Calade

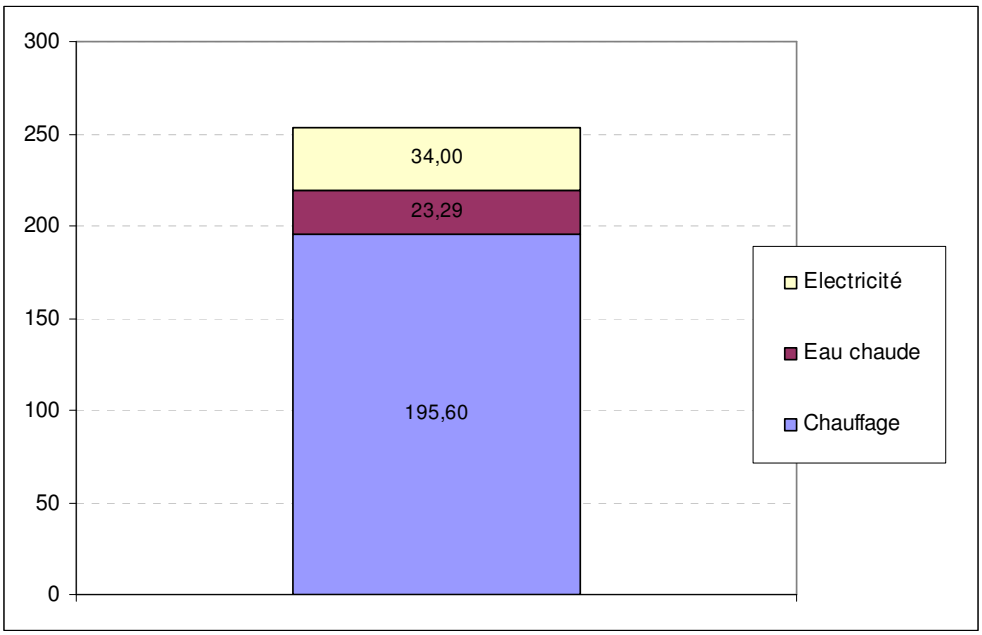
The building presentation according to the Factor 4 typology

Building name	La Vache Noire, bâtiment A
Type of building Number of dwellingsd Liveable surface Size of dwellings	Multi-family housing, 5 floors 80 4 160 m² 1 T1, 39 T2, 40 T3
Climatic area	H1
Construction date	1956
Heating system	Collective central heating with natural gaz
Location in neighbourhood with social and economic problems	yes
City	Arcueil
Description	Buildings located in the first area around of Paris. This area includes two buildings but the second one – a bar with 12 floors and 135 m length – is going to be demolished.

2.1. The energy consumption

The energy consumption has been assessed with the SEC model and compared with the real energy consumptions of the building (data provided by OPI HLM).

The energy consumption of La Vache Noire, Arcueil



Source La Calade pour Factor 4

Energy consumption and CO_2 emission with the their labelling

Final energy consumption : heating & SHW – kWh / m²

	218,9
Heating	195,6
Sanitary Hot Water	23,3

Primary energy – heating & SHW - kWhp/m² – year

243,0 **E**

CO_2 emission – heating & SHW - kg CO_2 / m²

51,2 **E**

Electricity in kWh / m²	34,0

Résults - La Vache Noire	For 1 m²	For 1 dwelling	For the building
Annual energy consumption in kWh	252,9	13 150	1 052 000
Primary energy consumption in kWh	330,7	17 196	1 376 000
CO_2 emission in kg	52,6	2 700	219 000
Energy annual expenses in €	17,35	902	72 171

Source La Calade for Factor 4

2.2. The energy savings strategy or actions towards the factor 4

The following list of actions has been determined in order to reach the factor 4 objective.

1 – Roof insulation : insulation in the lost attic of the building with the renovation of the roof *

2 – Insulation of the basement floor (100 mm); the basement is unheated and the insulation will reduce the transmission losses from the dwellings to the basement

3 – Pipe insulation *

4 – Controlled mechanical ventilation : installation of an hygro regulated CMV. CMV with energy recovery is very difficult to set up. CMV is an obligation with the setting of new windows and the improvement of walls insulation *

5 – Insulation of façades : 150 to 200 mm external insulation of the entire façade will reduce the thermal losses. This action is an obligation for reaching the CO_2 factor 4. **

6 – Thermostatic valves in all the dwellings **

7 – Balance between distribution : this action is necessary for a better management of the boilers*

8 – Actions to save hot water : the reduction of water consumption (new taps) makes it possible to reduce the needs of hot water

9 – New boiler : the project includes the setting up of a new condensing boiler *

10 – Individual water meters *

11 – Low energy windows : setting of new windows. The U-value of the new windows is 1.8 W/m² - °C

11bis – Very low energy windows : in this case, the U-value of the new windows is only 1.1 W/m² - °C

12 – Solar hot water : installation on the roof of a collective solar hot water which reduces the energy consumption for hot water by 37.5 %

13 – Energy savings through tenants behaviour : information and training of residents in order to support an energy savings strategy

14 – Energy efficient lighting : supply of low energy consumption lamps to households (about 4 lamps per dwelling)

15 – Electricity savings in the dwelling : training of residents, incentive to purchase hard white goods with the grade A or A+, awareness to close audiovisual equipment

16 – Electricity saving in the common spaces of the building : low energy consumption lamps to light the common spaces and variable speed motor for the lifts *

** : foreseen by the social owner in its rehabilitation project*

*** : partially foreseen : only for the extension of the building*

With the actions listed above, iterative scenarii had been worked out by La Calade until the good one or until the factor 4 objective with an economical optimization has been reached.

3 scenarii are presented with the analysis results (such as energy and CO_2 labelling) and figures show:

- **the energy optimum,**
- **the CO_2 optimum**
- **the optimum as regarding the investments as well as the households expenses,**

towards an optimisation of the retrofitting programme.

1. Scénario 1 to 13 with the 13 first technology actions of the previous list.

The impacts on the energy and economic balances are presented in the following table and schemas with the additional action or technology listed there with their number in the previous list.

The impacts on the energy, CO_2 and economic balances are presented in the following table and charts.

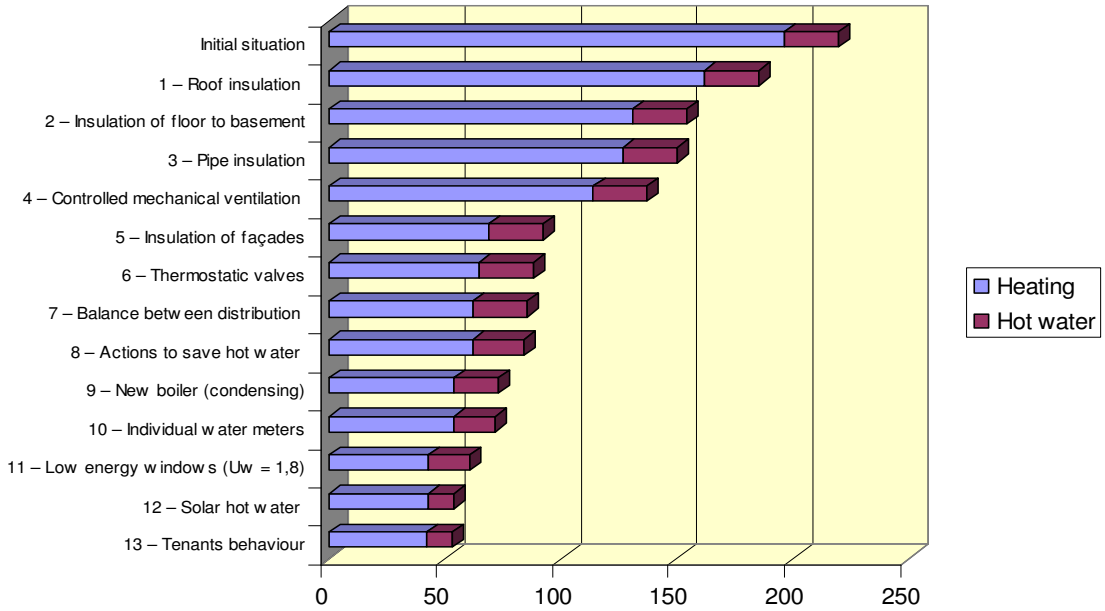
Actions / **Data or results**	**Unit**	**initial**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Energy primary	kWh / m²	331	294	259	255	240	190	185	183	181	169	167	155	148	146
Final energy	kWh / m²	253	220	188	185	171	126	122	120	118	107,1	105,7	94,7	88,2	86,8
Heating	kWh / m²	196	162	131	127	114	69	65	62	62	54	54	43	43	42
Hot water	kWh / m²	23,3	23,3	23,3	23,3	23,3	23,3	23,3	23,3	21,9	19,1	17,6	17,6	11	11
Electricity	kWh / m²	34	34	34	34	34	34	34	34	34	34	34	34	34	34
CO_2 emission	kg CO_2 / m²	52,6	44,8	37,5	36,6	33,5	22,9	21,9	21,4	21,1	18,5	18,1	15,6	14	13,7
Residents charges *	€ / m²	25,2	22,1	19,2	18,8	17,6	13,4	13	12,8	12,7	11,7	11,5	10,5	9,9	9,8
Investment	€ / dwelling	0	260	650	858	1638	4758	4966	5122	5174	6630	6734	9438	10998	11050
CO_2 FACTOR		1	1,2	1,4	1,4	1,6	2,3	2,4	2,5	2,5	2,8	2,9	3,4	3,8	3,8
Pay back period **	years	2	2	3	4	8	8	8	8	8	9	9	12	14	14
LCEC	€ / m² - year	0	-2,8	-5,4	-5,5	-6	-7,8	-7,8	-7,8	-7,8	-7,7	-7,6	-6,6	-5,4	-5,5

* : the expense is the net present value of the expense, including the forecast of energy prices evolution

** : the pay back return includes the forecast of the energy prices evolution

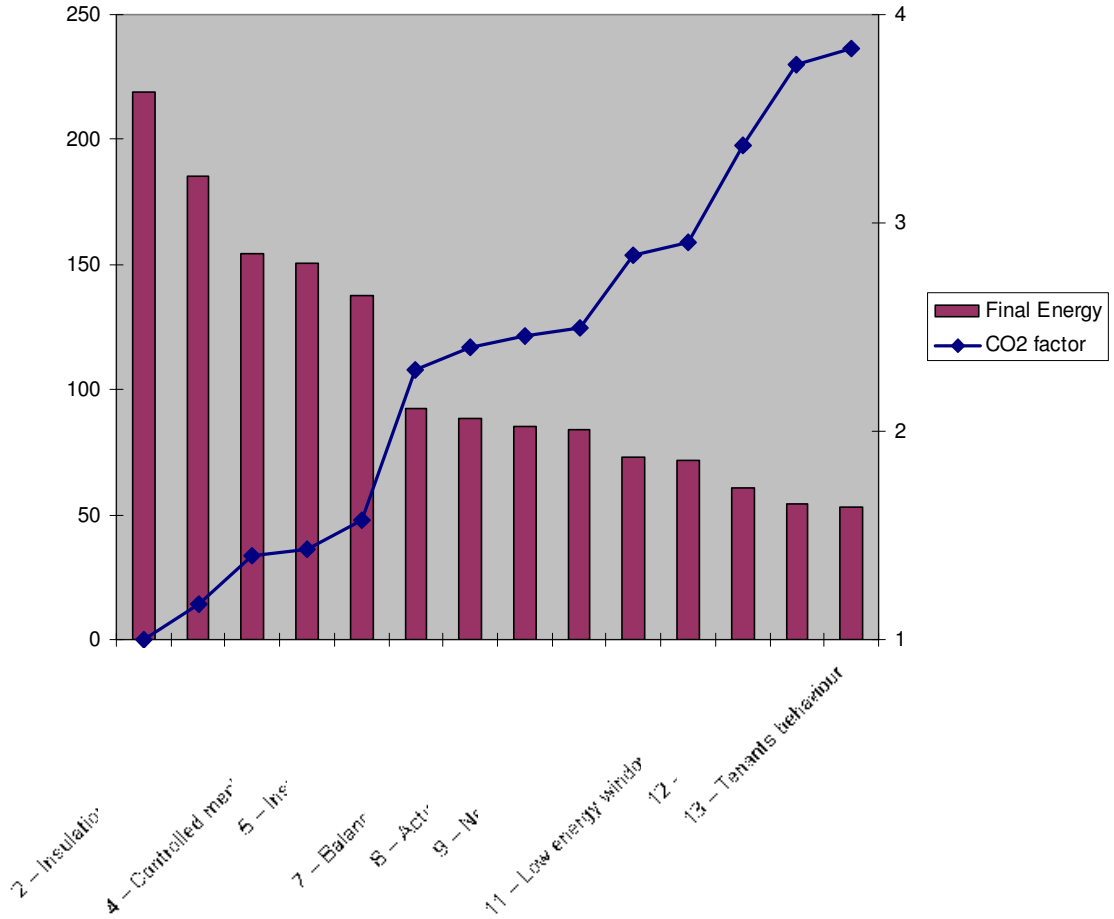
Source La Calade for Factor 4

Evolution of the heating and hot water energy consumption for each of the actions or technology list towards the factor 4 objective



Source: La Calade for Factor 4

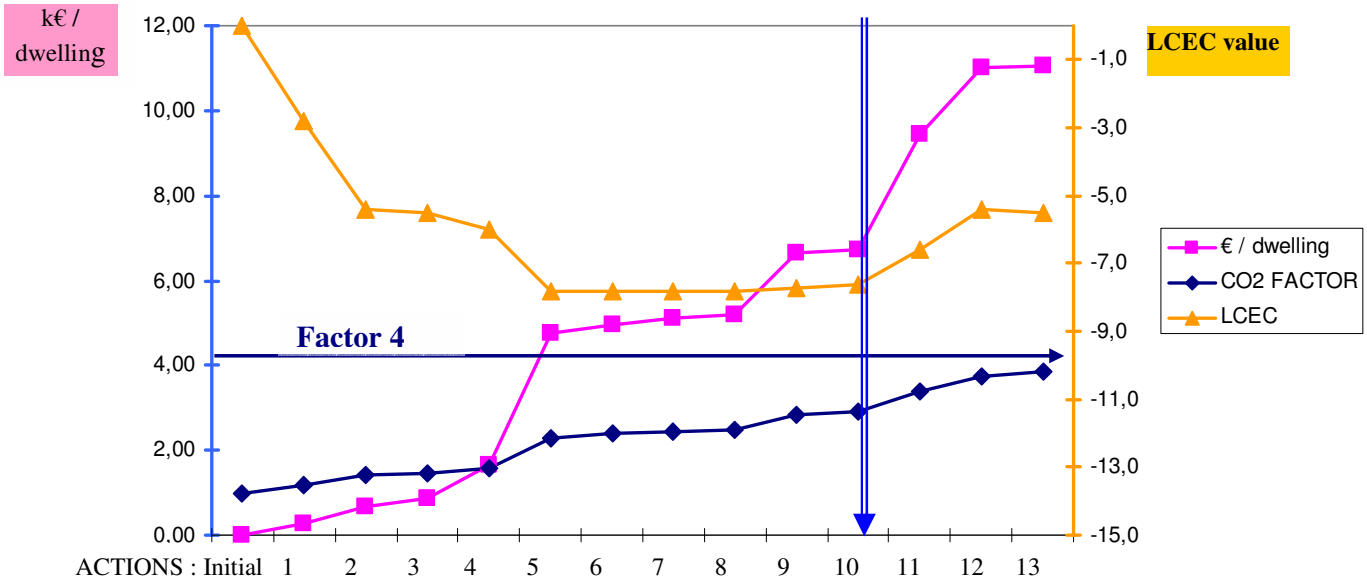
Evolution of the final energy consumption and impact on the CO_2 factor for each action or technology of the list towards the factor 4 objective



Source: La Calade for Factor 4

So at least, the profitability can be estimated as follows (with investments in K€ on left and LCEC right)

Evolution of the profitability, investment and CO_2 factor towards the factor 4 objective



Source La Calade for Factor 4

This chart or schema shows the impacts of the scenario on **the CO_2 factor : 3.8** as an issue of 13 technology actions.

The investment is close to 11 k€ and the LCEC reaches a benefit of 5.4 € / m² - year.

The chart can show that **the profitability of the project (LCEC) reaches an optimum for the actions going from 6 to 10** (excluding low energy windows).

From the action 11, the profitability of the project decreases with a strong increase of the investment cost (this is a calculation without subsidy).

The investment costs includes several steps : < 2 000 € for actions 1 to 4; 5000 € for actions 5 to 8; 7000€ for action 10 and an heavy increase for actions 11 and 12.

2. Scénario 11 bis with the 13 first technology actions of the previous list but with the 11 bis instead of the 11 one.

Another scenario (with the technology action number 11 bis instead of 11) can consist in setting very low energy window (Uw = 1.1). In this case, the final result is a CO_2 factor equal to 4.3 for an investment cost of 11,7 k€ and a LCEC benefit of 5.5 € / m² – year.

3. ***Scenario 16 with the 10 first technology actions of the previous list and the last 3***

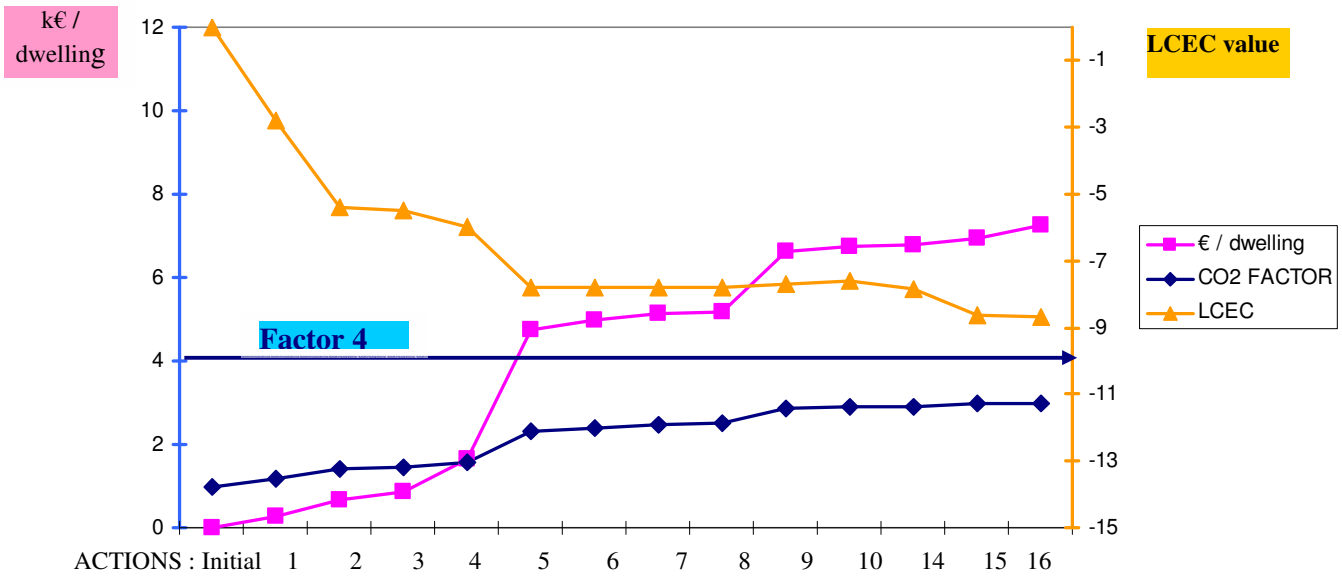
Up to now, there was no action on electricity consumption. We can include these actions from the action 11 and assess **the final situation**.

Scenario 16 with the actions or technologies 1 to 10 and 14 to 16 upon electricity towards the factor 4 objective

	Unit	initial	1	2	3	4	5	6	7	8	9	10	14	15	16
Energy primary	kWh / m²	331	294	259	255	240	190	185	183	181	169	167	160	139	130
Final energy	kWh / m²	253	220	188	185	171	126	122	120	118	107,1	105,7	102.7	94.9	91.4
Heating	kWh / m²	196	162	131	127	114	69	65	62	62	54	54	54	54	54
Hot water	kWh / m²	23,3	23,3	23,3	23,3	23,3	23,3	23,3	23,3	21,9	19,1	17,6	17.6	17.6	17.6
Electricity	kWh / m²	34	34	34	34	34	34	34	34	34	34	34	31	23	19.5
CO_2 emission	kg CO_2 / m²	52,6	44,8	37,5	36,6	33,5	22,9	21,9	21,4	21,1	18,5	18,1	18.0	17.7	17.6
Residents charges	€ / m²	25,2	22,1	19,2	18,8	17,6	13,4	13	12,8	12,7	11,7	11,5	11.1	10.0	9.5
Investment	€ / dwelling	0	260	650	858	1638	4758	4966	5122	5174	6630	6734	6786	6926	7244
CO_2 FACTOR		1	1,2	1,4	1,4	1,6	2,3	2,4	2,5	2,5	2,8	2,9	2.9	3.0	3.0
Pay back period	years	2	2	3	4	8	8	8	8	8	9	9	9	9	9
LCEC	€ / m² - year	0	-2,8	-5,4	-5,5	-6	-7,8	-7,8	-7,8	-7,8	-7,7	-7,6	-7.86	-8.65	-8.69

Source La Calade for Factor 4

Evolution of the profitability, investment and CO_2 factor including electricity savings actions towards the factor 4 objective



Source La Calade for Factor 4

The result is **a better profitability of the project which reaches near 9 € / m² - year**.

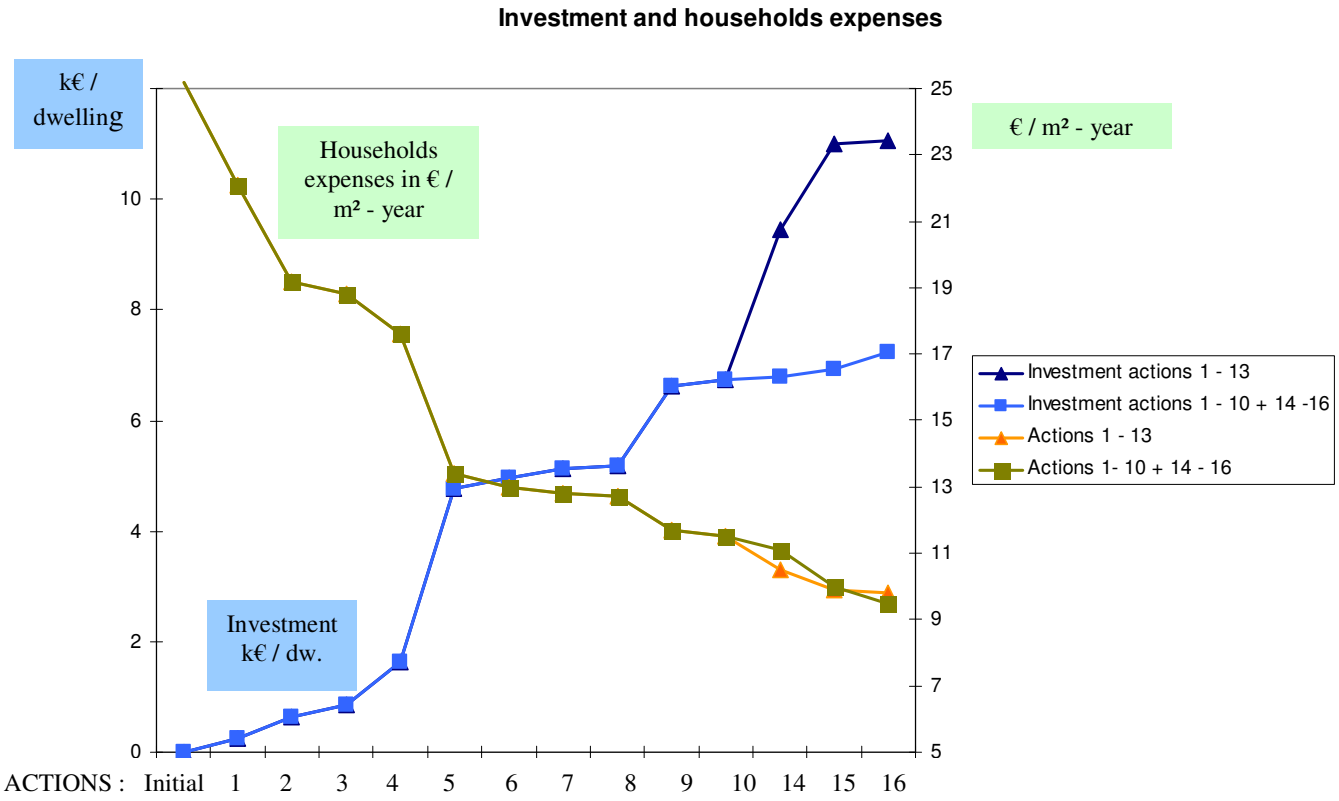
<u>Comparison with the households expenses</u>

But **we must compare this result with the evolution of the charges for the households** (without investment cost included neither rent increase).

Compared to low energy windows and solar hot water, the electricity savings investments are much less expansive for a similar result for households.

So as a conclusion we can write that **the factor 3 + actions for electricity savings are may be the economic optimum for this building,** as shown on the next schema.

Investment and households expenses evolution towards the factor 4 objective



Source La Calade for Factor 4

Then as for the business as usual scenarii described in the deliverable 9, we can use the same presentation for the results presentation for this optimised scenario 16 or Factor 4 scenario.

Final balance

	AVANT	APRES	Economie en %
Résultats en ratios unitaires			
Consommation d'énergie annuelle en kWh par m^2	252,9	91,4	64%
dont chauffage	196	54	72%
eau chaude sanitaire	23,3	17,6	25%
électricité parties communes	8,0	4,5	44%
électricité logements	26	15	42%
Consommation d'énergie primaire en kWh par m^2	330,7	130,4	61%
dont chauffage et ECS	243,0	79,6	
Emission de CO_2 en kg par m^2	52,6	17,6	67%
dont chauffage et ECS	51,2	16,8	
Dépenses énergétiques annuelles en € par m^2	25,2	9,5	62%
Dépenses énergétiques /an hors effet prix énergie	17,3	6,9	60%

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Résultats par logement		
Consommation d'énergie annuelle en kWh par an	13 150	4 753
Consommation d'énergie primaire en kWh par an	17 196	6 779
Emission de CO_2 en tonnes par an	2,7	0,9
Dépenses énergétiques annuelles en € par an	1 310	493
Résultats pour le(s) bâtiment(s)		
Consommation d'énergie annuelle en MWh	1 052	380
Consommation d'énergie primaire en MWh	1 376	542
Emission de CO_2 en tonnes CO_2 par an	219	73
Dépenses énergétiques annuelles en € par an	104 772	39 418

Investissement unitaire en € / m^2			
Chauffage	125,5		
Eau chaude sanitaire	4		
Electricité	9,8		
Total	**139,3**	**Temps de retour**	
Autres investissements incontournables ayant un impact énergétique	0	**9**	**9**

Investissement par logement en €		
Chauffage	6 526	
Eau chaude sanitaire	208	
Electricité	510	
Total	**7244**	
Autres investissements incontournables ayant un impact énergétique	**0**	**7244**
Investissement pour le(s) bâtiment(s) en €		
Chauffage	522 080	
Eau chaude sanitaire	16 640	
Electricité	40 768	
Total	**579 488**	
Autres investissements incontournables ayant un impact énergétique	0	

Bilan économique	**BENEFICE**		
	€ / m^2 - an	€ / logement - an	€ / projet - an
Investissement en € actualisés par an	7,02	365	29 196
Autres investissements incontournables ayant un impact énergétique	0,00	0	0
Maintenance annuelle		0	0
Economie d'énergie à prix de l'énergie constant (hors inflation)	-10,44	-543	-43 439
Hypothèse hausse des prix de l'énergie	-5,27	-274	-21 915
Bilan net en € net actualisés par m^2	**-8,69**	**-452**	**-36 158**

FACTEUR CO2	**3,0**

At least with this Factor 4 scenario, as a conclusion of the analysis, we can say that:

- The economic balance shows that the optimum investment would be 7 250 € per dwelling, i.e. a Net Present Value of 7 € / m² - year.
- Even if the LCEC analysis is not similar to the rent calculation, we can estimate that the increase of the rent could reach at about 0.7 € per m² and per month.
- The present energy savings without energy price effect (expected increase of the gas and electricity prices) would be 10.4 € /m² , i.e. 0.9 € per m² and per month. The balance could be ensured without an increase of the couple rent + charges and by taking an insurance against the evolution of energy prices.

This approach is rather new in France where social owners never manage actions as regarding electricity. It is not the case in other countries as it can be seen in the Concerto projects and this should be an important improvement uin the French social owners habits and ways of working…

Remark:

The Demand Side Management (coming from Canada and especially Hydro Quebec in the 80^{ies}) about electricity savings was only used in France for remote sites (Ademe programme). For other territories there were only a few projects; for example in Lille and Dunkirk (Save project, Agence Régionale de l'Energie Nord Pas de Calais and Philippe Outrequin) and Bordeaux (Save project, Aquitainergie, Gaz de Bordeaux and Philippe Outrequin, Europlan) in the 90^{ies}..

3. CASE STUDY IMMEUBLE BERRY, CHÂTEAU-THIERRY, UNILOGI

Source UNILOGI

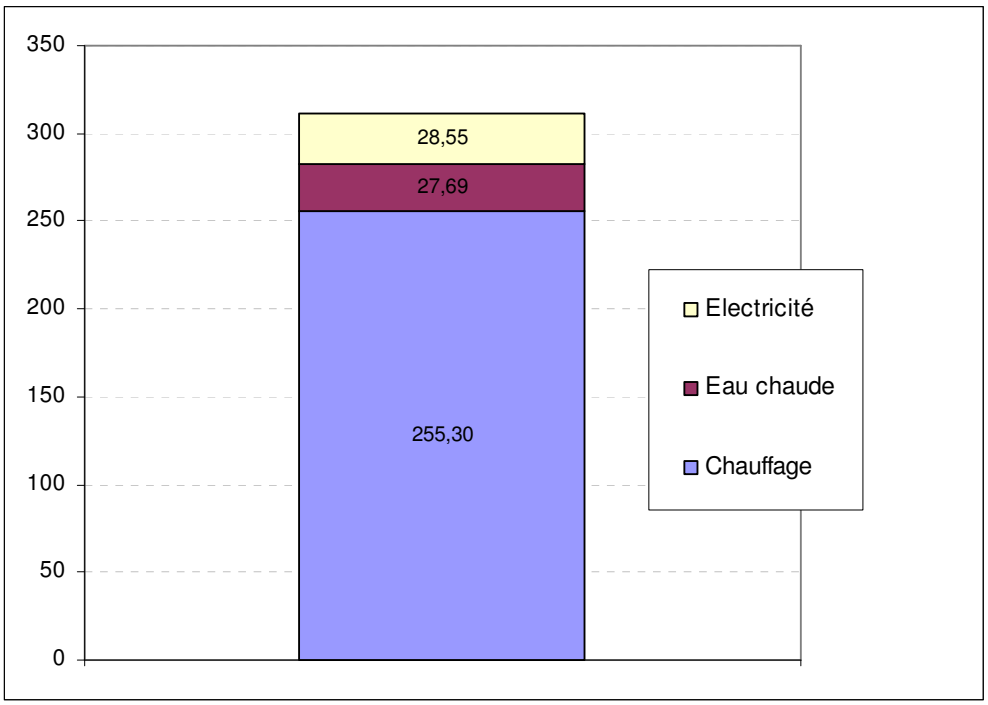
Building description according to the Factor 4 typology

Building name	BERRY Building
Type of building Number of dwellings Liveable surface Size of dwellings	Multi-family housing, 5 levels 19 1 175 m² 4 T2, 6 T3, 9 T4
Climatic area	H1
Construction date	1971 - 1975
Heating system	Collective central heating with fuel oil
Location in neighbourhood with social and economic problems	No
City	Château-Thierry
Description	

3.1. Energy consumption before works

The energy consumption has been assessed with the SEC model and compared with the real energy consumptions of the building (data provided by UNILOGI, La Maison du CIL).

Final energy consumption – Building BERRY, Château-Thierry



Source La Calade for Factor 4

Final energy consumption : heating & SHW - kWh / m²

	283.0
Heating	255.3
Sanitary Hot Water	27,7

Primary energy – heating & SHW - kWhp/m² – year

286,0 **E**

CO2 emission – heating & SHW - kg CO_2 / m²

83.1 **G**

Electricity in kWh / m²	28.6

BERRY Résults	For 1 m²	For 1 dwelling	For the building
Annual energy consumption in kWh	311.6	19 268	1 098 000
Primary energy consumption in kWh	359.7	22 247	1 268 000
CO_2 emission in kg	84.2	5 200	297 000
Annual energy expenses in €	23.1	1 428	81 369

Source La Calade for Factor 4

3.2. Energy savings actions towards a Factor 4 scenario

The actions carried out for reaching the CO_2 factor 4 are the following

1 – New boiler : the project includes the setting of a new condensing boiler with natural gas which replaces an old fuel oil boiler.

2 - Insulation of façades : 200 mm external insulation of the entire façade will reduce the thermal losses. This action is an obligation to reach the CO_2 factor 4.

3 – Insulation of floor to basement (100 mm); the basement is unheated and the insulation will reduce the transmission losses from the dwellings to the basement

4 - Roof insulation : insulation in the lost attic of the building with the renovation of the roof

5 – Controlled mechanical ventilation : installation of a hygro regulated CMV. CMV with energy recovery is very difficult to set. CMV is an obligation with the improvement of walls insulation

6 – Thermostatic valves in all the dwellings

7 – Energy savings through tenants behaviour : information and training of residents to support energy savings strategy

8 – Actions to save hot water : the reduction of the water consumption (new taps) makes it possible to reduce the needs of hat water

9 – Energy efficient lighting : supply of low energy consumption lamps to households (about 4 lamps per dwelling)

10 – Electricity savings in the dwelling (demand-side management) : training of residents, incentive to purchase hard white goods with the grade A or A+, awareness to close audiovisual equipment

11 - Solar hot water : installation on the roof of a collective solar hot water which reduces the energy consumption for hot water by 37.5 %

The impacts on the energy, CO_2 and economic balances are presented in the following table and charts.

The factor 4 scenario with the actions or technologies towards the factor 4 objective

Actions Results	Unit	Initial	1	2	3	4	5	6	7	8	9	10	11
Energy primary	kWh / m²	360	375	250	220	206	183	179	177	175	167	147	136
Final energy	kWh / m²	312	300	188	161	148	127	123	122	120	117	109	99
Heating	kWh / m²	255	244	131	105	92	71	67	65	65	65	65	65
Hot water	kWh / m²	27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.7	26	26	26	15.6
Electricity	kWh / m²	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	25.6	17.6	17.6
CO_2 emission	kg CO_2 / m²	84.2	64.7	38.4	32.1	29.1	24.1	23.3	22.9	22.5	22.4	22.1	19.7
Residents charges *	€ / m²	35	29.3	18.9	16.4	15.2	13.2	12.9	12.7	12.6	12.1	11.0	10.1
Investment	€ / dwelling	0	1 670	5 381	5 844	6 617	7 545	7 793	7 854	7 916	7 978	8 145	10 000
CO_2 FACTOR		1	1.3	2.2	2.6	2.9	3.5	3.6	3.7	3.7	3.8	3.8	4.3
Pay back period **	years	-	5	5	5	5	6	6	6	6	6	5	6
LCEC	€ / m² - year	0	-4.7	-12.7	-14.9	-15.4	-16.6	-16.5	-16.6	-16.6	-16.8	-17.6	-16.77
Energy Labelling		E	E	D	C	C	C	C	C	C	C	C	B
CO_2 labelling		G	F	E	D	D	D	D	D	D	D	D	C

* : the expense is a net present value of the expense, including the forecast of energy prices evolution

** : the pay back return includes the forecast of energy prices evolution

Source La Calade for Factor 4

As for the first French case study, the tables on the next page give the results of the analysis and then the figures shows:

- the energy optimum,
- the CO_2 optimum
- the optimum as regarding the investments as well as the households expenses

Simulation – 11 energy efficient actions

	AVANT	APRES	Economie en %
Résultats en ratios unitaires			
Consommation d'énergie annuelle en kWh par m^2	311,6	98,7	68%
dont chauffage	255	65	74%
eau chaude sanitaire	27,7	15,6	44%
électricité parties communes	2,6	2,6	0%
électricité logements	26	15	42%
Consommation d'énergie primaire en kWh par m^2	359,7	135,6	62%
dont chauffage et ECS	286,0	89,9	
Emission de CO_2 en kg par m^2	84,2	19,7	77%
dont chauffage et ECS	83,1	19,0	
Dépenses énergétiques annuelles en € par m^2	35,0	10,1	71%
Dépenses énergétiques /an hors effet prix énergie	23,1	7,2	69%

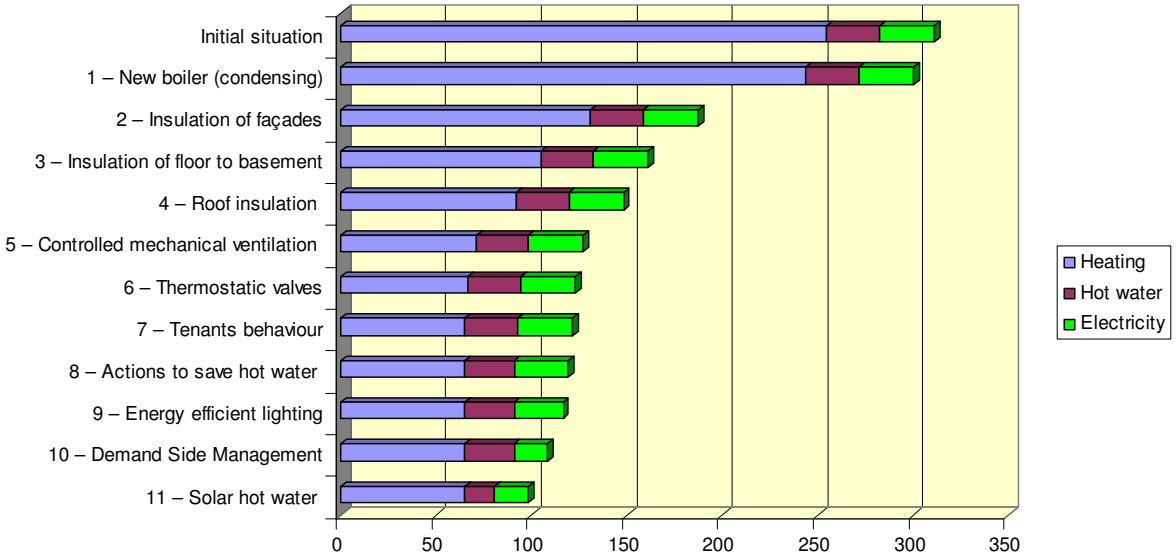
B

C

Résultats par logement				
Consommation d'énergie annuelle en kWh par an	19 268	6 104		
Consommation d'énergie primaire en kWh par an	22 247	8 386		
Emission de CO_2 en tonnes par an	5,2	1,2		
Dépenses énergétiques annuelles en € par an	2 165	622		
Résultats pour le(s) bâtiment(s)				
Consommation d'énergie annuelle en MWh	1 098	348		
Consommation d'énergie primaire en MWh	1 268	478		
Emission de CO_2 en tonnes CO_2 par an	297	69		
Dépenses énergétiques annuelles en € par an	123 418	35 441		
Investissement unitaire en € / m^2				
Chauffage		114,5		
Eau chaude sanitaire		31		
Electricité		3,7		
Total		**149,2**	**Temps de retour**	
Autres investissements incontournables ayant un impact énergétique		13	**6**	**6**
Investissement par logement en €				
Chauffage		7 081		
Eau chaude sanitaire		1 917		
Electricité		229		
Total		**9227**		
Autres investissements incontournables ayant un impact énergétique		**773**	**10000**	
Investissement pour le(s) bâtiment(s) en €				
Chauffage		403 637		
Eau chaude sanitaire		109 282		
Electricité		13 043		
Total		**525 961**		
Autres investissements incontournables ayant un impact énergétique		44 065		

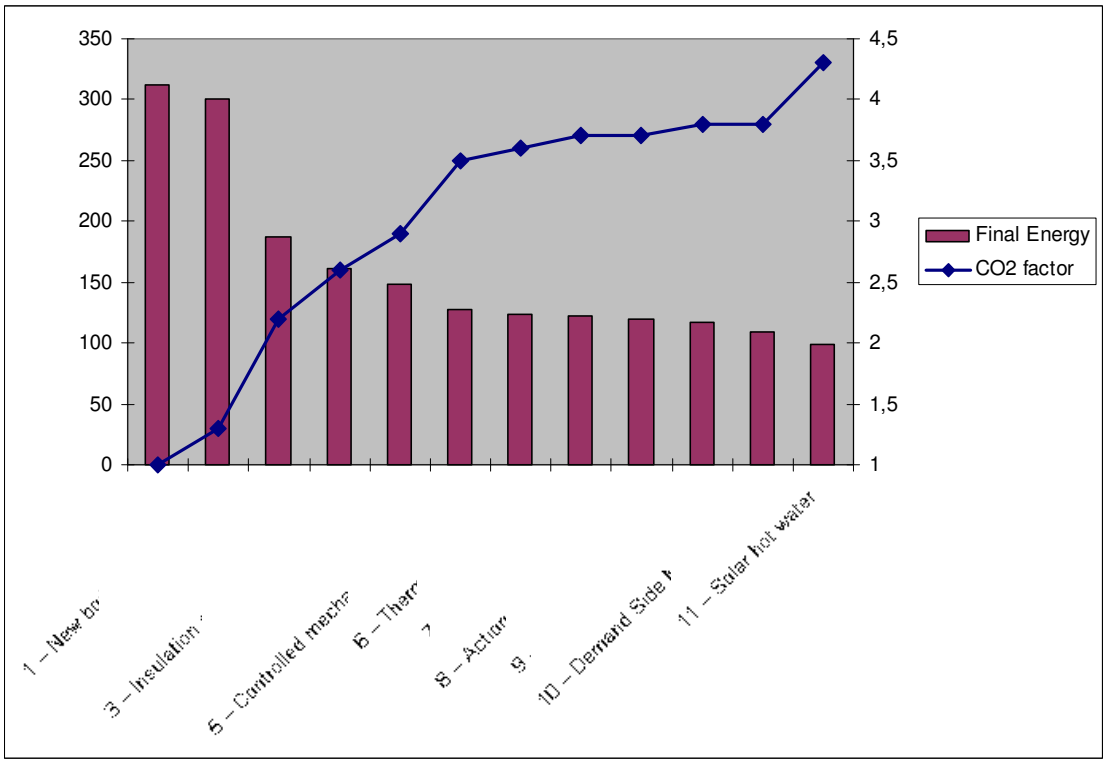
Bilan économique	**BENEFICE**		
	€ / m^2 - an	€ / logement - an	€ / projet - an
Investissement en € actualisés par an	7,43	460	26 207
Autres investissements incontournables ayant un impact énergétique	0,75	46	2 642
Maintenance annuelle		0	0
Economie d'énergie à prix de l'énergie constant (hors inflation)	-15,93	-985	-56 149
Hypothèse hausse des prix de l'énergie	-9,03	-558	-31 828
Bilan net en € net actualisés par m^2	**-16,77**	**-1037**	**-59 128**

Evolution of the heating and hot water energy consumption for the Factor 4 scenario



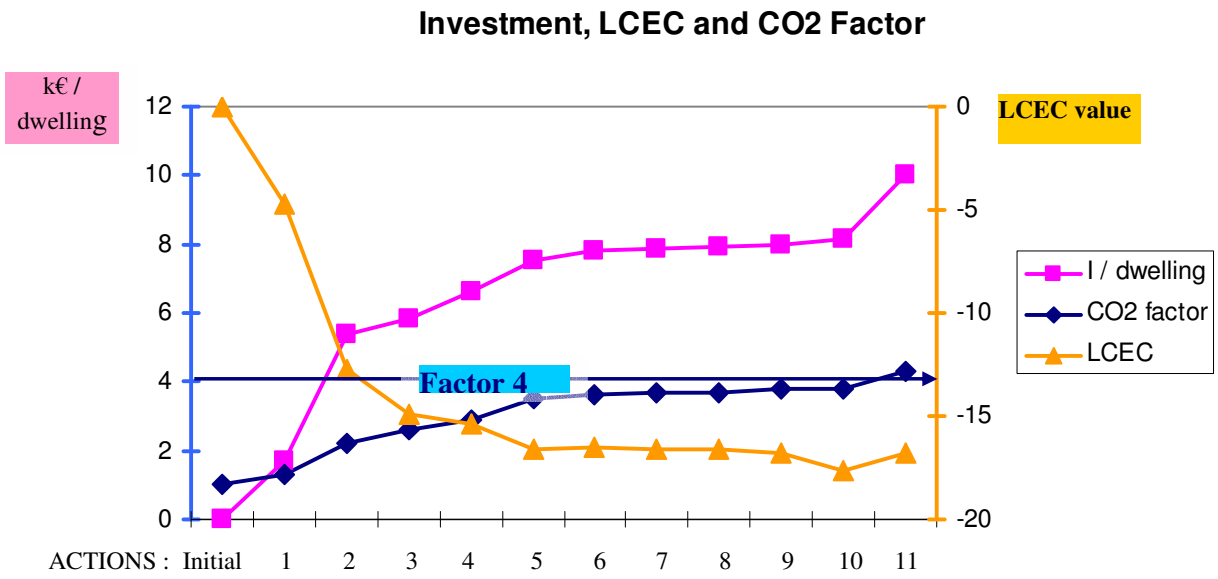
Source La Calade for Factor 4

Evolution of the final energy consumption and impact on the CO_2 factor
With the Factor 4 scenario



Source La Calade for Factor 4

Evolution of the profitability (LCEC), investment and CO_2 factor with the Factor 4 scenario



Source La Calade for Factor 4

This chart shows the impacts of the scenario on the CO2 factor : 4.3 as an issue of 11 technology actions.

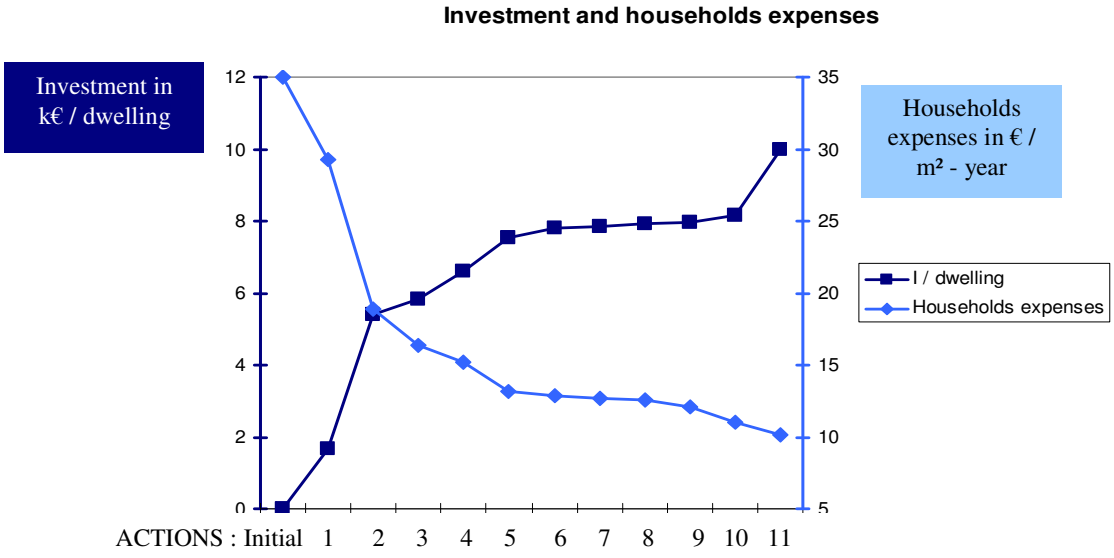
The investment is equal to 10 k€ and the LCEC reaches a benefit of 16.8 € / m² - year.

The chart can show that the profitability of the project (LCEC) reaches an optimum for the actions going from 5 to 10.

From the action 11 (solar hot water), the profitability of the project decreases with a strong increase of the investment cost (this is a calculation without subsidy).

The investment costs includes several steps : 6 300 € for actions 1, 2 and 5 is a necessity; 7 500 € makes it possible to be near to the economic optimum; 8 200 € is the investment amount which reaches the economic optimum.

We can compare this result with the evolution of the charges for the households (without investment cost included neither rent increase).



So the results can be those ones:

- The level of expenses reached after the action 6 is close of the economc optimum for the households. The carrying out of the 10 actions (upon 11 maximum) makes it possible to give a very strong reduction of charges for households whereas the investment is still limited about 8 000 € per dwelling. This scenario could an optimum which makes it possible to reach CO_2 factor equal to 3.8.
- The LCEC analysis shows that the investment cost for actions 1 to 10 is equal to 8 150 € / dwelling, i.e. a present net value of 6.4 € / m² - year.
- Even if the amortizing conditions are not exactly the same that the NPV calculation, we can estimate that the potential rent increase could be about less than 0.6 € / month.
- In the same time, the energy savings without price effect (increase of the gas price) is 15 € / year i.e.approximately 1.2 € per month.
- The integration of solar hot water can benefit of subsidies. In this case, the project can be also profitable with an improvement of the final CO_2 factor !!

4. CASE STUDY LA CARAVELLE, SAGECO

Source SAGECO

This building is similar to two other buildings. The three buildings form « La Caravelle » and represent a total of 1 800 dwellings.

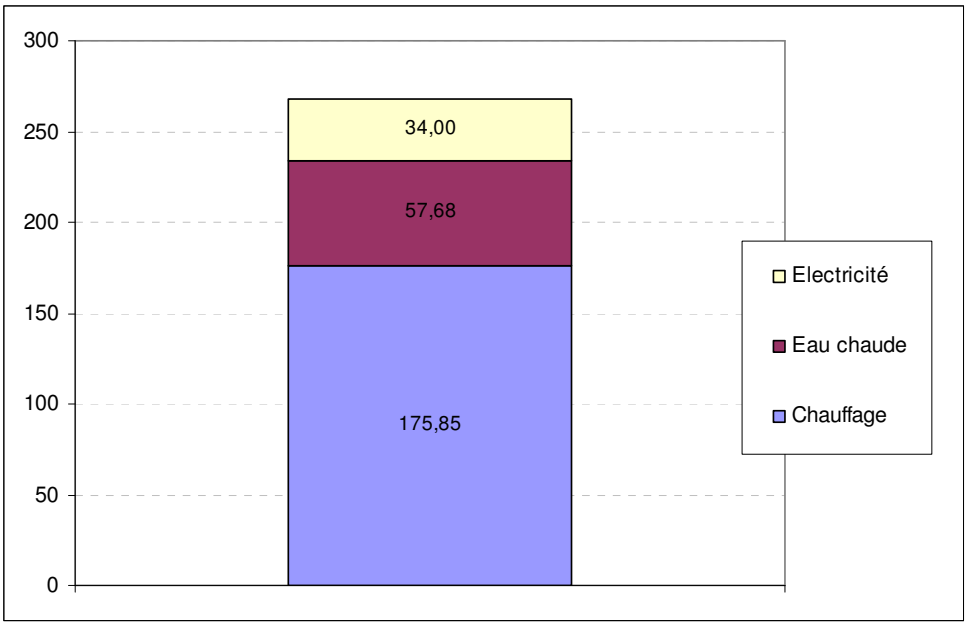
Building presentation according to the Factor 4 typology

Building name	La Caravelle
Type of building Number of dwellingsd Liveable surface	Multi-family housing, 10 levels, 23 stairs 658 41 321 m²
Climatic area	H1
Construction date	1966, retrofitted strated in 1999
Heating system	Collective central heating with natural gaz
Location in a neighbourhood with social and economic problems	No
City	Villeneuve-la-Garenne
Description	The dwellings are lighty, they have space enough and they are well adapted. There are shops and equipments in the near surroundings

2.1. Energy consumption

The energy consumption has been assessed with the SEC model and compared with the real energy consumptions of the building (data provided by SAGECO).

The energy consumption of La Caravelle, Villeneuve-la-Garenne



Source La Calade pour Factor 4

Note : The energy consumption has been calculated with the final version of the SEC model (and so there are some differencies with the version described in the Deliverable 9).

Energy consumption and CO_2 emission with the their labelling

Final energy consumption : heating & SHW - kWh / m²

	233
Heating	175
Sanitary Hot Water	58

Primary energy – heating & SHW - kWhp/m² – year

	259	E

CO2 emission – heating & SHW - kg CO_2 / m²

	55	E

Electricity in kWh / m²	34

Résults - La Caravelle	For 1 m²	For 1 dwelling	For the building
Annual energy consumption in kWh	267	16 800	11 055 000
Primary energy consumption in kWh	347	21 800	14 336 000
CO_2 emissions in kg	56	3 500	2 314 000
Dépenses énergétiques annuelles en €	18	1 140	751 400

Source La Calade for Factor 4

2.2. The energy savings strategy towards the factor 4

The energy balance indicates a very high level of energy consumption for sanitary hot water. The system is absolutely not efficient.

The actions carried out for reaching the CO_2 Factor 4 are the following ones:

1 – Insulation of façades : 200 mm external insulation of the entire façade will reduce the thermal losses. This action is an obligation for reaching the CO_2 factor 4 *

2 – The energy balance indicates a very high level of energy consumption for sanitary hot water; the system is absolutely not efficient : Pipe insulation of hot water distribution, remplacement of accumulation system by semi instantaneous system, installation of individual meters *

3 – Insulation of basement floor (100 mm); the basement is unheated and the insulation will reduce the transmission losses from the dwellings to the basement *

4 – Actions to save hot water : the reduction of water consumption (new taps) makes it possible to reduce the needs of hot water *

5 – Controlled mechanical ventilation : installation of a CMV with hygro regulation *

6 – Balance between distribution : this action is necessary for a better management of the boilers

7 – Thermostatic valves in all the dwellings *

8 – Energy savings through tenants behaviour : information and training of residents in order to support an energy savings strategy

9 – Solar hot water : installation on the roof of a collective solar hot water which reduces the energy consumption for hot water by 37.5 %

10 – Very low energy windows : in this case, th e U-value of the new windows is only 1.1 W/m² - °C

11 – Energy efficient lighting : supply of low energy consumption lamps to households (about 4 lamps per dwelling)

12 – Demand side management of electricity in the dwelling : training of residents, incentive to purchase hard white goods with the grade A or A+, awareness to close audiovisual equipment

13 – Electricity saving in the common spaces of the building : low energy consumption lamps to light the common spaces and variable speed motor for the lifts *

14 – Installation of a condensing boiler *

* : foreseen by the social owner in its rehabilitation project

This list has been detremined towards a factor 4objective.

The impacts on the energy, CO_2 and economic balances are presented in the following table and schemas

Evolution of the energy, CO_2 and economic balances with actions towards the factor 4

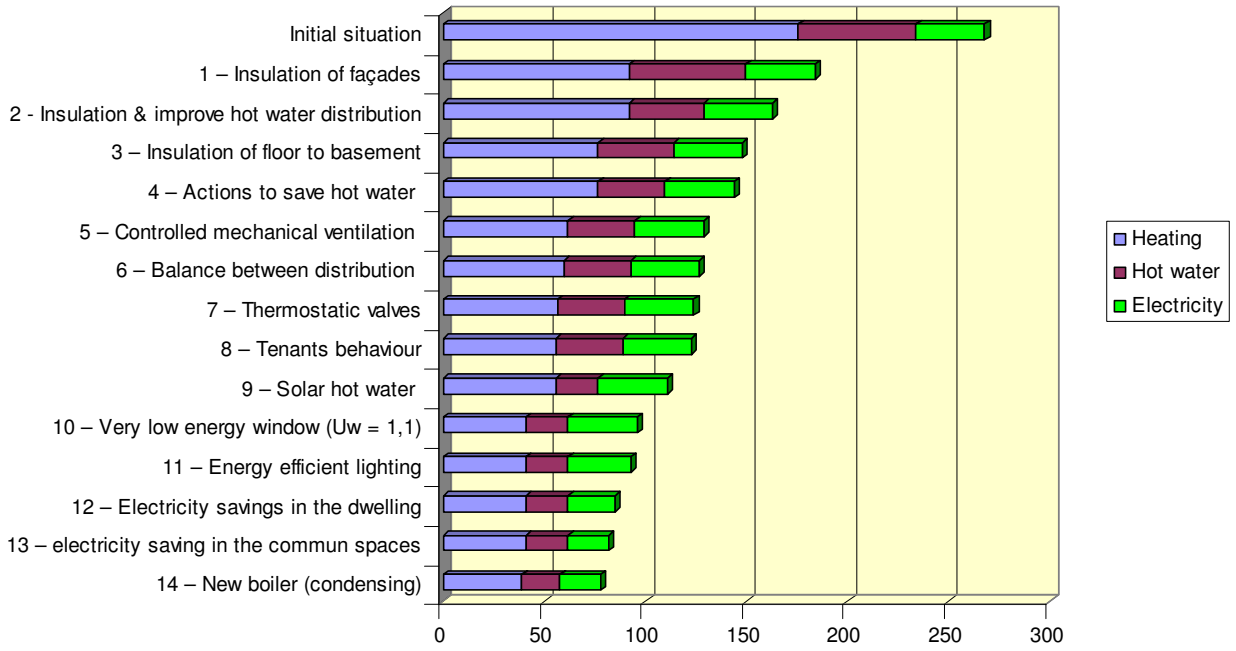
Actions	Unit	initial	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Energy primary	kWh / m²	347	253	231	214	210	193	191	188	186	173	156	149	129	120	115
Final energy	kWh / m²	267	183	163	148	144	129	127	124	123	111	96	93	85	82	78
Heating	kWh / m²	176	92	92	77	77	62	60	57	56	56	41	41	41	41	39
Hot water	kWh / m²	58	58	37	37	33	33	33	33	33	21	21	21	21	21	19
Electricity	kWh / m²	34	34	34	34	34	34	34	34	34	34	34	31	23	20	20
CO_2 emission	kg CO_2 / m²	56	36	32	28	27	24	23	23	22	19	16	16	15	15	14.4
Residents charges *	€ / m²	26.5	19	17	15.5	15	14	13.5	13	13	12	11	10	9	8.6	8.2
Investment	€ / dwelling	0	3 678	4 145	4 354	4 417	5 359	5 547	5 798	5 861	7 745	11 827	11 890	12 059	12 254	13 950
CO_2 FACTOR		1	1.5	1.8	2	2.1	2.4	2.4	2.5	2.5	2.9	3.5	3.6	3.6	3.7	3.9
Pay back period **	years	-	8	7	6	6	7	7	7	7	8	12	12	11	11	12
LCEC	€ / m² - year	0	-5.5	-6.9	-8.1	-8.4	-9.0	-8.9	-8.8	-8.8	-8.1	-7.0	-7.2	-8.0	-8.3	-7.6
Energy labelling	E	D	C	C	C	C	C	C	C	C	B	B	B	B	B	B
CO2 labelling	E	D	D	D	D	D	D	D	D	D	C	C	C	C	C	C

* : the expense is a net present value of the expense, including the forecast of energy prices evolution

** : the pay back return includes the forecast of energy prices evolution

Source La Calade for Factor 4

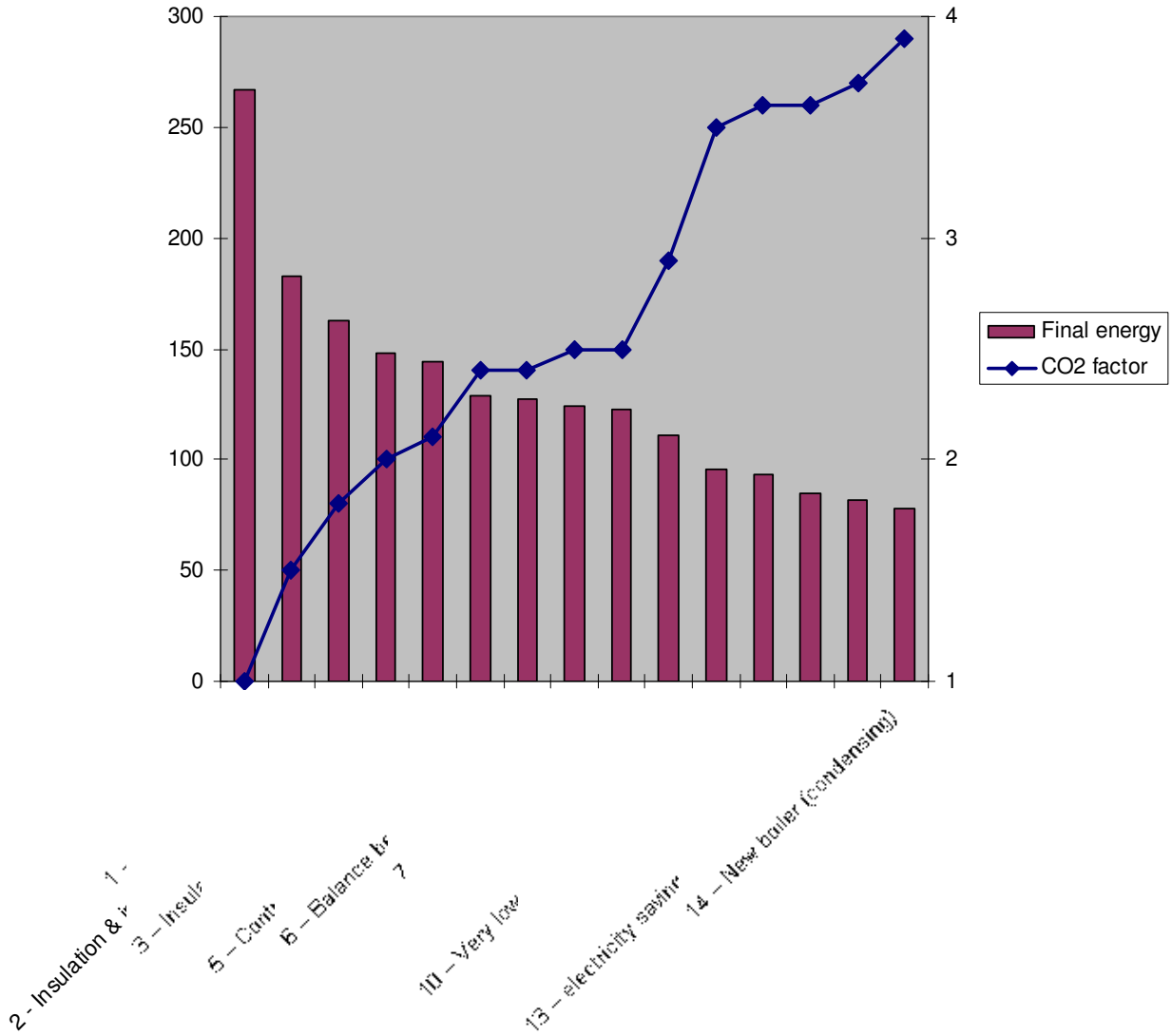
Evolution of the heating and hot water energy consumption in regards to the scenario



Source La Calade for Factor 4

- <u>The energy and CO2 emissions optima</u>

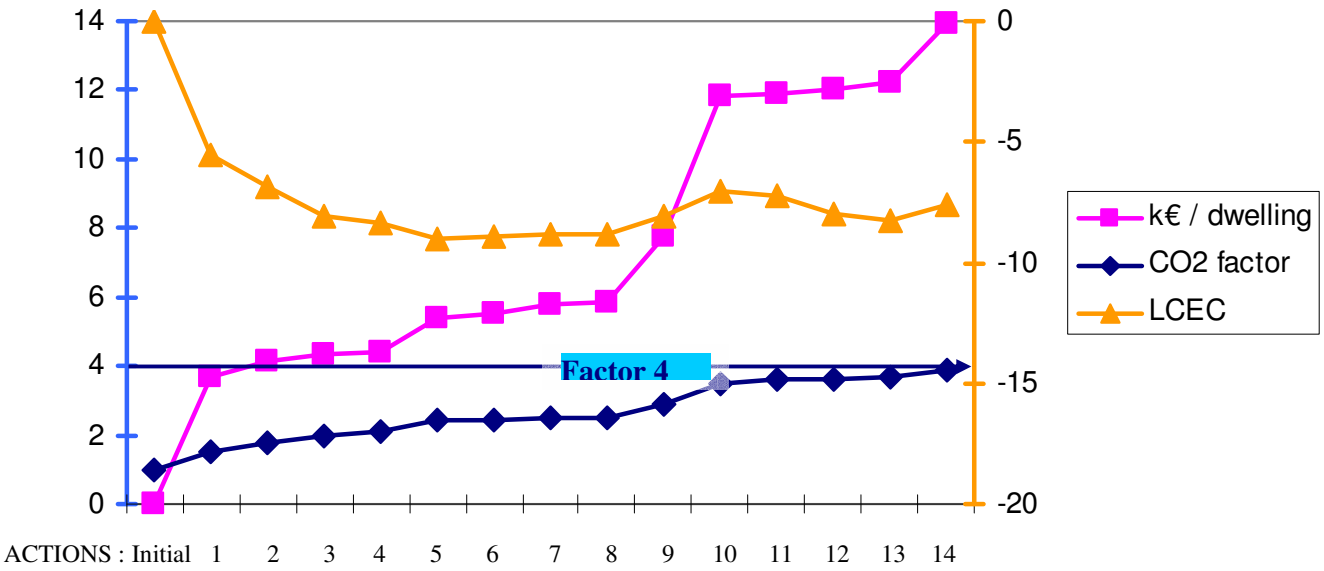
Evolution of the final energy consumption and impact on the CO_2 factor



Source La Calade for Factor 4

So at least, the profitability can be estimated as follows:

Profitability, investment and CO_2 factor



Source La Calade for Factor 4

This chart shows the impacts of the scenario on **the CO_2 factor : 3.9** as an issue of 14 technology actions.

The investment is close to 14 k€ and the LCEC reaches a benefit of 7.6 € / m² - year.

The chart can show that **the profitability of the project (LCEC) reaches an optimum for the actions going from 5 to 8**.

From the actions 9 (solar hot water) and 10 (very low energy windows), the profitability of the project decreases with a strong increase of the investment cost (this is a calculation without subsidy) but the CO2 impact is important : the CO2 factor goes from 2.5 up to 3.5.

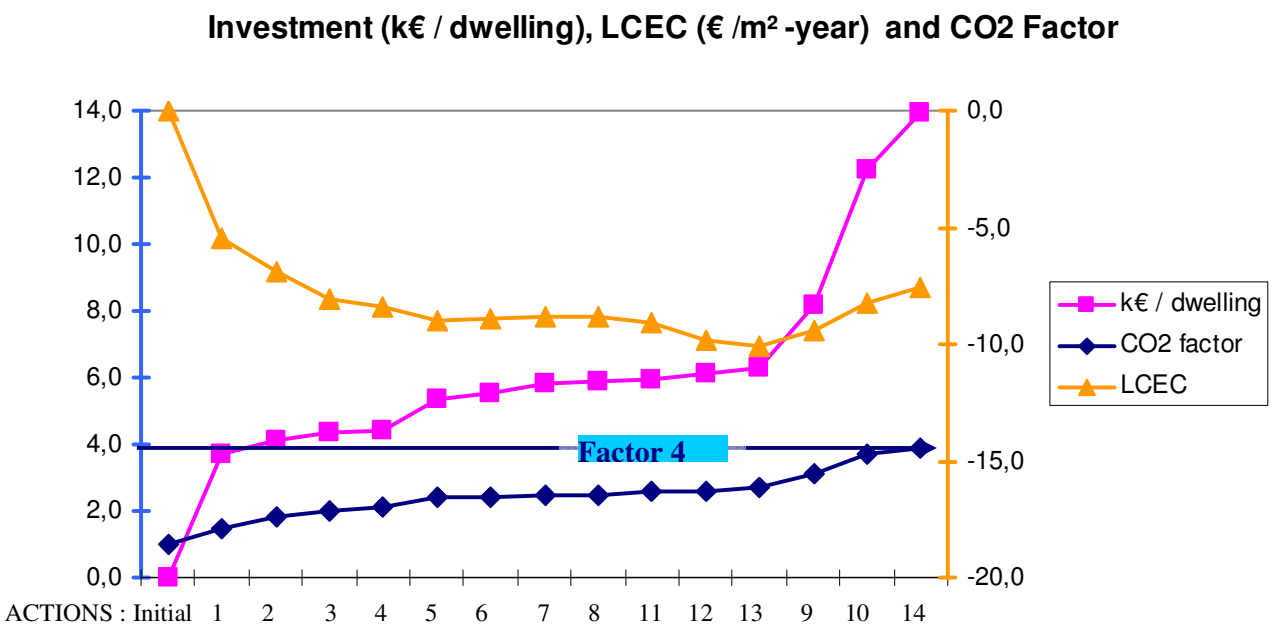
The actions on electricity demand improves the economic balance with only a slight effect on the CO2 factor. The impact of these actions is important fot the households : their direct expenses decrease by 2 euro / m² - year.

The action 14 consists in changing the boiler by a condensing boiler. This is foreseen by the social owner in order to reduce the energy consumption by about 7 %. But the cost is relatively high.

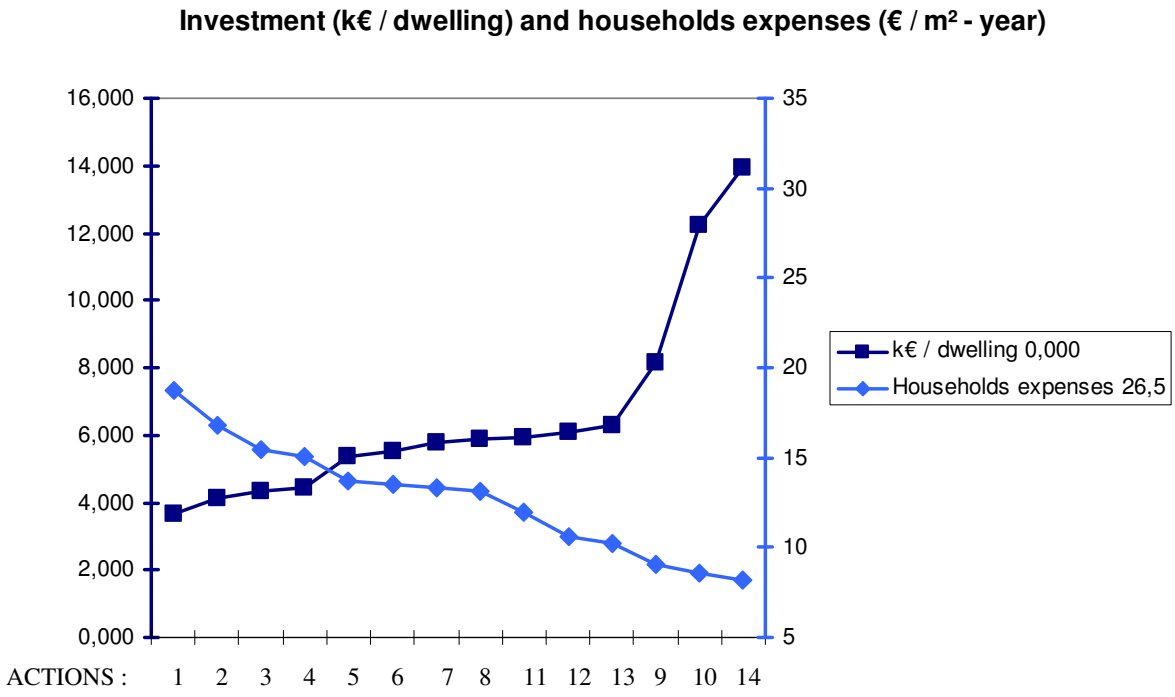
- <u>The economical and social optimum as regarding investments and households expenses</u>

We can compare this result with the evolution of the charges for the households (without investment cost included neither rent increase). Compared to low energy windows and solar hot water, the electricity savings investments are much less expansive for a similar result for households. **The factor 3 + actions for electricity savings are may be the economic optimum for this building.**

Profitability, investment and CO_2 factor with optimisation of the electicity demand



Source La Calade for Factor 4



Source La Calade for Factor 4

Final balance

	AVANT	APRES	Economie en %
Résultats en ratios unitaires			
Consommation d'énergie annuelle en kWh par m^2	267,5	77,7	71%
dont chauffage	176	39	78%
eau chaude sanitaire	57,7	18,7	68%
électricité parties communes	8,0	4,5	44%
électricité logements	26	15	42%
Consommation d'énergie primaire en kWh par m^2	346,9	115,1	67%
dont chauffage et ECS	259,2	64,4	
Emission de CO_2 en kg par m^2	56,0	14,4	74%
dont chauffage et ECS	54,6	13,6	
Dépenses énergétiques annuelles en € par m^2	26,5	8,2	69%
Dépenses énergétiques /an hors effet prix énergie	18,2	6,1	66%

B

C

Résultats par logement		
Consommation d'énergie annuelle en kWh par an	16 801	4 879
Consommation d'énergie primaire en kWh par an	21 787	7 230
Emission de CO_2 en tonnes par an	3,5	0,9
Dépenses énergétiques annuelles en € par an	1 667	515
Résultats pour le(s) bâtiment(s)		
Consommation d'énergie annuelle en MWh	11 055	3 210
Consommation d'énergie primaire en MWh	14 336	4 757
Emission de CO_2 en tonnes CO_2 par an	2 314	594
Dépenses énergétiques annuelles en € par an	1 096 867	338 924

Investissement unitaire en € / m^2			
Chauffage	138,3333333		
Eau chaude sanitaire	37		
Electricité	6,8		
Total	**182,1333333**	**Temps de retour**	
Autres investissements incontournables ayant un impact énergétique	40	**10**	**12**

Investissement par logement en €		
Chauffage	8 687	
Eau chaude sanitaire	2 324	
Electricité	427	
Total	**11438**	
Autres investissements incontournables ayant un impact énergétique	**2 512**	**13950**

Investissement pour le(s) bâtiment(s) en €	
Chauffage	5 716 072
Eau chaude sanitaire	1 528 877
Electricité	280 983
Total	**7 525 931**
Autres investissements incontournables ayant un impact énergétique	1 652 840

Bilan économique	**BENEFICE**		
	€ / m^2 - an	€ / logement an	€ / projet - an
Investissement en € actualisés par an	9,20	578	380 304
Autres investissements incontournables ayant un impact énergétique	1,57	99	64 821
Maintenance annuelle		0	0
Economie d'énergie à prix de l'énergie constant (hors inflation)	-12,06	-757	-498 295
Hypothèse hausse des prix de l'énergie	-6,28	-395	-259 648
Bilan net en € net actualisés par m^2	**-7,57**	**-475**	**-312 817**

FACTEUR CO2	**3,9**

So, as a conclusion of the analysis, we can say that:

- The economic balance shows that the optimum investment would be 7 250 € per dwelling, i.e. a Net Present Value of 7 € / m² - year.
- Even if the LCEC analysis is not similar to the rent calculation, we can estimate that the increase of the rent could be at about 0.7 € per m² and per month.
- The present energy savings without energy price effect (expected increase of the gas and electricity prices) would be 10.4 € /m² , i.e. 0.9 € per m² and per month. The balance could be ensured without an increase of the couple rent + charges and by taking an insurance against the evolution of energy prices.

5. CONCLUSION

These 3 cases studies shows how the SEC model could be used as a decision aid tool as well as a management tool.

It allows to optimise the retrofitting programme as regarding 3 optima:

- an energy optimum,
- a CO_2 optimum
- a socioeconomic optimum (including investments as well as households expenses),

for a single building as well as for all the buildings in a neighbourghood or the whole building stock of a social owner.

So the SEC model can help within a sustainable development approach to:

- optimise a building retrofitting programme,
- manage the building stock or to work out a strategic management plan for the building stock of a social owner,
- manage a social housing strategy at a territorial scale.