Programme of actions towards a factor 4 in existing social housings in Europe

Factor 4 Brochure/Synthesis

Towards sustainable strategies for energy retrofitting of social housing building stocks and at territorial scales

SUSTAINABLE ENERGY EUROPE 2005-2008 Official Partner

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http://www.suden.org/Factor4

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Contents

Preliminary remarks on the Factor 4 European project itself

1. The overall budget for this project was only 675 200 € (with 50 % paid by the EACI) for 11 partners in 5 countries and an important research programme on life cycle energy cost (LCEC) analysis and the Factor 4 models elaboration. So this budget did not allowed to do all the tasks we would like to manage, especially for the Romanian partner because his budget was only up to 14 500 €.

2. The project duration was 30 months from the 1st of January 2006 to the 30 of June 2008

3. The coordinator was SUDEN (Sustainable Urban Development European Network), a non profit association whose objective is the promotion and implementation of sustainable development approaches at various territorial scales. **The scientific coordinator was La Calade**, a French small consultant company involved in various national and European research and demonstration projects as regarding methodological frameworks and assessment tools, especially as regarding energy, life cycle cost analysis and sustainable development.

4. **All the results are available free on the web site, except the Factor 4 models**. For the models, you have to contact the partners who have worked out the models (because their way of using is different according to the country):

- Cenergia for **ASCOT** in Denmark,
- ABITA or Ricerca & Progetto for **BREA** in Italy
- Volkswohnung for **VROM** in Germany
- La Calade for **SEC** in France

and in case of any other question, go to the web site www.suden.org/Factor4 or contact SUDEN: ccv@wanadoo.fr

5. **The Factor 4 approach and its Factor 4 model(s) is a first step for the partners involved in the project as well as for those (especially social owners and local authorities but also public administration) who want to set up sustainable energy strategies for their building stock (portfolio) and next steps are still needed** in order to reach the factor 4 European Union objective. We must go from best practices to best policies and set up sustainable or integrated strategies due to the use of the Factor 4 models and to the Factor 4 recommendations, for working out:

- building stocks management strategies including energy issues as well as socioeconomic ones by social owners,
- building stocks retrofitting strategies including energy issues as well as socioeconomic ones by local authorities at various territorial scales (city, region… and at the national scale).

At least this Factor 4 project deals only with social housing and the Factor 4 models have now to be adapted to single housing, to tertiary buildings and to public ones…

SUMMARY

This document is a synthetic presentation of the Factor results. It presents first **the objectives of the Factor 4 project** and then **its main result**, **which is**

the Factor 4 approach for setting up sustainable strategies for energy retrofitting of social housing portfolio (building stock) and for territorial strategies as regarding energy retrofitting of social housing.

The Factor 4 approach has 4 phases:

- a building typology for selecting representative buildings to analyse
- a building scale LCEC analysis for optimising the energy retrofitting programme of each representative building
- a building stock (portfolio of a social owner or all the social housings on a territory) analysis
- the sustainable energy retrofitting strategy for the whole building stock or for the whole territory.

At least we focus on the main barriers against energy retrofitting, against a LCEC analysis or against the European Union's factor 4 objective.

Recommendations for the attention of key decision makers (social owners, local authorities, national public agencies, public administration, banks…)

The numerous analyses of best practices and of business as usual retrofitting programmes managed in the Factor 4 project have shown that:

- there are many types of buildings and so various energy retrofitting solutions, **there is not any universal (technical) solution for energy retrofitting of buildings**,
- subsidies (or structural funds) should be allowed only to projects with a general interest,
- **the LCEC analysis is the most rational way for managing energy in buildings** because it includes also socioeconomic issues and the budget available, and especially for energy retrofitting of buildings.

And we can assess now that:

- **LCEC (such as the Factor 4 model) is an interesting complement to the EPBD, allowing to include the EPBD in a sustainable development approach towards urban sustainability,**
- **a LCEC analysis should be used for optimizing the efficiency of any investment, and especially in case of a public investment (or subsidies)**
- an evaluation as regarding the collective interest should be managed in case of public subsidies (before allowing them)[1]**.**

[1] See the recommendations in the chapter 11 of this Factor 4 Brochure and the deliverable 11

1. REMINDER ON THE ENERGY EUROPEAN POLICY TOWARDS A FACTOR 4

The Kyoto protocol has been signed in 1997 by 84 countries among which all the European countries. It fixes objectives to industrial countries in reducing CO_2 emissions and the main green effect gas (GES) reduction of an average of 5.2 % in 2010 as regarding 1990.

The European Union engaged herself in a 8 % reduction for the 2008-2012 period and each of the Member States got its own reduction quota as regarding the Kyoto protocol's article 4.

In most of the countries **a national programme has been set up and energy reducing as well as renewable energy use programmes have been set up**.

"The 2005 Review of the EU Sustainable Development Strategy: Stocktaking of Progress" (COM (2005) 37 final) has a Chapter 3 dealing with the Climate change and clean energy.

Measures for energy efficiency and Renewable energy sources are among the most important actions for getting the targets fixed in the Kyoto protocol, as written in the European Climatic Change Programme (ECCP) which is the key document for Europe. The Green Paper is also focussed on a rational use of energy.

The European Union objectives (Energy Pack January 2007) are :

- 20 % reduction of GEG before 2020 (base 1990)
- 20 % of renewable energy sources before 2020
- To reach the potential energy saving before 2020 (estimated at 20 % of the EU primary energy consumption per year).

At least the European energy policy is to reduce by a factor 4 energy consumption in European countries before 2030.

1.1. WHY A FACTOR 4 ?

Reminder of the main issues :

- **In order to keep the Planet temperature increase under 2°C** it is necessary to limit the CO_2 concentration increase (+ 1,5 % per year today at the Planet scale) in order to stay under 400 ppm in 2050 (368 in 2005)
- For that, GEG emissions resulting from human activities must go from 7 Gt carbon / year in 2005 to 3,5 GT C/year in 2050. In order to reach this factor 2 at the Planet scale, industrialised countries must reduce their emissions by a factor 4. This is the European Union engagement as well as the France one (POPE Law, 13 July 2005).
- For example for France, the reduction by a factor 4 means to go from 6,76 t CO_2 per year and per inhabitant in 1990 (6,65 t in 2005) to 1,44 t CO_2 in 2050. As this challenge is very important, some ones have suggested (Syrota report, September 2007) to respect a convergence principle at the EU scale : the overall European average must be reduced by a factor 4, which means that all the European GEG emissions would be under 2,2 t CO_2 per inhabitant in 2050. For France, the factor reduction would be a factor 2.6 instead of a factor 4, which seams much more realistic for some French people. But this means too that for Germany the factor 4 would become a factor 6…
- The reduction of GEG emissions by a factor 4 cannot be done only with an energy consumption reduction. Before 2050, we may hope that CO_2 picking up techniques will be improved, that new energy sources such as hydrogen or renewable energy (such as solar energy) will be improved, well known and much more used.
- And we cannot forget that:
  - the development of China, India and the other countries under development will be much more important and could be without any control,
  - deforestation can be much worse that it is…

So as regarding the precaution principle, we could say that **the challenge is to reach the factor 4 between 1990 and 2050… but perhaps only 2.6 in France as regarding energy consumption ?**

And, as regarding the factor 4 objective, we can raise some questions:

1. Is it for any of the EU member states ?
2. Is it for any activity sector (building, transport…) ?
3. Is it for both new and existing buildings ?

If now we focus on existing buildings, we must say that:

➢ **Buildings represent 40 % of the energy use in Europe and around 35 % of CO_2 emissions.**

So if we want to reach the Kyoto objectives and the targets fixed by each Member State in Europe, we need to work upon new buildings but also on existing ones and especially on all those which will still be in use in 2050.

In France 23 % of GEG emissions are coming from buildings and buildings are responsible for 40 % of final energy consumption.

In Denmark, the total energy consumption in the building sector represents 40 % of the total energy consumption (year 2008). The total energy consumption in household (space heating, domestic hot water and electricity for lighting and electrical appliances) was 189 PJ and it corresponds to 30 % of the total energy consumption in Denmark (year 2004). At least the CO_2 emission from household represents 22.9 % of the total emission in Denmark, and since 1990 the CO_2 emission has decreased by 35 %.

In Italy the residential sector represents 18% of the total energy consumption, and it is distributed as follows:

- 57% for heating
- 25% for domestic Hot Water
- 11% for electric appliances
- 7% for cooking

The energy consumption of a traditional building of average quality is 150 kWh/m^2.year, while buildings constructed before the first energy consumption Building Regulation (Law n° 373 1973), which include roughly 17,5 million houses, have an energy consumption of 250 kWh/m^2.year (source: ENEA). At least the residential sector contributes to the total national CO_2 emissions with a share of 17%.

➢ **The demolition and construction ratios have an impact on the results**:

For example foe France:

- if we take into account the demolition ratio (0,2 % per year) and the construction ratio (1 % per year) observed until 2005 and if there is not any energy substitution policy, fossil energy and thermal electricity consumption in residential buildings should be reduced with a factor 3.5 and allow us to reach the factor 4 for the whole housing sector.

- if we take higher hypotheses for demolition and construction (1,6 % in 2007) in France, the CO_2 factor would be for existing housing only up to 2,8 to 3.

So the factor 4 must be considered as a signal, an objective to reach but also a challenge: a technological, economic and social challenge and not only an environmental or ecological one.

➢ **The social housing sector** is often the easiest to aware because it uses public subsidies and it is structured in strong networks and, at least, because some owners have an important number of buildings.

So if we show what is possible for social owners, this should be an example too for **the private sector** as well as for **public administration**.

The awareness of tenants and inhabitants as well as socio-economic actors should also help towards energy efficiency, GEG reduction and sustainability.

1.2. WHY THE FACTOR 4 PROJECT ?

It seems to be impossible to reach the European factor 4 if we focus only on energy issues and if we do business as usual, even with some best practices. We must deal with the whole existing building stock. So each social owner must deal with his whole portfolio and each municipality with its territory

For example in France:

- ❖ The French Syrota report conclusions are:
  - For the mid term, if we go on as we do up to now, we will not be able to reach the European objectives in 2020.
  - The available or potential techniques should allow to get a 20 % reduction of CO_2 emissions in 2020 and to reach a factor 2.1 to 2.4 (without taking into account CO_2 captation nor its stockage) in 2050... which is not enough…
- ❖ The « Grenelle » Law I project

A national debate with a lot of working groups and various communications in the media was held in France in 2007 and a law is now becoming. But the content of this new law is 800 000 social housing dwellings to retrofit before 2020 with energy saving, going from more than 230 kWhpe/m² with an E, F or G labelling to a C labelling (< 150 kWhpe / m²)[2], with national public subsidies up to 2 500 € per dwelling. If so the median consumption of the social housing building stock would go from 170 to 150 kWh / m², which means only **12 % energy saving...**

The success of the European policy will be obtained only if we can manage win-win strategies and if we take into account all the problems and objectives of each category of actors, including the lack of enable budget. So we need sustainable development approaches (dealing together with environment, economic and social issues) in order to reach the factor 4 objective (and the 3x20 European objectives) and this is the purpose of the Factor 4 project.

1.2.1. Environmental and ecological issues

Environmental (energy) or ecological (GEG emissions) issues/objectives are well known and we already mentioned them. But, if these issues are very important, we think that policies or strategies cannot deal only with these objectives or issues (as it is too often the case for research policies or public subsidies at the European level as well as at each national level).

1.2.2. Economic issues

The main objective of social owners is to provide housing with both a good technical quality and an affordable price in order to make families able to pay for it. So economic issues are always in the back ground of any social housing project.

But if economic issues are often focussing on the pay back return, the optimisation of the use of a budget (for all the concerned actors) is not so often an obvious objective shared by all the actors involved in the project..

And, **up to now, it seems that there was not any Life Cycle Energy Cost analysis linked to the EPBD implementation in order to deal with the EPBD inside a sustainable development approach.**

At least, we have to mention one socio economic environmental issue becoming up to date in public national or European researchers: energy precariousness. Some researches (including one of the SAVE projects supported by the Executive Agency for Competitiveness & Innovation) deal now with this important issue. And the LCC approach is also a good tool for reducing energy precariousness.

[2] pe = primary energy

1.2.3. Social issues and fuel poverty

The emergence of social ghettos in some neighbourhoods and the degradation of housing condominiums after privatization of the public housing stock in countries in transition, are two examples of the need for new approaches for social housing which meet sustainable development objectives (including for example social cohesion and citizens/inhabitants objectives).

Fuel poverty is defined in UK when a family spends more than 10 % of its income for heating its flat up to 18 or 21 °C (according to the type of rooms).

Poverty threshold (which is under 60 % of the median income) concerns more and more inhabitants (56 Millions of inhabitants in Europe in 2003) and especially in new Member states: according to Eurostats (2005), it concerns 3,9 Millions in Romania (18.2 % of the overall population: 21.604 Millions inhabitants).

This must be taken into account and we must keep in mind that a life cycle energy cost analysis can be an important tool for fighting against fuel poverty and energy precariousness.

1.2.4. Governance issue

Social housing governance deals with the relations among its four main groups of actors: public authorities, social housing providers, households and the private sector.

In the decentralization of competences in social housing policies and taking into account public participation and the need for public-private partnerships, governance is becoming a key issue in ensuring sustainability and effectiveness for answering the housing needs. The clear division of responsibilities among the actors including the financing, development, ownership and management of social housing estates is crucial.

And a Life Cycle Cost approach means also:

- a new way of working for many social owners because the various departments have to work together and to know and be aware of things managed by the various departments of their company (as regarding maintenance costs and life time of components for example),
- close partnerships with the various actors involved
- transparency including on costs and benefits… (which is one of the barriers for its better development…)
- a new way of working for the other actors, especially in public administration and banks.

1.2.5. The Factor 4 approach: a sustainable development approach

For all these reasons the results of the Factor 4 project should impact the energy demand policy and modify the use of energy as well as many actors behaviour as regarding energy management and control.

The Factor 4 project's objective is to deal with all these issues together within a sustainable development approach based on a Life Cycle Energy Cost analysis.

2. THE FACTOR 4 EUROPEAN PROJECT OBJECTIVES, CONTENT AND RESULTS (THE FACTOR 4 APPROACH)

This Factor 4 Brochure underlines the interest of the life cycle energy cost analysis and gives the main results of the Factor 4 research and demonstration works (specifying also where additional information is available, in which deliverables).

2.1. THE FACTOR 4 PROJECT'S 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 by a minimum of 30 % in a short term and more in a long term 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 project aims at:

- working out innovative solutions (including their test) for energy retrofitting,
- providing technical and economic information for social owners but also for their financial partners, for tenants and (small) local professionals on energy efficient techniques,
- facilitating the dialogue between social owners and their financial partners,
- the promotion of the initial diagnosis of all the buildings (of a social owner) through their representative types in order to set up an energy retrofitting strategy for their whole portfolio (building stock),
- the dissemination and larger use of the life cycle (energy) cost analysis,
- the promotion of territorial regulation in order to get adapted ones at the neighbourhood scale as well as at the project scale.

The Factor 4 project's main objective is to help social owners to set up sustainable energy retrofitting strategies for their whole building stock taking into account energy savings and the reduction of greenhouse effect gas (GEG) emissions towards a factor 4 according to the European policy which is to cut by 4 GEG emissions before 2050.

And, a the life cycle energy cost analysis allows to set out sustainable strategies because it allows to deal together with energy savings, the reduction of GEG emissions and socio economic issues such as the pay back return for social owners and the reduction of charges for tenants, the Factor 4 project is focussed on the life cycle energy cost analysis.

2.2. THE FACTOR 4 APPROACH

The first question to deal with is how to reach the factor 4 level[3] ? With which technical and economic means?

These questions are for any social owner as regarding his whole building stock but also for any territorial approach: for a neighbourhood (inside a neighbourhood regeneration project) as well as for a city, a region or for the whole national social housing building stock (id est for setting up a national strategy).

For answering this question, we made:

- **a state of the art as regarding the existing tools and models** (cf. deliverable 5)[4] in order to be sure that there was not any existing tool able to help us to reach our objectives,
- **the social housing typology** in each country,
- **a best practice analysis** in each country,

[3] Reaching the factor 4 means to divide CO_2 emissions by 4 after retrofitting works.

[4] And the French deliverable 10

- **a Factor 4 model** and, after some tests, operational national Factor 4 versions adapted to each national context (including technological and economical issues),
- **a barrier analysis** in each country and at the European level

and we built up **the Factor 4 methodology or approach** (see also the following chapter 2.3):

The Factor 4 approach is made of the following phases:

- **a building typology** for selecting the representative buildings of the building stock (Phase 1)
- the analysis of each of the representative buildings and the optimisation of their energy retrofitting programme with the life cycle energy cost model (Phase 2: **the building scale analysis**)
- **the life cycle cost analysis at the whole building stock scale** (Phase 3)
- the setting of **the building stock sustainable energy strategy for the whole building stock** identifying the optimised retrofitting programme for each building and with at least

    the selection of retrofitting works at once and others later on according to the financial possibilities

    an estimation of the budget or subsidies needed

    the reduction of charges for tenants.

The Factor 4 approach is for various actors:

- **for social owners** for setting up strategies for their buildings and their whole building stock
- **for local authorities and public administration** for territorial strategies: for identifying the needed level of subsidies for social owners, for setting regulation or rules, for regeneration projects at the neighbourhood or city scale, etc.
- **for banks** for defining financial rules
- **for building companies and industrial** in order to better know and so to anticipate the future development of technologies, which brings a better local know how and competitiveness.

2.2.1. Phase 1: Building typology, estimation of the factor 4 challenge (reduction of energy consumption and CO_2 emission) and selection of representative building types

The building typology was the first task inside the Factor 4 project (deliverable 3).

Then we analysed the main issues as regarding **social housing energy consumption and CO_2 emissions** and so we estimated what is the challenge, what has to be done in each country in order to reach the factor 4 (deliverable 4).

At least we identified **representative building types which will still be in use in 2030 - 2050** in order to analyse them in the further steps of the Factor 4 project (deliverable 4).

Remark:

This building typology for the selection of representative buildings is the first step of each Factor 4 approach and can be done for the whole building stock of a social owner or for an area such as a neighbourhood, a city or a region.

2.2.2. Phase 2: The building scale analysis

Many energy analyses have been done during the project (and first for the validation and finalisation of the Factor 4 models) and many others will still be done later on with the factor 4 models.

Some of these analyses are shown in the deliverable 7 (before the CO_2 optimisation of the retrofitting programme which are often considered as best practices) and in the deliverable 9 (where best practices were analysed) and in the deliverable 10 as well as in the Annex 1 with some results of the optimisation combining environmental (energy), ecological (CO_2) and socioeconomic issues.

- **A/ The energy analysis with the Factor 4 model**

The energy analysis is based on data if they are available or on estimations given by some versions of the Factor 4 model (such as the French SEC model) if not.

This analysis gives energy consumption and CO_2 emissions and it gives also the energy and CO_2 labelling.

- **B/ Best practice analysis for the Factor 4 model validation**

In order to validate the Factor 4 model, many case studies were analysed and especially best practices in each country.

Usual best practices are presented in the deliverable 9 (in national languages) and some examples of retrofitting programmes going until the factor 4 are presented in the deliverable 7 (in English).

- **C/ The optimisation of each representative building retrofitting programme**

The project focussed first on solutions for an optimisation of the energy retrofitting programme for each social housing representative building and on short, mid and long term solutions for reaching the factor 4.

An optimisation can be done with only an ecological objective (the reduction of CO_2 emissions) or with a social one (the reduction of charges for renters) or with all the criteria/objectives together in a sustainable development objective (as shown in the figure in chapter 2.2.5 and in the appendix 1), which is the real aim of the Factor 4 approach

This overall optimisation follows the Factor 4 methodology or approach described in the 2.3. chapter.

2.2.3. Phase 3: The building stock analysis (on a territory or for a social owner)

The analysis was done (and can be done):

- **at the neighbourhood scale** with the example of a project inside the French national neighbourhood regeneration managed by the National Agency ANRU (in the French deliverables 9 and 10 for example),
- **for the building stock of a social owner** (for the French social owner SAGECO for example as shown during the final conference[5]),
- **for the whole national building stock** with elements for setting up a national strategy towards sustainability (as shown in the French deliverable 10 for example).

These numerous cases studies managed in each country allow us to suggest elements for setting up a national strategy as well as other territorial strategies and show to social owners and to local authorities the way for setting up their own strategy for their whole existing building stock (portfolio).

2.2.4. Opportunities, incentive measures and barriers

Opportunities and incentive measures have been presented in the deliverable 10 with an important focus on the Italian example.

And as the barriers are not always the same in all the European countries, we analysed them in each of the Factor 4 countries as well as at the European level (deliverable 11) and we suggested some recommendations (in this Factor 4 Brochure in various national languages and during the final conference at the French ministry of Energy, Environment, Sustainable development and Land planning in Paris).

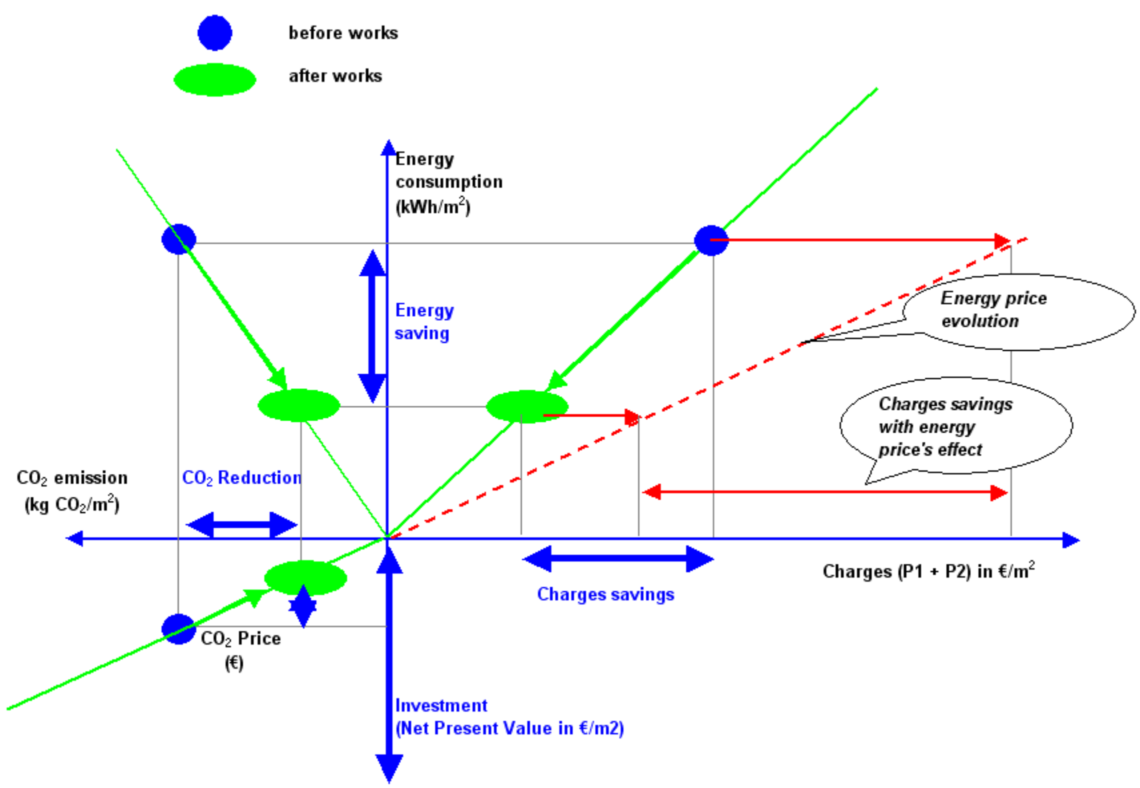
[5] the slides can be downloaded on the web www.suden.org/Factor4

2.2.5. The main result: the Factor 4 model and its operational national or regional versions

For reaching the factor 4, for such a deal, for managing both energy and life cycle energy cost analyses, the research partners worked out a specific Factor 4 model which is **a life cycle energy cost model with 3 types of optimum together**[6] (as shown in the following figure).

- **an environmental optimum**: an energy optimum (energy saving and use of renewable energy)
- **an ecological optimum**: an optimum as regarding the reduction of GEG emission (towards the factor 4 or more if possible)
- **a socio economic optimum** as regarding together the pay back return of investment for the social owner and the reduction of yearly charges for tenants. This socioeconomic optimum can be integrated at the building scale but also at the building stock scale: in any social owner's strategy or in any territorial strategy by giving priority to energy retrofitting programmes for poor people (tenants or in the private sector)

The sustainable (energy - CO_2 and socioeconomic) optimisation of a building retrofitting programme with the Factor 4 model



Source La Calade for Factor 4

The Factor 4 model allows to use various criteria (as shown in appendix 1) and to set up various scenarii as regarding hypotheses which can be modified if necessary (such as the energy price increase for example)[7] **and so it allows to choose the best strategy towards sustainability**. This best strategy is according to us the only possible way for reaching the factor 4 objective, especially when

[6] which is the characteristic of a sustainable development approach

[7] These hypotheses must be discussed and validated in a working group gathering all the actors and especially public and financial ones

money is missing (which is almost always the case but which is much more under pressure during financial crises).

These simulations allow to:

- choose the buildings which should be demolished and those to retrofit, to identify the buildings which should have the most important retrofitting programme, in the building stock of a single social owner or on a territory such as a neighbourhood when there is a regeneration project (within a dialogue among all the actors of course),
- identify the priorities as regarding retrofitting works (including energy as a criteria among traditional ones such as social issues for example),
- facilitate the dialogue between social owners and local authorities as well as with their financial partners,
- facilitate the dialogue with tenants.

At least, in order to take into account the specificities as regarding techniques, regulation, incentive measures or taxes but also prices (which can be also different even inside one country),[8] specific operational versions of the Factor 4 model have been worked out

- in Denmark (the ASCOT model[9]),
- in France (the SEC model),
- in Germany (the VROM model)
- and in Italy (the BREA model).

Some other specificities can be noticed too: one of the main difference is the possibility for calculating the U value which is integrated in the French SEC model but has to be calculated before using the other versions of the Factor 4 model because they are needed for using these models.

The Factor 4 model is a life cycle energy cost model which can be used as **a decision aid tool for social owners, local authorities (municipalities but also regions for example) and their financial partners for setting up energy retrofitting sustainable strategies** (best strategies including some best practices).

This building stock scale for setting out territorial or building stock strategies is the most interesting interest of the factor 4 approach and of the factor 4 models.

[8] Cf. deliverables 5 et 7 and the Factor 4 Newsletter 2 in English and the deliverable 8 in national languages

[9] The Danish research partner improved the ASCOT model they had worked out for the HQE^{2}R approach for transforming existing neighbourhoods in sustainable neighbourhoods. (cf. www.suden.org and http://hqe2r.cstb.fr), because the ASCOT model was selected among all the existing tools (in the initial state of the art) as the best one for the purpose of the Factor 4 project (cf. the deliverable 5 in English or the deliverable 10 in French).

The main interests of the Factor 4 approach and of the Factor 4 models

The Factor 4 model is **a financial and economic complement of the conventional usual technical and energy (or now energy and CO_2) diagnoses which :**

- allows to integrate the EPBD directive inside an overall sustainable development approach,

- allows the optimisation of energy retrofitting programmes and the setting up of sustainable energy retrofitting strategies (as regarding energy, CO_2 and a socioeconomic optimum[10]) and so a realistic approach which takes into account the budget available (of tenants, of social owners, of municipalities…) in order to optimise its impact or efficiency as regarding the general interest,

- allows to take into account electricity consumptions of dwellings which are not integrated in the EPBD and which are never considered by social owners up to now (even if they are important charges for tenants, sometimes more important that the rent for which there are public subsidies),

- allows to take into account the energy risk (through energy prices increase),

- is a decision aid tool for social owners as regarding their the whole building stock and for local authorities in order to set up overall sustainable strategies for existing social housing and to define when and where subsidies or incentive measures will be the most efficient and needed,

- is a decision aid tool for public agencies or banks in the definition of selection criteria for public subsidies,

- allows to take energy into account in any strategic management plan (of social owners) as well as in any urban project (by local authorities, urban planners…),

- helps social owners in improving their dialogue with their financial local and national partners,

- is rather easy to use by social owners themselves[11] as well as by the other actors involved (public administration and local authorities),

- and at least it can help local authorities to set up local energy management strategies and moreover **to set up local urban development strategies including energy at various territorial scales (neighbourhood, city, conurbation, region…) towards urban sustainability**, id est:

- to reduce energy precariousness,
- to be active as regarding the 3x20 European objectives and especially the factor 4,
- to guaranty the best efficiency of public subsidies or investments,
- to improve the synergy and coherence between energy policies with social ones, between energy European programmes (DG TREN, EACI and DG Research) and those from the DG Regio (structural funds) for example
- etc.

These various issues or themes are illustrated and developed in the various deliverables available on the web site and listed in the appendix.

The technologies managed at the end of the project by the various versions of the Factor 4 model are shown in the table on the next page. Each version can still be modified according to the national or to local needs and so the energy efficient technologies data base (deliverable 6) in the first version of the European data base and will be up dated in each country according to the needs and to the innovative technologies which will come on the markets..

[10] including the pay back return and the reduction of charges for tenants

[11] But for a universal "secured" use of the model, a specific software should be worked out in order to avoid errors by adding data in the model

List of the energy saving technologies included in each version of the Factor 4 model

ASCOT	BREA	SEC	VROM	TECHNOLOGIES	NB[12]
				Heating	
√	√	√	√	Controlled mechanical ventilation (including ventilation with heat recovery)	H 1
	√	√		Thermo-hydraulic balancing	H 2
	√	√		Individual meters	H 3
√			√	Air tightness	H 4
√	√	√		Tenants behaviour	H 5
√	√	√	√	Additional thermal insulation of walls	H 6
√	√	√	√	Additional thermal insulation of floor	H 7
√	√	√	√	Additional thermal insulation of roof	H 8
√	√	√	√	Cold bridges reduction	H 9
√	√	√	√	Windows renovation	H 10
√	√	√		Passive solar heat design	H 11
√	√	√	√	Boilers / new heating system including CHP	H 12
√	√	√		Building energy management systems (BEMS)	H 13
√	√	√		Thermostatic valves	H 14
	√	√		Heat pumps	H 15
√	√	√		Pipes insulation	H 16
				Sanitary Hot Water	
	√	√		Individual meters	W 1
√	√	√		Solar heater water	W 2
√	√	√		Hot water distribution lagging (insulation)	W 3
	√	√		Hot Water loop / New hot water tank with semi instantaneous system	W 4
√	√	√		Hot Water taps / Energy savings through water saving	W 5
				Electricity	
√	√	√		Low energy consumption lamps	E 1
√	√			Electricity savings through ventilation	E 2
	√	√		Regulation of circulation pumps of individual boilers	E 3
√	√	√		Tenants behaviour	E 4
√	√	√		Hard white goods : grade A or A+	E 5
	√	√		Closing audiovisual and electric equipment	E 6
√	√			Daylight optimisation	E 7
√	√			PV panels	E 8
√	√			Roofed clothes drying yards	E 9
	√	√		Collective laundry	E 10

Remark: This is a fist list of technologies. The Factor 4 models will be improved when used by social owners or local authorities and additional technologies will be taken into account in the further versions of the models (to be yearly up dated)

[12] Number of the technology sheet

2.3. THE FACTOR 4 APPROACH AND ITS MAIN ISSUES

2.3.1. An improvement of the data available and of the way of working

First of all we must notice that:

- **energy statistics are very poor**, even in social housing where there are social owners with important building stocks,
- **the available building typologies in social housing are most often according first to their location and then to the construction date.** There are poor data on the technologies used and most often not any correlation with socioeconomic data on tenants (incomes level for example),
- **socio-economic data and statistics are very few (poor)** and most often they are not taken into account by social owners as well as by local authorities when some choices have to be done - in the selection of buildings to demolish or to retrofit, in the selection of the retrofitting programmes (how far to retrofit, which energy and CO_2 objectives) as well as in the selection of the various levels of subsidies with their attribution criteria),
- **energy experts always want to go as further as possible as regarding energy savings (and CO_2 reduction),** without any economic or efficiency analysis (as regarding the general interest),
- **social policies and renewal projects in neighbourhoods with social problems do not take into account energy and CO_2 objectives,** even if there is a charges reduction and so an improvement budget for tenants,
- **…**

So the Factor 4 approach makes all these actors working together with the general interest and public subsidies efficiency towards the 3x20 European objectives as common objectives without forgetting any type of issue (social, environmental, ecological or economic ones).

2.3.2. A sustainable (multidisciplinary and integrated) approach towards a better quality of life and the global interest (and so urban sustainability)

The economical impact of any energy retrofitting programme (work) has been studied as regarding its life cycle cost, id est the total cost of the works (investments) without the amount due to energy savings in each of the further years.

This estimation has been managed with the Factor 4 models which are the most important results of the Factor 4 project. [13].

Even if energy content in materials and equipments is becoming more and more important (when energy consumption is under 50 kWh/m^2.year), the most important objective is today the reduction of energy consumption of buildings and especially in existing buildings (where we are still far from this 50kWh/m^2.year objective) and so we measured this energy consumption.

The life cycle cost analysis allows to take into account all the costs or expenses (such as maintenance ones) due to a specific investment during the whole life of the building. This life cycle cost can be negative and this means that the savings will be more important than the investment; it can also be positive and it means that the investment is more important than the expected savings.

From a micro-economic point of view, id est when involving only the directly concerned actors, **a retrofitting programme should be engaged only if the life cycle cost of the programme is negative** because this means that the concerned actors will benefit from it, will save money in the long term. The micro-economical objective consists in the optimisation of the life cycle cost, id est in looking for the minimum life cycle cost. **The micro-economic optimum is the profitability threshold for the couple social owner + tenant.[14]** (See the chapter 7).

[13] Cf. deliverables 5 in English and 8 in national languages on the model itself and the deliverable 6 for the energy efficient techniques "included" in each national model.

[14] Cf. glossary

Macro-economic objectives can also be taken into account for choosing a retrofitting programme. It is the case for example when you decide to add **an energy constraint** as regarding energy consumption (under 50 kWh/m^2 for example). (See the chapter 8).

It is also possible to identify the level of needed subsidies for social owners for any retrofitting programme in order to reach the optimised life cycle cost for the actors (the social owner and tenants) as well as most of the macro-economical requirements. For example if the optimised life cycle cost gives 120 kWh/m^2 for energy consumption and if the macro-economical threshold or minimum requirement is 80 kWh/m^2, **it is possible to estimate the needed level of subsidies or financial support**. Of course it is a theoretical approach but this approach could be useful for choosing the buildings to retrofit or for selecting the level of investment for each type of buildings for example. This theoretical approach can be useful **to estimate the needed investment level of a potential new regulation**.

PART 1

THE MAIN ISSUES

FOR SOCIAL HOUSING ENERGY RETROFITTING

AND THE FIRST STEP OF THE FACTOR 4 APPROACH :

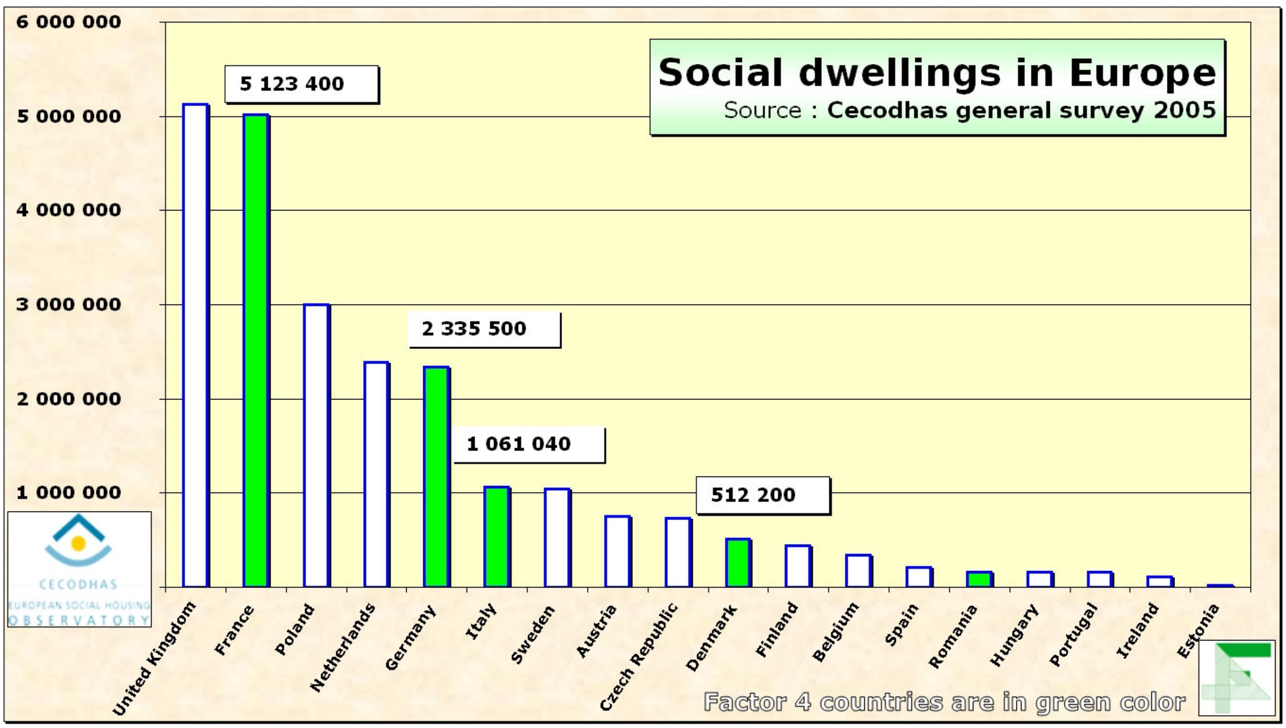
THE BUILDING TYPOLOGY

3. ENERGY AND CO_2 ISSUES IN EUROPEAN SOCIAL HOUSING RETROFITTING

3.1 REMINDER ON THE DISTRIBUTION OF SOCIAL HOUSING AMONG ALL EUROPEAN COUNTRIES

Among the 23.5 millions European rental social housing, the housing companies[15] of the 5 countries represented in the Factor 4 consortium manage more than 9 millions dwellings (39% of European social dwellings).[16]

Number of social dwellings in Europe



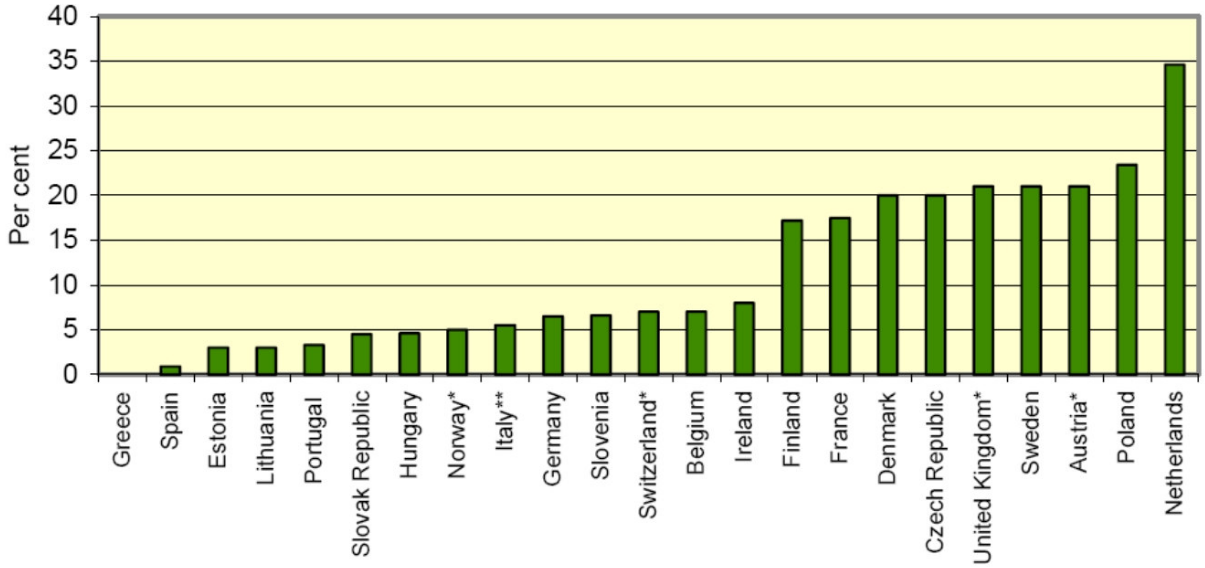
[15] The social housing sector in Romania is not properly managed by housing companies, but taking into account the close perspective of European integration it is expected this European practice to be adopted.

[16] For more information on each national typology, see the deliverable 3

The share of the social housing sector in the overall housing rental stock found in each country is indicated in the following figure.

Share of social rental dwellings in the housing supply

Figure 1. Share of social rental dwellings in the housing supply, circa 2000



Sources: The main source is *Housing Statistics in the European Union 2004*. For other countries marked with * figures are provided by authorities in these countries. For Italy ** the figure is provided by other international sources. For some countries the figures refer to occupied dwellings, for other countries to whole dwelling stock. There are also differences in how "social rental dwelling" is defined.

Energy retrofitting has impacts on local and global environment (energy consumption and CO_2 emissions) as well as with economic issues (savings, pay back return of investments…) and also with social aspects such as energy precariousness.

The first step of the Factor 4 project work programme was to better know each national building stock[17] (including energy consumption and CO_2 emissions) and to identify representative building types for the life cycle energy analysis.[18]

3.2. DENMARK

3.2.1. The Danish social housing typology

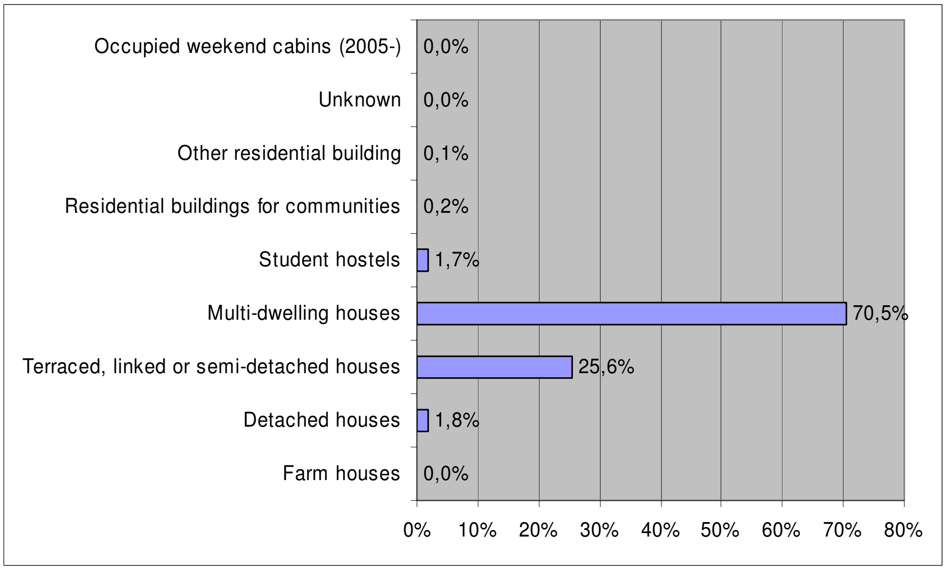
In year 2005 there are total 513,745 social housing in Denmark according to the Statistics Denmark (SD) with a distribution shown in the Figure 1. It seems from the figure that 70% of the housing is multi dwelling houses or building block (and it correspond to the KAB Statistic of which 69% is building blocks).

[17] Cf. Deliverable 3
[18] Cf. Deliverable 4

The distribution of new construction of social houses including all terraced, linked or semi-detached and multi-dwelling houses are depending on the construction date. The constructions of new social houses were highest during the period from 1970 to1974 and then it has been decreasing.

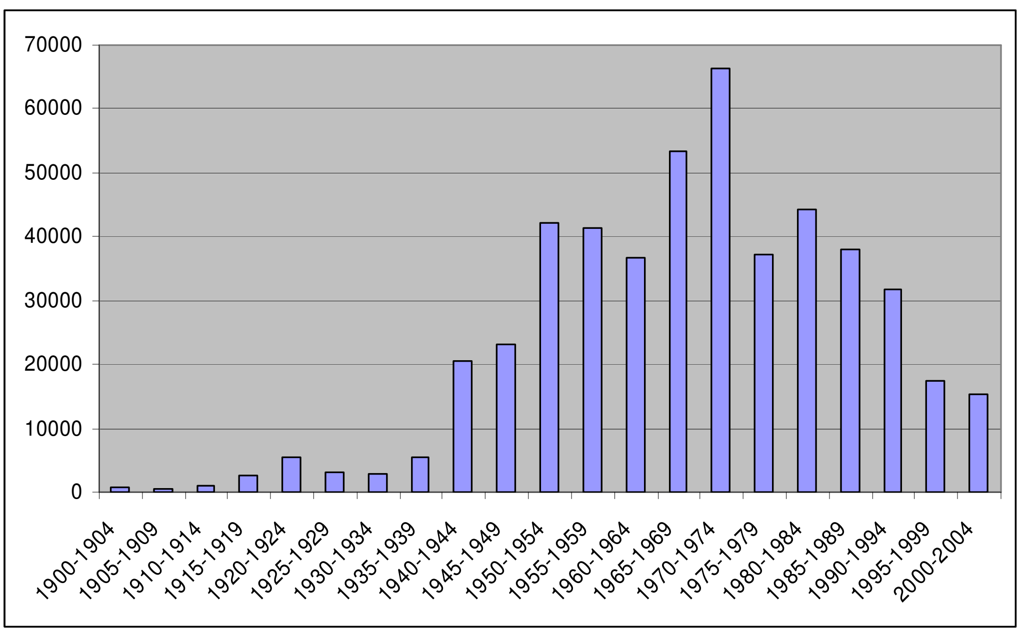
The development of number of social housing during the last 25 years is showing in the figure 3. In 1981 there were 334.000 houses and 513.000 houses in year 2005 or an increase on 2% per year.

Figure 1 Distribution of the Danish social housing stock in different construction types



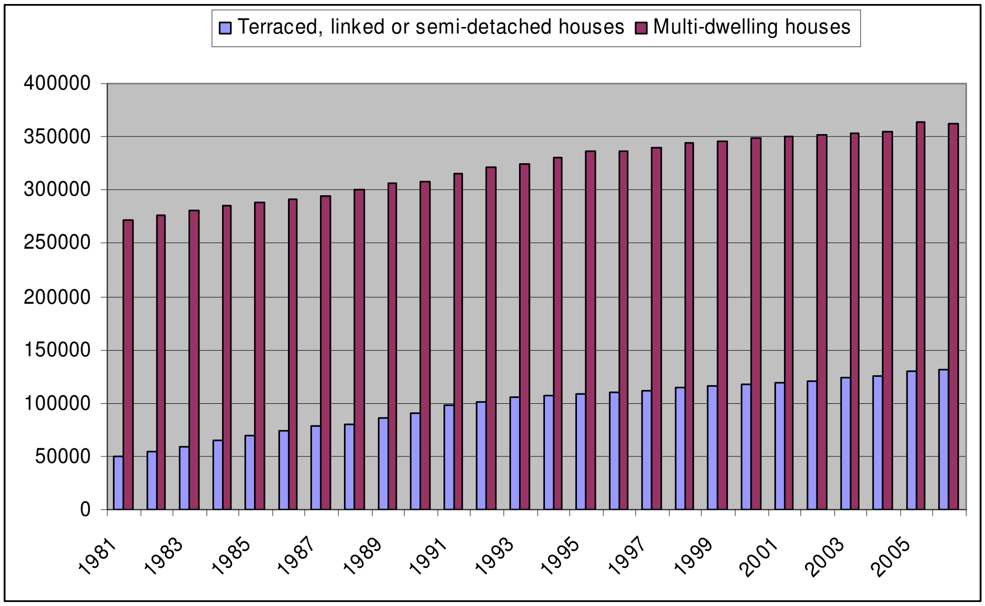
Source Cenergia with data from Statistics Denmark

Figure 2 - Distribution of the construction of new social houses including all terraced, linked or semi-detached and multi-dwelling houses depending on the construction date



Source Cenergia with data from Statistics Denmark

Figure 3 - Development of number of social housing in Denmark



Source Cenergia with data from Statistics Denmark

3.2.2. The Danish social housing context as regarding energy and CO_2

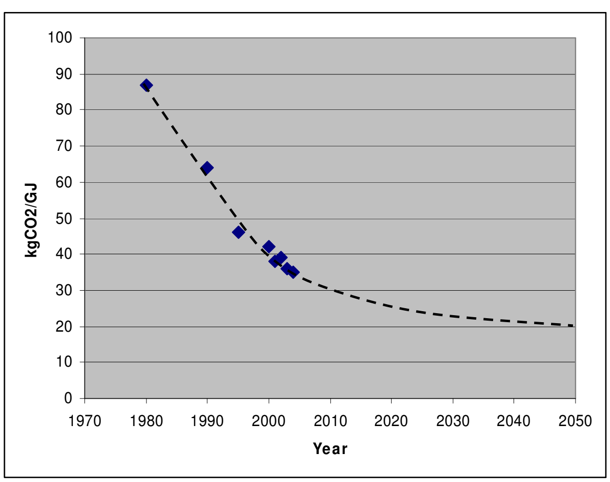
The yearly energy consumption for space heating and domestic hot water in 17,189 dwellings in the selected category is 155 GWh. The 17,189 dwellings represent 3.3% of the whole social housing stock in Denmark. Extrapolating the data from the KAB Statistic to all social housing schemes in Denmark the total energy consumption in the social housing scheme is 4626 GWh or 11% of the whole building sector.

Yearly energy consumption and CO_2 emission from the social housing scheme in Denmark.

	Number of Dwellings	Energy consumption [GWh/year]	CO_2 emission [ton/year]
KAB estates (KAB Statistic)	17,189	155	20,153
All social housing in Denmark (SD Statistics)	513,000	4,626	601,000

The CO_2 emission from the social housing stock contributes by 15% of the whole building sector or 1% of CO_2 emission of the country. In fact most of them are connected to district heating systems which improved their CO_2 emissions as shown in the following figure.

The development of the CO_2 emission from district heating during the last 25 years.



The number dwellings in the social housing stock in Denmark are given in the table below as it is today and in year 2050 assuming a 20 % increase in the number of social housing (new construction). The distribution between district heating (93%) and N-gas (7%) correspond to the KAB Statistic. The total number of social housing in year 2006 and the distribution between building block (71%) and low rise buildings (29%) is from the Danish Statistic.

No Dwellings				**2006**	**2050**
District heating	93%	Block	71%	338.579	406.295
		Low	29%	138.801	166.561
N-gas	7%	Block	71%	24.820	29.784
		Low	29%	10.175	12.210
				512.375	**614.850**

The number of sqm in the social housing stock is given in the following table. The average size of the dwellings in the selected category is from the KAB Statistic. The total sqm is found by multiplying the number of dwellings by the average size of the dwellings of the selected category.

Sqm.		**Average size per dwelling**	**2006**	**2050**
District heating	Block	66,0	22.346.216	26.815.459
	Low	75,3	10.451.716	12.542.060
N-gas	Block	47,4	1.176.466	1.411.760
	Low	74,0	752.949	903.539
			34.727.348	**41.672.818**

The total energy consumption for space heating and domestic hot water is given in the following table. The average energy consumption in the selected category is from KAB Statistic. The total energy consumption is found by multiplying the sqm by the average energy consumption of the selected category.

Energy, PJ per year		**[kWh/m2]**	**2006**	**2050**
District heating	Block	123	9,9	11,9
	Low	145	5,5	6,5
N-gas	Block	150	0,6	0,8
	Low	134	0,4	0,4
			16,3	**19,6**

The total CO_2 emission is assuming the CO_2 emission by using district heating decrease from 35 to 20 $kgCO_2/GJ$ and the CO_2 emission from N-gas is unchanged.

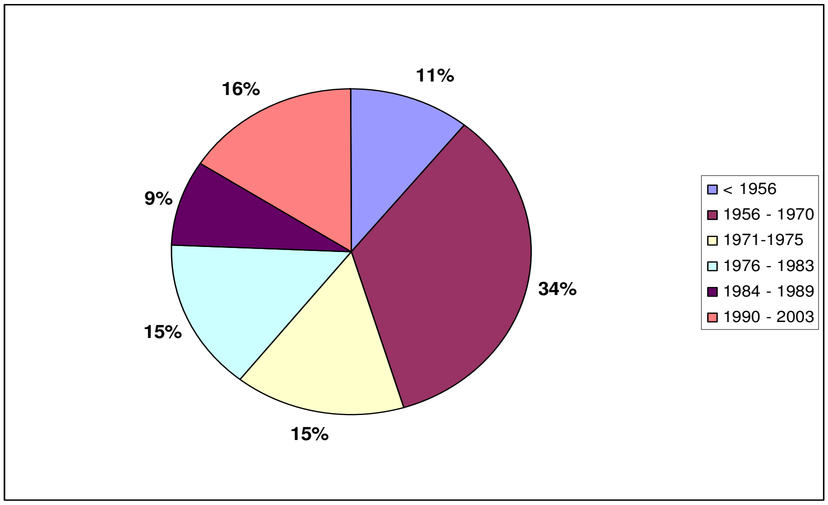
CO_2, ton pr. year		**[kg/GJ]**	**2006**	**2050**
District heating	Block	35	346.322	237.478
	Low	35	190.953	130.939
N-gas	Block	57	36.212	43.454
	Low	57	20.704	24.844
			594.190	**436.715**

3.3. FRANCE

3.3.1. The French social housing typology[19]

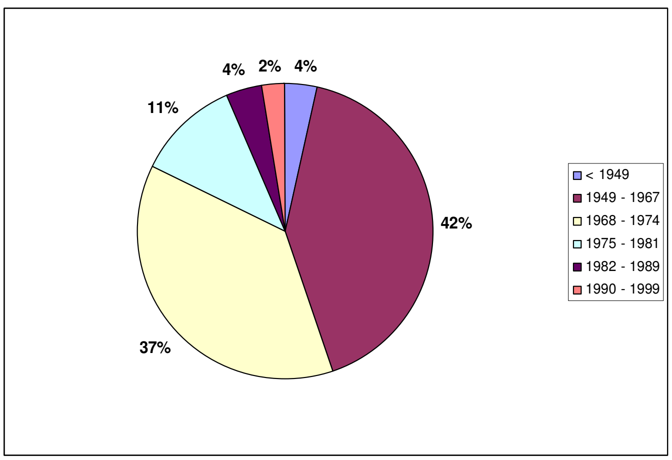
Most of the French social housing building stock has been built between 1956 and 1975 (more of half of the building stock in 2005) and most of the buildings built between 1956 and 1975 have been built in poor social areas (named ZUS) which are for a great majority (70 %) in only one climatic area: H1.

The French social housing building stock according to the construction date

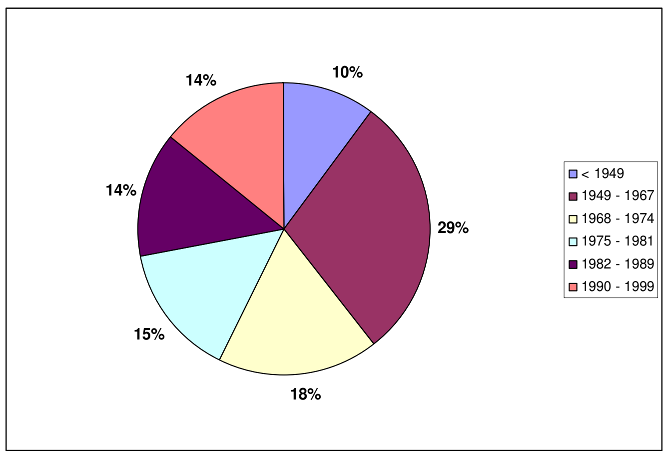


Source : La Calade for Factor 4 (with data coming from HTC)

The dwellings in poor social areas
80 % of this building stock has been built between 1949 et 1974



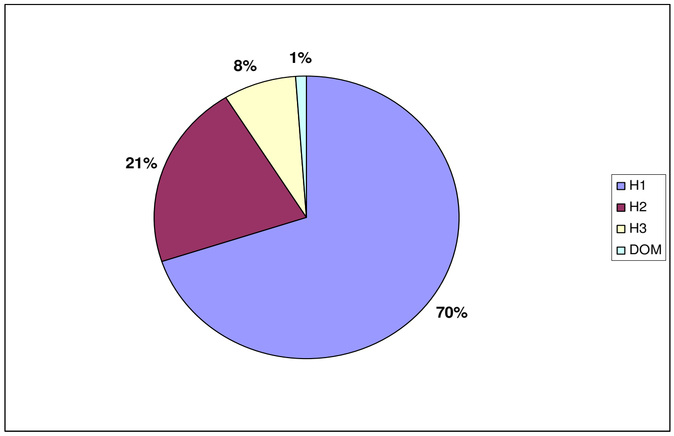
The dwellings out of the poor social areas
43 % of this building stock has been built since 1974



Source : La Calade from data coming from Observatoire de ZUS

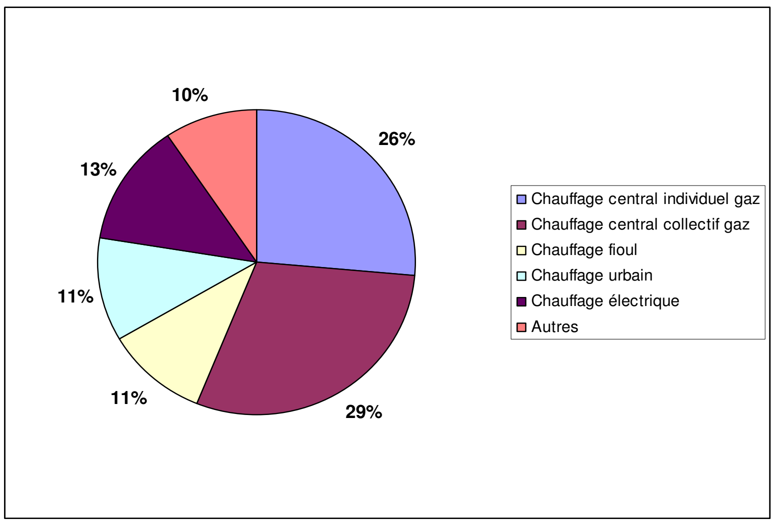
[19] Cf. deliverable 3 (HTC and La Calade for France) and deliverable 4 (La Calade for France)

The French social housing building stock according to the climatic areas



Source: La Calade for Factor 4 (according to data given by HTC)

The French social housing building stock according to the heating system



Source : La Calade for Factor 4

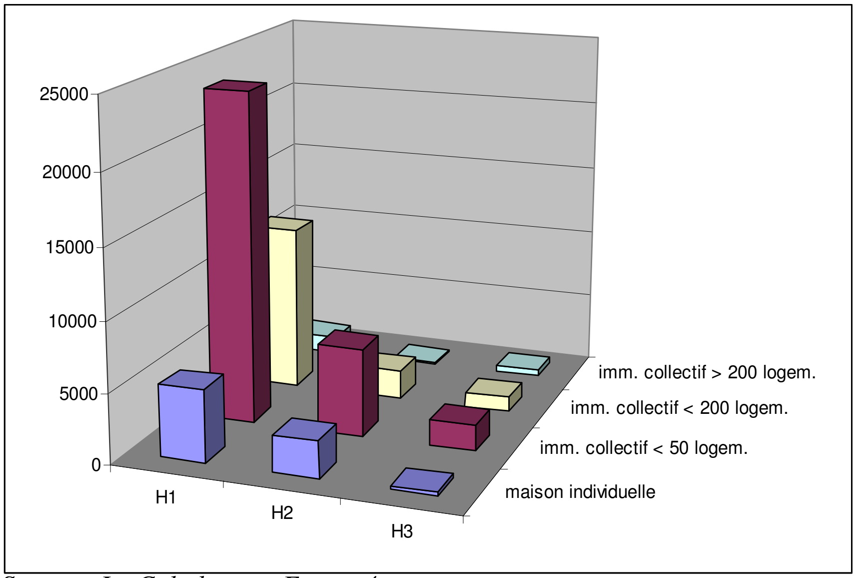
At shown in the above schema, **gas is the energy source in most of the dwellings with 55 % of them**. Fuel is used in 11 of the dwellings and 11 % of social housing dwellings are connected to a district heating system. At least electricity is used in 13 % of the dwellings.

3.3.2. The French social housing context as regarding energy and CO_2

The whole CO_2 emissions are valued to 11.8 Mt CO_2 for the 2004 social housing building stock (USH).

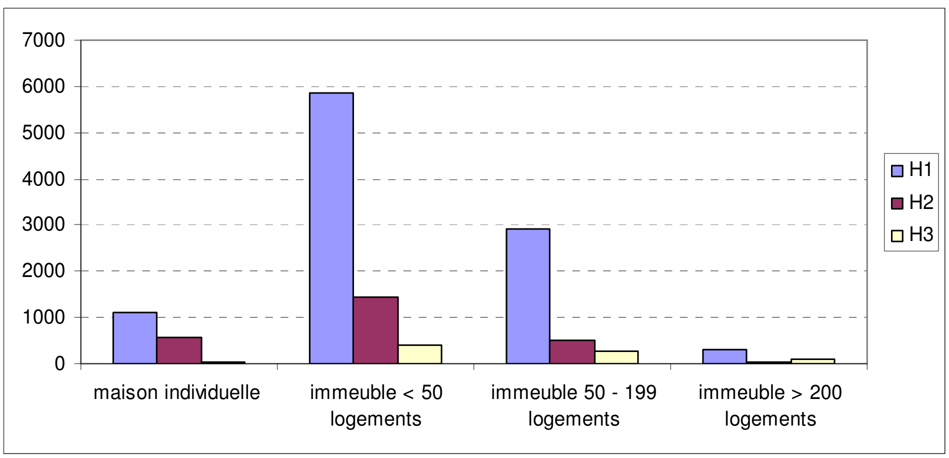
In as much as we work upon a building stock (the one belonging to USH members) which corresponds to 88 % of the national public social housing building stock, it would be advisable to correct those emissions by a factor equal to 1.14, and this gives **an overall CO_2 emissions level estimated to 13.5 Mt CO_2** .

Social housing energy consumption in GWh as regarding the building size and the climatic area



Source : La Calade pour Factor 4

CO_2 emissions from the social housing building stock in thousands of tons per year, per building size and per climatic area



Source : La Calade for Factor 4

If one wishes to give to this building stock the objective of a reduction of its greenhouse gas emissions by a factor 4, **the objective would be to reduce the CO_2 emissions by 6.9 Mt before 2050**, that is to say more than half (60 %) of the social housing building stock present greenhouse gas emissions.[20]

After the "Grenelle de l'Environnement", an important national debate during the last Summer time, many questions are still raised and this Factor 4 Brochure wants to be a contribution for finding solutions, before the next laws which should be voted during before the end of 2008.

CO_2 emissions from heating and hot sanitary water is estimated at 42 kg CO_2 / m², which means an average with the E label (36 – 55 kg CO_2/m²) and in final energy, French social housing has an average energy consumption around 187 kWh/m².

[20] For statistics on the building stock, see the deliverable 3 and for the building stock analysis as regarding energy consumption and CO_2 emissions look at the deliverable 4

Energy consumption and GEG emissions in French social housing

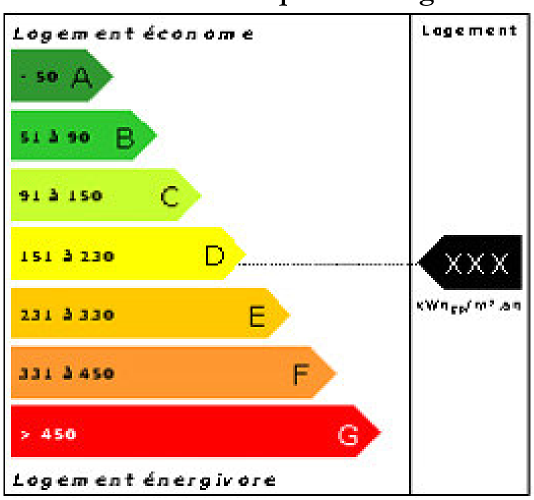
	Social housing building stock gathered by USH	Main housing	Total residential housing
Building stock in million of dwellings (2004)	3,8	26,51	31,56
Correspondant live able area (m^2)	267 millions		2 666 millions
Average final consumption for all uses	56 770 GWh or **213 kWh/m²**	469 TWh or 209 kWh/m² (except wood)	484 TWh or 181 kWh/m² (except wood)
Average final consumption for heating and hot sanitary water	**187 kWh/m²**		
Average primary consumption for heating and hot sanitary water per live able m²	75 700 GWh or **284 kWhep/m²**	**310 kWhep/m²** (includ. wood)	700 TWh or **240 kWhep/m²** (except wood)
Average primary consumption for heating	**218 kWhep/m²**		
Total CO_2 emissions	**11,8 Mt CO_2**		
CO_2 emissions from heating and hot sanitary water	**42 kg CO_2 / m²**		

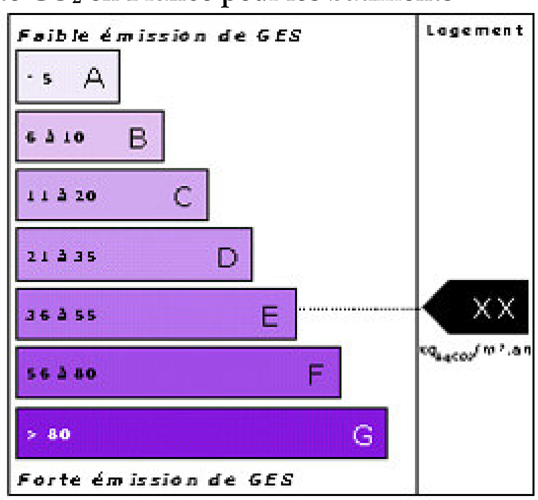
Source La Calade for Factor 4

Reminder on energy labelling in France

Energy labelling with energy consumption per m² **CO_2 labelling and CO_2 emissions per m²**

Etiquette Energie et Etiquette CO_2 en France pour les bâtiments





Source Ademe

In France there is only one energy labelling and not various ones according to climatic areas such as in Italy for example, which seems much more realistic…

3.4. GERMANY

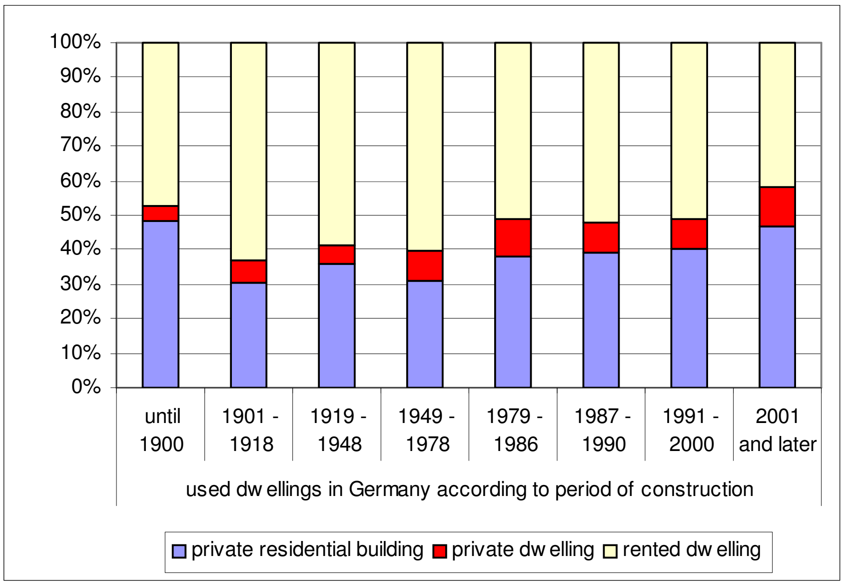
3.4.1. The German social housing typology

The latest available statistics on the dwelling situation in Germany is from 2004:

total number of dwellings 2004 in residential buildings	35,15 mill
in buildings with 1 dwelling ("single family")	10,91 mill.
in buildings with 2 dwellings	7,02 mill.
in buildings with 3 or more dwellings	20,65 mill.
average living area, all dwellings	85,6 m^2 per dwelling
	40,8 m^2 per occupant
average number of rooms per dwelling	4,4

The following illustration shows that the relevance of rented dwellings has continuously decreased in Germany over the past century, reaching some 42 % of the total number of dwellings at present. In the long run, it is expected that there will be a demand of about 35 – 40 % of all dwellings be remaining as rented dwellings, most of them located in cities.

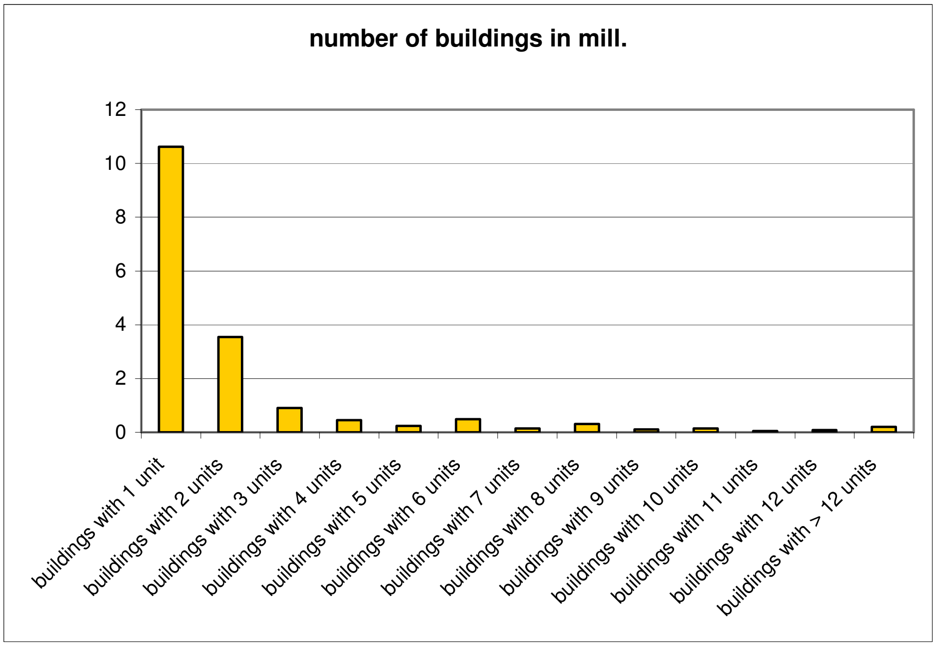
Development of relative portions of rented dwellings versus private property of housing in Germany (total number of dwellings in the last period: 38 mill.)



Source: GdW Bundesverband deutscher Wohnungs- und Immobilienunternehmen e.V.; Wohnungswirtschaftliche Daten und Trends 2005/06

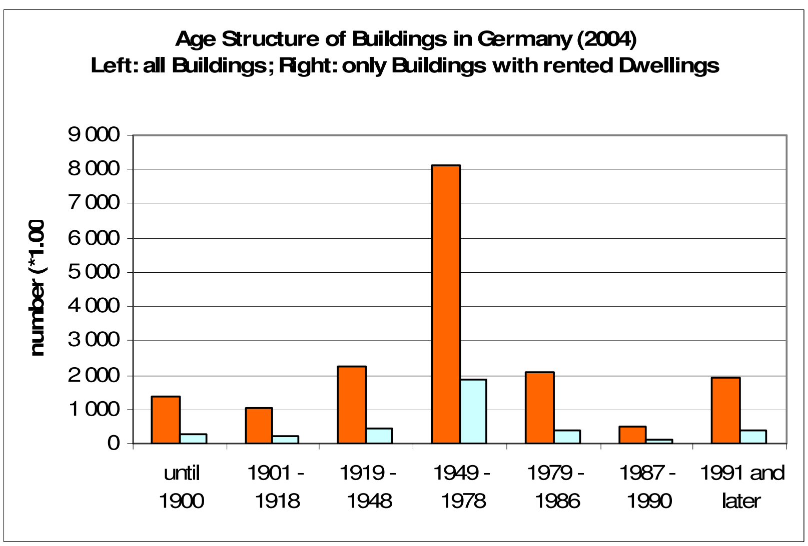
The next illustration shows that the number of residential buildings (2004) is dominated by buildings with 1 or 2 units. These buildings are usually not rented. Rented buildings from housing companies contend usually 3 or (much) more dwellings per building.

Number of buildings (in mio.) with x dwelling units per building in Germany (2004)



Source: GdW (2005)

The age structure of buildings in Germany is very inhomogeneous due to the big reconstruction program after World War II. The next illustration shows an overview, where the absolute number of buildings according to their construction period is extracted from GdW and the portion of rented buildings in each construction period is estimated.



Source: GdW (2005)

The total number of **residential buildings** in Germany is **17.3 mill.**, whereas the number of buildings rented by **housing companies** is estimated to be **3.66 mill**.

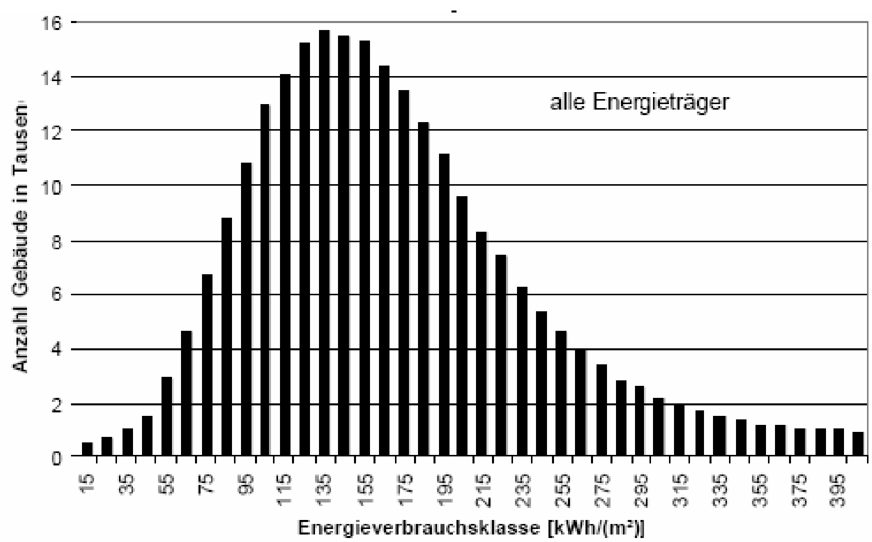
The weighted average of the age of rented buildings is **49. 8 years**.

In 2004, 330.000 new dwelling units (0, 94 % of the existing stock) have been constructed, 26 % of these by housing companies. This also indicates the decreasing significance of rented dwellings compared to privately owned buildings, a development, which is considered to be maintained in the mean term in Germany.

3.4.2. The German social housing context as regarding energy and CO_2

A periodic investigation is available that provides detailed data on energy consumption of rented buildings on the basis of heating cost billing. This investigation is carried out by Techem AG, Frankfurt, since 1977/78 /3/. Currently, **over 450.000** buildings in West- and East-Germany are covered, which are supplied by either gas or heating oil collective heating systems or district heating. The sample comprehends buildings with heating only or heating plus domestic hot water preparation.

Overview of the distribution of the specific end energy (gas, oil, DH) consumption (kWh/m²)

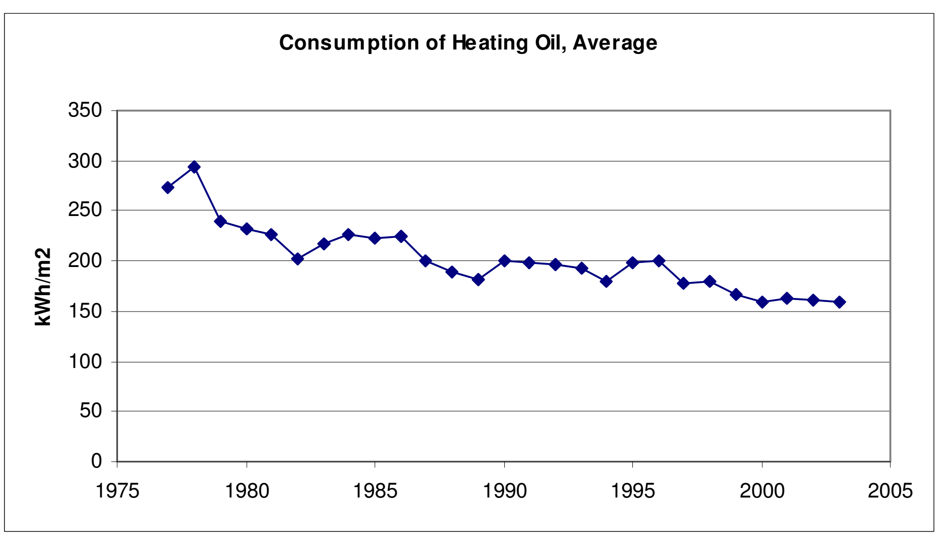


Source: Techem AG (Frankfurt 2005): Hilfen für den Wohnungswirt

The average specific heating demand of the buildings according to this illustration is about 160 kWh/m².

Over the time the investigation was made by Techem (1977/78 – 2003/04), a significant drop of the energy consumption can be seen:

Development of the average of the end energy consumption of buildings (kWh per m²) billed by Techem; heating only (no tap water), values not corrected with degree days.



Source: Techem (Frankfurt 2005)

This illustration indicates also the influence of Eastern-German buildings that were covered by Techem since 1991. Both the demolition rate and the retrofit rate has been high in East-Germany, eventually resulting in average consumption rates that are similar to current West-German values.

A drop in energy consumption of **over 40 %** since 1977 until 2003/04 can be seen from this illustration. A part of this decrease is due to reduced degree days since the 90ties due to climate change, but the remaining improvement, being due to behavioural changes after introducing of energy billing in the 70ies and to improvements in building standards and efficiency of the heating systems is still remarkable.

The sample investigated by Techem could distinguish between different heating systems. The average consumption rates according to heating oil, gas or district heating in 2003/04 was as follows:

	kWh/m^2 (end energy)
heating oil	159,2
natural gas	161,8
district heating	123,8

The difference between oil/gas and district heating is the boiler losses that do not occur using district heating. The table indicates that the **average boiler efficiency** of both oil and gas boilers is in the range of **75 %**. Due to the very large sample underlying this calculation, this is a significant result.

The statistical billing data of Techem contend buildings with heating only and with heating and domestic hot water supply combined. Assuming that there are no differences in the average heating demand of buildings with these different types of supply, and considering an average boiler efficiency of 75 %, the **average consumption of domestic hot water is 15 kWhth/m^2**.

The Techem data, collected only for multi-family buildings, show that there are big individual differences of both the heating consumption and the consumption of domestic hot water, showing frequently a factor of 3 and more within the dwellings of one single building. This corresponds also with experiences that have been made in our own buildings of Volkswohnung.

Retrofit rate and remaining energy conservation potential

From the rented buildings operated by housing companies being older than 25 years, 56,5 % are completely retrofitted, 27,4 % are partly retrofitted (new windows, modernized heating systems etc.) and 16,1 % are in need for retrofit. In our own building stock at Volkswohnung, 44 % of our buildings are completely retrofitted so far.

There are no data available on the year of retrofit of a specific building. We estimate, that less than a quarter of the buildings that have been completely retrofitted comply with an up-to-date standard, resulting in heating demand below 75 kWhth/m^2, since this standard has become usual in Germany only since mid 90's. Buildings having been retrofitted earlier, in general will have a heating demand of 100 – 120 kWhth/m^2 (windows > 1,6 W/(m^2·K), insulation thickness 6 – 10 cm, sub-optimal tightness, no controlled ventilation, conventional boilers etc.). Concluding, there is a retrofit potential until 2050 of about 72 % of the existing rental buildings thus enabling an improvement potential of > 100 kWh/m^2 for about 2,75 mill. rented buildings. Concluding, a **thermal energy conservation potential** of **99 TWhth/a in rented dwellings** until 2050 or about **33,1 mill. t CO_2 per year until 2050 is a reasonable estimate for Germany**).

This rough estimate is considered to be an under-estimate, since for rental buildings there is a (very constant) rate of demolition of 0,06 % in West-Germany (this rate is at present 10-fold higher in East-Germany due to a very high rate of empty dwellings because of decrease in population by migration) leading to a total of about 30 % demolished buildings until 2050 that are substituted by buildings with higher efficiency than retrofitted buildings (though with a larger living area per occupant).

For Volkswohnung, the demolition rate of our buildings is almost zero, since the costs of retrofit are lower than the costs of new rental buildings that result in costs that surmount the present rent level in Karlsruhe. Therefore, the market for new rental buildings in Karlsruhe is very limited.

3.5. ITALY

3.5.1. The Italian social housing typology[21]

In the last five years social housing in Italy has gone through a period of terrible crisis. With the reappearance of the phenomenon of housing distress, the Government has not stepped in to support the supply of social housing.

The last financings date back to 2001, but due to budgetary reasons, those meant to provide for the completion of regional programs have been reduced by 50% of their original value.

The tradition channels destined to satisfy the demand for social housing, public building and subsidized housing, have passed respectively from 90,000 housings financed in 1984 to 13,000 housings in 2004.

Those who have managed the supply of social housing in Italy have traditionally been the following:

- the I.A.C.P. (Istituti Autonomi Case Popolari), associated with Federcasa – complete projects that are paid for by the State, and destined exclusively for rent-controlled use.
- Housing Cooperatives, associated with national groups which include principally: A.N.C.Ab and Federabitazione, which complete projects with subsidized mortgages or public subsidization, traditionally destined in the past mostly for property, but in the last several years exclusively for rent.
- Welfare agencies, which have in the past, with the investments of public welfare funds, created a portfolio of housings destined to supply lower-cost tenant housing.
- Town Councils which have proprietorship of various housings destined for rent-controlled leasing.
- Construction companies which create housings destined for ownership with a partial subsidization by the State.

In the beginning of 2000 the social housing supply was valued as the following:

- I.A.C.P.: 1,000,000 rent-controlled housings
- Cooperatives: 40,000 rent-stabilized housings plus around 35,000 housings per year destined to ownership at lower prices.
- Welfare agencies: 100,000 housings rent-stabilized housings
- Towns Governments: 100,000 rent-controlled housings
- Companies – 20,000 housings per year destined for ownership at lower prices

Following the launch of sales programs for the public housings, aimed at roommates and the reduction of public financing, the scenario has changed in the following ways:

- I.A.C.P.: 800,000 rent-controlled housings
- Cooperatives: 45,000 rent-stabilized housings plus around 6,500 housings per year destined to ownership at lower prices.
- Welfare agencies: complete cession of properties
- Town Councils: 80,000 rent-controlled housings
- Companies – 4,500 subsidized housings per year destined for ownership

In total, the number of social tenant housings in Italy destined for rent is therefore estimated at 925,000, compared to the 3,200,000 rental housings available on the free market.

[21] Cf. deliverable 3

The erosion of residential tenant property which is traditionally aimed at satisfying the social demand for habitation (70% for private property; 19% IACP and state administration property; 11% belong to private companies, welfare agencies, and cooperatives) derive from several overlapping factors: firstly, the lack of investment attractiveness due to an onerous fiscal regime and the uncertainty of contractual conditions (only recently an object of legislative intervention); the traditional tendency of Italians to prefer access to property, motivated also by the scarce presence of housing supply in the real-estate market which is affordable to middle-income individuals; a downturn in interest rates on mortgages, which has spurred the desire to acquire housing; finally, the huge shift of public residential properties from belonging to *Istituti Autonomi Case Popolari* to belonging to both public and private welfare agencies.

Italian buildings are for the most part characterized by envelopes with poor thermal performances and low efficiency plants. About the two-thirds of them was built before the first Italian law (373/76) which fixed limits on energy consumptions (next table).

Dwelling construction period (since 2001) and data aggregation according to energy regulation periods

Italia – dwellings *(Source: censimento ISTAT 2001)*			**Italia -** dwellings construction according to energy regulations period		
Period of construction	**N**	**%**	**Period of construction**	**n**	**%**
Before 1919	3.893.567	14%			
From 1919 to 1945	2.704.969	10%			
From 1946 to 1961	4.333.882	16%			
From 1962 to 1971	5.707.383	21%			
From 1972 to 1981	5.142.940	19%	Before 1976	19.209.800	70%
From 1982 to 1991	3.324.794	12%	From 1977 al 1991 (*)	5.897.734	22%
From 1992 to 2001	2.161.345	8%	From 1992 al 2001 (**)	2.161.346	8%
Total	*27.268.880*	100%	*Total*	*27.268.880*	*100%*
(*) Law 373/76 (**) Law 10/91					

Source Ricerca & Progetto

3.5.2. The Italian social housing context as regarding energy and CO_2[22]

For long time regulations about energy efficiency ignored the existing buildings, as they focused on tightening the limits on thermal insulation an plant efficiency of new constructions.

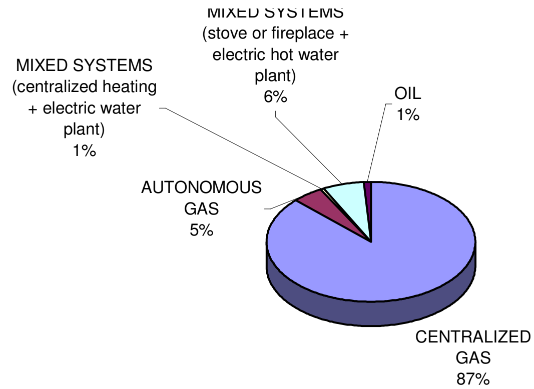
Even buildings built up according to Laws 373/76 and 10/91 have a poor energy efficiency quality mainly due to structural reasons typical of the Italian building process. Causes are mainly the following:

- Very few controls on construction quality;
- Building industry: mainly made of small size builders, very interested on immediate gain and not to the quality and innovation of the construction process
- Building market: the promoter of a construction is often not the same entity that uses the building. This implies that they are more interested in immediate profits than in long term ones associated to the building use.
- Use of the building: related both to the way the building is operated and to users behaviours (for ex. High thermal levels during the winter and low temperatures during the summer).

Recently two decrees, the 192/05 and the 311/06, stated strict energy requirements, also for existing buildings that are going under reconstruction, extraordinary maintenance of the envelope or that change their plant. Still these decrees are not fully operative, as they need to be completed with implemental regulations, which we are waiting since two years.

Independently of what rules say, energy redevelopment is today particularly convenient, as it brings great economic and environmental benefits. On the one hand the rising price of fuels, on the other hand public incentives which allow to redeem the 55% of expenses, the result is that payback time has become pretty short.

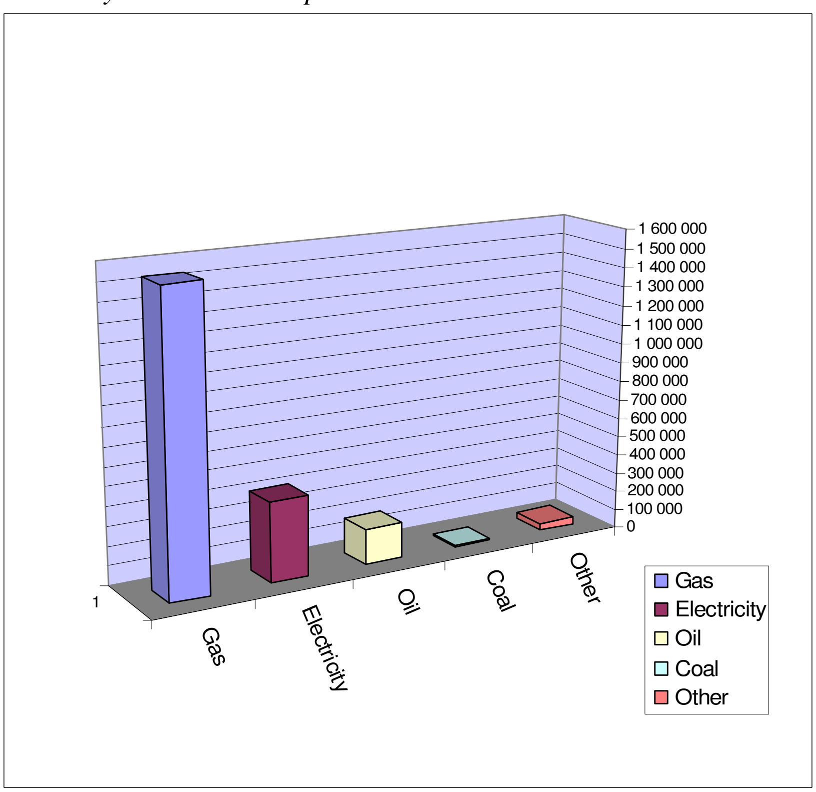
[22] Cf. deliverable 4



ITALY - SOCIAL HOUSING BUILDINGS CO_2 EMISSION (Tons)

Energy and heating system	Total nb of dwellings	CO_2 tons
Gas	722 147,50	1 534 924,51
Electricity	141 432,50	415 528,69
Oil	45 695,00	185 487,43
Coal	3 052,50	6 488,09
Other	12 672,50	37 231,81
	925 000,00	2 179 660,52

Estimation by ABITA soc coop

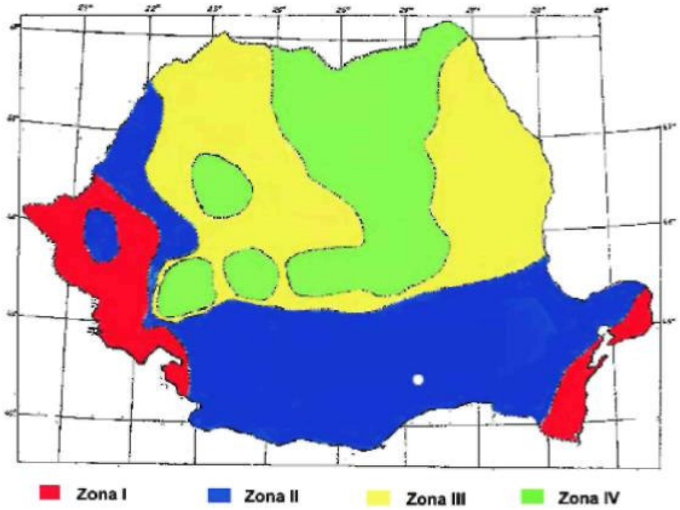


Source ABITA for Factor 4

3.6. ROMANIA

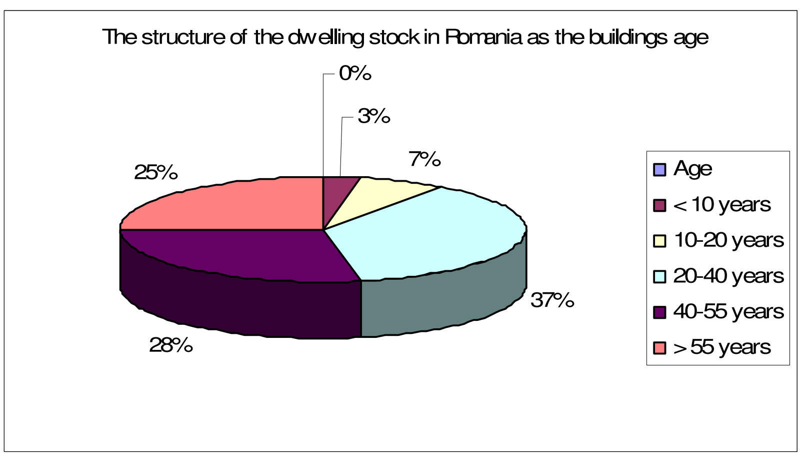
There are four climatic areas, Vrancea being in zone III.

The climatic areas in Romania



According the Census of Population and Dwellings from March 2002 the total number of the recorded dwellings was over 8 millions (**8,2 millions**), **out of which 52,5% situated in urban areas and around 2.4 millions built before 1985.**

Most of the existing residential buildings were built 15 to 55 years ago; they are obsolete and have thermal insulation in bad condition.



Some major changes produced within the Romanian society after 1989, especially the reconsideration of the property right including land property, had important consequences for the **housing** field. These consequences ended to reshape the profile of the sector which presents now some reversed features:

- The share of the dwellings private ownership passed over 97%
- The number of the households in the rented dwellings decreased from about 1,600 000 in 1992 to around 320000 in 2002
- The dominant **new** dwellings type became the single family houses (95% out of the total between 1990-2000).

3.7. CONCLUSION

Statistics are still very poor in Europe as regarding energy consumption and CO_2 emissions according to various building types, with criteria on the building frame, heating systems, sanitary hot water systems, the technologies and social criteria together.

We could see also that the way of collecting the data is very important and has to be checked in order to be sure about the quality of the data collection.

At least we saw it is impossible today to make a European comparison because the data are not validated and because they are nor according to the same units nor to the same collection system or rules.

A real building typology with all the data needed is still to be done in each country and this is the first step of the Factor 4 approach, for the building stock of a social owner or for a territory (such as a region for example).

4. REMINDER ON SOCIAL ISSUES IN SOCIAL HOUSING

Energy and CO_2 issues are not the only important ones for social housing. Social owners have a mission which is to provide quality social housing, for the renters (id est housing or dwellings with comfort as well as with small charges because they are for low income families) and for the overall society (general interest concept, id est for example with the smallest environmental and health impact).

4.1. THE DANISH CONTEXT

Between 1990 and 2004, the total energy efficiency of households increased by 12.1%. For heating, the improvement in efficiency was of the same magnitude. Substitution of old oil burners with new natural gas burners and district heating has contributed significantly to the improvement. In the period 1990-2004, large electrical appliances exhibited an improvement in energy efficiency of 24.1%. This development, and a decrease in the use of electricity for heating, has contributed in stabilizing the total electricity consumption by the Danish household sector.

The intensified energy conservation efforts focus in particular on energy consumption in buildings. The main initiatives include more stringent energy requirement in the Building Regulations, an improved energy labelling scheme, enhanced inspection of boilers and ventilation systems. In addition to general energy and CO_2 taxation, four programmes have been initiated to improve energy savings and efficiency in the household and the tertiary sectors:

- Energy labelling of electrical appliances.
- Establishment of the Electricity Saving Trust, which promotes electricity savings in households.
- Energy saving activities carried out by electricity, natural gas and district heating companies.

Energy prices and taxes are among the most important determinants of energy consumption and have been successfully used to promote energy savings in Denmark. From 1990 to 2005, revenues from "green" taxes increased from DKK 13.9 to 36.3 billion or by 161%.

4.2. THE FRENCH CONTEXT

If we look at the French context, INSEE enquiries on housing show that the income of families living in social housing is 25 % lower than the average income of French families, which approximately corresponds to the third decile in the income distribution.

According to the ZUS[23] observatory, the incomes of families living in ZUS (mostly in social housing) are 33 % lower than the national average, which corresponds to the second decile.

If we look at the INSEE inquiry « Budget de famille » (or Family budget, 2006), for these 2 deciles (representative of social housing), we can see that the energy expense for housing is up to 7% of the total yearly expense of families, id est between **1 200 to 1500 € per year and per family or 100 to 125 € per month and per family !!!**

As a comparison, for 30 buildings in Paris (with 4 500 dwellings), with gas or the urban district heating systems, we calculated that the average energy expense is up to 14,8 €/m² - year per dwelling, id est almost 1 000 € per year without fix cost (subscription) for a 67 m² dwelling.

If we include the expected energy prices increase (for gas, fuel oil, electricity…), this average expense would reach as an average 18,2 €/m² per year for the 2008 – 2030 period, id est more than 1 200 € per year without the subscription cost. These energy expenses are so really important expenses which have an important pressure on the purchase power of families (as it can be seen on the first schema below).

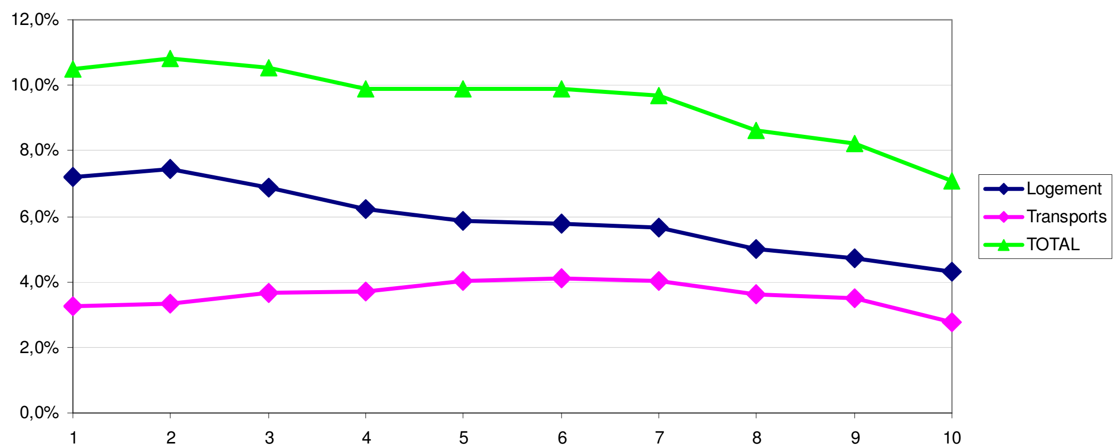
Evaluation of the expense due to energy in their overall expense for families in 2006

Level of expense per decile in € per year and per family

Décile 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
16566	18518	21617	23571	25390	26839	30384	32387	36523	45267	27705

Source INSEE (« Budget de famille» inquiry) 2006

Part of the yearly energy expense per decile in the total expense of families (%)

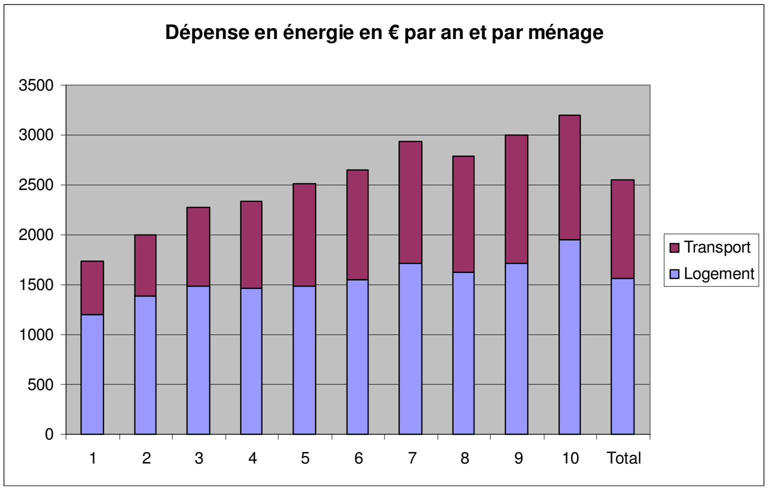


Source La Calade from the "Budget de famille" INSEE inquiry, 2006

This schema shows that it is for the families with the smallest incomes (and so mostly in social housing) that energy expense due to housing is the most important in their overall expenses, even if these expenses are less important than those for the families with a higher level of income as shown in the table below.

[23] ZUS ("Zone Urbaine Sensible") means poor urban areas or urban areas with (mainly social but also environmental and economic) problems

Energy expense in € per year and per family for transport and housing



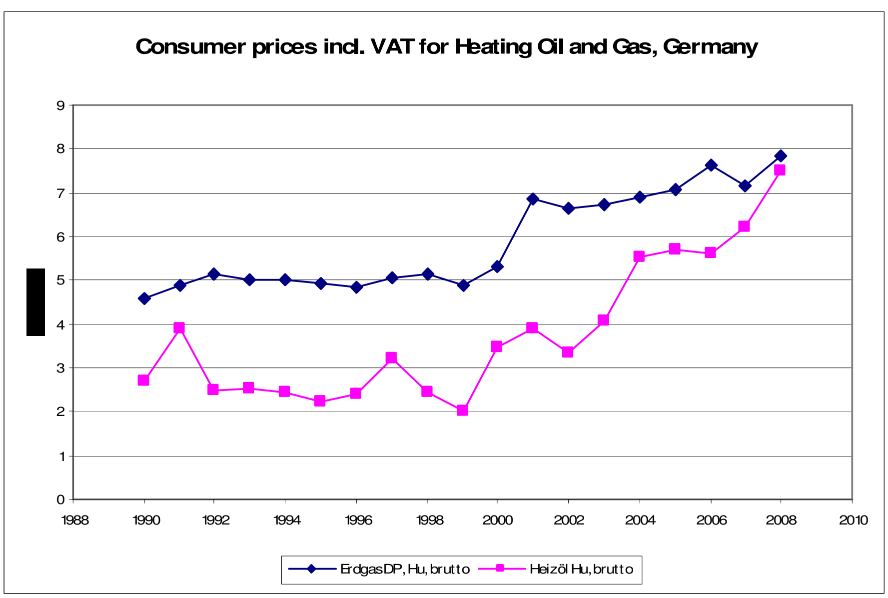
Source : La Calade from the "Budget de famille" INSEE inquiry, 2006

4.3. THE GERMAN CONTEXT

The target in this Factor 4 project is social housing. Tenants, who are encompassed by this connotation belong to low income households – households with income of 50 % of the average or less. The net income average of households in Germany in 2005 was 22.500 €/a, and of working class households 17.600 €/a (source: Federal Authority on Statistics (destatis), press release Nr. 496 (2006)).

Tenants of social housing companies often have only 10.000 €/a or less at their disposal. For such households, paying rents in the range of 4,00 to 4,50 €/m2, which – depending on the flat size - corresponds to about 3.500 €/a, the additional cost for waste disposal, fresh water supply, sewage charge, electricity and heating / domestic hot water sum up to total cost of their dwelling which cover over 50 % of the available income. For this reason, rising energy prices result in great social burden. With current high energy prices and the perspective of still further increases, reducing energy cost by energy conservation is therefore – apart from ecological requirements – of high priority for the society.

Gross oil and gas prices for consumers: annual average values 1990 – 2008 (first quarter in 2008)

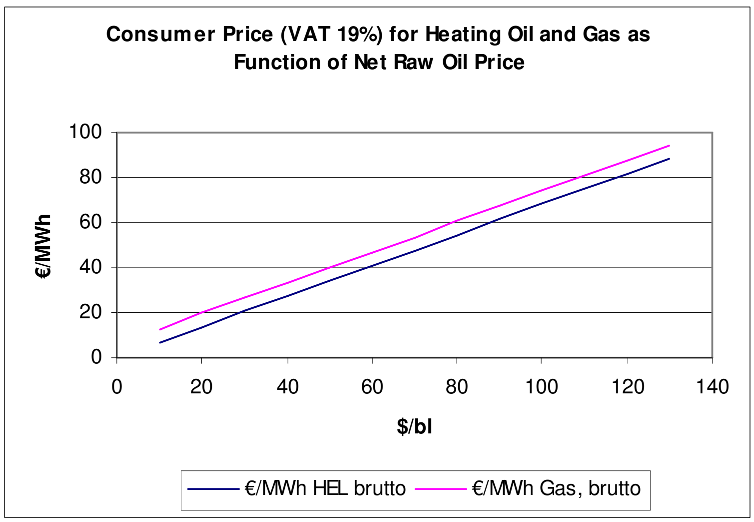


Source: Statistisches Bundesamt (Gas: variable price corrected for calorific value, 1 ct/kWh added for fixed gas price); VAT 16 % until 2006, 19 % since 2007

Considering recent developments of prices for raw oil, further price increases for consumers in Europe must be expected. Significant reductions seem unrealistic for the future.

While there is no immediate relation between raw oil prices ($/bl) and end energy prices on the European markets, in the long run, oil (and gas) prices must reflect the fundamental raw oil price. The illustration below presents an estimate of the resulting market prices in Europe, depending from raw oil prices, assuming an exchange rate of 1,45 $/€, an energy demand of 20 % from the well-head to the end user and a profit margin of 10 %. For gas prices, coupled to oil prices, a margin of 1 ct/kWh compared to oil has been added. According to this chart, the actual market oil price of over 120 $/bl will soon cause a still further price increases for end consumers up to 9 ct/kWh, if this high raw oil price level is going to prevail. This will have grave consequences for living cost.

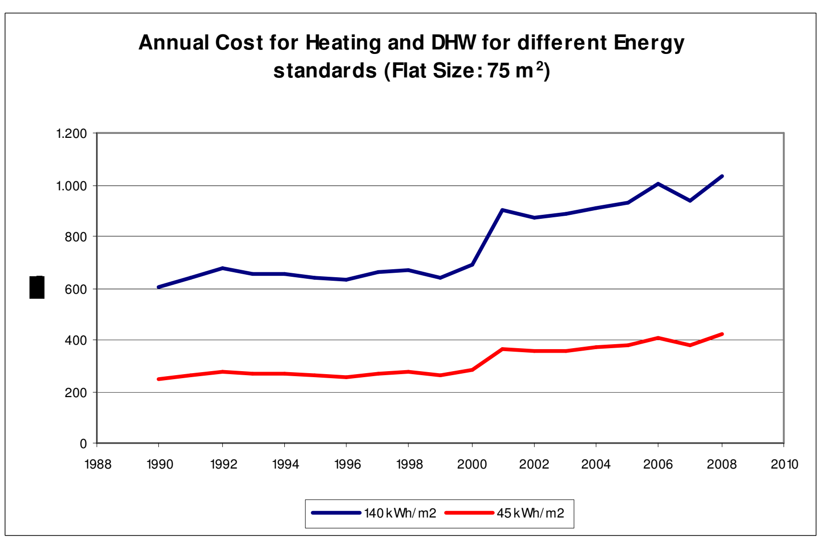
Oil and gas end consumer price dependency from raw oil prices
(estimate by Volkswohnung)



The average energy demand for low temperature heat (heating, DHW) in existing rented buildings in Germany (see chapter 3.3) is about 160 kWh/m² (140 kWh/m² for heating, 20 kWh/m² for DHW). After high standard refurbishment, heating demand may be reduced to 45 kWh/m². The resulting energy cost for a dwelling of 75 m² living area as a function of energy price is shown below:

Annual cost for heating and DHW,

75 m² dwelling, for different insulation standards



The chart illustrates that at today's energy prices, the difference between well insulated and not refurbished in terms of energy cost is about 600 €/a (or 0,67 €/m^2.month). For low income households, this makes a big difference. It corresponds to a marginal cost of 160 €/m^2 for energy retrofit investments (calculated with an interest of 4 % and over the lifetime of the renovated building of 40 years, or 225 €/m^2 with an interest rate of 2 %.

Since, according to the experiences of VoWo, the current cost of energy retrofit are in the range of 200 €/m^2 for typical multi-family buildings, one can conclude that energy retrofit of multi-family buildings pays – in a lifecycle analysis – pays for its own at current energy prices. If added to the rent, the sum of rent plus heating/DHW cost (called "Warmmiete" in German) remains constant for the tenant at energy prices of today. So he has gained nothing in terms of financial burden, but has an insurance against even higher energy prices in the future (and profits from better comfort in his flat).

A second look shows that the situation is more complicated. Refurbishment will almost every time embrace not only energy retrofit, but also other modernization measures (elevators, lighting, electric equipment, sanitary facilities, green areas etc.), with cost in the same order of magnitude. Therefore, increase of rent is inevitable, but justified because of the much increased quality of a totally renovated building.

For the housing provider, temporary vacancies in their buildings are an important issue. Therefore he will make use of public support programs and of "tenant management" (relocating tenants according to their needs of dwelling size and rent level) to be able to adjust the rents as moderate as possible. It is a continuous task for the management of the housing company to find an optimized and acceptable long-term strategy to maintain a sustainable profitability of its building stock.

4.4. THE ITALIAN CONTEXT

In Italy there are 26.5 millions houses, of which 9 millions are mono or double family houses. The total constructed volume of residential buildings is 5,5 billions of m^3. Of these 26,5 millions houses, 17,5 millions have been constructed before 1973 (year of first energy conservation Building Regulation) and hence without attention to energy conservation.

Between 2000 and 2005, energy consumption in the residential sector has grown all together of 16,4%, from 26,5 MTOE to 30,8 MTOE. The energy intensity has register a growing trend between 2003 and 2005, reaching the value of 42,4 TOE/M€ in 2005.

Heating represents the major final energy consumption in the residential sector. Each of the 19 millions dwellings with a heating system consumes roughly a ton of oil per year for this function.

It's an average between very different values depending on geographical locations, very high in the north of the country and in mountain areas, and very low in the South, on sea coastal areas where, specially in second houses, the heating system is not normally installed. Is has been calculated that energy consumed in the construction of the house is equal to the energy consumed in 5 years for heating, or in 3 years of all the energy consumption of the building, being the estimated total primary energy consumption in the construction phase equal to 11 MTOE.

In terms of primary energy, the building sector is responsible of 45% of the national energy consumption and CO_2 emissions.

In this situation, where the building sector has a great importance in terms of energy consumption, the performances are scarce both in terms of thermal insulation and heating systems efficiency.

Even if in Italy a lot of work is done in order to increase consciousness of energy saving and energy efficiency issues, and that there is an increasing number of operators which can provide technological advanced solutions, the increase of energy efficiency in buildings remain a target largely unfulfilled.

A study done in 2002 by EURIMA (European Insulation Manufacturing Association), in which have been analysed the insulation typology of walls and roofs in different EU Countries, shows that the insulation of buildings in Italy is lower then in other Countries. In Italy, every year 7 millions m^3 of insulation products are sold on a year base, with an annual increase of 3,5%, which corresponds to 0,1 m^3 per inhabitant. An even larger difference with other UE Countries concerns windows, through which it is estimated that occur 20-25% of total energy losses of the buildings. In this sector since 1990 many European Countries have improved significantly the quality of the building stock, while in Italy the situation has remained stationary: of the 410 millions m^2 of windows, 75% are nowadays still single glazed, while only 1% of total are low-emittance double glazing.

The adoption of EU directive on building energy performance is a critical point, an occasion in which Italy should re-think the rule that the construction sector should play in terms of achievement of the national objectives of energy conservation.

Energy markets in Italy are characterized by ownership unbundling: final consumers can freely choose a provider for electricity (from July 1st 2007). With regard to energy costs, over the period 2003-2007, in Italy natural gas prices charged to final domestic consumers increased by 19,61% while electricity prices charged to final domestic consumers increased by 14,42%. (Source Eurostat).

Surveys at EU level show unclear results concerning the phenomenon of fuel poverty in Italy, but according to national statistics in 2005, 10,9% of the households declared they were unable to heat their home adequately (22% in the South of Italy) and 9% were in arrears with payment of energy bills (15,3% in the South). (Source: Istat).

In order to identify which components of the buildings could lead to a major potential of energy savings in case of retrofitting, it is necessary to look at 2 factors: the weight of a single component on the total consumption and the margin of improvement for each component.

On the basis of these 2 factors, it has been calculated that the major energy savings can be achieved on the Heating, which could be improved up to 80% between the more efficient solution and the less efficient solution.

For what concerns the consumption of electrical appliances, of which air conditioning is responsible for 20% of the total, the potential increase of the efficiency is of 30% from the less efficient solution to the more efficient solution.

In terms of reduction of the costs supported by an “average” family, in case the family has all the less efficient technologies implemented in its house, it could save 700 € if it should implement all the most efficient technologies. This correspond to a reduction of 70% of its actual total energy cost.

At least, we can say that the average household energy expense is 1.344 €/year and the increase of energy tariffs in the last 12 months is as following:

- Electricity +12,5%
- Natural gas +14,5%
- Increased energy bill +200 €/year

The housing consumption as share of total household consumption (the EU average is 21,2%) is up to 25,5% (2004) and the evolution of share of households' housing consumption on total consumption is up to +31,4% (1995-2004).

And all these data show the urgency of a sustainable energy retrofitting strategy at the national scale as well as for each Italian cooperative.

4.5. THE ROMANIAN CONTEXT

Energy retrofitting of residential buildings became a national priority due, at least, to 3 major reasons:

- The dwellings stock precarious condition – specially those built before 1990 - as regarding their thermal insulation has shown a great potential of energy saving
- The availability of energy resources shaped by reducing of internal reserves so the increasing of the dependency rate of imports (around 30% now, but estimated to 50% in the near future) and by the permanent energy price increase
- The need of compliance with the EU exigencies in this field

Most of the dwellings are in buildings 15 to 55 years old, having a poor degree of thermal insulation. The residential sector represents almost 40% of the total energy consumption while energy losses reach 30-40%. Energy used in the dwellings sector for heating and hot sanitary water represents more than 75% but its efficiency is only 43% at the national level (63% in Bucharest).

Under these circumstances, **around 2.5 millions of dwellings (almost 1/3 out of the total number) need interventions in order to improve their energy performance**.

The improving of buildings energy performance in Romania was a pre-accession condition and the specific EU regulations in the field were transposed in the national framework such as 91/2002/ EC Directive on energy performance of buildings which is the core of the Law 372/2005.

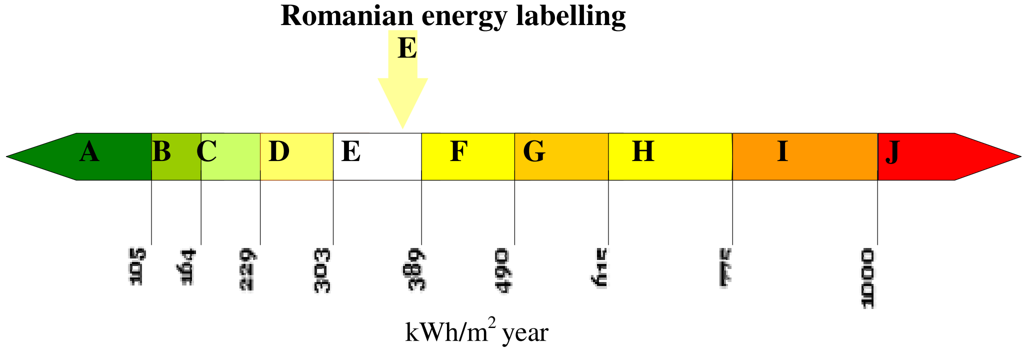
The Action Plan on Energy Efficiency adopted by Romanian authorities following the Directive 32/2006/EC stipulates that the programme of energy retrofitting of multi-stories buildings will provide a reduction of energy consumption by 25%, representing around 36,000 MWh/year for the period 2008-2010 (about 3,000 tons oil equivalent).

In this context, governmental programmes for buildings retrofitting launched in 2003 had an important role, and especially 2 of them:

1) The pilot programme on energy retrofitting of some residential buildings including social dwellings with a local authority as the owner (2003-2004)
2) The national programme on energy retrofitting of the multi-stories residential buildings (2005-2015), focused on the block of flats built between 1950 and 1990 in the urban area with a high population density and connected to the centralized system of thermal energy supply.

In spite of the efforts to implement energy retrofitting measures, there are modest results up till now. **The major obstacles were the exceptional high rate of private ownership (97%) and the low level of tenants' income** (who usually have already difficulties to cover the usual costs of the dwelling).

Romanian energy labelling



PART 2

THE BUILDING SCALE LCEC ANALYSIS

5. THE BUILDING SCALE ANALYSIS WITH THE FACTOR 4 MODEL

5.1. A QUICK, EASY AND CHEAP USE IN ANY CASE

The state of the art done at the beginning of the project (cf. deliverable 7) has shown that energy analyses are to much complicated both

- for the users of the tools themselves and so the results have many important errors
- for those who pay for them: the social owners as well as local authorities and most those from public administration. More often no one is able to see the errors in the results given by the technical consultants;

The Factor 4 model is easy to use as it was asked by social owners themselves.

The only problem which is still to be solved at the end of the Factor 4 project is to give some security to this use with an additional job on the software for allowing a secure use by anyone. This has still to be done when a large use is overseen, as it is in France for example.

The Factor 4 models are dealing correctly with most of the building cases as it has been said by social owners themselves during the final conference in Paris.

5.2. A LOT OF ANALYSES DONE IN EACH COUNTRY

Many best practices have been analysed or assessed with the Factor model in each country in order to validate the model and to finalise it. We must say that we confirm our idea that best practices are most often only focussed on energy or ecological objectives.

The SEC model for example has been tested on 32 case studies with 170 buildings and 5 439 dwellings[24], representative of buildings with more than 5 500 dwellings.

We illustrate this type of use with the analysis of some best practices in Romania.

This type of very simple and quick use can be for social owners of course for themselves and within the dialogue with public administration (local and territorial) as well as with financial partners.

5.3. THE ANALYSIS OF A ROMANIAN BEST PRACTICE AS AN EXAMPLE[25]

General data on the building

- Address: Bloc 122, Progresului St., Piatra Neamt (city)
- Construction year: 1978, Thermal rehabilitation project (IPCT): 2003
- Retrofitting works: 2004 and Monitoring period: 2004/2005 and 2005/2006 during winter
- Number of the dwelling units: 100 (single room or bachelor flat)
- Gross area (A_d) = 2746 m^2; Heated volume (V_{inc}) = 5063 m^3; Envelope area (A_{anv}) = 3621 m^2; Envelope area/Heated volume = 0.71
- Building structure: Walls: prefabricated reinforced concrete panels; Roof: garret framework; Windows: coupled/wood
- Heating system: Central heating – urban network/radiators ; Individual central heating, both with natural gas

[24] these case studies are in the deliverable 9 in national language. A synthesis of the French case studies is also in deliverable 10.

[25] The data are related to a pilot project developed mainly with the financial support of the Ministry of Transports and Constructions and they were presented at the Seminar on *Thermal works 2006-2009. Quality and efficiency* on February 2007 by a team representing the Association of the Energetic Auditors in Construction

- Climatic data: External temperature: t_e= -18°C (SR 19 07/1); Number of days-degrees: N = 3560 (SR 4839)

The building before retrofitting works

Energy performances of the building before retrofitting works

• Rm = 0,548 m^2K/W << Rp= 1,4 m^2K/W Rac= 3 m^2K/W

• G = 0,74 W/m^3K >> GN = 0,51 W/m^3K

• Q_0 = 189 kW → $q_0 = Q_0/V$ = 37,3 W/m^3

• $Q_{(heating)}$300,4 MWh/year → $q_{(heating)}$=Q /Ad = 109,4 kWh/m^2·year (or 150 kWh/heated m^2·year)

• Total Q $_{(heating + warm water)}$ = 516,2 MWh/year→ q total = Total Q /Ad = 188 kWh/m^2·year (or 255 kWh/heated m^2·year)

Energy retrofitting and its impacts the building energy performance

- Retrofitting works

- Additional insulation of the external walls by polystyrene of 8cm thickness
- Additional insulation of the garret floor by polystyrene of 12cm thickness
- New windows with a higher level of thermal insulation
- Taps with thermostat + costs repartition devices
- Washing & hydraulic equilibrating of the heating installation
- Thermal insulation of the underground distribution pipes (heating + hot water)
- Sanitary fittings with a lower water consumption and individual countering of hot water

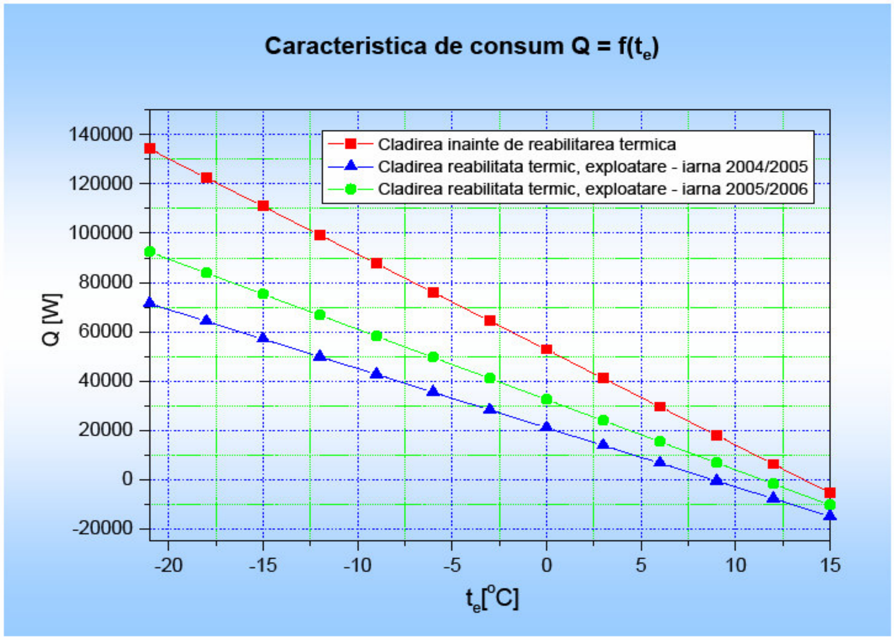
- Evaluation of the building performances

Energy performances

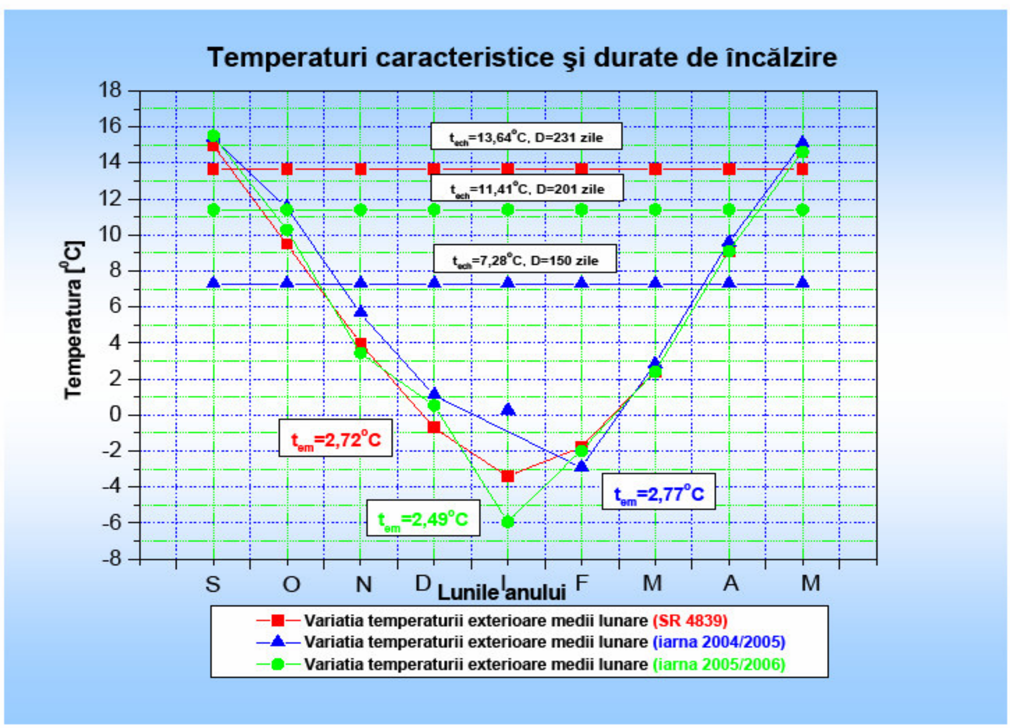
• Rm = 1,54 m2K/W		G = 0,413 W/m3K
• Q_0 = 79,5 kW	→	q = 15,7 W/m3
• $Q_{(heating)}$= 165 MWh/year	→	$q_{(heating)}$ = 82 kWh/m2·year
• Q total $_{(heating+warm water)}$= 193,6 MWh/year→		q total = 97 kWh/m2·year

• Yearly reducing of the thermal energy consumption : 62,5 %

Consumption before retrofitting, during the winter 2004/2005 and 2005/2006



The specific temperature and the heating duration between September and May



Source Jana Suler for APDL and Factor 4

Technologies, investment costs and energy savings

No.	Technologies	Investment costs*		Energy savings		Payback period (years)	
		Euro	%	KWh/year	%	**	***
1.	Additional thermal insulation external walls	43678	34.7	83361	25.8	21.8	13.1
2.	Additional insulation of the garret floor	6511	5.2	36796	11.4	7.4	4.5
3.	Windows with a higher level of thermal insulation	36040	28.7	58257	18.0	25.7	15.4
4.	Washing & hydraulic equilibrating of the heating installation	4178	3.3	15020	4.7	11.6	7.0
5.	Taps with thermostat + costs repartition devices	8528	6.8	24522	7.6	14.5	8.7
6.	Thermal insulation of the underground distribution pipes	1991	1.6	27278	8.5	3.0	1.8
7.	Improved sanitary fittings and individual countering of the warm water	24804	19.7	77499	24.0	13.3	8.0
8.	**TOTAL REHABILITATION MEASURES**	**125730**	**100**	**322733**	**100**	**16.2**	**9.7**

*Without VAT **Energy cost: 24Euro/MWh ***Energy cost: 40Euro/MWh

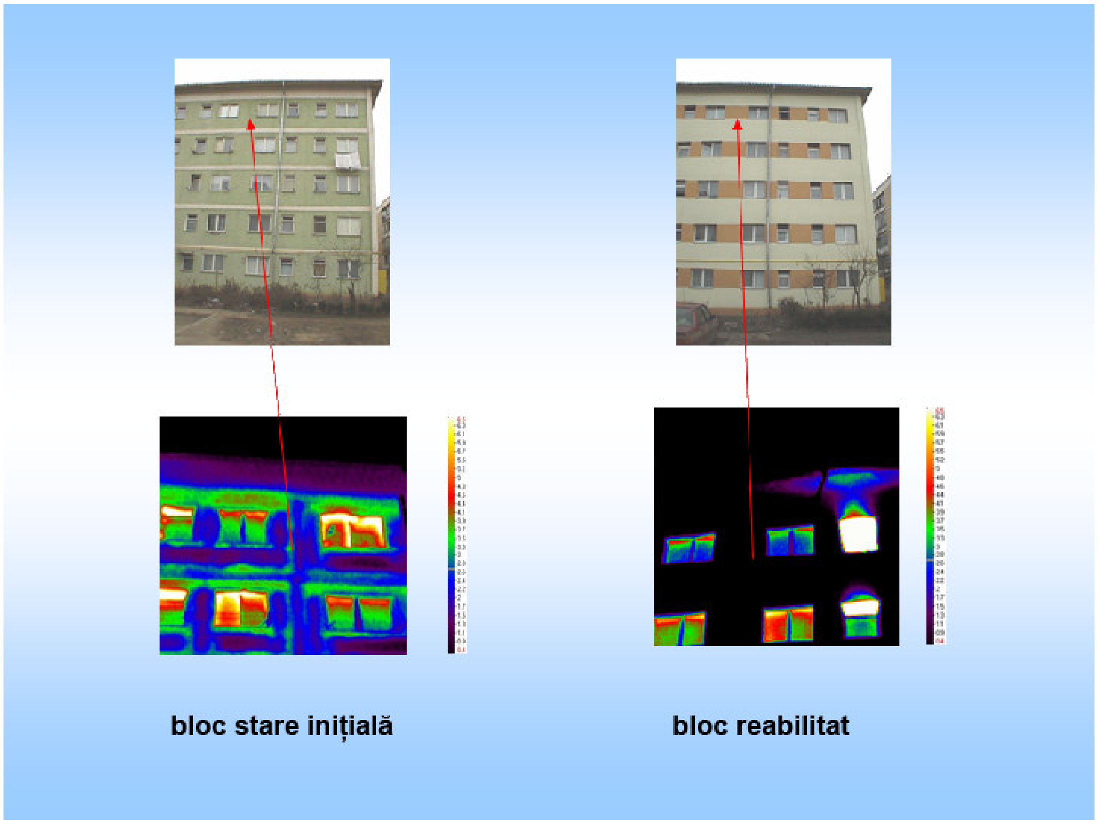
Unitary investment of the overall measures: 1257 Euro/dwelling

45.78 Euro/sq.m

- **Results**

The building after retrofitting works

Thermographies before and after retrofitting works



Source Jana Suler for APDL and Factor 4

Building performances before and after retrofitting works

Indicators	Unit	before retrofitting	after retrofitting, winter 2004-2005	after retrofitting, winter 2005-2006
G	W/m^3K	0.74	0.456	0.542
	%	100	62	73
t_{im}	°C	19	21.8	22.5
Q	MWh/year	516.1	308.8	285.5
	%	100	59.8	55.3
q	$kWh/year \cdot m^2$	188	112.4	103.9
CO_2 emission	$Kg/year \cdot m^2$	37.6	22.5	20.7

Conclusions

The main effects of the pilot project were:

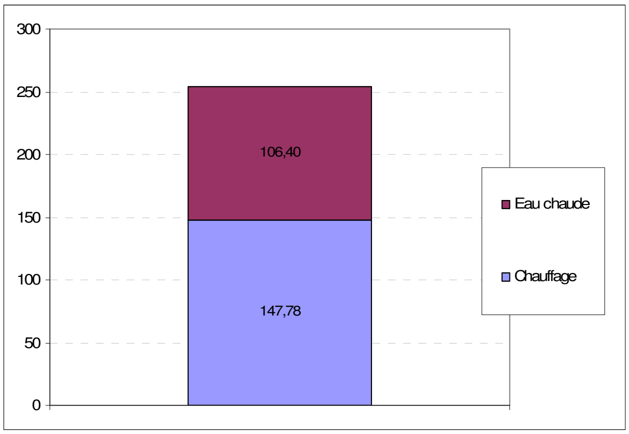
- ☺ The improvement of the hygienic conditions and the internal comfort degree
- ☺ The reducing of the thermal energy consumption so of the tenants expenditure by 40 to 50%
- ☺ The reducing of the pollution
- ☺ Moderate investment costs with a payback period of 10-15 years

The final conclusion of the experts was the necessity of a permanent monitoring action and the mention of the need for tenants' information and training for building companies in order to improve the quality of the works.

The analysis with the French SEC model[26]

A/ Initial analysis before retrofitting works

Consommation du bâtiment en kWh par m^2



Consommation finale - chauffage et ECS - en kWh / m^2

254,2

		marge	calculé
Chauffage	147,8	8%	159
ECS	106,4	-3%	103

Energie primaire - chauffage et ECS - en kWh ep/m^2 - an

317,7

Emission de CO2 - chauffage et ECS - en kg CO_2 / m^2

31,8

Remarque: les étiquettes ne sont pas mentionnées car le modèle n'est pas adapté spécifiquement au contexte roumain.

B/ Results after the retrofitting programme

We present here the results as for the French analysis because they were given, by the SEC model.

In **the first figure** we can see the results after the retrofitting programme. The first figure shows the evolution of the Net present Value (BNA) and of the CO_2 factor (F4) according to the various techniques chosen.

The second figure shows the evolution of the investment needed according to the chosen techniques.

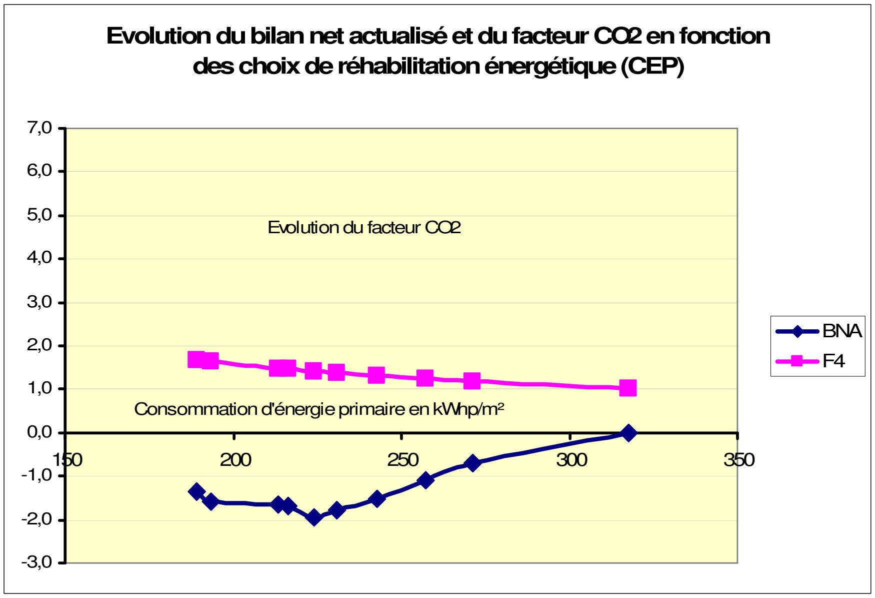
The third figure shows the savings for tenants or for the users of the dwellings according to the chosen techniques and taking into account the energy price increase (with the blue curve) and with constant energy price (with the pink curve).

At least **the final table** summarises all the results and confirms that the retrofitting programme was a positive solution.

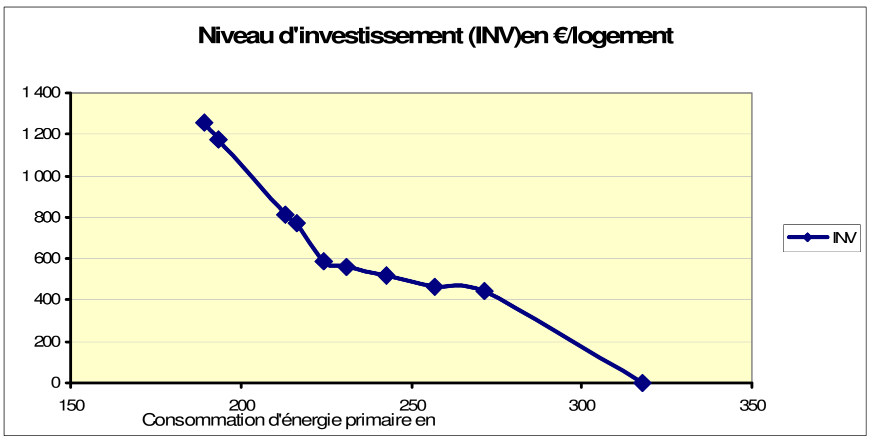
Comments:
You can notice some differences between the results expected by the experts, the data measured and the results given by the SEC model. Romanian experts and the SEC model give the same results but the real data are not the same. This can be explained by 2 facts: first the know-how of the local building companies is not as good as expected and second residents / tenants should have been aware in order to modify their habits…

[26] The budget did not allow to set out a Romanian model and so this is still to be done… as we wanted to do in another SAVE proposal but this one was not selected…

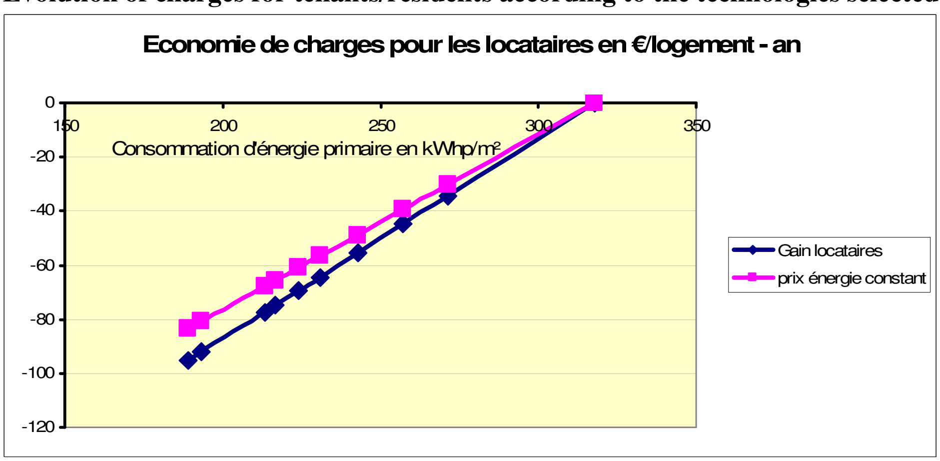
Evolution of the LCEC according to the technologies selected



Evolution of the investment per dwelling according to the technologies selected



Evolution of charges for tenants/residents according to the technologies selected



Source La Calade for Factor 4

	AVANT	APRES	Economie en %
Résultats en ratios unitaires			
Consommation d'énergie annuelle en kWh par m^2	254,3	151,4	40%
dont chauffage	148	72	51%
eau chaude sanitaire	106,4	79,4	25%
électricité parties communes	nc	nc	
électricité logements	nc	nc	
		189,4	

	AVANT	APRES	Economie en %
Emission de CO_2 en kg par m^2	31,8	18,9	40%
dont chauffage et ECS	31,8	18,9	
Dépenses énergétiques annuelles en € par m^2	11,6	6,9	40%
Dépenses énergétiques /an hors effet prix énergie	10,2	6,1	40%

	AVANT	APRES
Résultats par logement		
Consommation d'énergie annuelle en kWh par an	5 162	3 074
Emission de CO_2 en tonnes par an	0,6	0,4
Dépenses énergétiques annuelles en € par an	235	140
Résultats pour le(s) bâtiment(s)		
Consommation d'énergie annuelle en MWh	516	307
Emission de CO_2 en tonnes CO_2 par an	65	38
Dépenses énergétiques annuelles en € par an	23 538	14 011

Investissement unitaire en € / m^2		Temps de retour	
Chauffage	38		
Eau chaude sanitaire	4		
Electricité	0		
Total	**42**		
Autres investissements incontournables ayant un impact énergétique	20	9	13

Investissement par logement en €		
Chauffage	771	
Eau chaude sanitaire	81	
Electricité	0	
Total	**853**	
Autres investissements incontournables ayant un impact énergétique	**404**	**1257**

Investissement pour le(s) bâtiment(s) en €	
Chauffage	77 140
Eau chaude sanitaire	8 120
Electricité	0
Total	**85 260**
Autres investissements incontournables ayant un impact énergétique	40 360

Bilan économique	**BENEFICE**		
	€ / m^2 - an	€ / logement - an	€ / projet - an
Investissement en € actualisés par an	2,46	50	4 996
Autres investissements incontournables ayant un impact énergétique	0,89	18	1 807
Maintenance annuelle		0	0
Economie d'énergie à prix de l'énergie constant (hors inflation)	-4,11	-84	-8 353
Hypothèse hausse des prix de l'énergie	-0,58	-12	-1 173
Bilan net en € net actualisés par m^2	**-1,34**	**-27**	**-2 723**

FACTEUR CO2	**1,7**

5.4. SCENARII TOWARDS AN OPTIMISATION

5.4.1. The potential uses

Many uses have been done with the Factor 4 model. We distinguish several potential cases:

- **The « usual » research of a factor 4:**

This is the typical best practice supported by the European Commission as well as by national and local public administration. The deliverable 7 describes some of these case studies in each country.

We illustrate this type of use with the Danish example of Kildevaenget.

- **Scenarii towards a retrofitting optimisation:**

We illustrate this type of use with

- an Italian case study
- the results of a French analysis for working out a building stock strategy.
- the strategy of Wolkswohnung for its whole building stock

- **Scenarii at a territorial scale** :

This is illustrated by the neighbourhood regeneration of Moulins-sur-Allier.

5.4.2. A scenario towards the ecological optimum (or the factor 4) in Denmark: the KILDEVÆNGET case study

Kildevænget (located in Gladsaxe) is a social housing stock with 450 housing units in a three floor level and basement[27]. The total rented floor area is 35,136 m^2 and the average size of the apartments is 78 m^2. The whole settlement is heat supplied by district heating from a combined heat and power plant. The district heating is lead into the building blocks through a central boiler room and is distributed to five sub-boiler rooms. The domestic hot water is produced in each sub-boiler room from where the space heating and domestic hot water are distributed to the apartments through an internal district heating network with separate pipes for space heating and domestic hot water. The total consumption of district heating is monitored in the central boiler room and covers the total space heating and domestic hot water demand including losses from the internal district heating network.

Kildevænget represents the category in the Danish typology with the largest treated floor area:

Climatic data:	Copenhagen
Type of building:	Building block
Year of construction:	1958 (no energy requirement, BR0)
Heating supply:	District heating (CHP)
Distribution:	Single pipe system
BEMS:	yes

Since the construction date several improvements have been introduced:

1985:	The heat supply changed from oil to district heating.
1986:	New windows with 2-layer glass with integrated air inlet dampers.
2003:	New 4000 litre domestic hot water storage in each sub-boiler room.
2005:	New internal district heating network.
2006:	Automatic light control on the stair cases and in the basement.
2006:	The pump in the internal distribution network is replaced by new automatically controlled pumps.

[27] The full example is in the deliverable 7 with the Danish case studies

Kildevænget, Gladsaxe

South West facade

North East facade

3 kW pump for space heating distribution

4 000 Litres domestic hot water storage

Source Cenergia, DK

Common laundry facilities in the basements

Remark

Such common laundries are almost in all social housing buildings in Denmark

Monitored heat consumption

The consumption of district heating, electricity and water for the whole settlement have been monitored during the last five years. The district heating is the total district heating that enters the central boiler room divided by the total heated floor area. The consumption of electricity is the common use excluding individual electricity usages in the apartments. The common electricity covers the pumps, lighting in staircases and basements, outdoor lighting, laundries and lightings in rooms for common activities. The monitored data are shown:

Monitored consumptions per treated floor area in Kildevænget.

	2000	2001	2002	2003	2004	2005	Gen
Heat	144	132	129	131	135	135	134
Water	0.81	0.78	0.77	0.76	0.70		0.76
Elektricitet	8.0	8.1	8.2	7.8	6.0		7.6

The monitored data are adjusted compared with a normal climatic year and it is possible to compare the data year by year. The average energy consumption during the last five years is 134 kWh/m^2 and it is 9 % above the average of the category which is 123 kWh/m^2. In general the heat consumption in Kildevænget is too high mainly because the flow temperature of the internal distribution network is high and consequently the heat losses from the piping to the ground are too high. Also the tenants' energy behaviour is assessed to be bad. There are no explanations of the variations between years.

The energy manager has proposed an extension of the district heating heat exchanger to improve the operation in order to achieve lower heat losses from the internal district heating network. Today the whole settlement receives a penalty from the district heating supply company as a result of too high return temperature. Also an awareness campaign for the tenants has been proposed to improve the operation of the radiators in the apartments. It is estimated that a 2 % energy saving can be achieved by better operation of the radiators and it is equivalent to 30.000 DKK per year (4 000 Euro).

Automatic light control in stair cases has been installed in one block and an electricity saving of 70 % has been identified. It is recommended by the energy manager to install the automatic light control in the remaining stair cases.

Calculation of energy consumption

The energy needs for space heating and domestic hot water including losses in the internal district heating network are calculated by ASCOT and Be06 and the results are:

Be06	158 kWh/m^2	ASCOT	121 kWh/m^2
Målinger 2005	135 kWh/m^2		

Assumptions

The area of the building elements have been measured on the original drawings.

Input data to the ASCOT model

Project ID	**Kildevænget**	
Year of construction	1958	
Size of the buiding project (treated floor area)	1760	m²
Number of dwellings	24	
Number of floor levels	3	
Building category	Building block with flats	
Central- or individual heating	Central heating system	
Internal distribution	Insufficient insulation	
Energy resource (Fuel type)	District heating	
Efficiency of the heat production	88%	
Reference, electricity	31	kWh/m²
Reference, water inclusive hot water	0.70	m³/m²
Reference consumption hot water	30%	
Weather data		
Station	DK, Copenhagen	
Building characteristics		
Wall, U-Value	0.45	W/m²K
Roof, U-Value	0.39	W/m²K
Floor, U-Value	0.54	W/m²K
Window, U-Value [W/m2K]	2.40	W/m²K
Data for new heating system		
Central- or individual heating	Central heating system	
Heating supply system	District heating	
Efficiency of the heat production	95%	
Economic data		
Investment of reference project	0.00	DKK/m2
Set aside (maintenance)	2.5%	%
Expected economic lifetime	30.00	years
Discount rate	5.0%	
Tax of interest	0.0%	
Inflation of energy	2.5%	
Inflation of maintenance	2.0%	

The whole settlement includes 16 building blocks, and block No. 15 is used for the Be06 calculations. The block consists of 24 dwellings in three floor levels with a total treated floor area of 1760 m^2. The building block is calculated with unheated stair cases and basement.

The external wall is cavity brick wall with insulation between the outside. The flowing U-values have been used:

External wall, 140 mm cavity wall with 10 % massive wall.	0,45 W/m^{2}K
Partition wall to staicases.	1,75 W/m^{2}K
Basement wall below ground level	0,54 W/m^{2}K
Basement wall above ground level	0,54 W/m^{2}K
Floor slap between ground floor and basement	1,14 W/m^{2}K
Floor in basement	0,56 W/m^{2}K
Roof/sealing	0,39 W/m^{2}K
Windows, 2 layer of glasses	2,40 W/m^{2}K

The total window area is 18 % of the treated floor area.

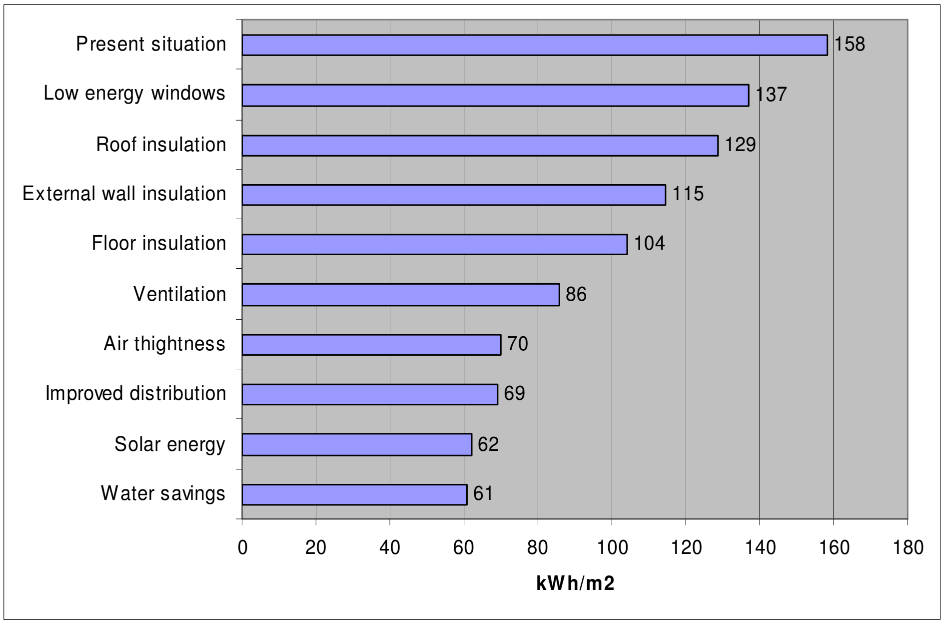
The dwellings are ventilated by natural ventilation with extract air from kitchen and toilets.

- **Energy Scenario**

The housing scheme is well preserved with regular maintenance and with some energy savings improvements. The energy consumption is high compared to the energy standard in new houses and the energy performance must be improved considerably if the houses should be attractive also in year 2050. It is assessed that comprehensive energy savings initiatives must be implemented if the housing scheme is still well preserved in year 2050. The following text describes how 60 % energy savings can be achieved by implementing different energy savings measures. 100 mm external wall insulation is proposed which in reality will be difficult since the present architectural design has great value and must be protected in the future. It is necessary to develop techniques which can improve the external wall without changing the architectural design of the building. The fresh air and good indoor air quality must be established by installing mechanical ventilation with heat recovery. This kind of installation needs space but different demonstration projects have shown attractive solutions in the existing housing stock. Utilisation of solar energy is proposed as supplementary energy supply system for heating domestic hot water. The system is a centralised system with two sq. solar collectors per dwelling and the existing distribution network for hot water. The present heat loss from distribution is high and in the future these losses will represent a bigger contribution of the total heat demand in the future when net space heating demand is reduced. Therefore it is necessary to improve the distribution network, and research is necessary to achieve a full energy efficient supply system for housing.

The energy consumption is calculated by the software Be06 when implementing different energy saving technologies and the results are shown in the Figure below. The proposed energy improvements give a total energy saving of 65 %.

Energy savings obtained by installing different energy savings technologies



Source Cenergia

In addition to the energy savings for space heating the water savings also gives a lower heat demand for producing domestic hot water.

- Installation of new low energy windows reduce the energy consumption for space heating from 158 kWh/m^2 to 137 kWh/m^2.
- Extra insulation on the roof reduces the heat consumption to 129 kWh/m^2.
- Wall and floor insulation reduces the heat consumption to 115 kWh/m^2.
- Mechanical ventilation with heat recovery reduces the heat consumption to 86 kWh/m^2 assuming counter flow heat exchanger and low energy DC-fans.
- Improved air tightness to passive house level (0.6 l/sm^2 with an air pressure on 50 Pa) reduces the yearly heat consumption to 70 kWh/m^2.
- Improved insulation of district heating distribution network reduces the energy consumption to 69 kWh/m^2.
- Solar heating system for heating domestic hot water reduces the heat demand to 62 kWh/m^2. The solar heating system is a central system with a collector area of 2 sq. per dwelling.
- Finally water savings reduces the heat consumption to 60 kWh/m^2.
- Roof insulation: by adding 200 mm insulation in the roof attic the energy for heating is reduced by 8 %. The roof attic is empty and it will be easy to add a new layer of insulation.

Low e-windows: Installing new windows in the building reduces the needs for heating. The U-value of the existing windows is 3.1W/m^{2}K, and the value of the new low e-windows is 1.2 W/m^2. 29 % savings are achieved compared to the base case.

Façade insulation: 150 mm external insulation of the entire façade will reduce the energy for space heating. An external insulation will effectively reduce the transmission losses including minimising the heat losses through cold bridges. The external insulation is a dramatically change of the building but it is necessary if the target of 75 % reduction in CO_2 emission has to be achieved.

Floor slap insulation. The floor slap between ground floor and basement is insulated by 100 mm Rockwool. The basement is unheated and the insulation will reduce the transmission losses from the apartments to the basement.

Mechanical ventilation. By installing mechanical ventilation with heat recovery (MVHR) the ventilation losses are reduced. It is assumed high temperature effectiveness (85 %) with energy efficient distribution ducts and fans. To achieve the estimated saving it is anticipated that the building is very airtight obtained during installation of new windows and the external insulation of the building envelope.

DHW circuit for SH. All the technologies mentioned above reduce the need for space heating, and the main consumer is now the domestic hot water production and distribution. The space heating supply system is proposed to be changed by removing the whole internal distribution network, including the radiators in the apartments, and utilise the domestic hot water circuit for space heating, and install a heating coil in the air inlet ducts of the mechanical ventilation system. That will reduce the distribution losses considerably.

DHW circuit: Improvement of the distribution network for domestic hot water. The total energy consumption is now reduced by 76 % compared to the base case.

Solar heating: Finally solar heating for domestic hot water is proposed as a central system using the domestic hot water storage tanks in the five sub-boiler room as solar storage tanks. The DHW circuit will distribute the solar energy for domestic hot water and space heating as well. 1 m2 solar collector per apartment is proposed which means five systems with 90 m^2 solar collector each. The base energy consumption for heating is now reduced by 90 %.

The energy savings obtained by introducing the energy savings measures mentioned above are also calculated by the ASCOT tool and the results are shown in Figure 8 together with the Be06 results. It seems that the estimated savings calculated by the two tools corresponds quit well.

The different energy savings technologies are not identical defined in the two tools as the tenants' behaviour is not included in the Be06 programme, and losses from production and distribution are not defined in the same manner. In spite of these differences the results from the two calculation tools are close to each other.

- **Economic viability**

The cost benefit analysis is calculated by use of the calculation tool ASCOT and the results are given in the next table.

Key figures of the cost benefit analysis – Kildevænget

		per sqm.	per dwell	per block	per settlement
Present heat consumption	kWh	121	8873	212960	3993000
Reduced heat consumption	kWh	25.2	1848	44352	831600
Present CO2 emission	ton	0.034	2.53	60.7	1137.7125
Reduced CO2 emission	ton	0.013	0.96	22.9	430.2375
Present running costs	kr.	18	1,339	32,126	602,358
Reduced running costs	kr.	14	1,013	24,320	456,000
Extra investment costs	kr.	191	13,994	335,867	6,297,501

The yearly heat demand is reduced from 121 to 25 kWh/m^2 corresponding to an 80 % saving. To achieve the high rate of saving it requires an investment in low energy technologies of 14.000 Euro per dwellings or 6.3 million for the whole settlement.

The running costs are reduced from 1.340 to 1.000 Euro per dwelling corresponding to 20 %. The saving in percent is relatively low as the energy savings technologies require extra maintenance costs. That means the economic viability is not attractive for the tenants as the simple pay back time is calculated to 43 years. Even with an increase in the energy costs the investment is not a profitable investment for the tenants.

The following energy costs have been used in the economic costs calculations:

District heating	54	Euro per MWh

Electricity	276	Euro per MWh
Water	5.0	Euro per m^3

One of the objectives of the Factor 4 project is to reduce the CO_2 emission caused by the energy use in the building. This means heating, electricity and water. **The ASCOT programme is used to calculate the CO_2 emission and the list of improvements shown are able to achieve this Factor 4 objective**.

By introducing all the technologies mentioned in the list, the CO_2 emission will be reduced by 63 %, and the factor 4 objective of 75 % will not be reached. The CO_2 emission from heating is reduced by 85 % and the electricity by only 50 % which results in a total reduction of 63 %. It is assessed that it will be difficult to achieve further savings on site, but the CO_2 emission from public electricity supply will contribute to further CO_2 reduction as renewable sources like wind power and waste energy are expected to be more common as the energy resources in the future, and it will bring the total savings above the target of 75 %.Proposed energy savings of the case study – Kildevænget.

		Technologies	Already implemented	Possible implementation	Implementation needed Factor 4
Heating					
H	1	Passive solar heat design			
H	2	Controlled mechanical ventilation			x
H	3	Airtightness			x
H	4	Energy savings through water savings			x
H	5	Energy savings through tenants behaiviour			x
H	6	Windows			x
H	7	Individual meters	x		
H	8	Cold bridges reduction			x
H	9	Additional thermal insulation of walls			x
H	10	Additional thermal insulation of roof			x
H	11	Additional thermal insulation of floor			x
H	12	Pipe insulation			x
H	13	Balance between distribution			
H	14	Cooling			
H	15	Building energy management system		x	
H	16	Heat pumps			
H	17	Thermostatic valves	x		
H	18	New heating system including CHP		x	
Water					
W	1	Individuel meters	x		
W	2	Solar thermal collectors for domestic hot water			x
W	3	Hot water distribution			x
W	4	New hot water tank with semi-istantaneous system			
Electricity					
E	1	Energy efficient lighting			x
E	2	Electricity savings through ventilation			x
E	3	Electricity savings through tenants behaivour			x
E	4	Hard white goods - Grade A or better		x	
E	5	Roofed clothes drying yards			x
E	6	Daylight optimisation			
E	7	PV panels		x	
E	8	Regulation of circulation pumps of individual biolers	x		
E	9	Closing audiovisual and electric equipment			
E	10	Collective laundry	x		

Source: Cenergia, DK

5.4.3. The comparison of scenarii for the retrofitting programme of an Italian cooperative building

As each building is a very complex system, especially for what concerns the interactions between the envelope and plants, energy redevelopment projects require a holistic approach with a 360 degrees view of the problems.
As a matter of fact, energy redevelopment not only covers saving issues, but it can be an opportunity to improve the quality of the living ambient, healthiness and wellbeing, too. For example, when putting new thermally insulated windows, there is a chance to boost safeness against shocks and acoustic performances: with stratified glasses it is possible to respect the severe rules about facade acoustic insulation.

As for the building shell insulation, it can raise internal surface temperatures, providing a more comfortable thermal sensation and, when applied on the exterior, drastically reducing mould risk, especially on thermal bridges.

The comprehensive design of such a renovation asks for a solid framework, based on a proven methodology to determine energy and ambient performances and to arrange practical actions with respect to project goals.

In the balance of costs and benefits, the ranking of possible actions can be different, indeed, whether or not they have to be applied each one separately or in conjunction with other ones.

This idea is well expressed by the life cycle cost analysis, which can take into account direct and indirect costs during the whole work lifecycle, the whole life of the building. Through the life cycle cost analysis, it is viable to consider not only the savings in the energy bill, but also the favourable outcomes in smaller social and environmental costs.

The main goal of the retrofitting of the building stock in Italy is so to find up procedures that can help the decision making process and promote such an approach.

Starting from these premises, the professional firm "Ricerca e Progetto Galassi, Mingozzi e associati" in Bologna studied energy performances of an existing apartment block, on behalf of the cooperative "Murri", built during the '70s, as well as many similar houses.

The chance to redevelop that building with different actions, and the consequences on economic, social and environmental issues have been investigated according to the Factor 4 approach or methodology, as it greatly matters today as an investment opportunity.

The case study is a block of 24 flats built with prefabrication techniques owned by tenants. External walls are made by un-insulated concrete panels mounted on a framework of reinforced concrete, then an air gap and brickwork with plastering on the internal side. The horizontal roof is slightly insulated, but there are some suspicions about the integrity of the insulating layer. The ground floor, which covers unheated underground parking, is insulated on the intrados. Windows have aluminium frame and 3/4/3 glasses.

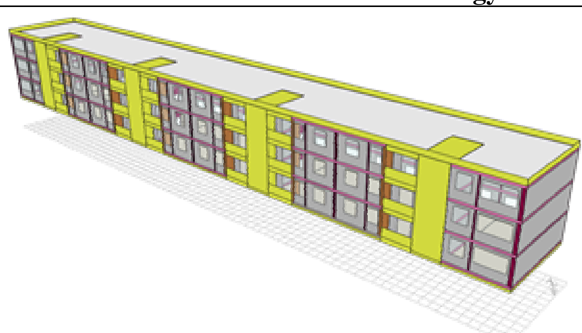
As for plant system, heat generator is centralized and it has never been changed, but only underwent some maintenance operations. The service company stresses that the boiler requires extraordinary maintenance. Hot water storage is quite insulated, while distribution pipes are inadequate.

Rooms have convector heaters. Energy expenses are paid by the condominium as a whole, and they are split on the basis of each apartment's heated surface.

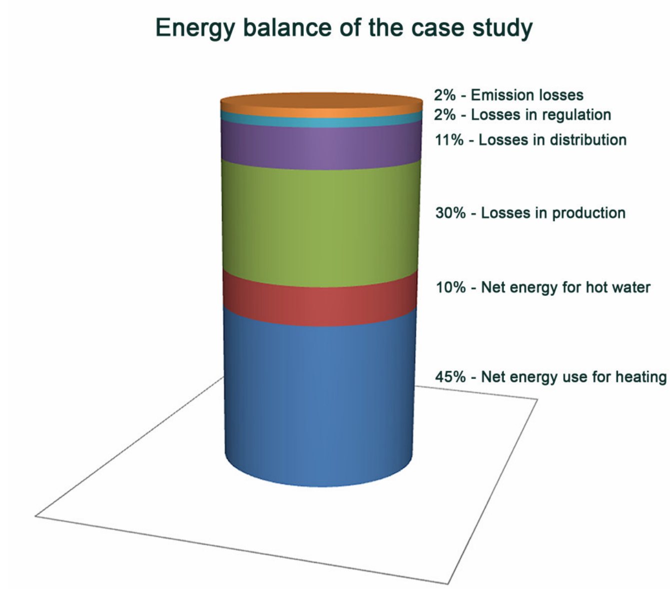
Energy consumptions are derived from utilities bills, and their normalization with the degree-days stated by law produces about 193 kWh/m^2 of primary energy per year.

In order to investigate the effects of redevelopment actions, a software model was prepared, containing all relevant data about energy performances, such as thermal transmittances and plant system efficiencies.

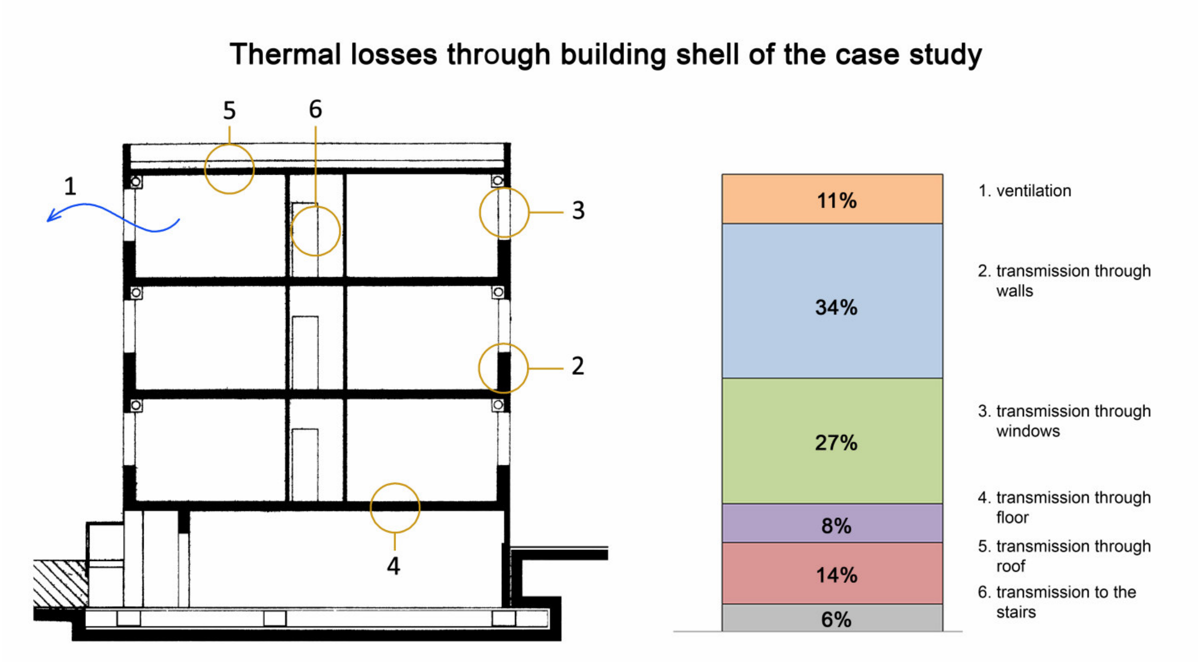
The model use for energy simulation



The calculation of energy use for heating was made according to UNI EN 832 and UNI EN 13790. Data derived from technical literature and from direct inspections, as well as measured consumptions, permitted to split thermal losses in their main parts: i.e. transmissions through walls, windows, roof, floor, etc.



Source Ricerca & Progetto

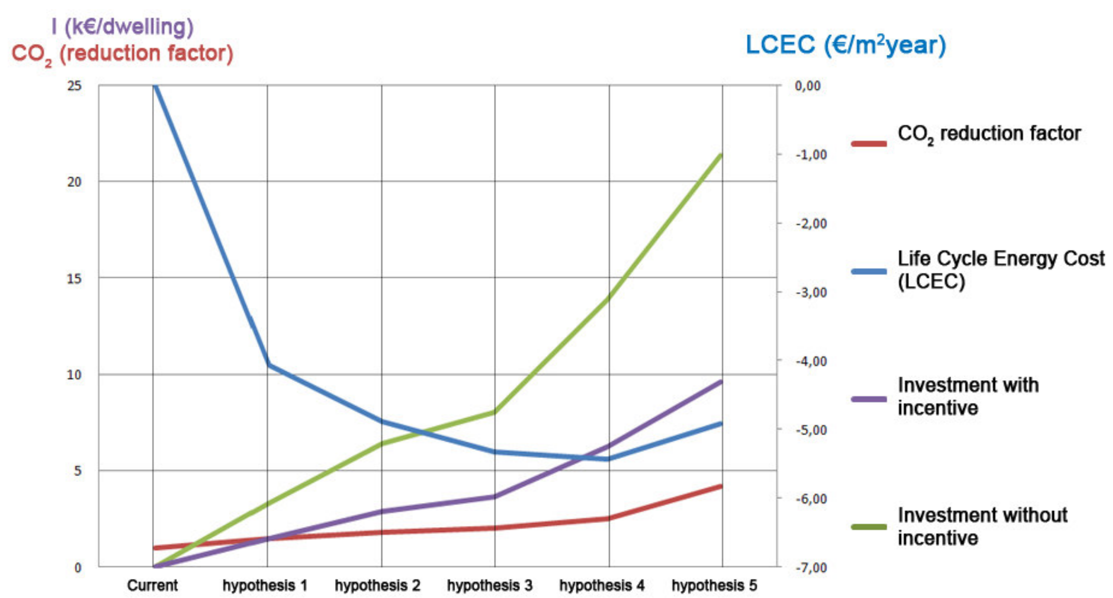


From this point, it was possible to define various actions, with the purpose of achieving the minimal performances required to get the public incentives, and a new better category in the energy classification as defined by the regional guidelines (still a draft going to become effective in short time).

Once fixed the redevelopment actions, costs were estimated by asking quotes to sellers and installers, and taking into account the accessory expenses, too, connected to scaffolding, safety measures, technical assistance.

Economic analysis is founded on the Net Present Value (NPV) of incomes (specifically savings) and costs: for a standard 20 years lifetime, the future cash flows are brought to the smaller values they would have today because of the money inflation, and at the same time energy costs (and thus future savings) are increased by the expected energy inflation.
The analysis is carried out separately for each single action, then for the sum of more actions, progressively added on the basis of their convenience. In the life cycle energy cost analysis, economic benefits are weighted with environmental and social outcomes.

The life cycle energy cost analysis

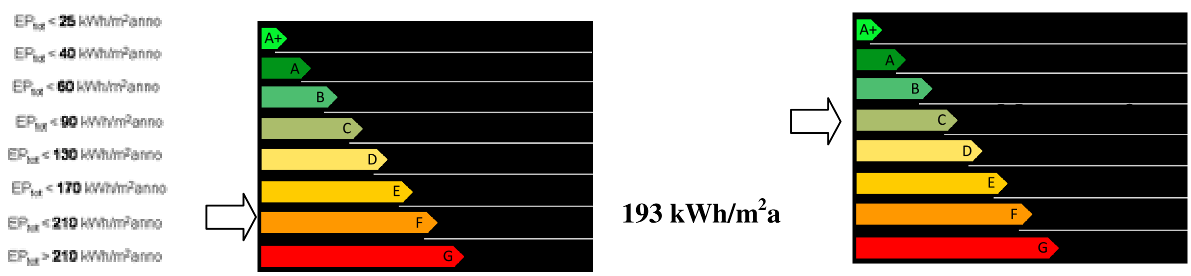


Starting from current situation, actions are applied on the basis of their opportunity, one after another.

In the case study, assuming the current money inflation, and giving the 55% redeeming of expenses for sure, the chosen actions, in their advisability order, are: new heating generator and insulation of distribution pipes, new roof insulation and waterproofing, solar panels for hot sanitary water, wall coating, new windows with good acoustical performance, too. The best choice has been recognized in doing all the actions except the last one (window renovation). In that case the current energy needs of 193 kWh/m^2 per year, which correspond to the class F in the energy performance ranking, would become a 63 kWh/m^2 per year and class C. The payback period would be 8.8 years; each dwelling would pay 6994 €, including the 55% incentive and would initially save 708 Euros in annual energy bills (savings are expected to raise, since energy inflation will probably be greater than money inflation) (cf. the table below).

Energy label according to the "Guidelines on Energy Certification" of Emilia Romagna Region

From class F to class C; average year savings on energy bill 708 €



Source: Ricerca & Progetto for Factor 4

Summary values of the selected scenario

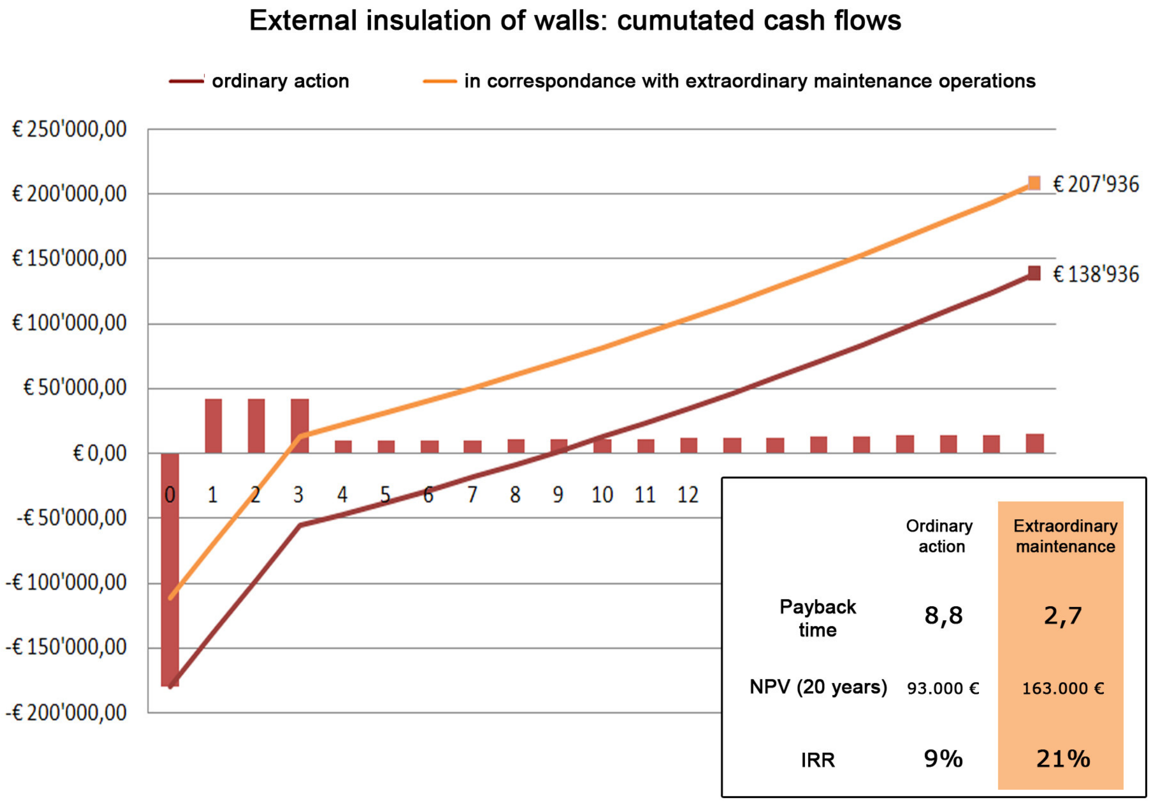
Investments	Energy and CO_2 emission savings	Net cost per dwelling with subsides	Payback
373.000 €	**67%**	**6.994€**	**8,8 years**

The value-added derives from a better control system of heat generator, hot sanitary water softening, anti-Legionellosis plant, much better thermal comfort in all the dwellings, and especially in the higher ones, since they would be protected from direct overheating, too, with a high reflectance waterproof membrane.

Energy consumption and therefore pollution and greenhouse gases would decrease by 67%.

The action on windows, which is the less profitable investment, will become significant when anticipating a little extraordinary maintenance works, which have to be made anyway because of performance deficits caused by aging. In this situation the energy redevelopment would be an extra-cost only, that will repay itself in much less time, giving at the same time a great deal of advantages.

The opportunity of a retrofitting planned in accordance with maintenance plan.

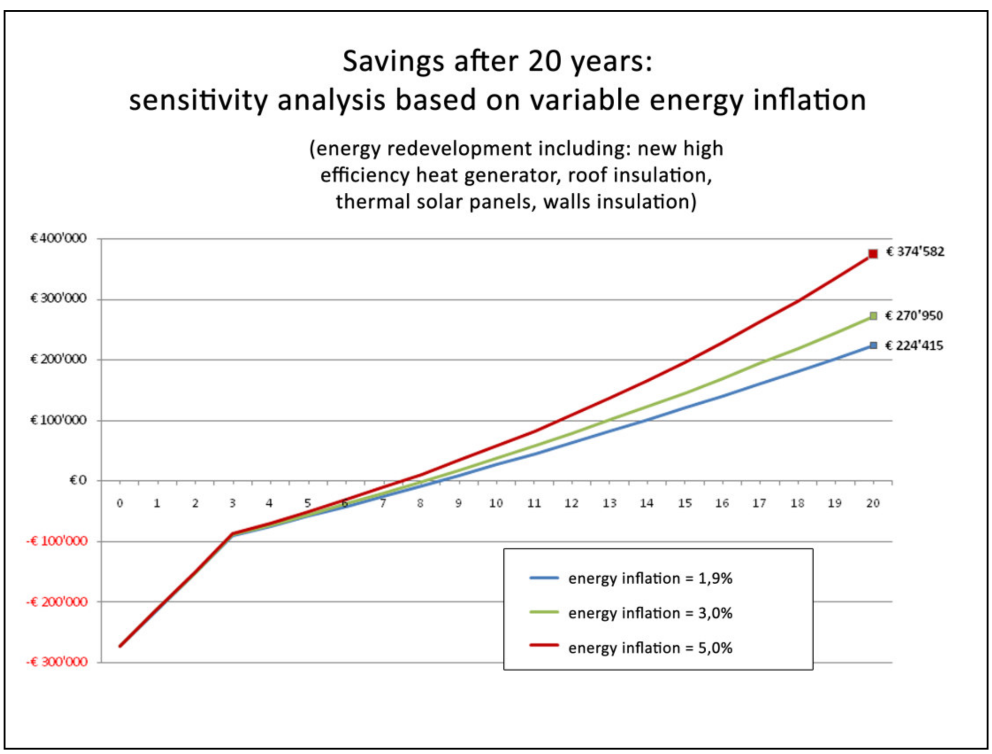


	Ordinary action	Extraordinary maintenance
Payback time	8,8	2,7
NPV (20 years)	93.000 €	163.000 €
IRR	9%	21%

Source: Ricerca & Progetto for Factor 4

A sensitivity analysis on the variation of the energy inflation was performed: it clearly appears that a small increase in energy price brings big savings in the future.

The sensitivity analysis on energy price increase: savings after 20 years



The results are encouraging. The way to present benefit both in terms of energy, CO_2 reduction and social ones is a good way to show global opportunities and convince tenants.

As concerns this specific case study, the next steps will be carried out by Ricerca & Progetto to estimate the reduction of charges for tenants and then by the coop Murri to suggest tenants to proceed with works and to give them all the assistance to ensure the result. The same cooperative together with Abita (ANCAb-legacoop) is studying now the possibility to finance such interventions and get advantages from energy savings according to Energy Service Companies mechanisms.

Looking to the existing buildings, their year of construction and their maintenance status, it appears a great potential in the direction of European Community objectives, which imply a 20% reduction of CO_2 before 2020, in respect to 1990 emissions.

It is evident that a complete analysis can arise only by examining each specific case, considering all the mentioned variables, and using an appropriate methodology.

5.5. THE FACTOR 4 MODELS: SIMPLE USEFUL DECISION AID TOOLS FOR THE BUILDING SCALE IN COHERENCY WITH THE EPBD

As we have seen in the previous chapters and as shown in the various deliverables, with the Factor 4 model(s) it is possible to analyse representative buildings (real existing buildings or best practices in energy retrofitting)[28].

The energy analysis done with the Factor 4 model is correct even if it could give more details. **So the Factor 4 models can be used at the building scale.**

Its objective is not to be used for doing energy diagnosis as those worked by conventional energy companies. But it is possible to use these diagnoses when using the Factor 4 models. The Factor 4 model is much less complicated than the existing models and so it is a useful decision aid tool for quick analysis, even if the sophisticated existing models are still necessary of course for the finalisation of the retrofitting programmes.

Further more many criteria can be used for such an optimisation at the building scale (as it can be seen also in the Appendix 1): social criteria as well as ecological or environmental ones can be used separately in some specific cases or together in order to reach the overall optimum as we did in the Factor 4 project/approach with the Factor 4 models.

So we can say that the Factor 4 model is a decision aid tool in coherency with the EPBD (and it is an interesting complement to the EPBD).

And this can be seen especially when dealing with building stocks strategies or territorial policies.

But the Factor 4 model has not been worked out for the building scale (most of the existing best practices) but for the building stock or territorial scales (for best policies). **The Factor 4 objective is to set up strategies for building stocks:**

- **strategies of social owners themselves**
- **and territorial strategies/policies of local authorities**

Such building stock strategies or territorial policies (best policies including best practices) are according to us the only way for reaching the European 3x20 objectives as well as the factor 4 objective.

[28] Cf. the various deliverables 9 in national languages

PART 3

THE BUILDING STOCK LCEC ANALYSIS

Some famous energy experts are promoting a universal solution or package but the numerous cases studies or best practices analysed in each country involved in Factor 4 have shown that there is not any universal solution or package.

Existing buildings are in vary different conditions (as regarding energy consumptions, CO_2 emissions, incomes of their users/tenants, etc.), and a technical unique solution is not at all possible, and first of all because the necessary budget for such a policy is not available and so this universal solution is not realistic at all.

But**, if there is not any universal solution, it is possible to find the best solution for each type of building and this is the objective of the Factor 4 approach**. The Factor 4 approach aims at an overall/multidisciplinary (sustainable) optimisation for each building type of a building stock in order to set up **a suitable strategy for each building stock according to its building types** and this is the further step of the Factor 4 approach we show in the following chapters.

6. SOME ISSUES OF A BUILDING STOCK ANALYSIS

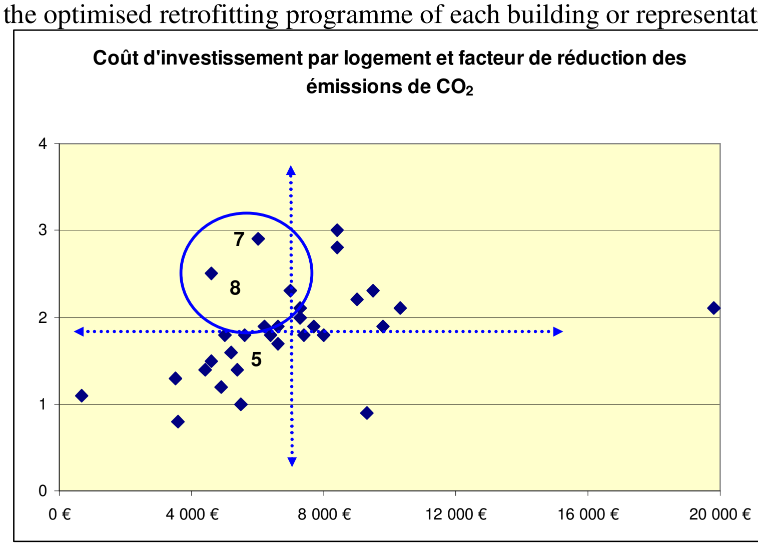
6.1. SCENARII TOWARDS AN OPTIMISATION FOR A BUILDING STOCK (FRANCE)

At the building stock scale, when you have finished all the optimisations for the representative buildings, you can set out a figure like the following one with all the optimised scenarii or retrofitting programmes in order to better see which programmes are the most interesting or profitable ones (see also the chapter 6.2).

The following figure shows the investment cost per dwelling and the CO_2 factor evolution of the optimised retrofitting programme of each representative building of the building stock of a social owner.

Investment cost per dwelling and CO_2 factor evolution

for the optimised retrofitting programme of each building or representative building



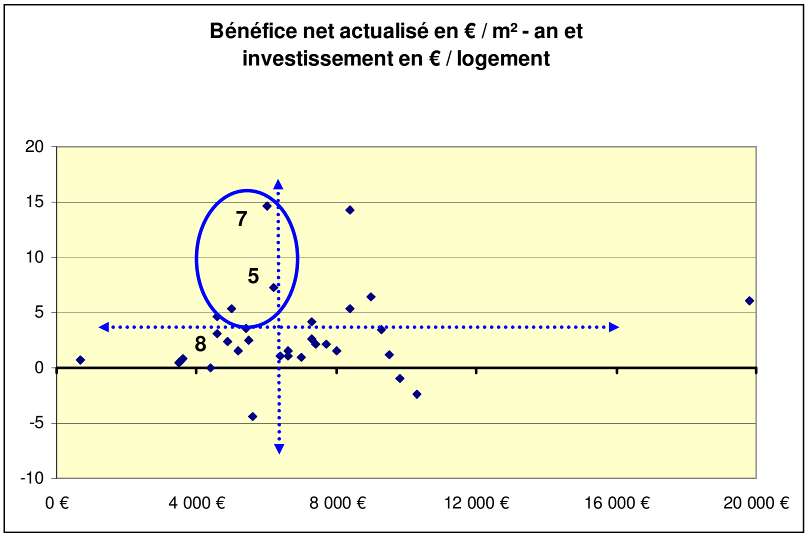
Source La Calade for the final Factor 4 conference

Then you can choose the buildings to retrofit (by adding the other criteria such as social issues or regulation adaptation of course).

For example, if your selection criteria is the investment / avoided CO_2 emissions, you will choose the buildings number 7 and 8 as shown is the above figure.

And, if you choose the Net Present Benefit as the main criteria, you will retrofit first the buildings 5 and 7 as shown in the following figure.

Net Present Benefit in €/m² per year and the investment per dwelling in €/dwelling



Source La Calade for the final Factor 4 conference

6.2. THE TECHNICAL ENERGY RETROFITTING STRATEGY OF THE VOLKSWOHNUNG (D) BUILDING STOCK

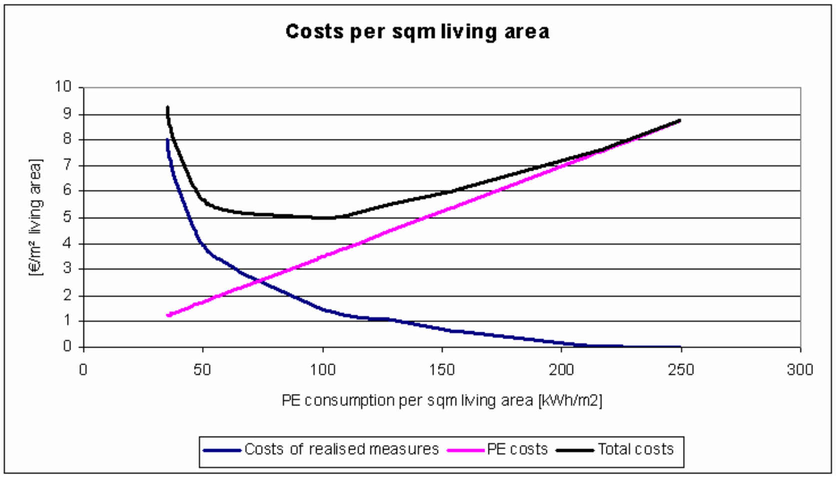
Energy retrofitting of buildings involves a number of different measures: new or additional insulation of the envelope surfaces, new windows with certain thermo-physical properties, mechanical ventilation with or without heat recovery, replacement of boiler, removal of heat bridges, introduction of new decentralized heating control etc. All measures have different cost structures and different benefits. In addition, some of the measures, as wall insulation, can be realized in different ways and, in this case, the cost / benefit – ratio will behave in a non-linear way. **It is therefore important to evaluate this combination of measures, which will provide the total cost minimum**, which in itself will also be dependent of external parameters, such as energy price, calculated interest rate and depreciation tome of the different components.

Of course, to solve this task a computer model is necessary, and this kis the first objective of the Factor 4 approach.

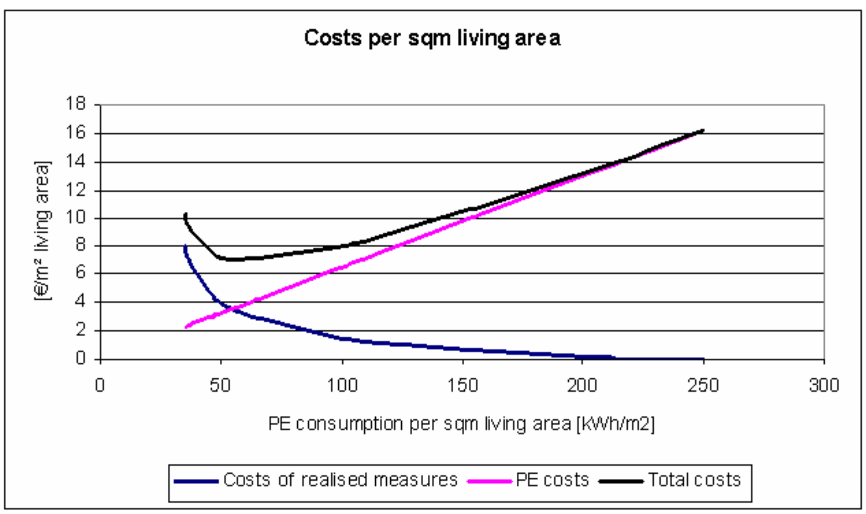
Since it is quite laborious searching for the optimum combination by trial and error, Volkswohnung has developed a model which is able to find the total cost minimum automatically, using a "steepest cost-gradient" calculation. The resulting model, called VROM ("Volkswohnung Retrofit Optimization Model"), is described in detail in deliverable 8.

As a result, it is possible for every building type to find out **the best energy retrofit strategy crossing technical issues and costs.** The calculation is a life-cycle type of calculation, since it uses the discounted cost of the investments involved over the technical lifetime of the different measures. The benefits of the different measures – in terms of energy savings - involved are calculated according to principles of building physics. The energy price is not varied with time (such as "percentage of annually increased energy price"), but kept fixed for a model run. The influence of the energy price on the cost minimum found can be explored by making different runs with varying energy prices. The illustration below shows an example for the result of a model run. Here, the total annual cost per sqm (= sum of annualized cost for energy conservation investments, maintenance cost and energy cost) are shown as result of an optimization by VROM: Beginning with a primary energy demand of 250 kWh/m² before retrofit, the model calculates for a number of (small) improvement steps, which combination of measures will allow for the least total annual cost. The chart below shows the rising annualized cost from investments and the falling energy cost (in this case, at an energy price of 35 €/MWh) due to the energy saving effect of the proposed measures. The measures investigated by the model in this case were insulation of walls, basement ceiling and attic with increasing insulation thicknesses, new windows (U-value 1.5 and 1.1 W/m^2.K), ventilation with or without heat recovery, boiler substitution, heat bridge withdrawal. Which of these measures are chosen, and which thickness of insulation, cannot be seen from the chart, but is provided by VROM as table. In the chart, a (flat) minimum of total cost is achieved with a combination of measures, which results in a primary energy demand for heating of about 85 kWh/m^2.

Total (optimized) cost in dependence from the achieved level of energy performance: VROM-result (primary energy price: 35 €/MWh)



Total (optimized) cost in dependence from the achieved level of energy performance: VROM-result (primary energy price: 65 €/MWh)



The illustrations above show that with increasing energy price the minimum is moving towards smaller primary energy demand for heating, as expected. However, since the cost increase on the left branch is quite steep, there is a “saturation”: Even with further increasing primary energy prices the optimized level of performance does not move below about 45 kWh/m^2 (which roughly corresponds to an improvement by a “factor 4”, considering heating energy only).

This result was achieved for a 5-storey multi-family building with 30 dwellings. Results for other types of buildings came also into the range of 40 – 50 kWh/m^2 cost minimum at high energy prices, but partly with quite different combinations of measures. This is discussed in more detail in the deliverables 7 and 8.

Using this approach, for every building type of Volkswohnung the optimized combination of conservation measures can be derived. Used as one criterion, together with other considerations concerning the long-term development plans for of Volkswohnung's building stock including financing issues, a cost efficient energy conservation strategy can be developed and implemented.

But the VROM model is only dealing with the building envelope on the one hand and it does not deal with other criteria and especially with socioeconomic ones. The objective of the Factor 4 approach is, as we already explained it for the building scale, to deal with all the issues and all the retrofitting techniques and not only with the envelope and to take into account all the issues, including socioeconomic ones.

6.3. A TERRITORIAL SCALE WITH THE ANALYSIS OF ALL THE BUILDINGS CONCERNED BY RETROFITTING ACTIONS IN A NEIGHBOURHOOD REGENERATION PROJECT

You can manage at the territorial scale as for the building stock of a social owner and select the representative buildings as it has been shown in the deliverable 10.

6.4. A TERRITORIAL ANALYSIS (BY LOCAL AUTHORITIES OR PUBLIC ADMINISTRATION) FOR DEFINING THE NEED FOR PUBLIC SUBSIDIES

Such an analysis can be done by a local authority in order to know the level of needed public subsidies in case of a political criterion as the main decision criterion for social owners, as for example going until the factor 4 or until 80 kWh/m^2 - as it is done in the Plan Climat (climate action plan) of Paris.

With a LCEC analysis (with each of the Factor 4 models), you can identify the needed level of subsidies for reaching your political objective or for reaching the optimum if social owners cannot increase the rent (as it the usual case in France for example) and have to pay the whole investment without any payback return. (See also the chapter 7).

6.5. TOWARDS THE CHOICE OF (ENERGY) EFFICIENT TECHNOLOGIES AND LOCAL OR REGIONAL STRATEGIES FOR ENERGY RETROFITTING

Various technical solutions can be found and the first task is to identify them[29] in order to set up scenarii with techniques even if they are not (yet) available at the local level. This is important **for suppliers (of equipments or products) as well as for maintenance enterprises** at the conurbation or local (regional) scale because this can help them to anticipate the market and to set up their own development strategy.

The optimisation with a LCEC analysis in a Factor 4 approach allows comparing a lot of various scenarii (and not only those given by sub contractors), taking time into account if necessary: to identify the works to be done now and those to be done in 4 or 5 years for example.

This LCEC optimisation allows to select the most energy efficient (including the socio-economic issues) techniques on the one hand and to set up long term strategies for the whole building stock towards sustainability.

[29] The deliverable 6 on energy efficient techniques is the first draft of a data base which can become a national or a regional data base with local specificities (technical ones or as regarding prices).

For example, for a building built around 1970 (before the first energy regulations) with 40 dwellings on 5 floors around Paris with a 20 years old collective gas heating system we got the results shown in the following table.

Scenarii or energy retrofitting programmes comparison

Techniques Scenarii	S 1	S 2	S 3	S 4	S 5
Mechanical Controlled Ventilation Hygro B	x	x	x	x	
Additional thermal insulation of roof	x	x	x	x	X
Additional thermal insulation of floor	x	x	x	x	X
Energy balance system	x	x	x	x	
Energy consumption control system	x	x	x	x	X
Pipes insulation	x	x	x	x	X
Tenants behaviour	x	x	x	x	
Boilers/ new heating system including CHP with gas		X	X	x	
Double glazing 1,6 (+argon)	X		X	x	
Double glazing 2,5 (PVC)					X
Additional thermal insulation of walls 10 cm	X		X	x	
Hot water distribution lagging (insulation)	x	x	x	x	X
Hot water taps	x	x	x	x	
Solar heating system				X	
Investment in €/dwelling	10 120	5 020	11 740	13 000	4 600
Pay back return	13	8	14	14	10
Primary Energy Consumption in kWhpe/m^2 and energy labelling	77,8 B	119 C	66,6 B	50 A	160 D
CO_2 emission and CO_2 labelling	15,6 B	23,8 D	13,4 C	8,6 B	32,2 D
LCEC without price effect	- 0,58	- 2,08	- 0,02	+ 0,50	- 0,94
LCEC with a price increase (Δp= 4 %/year)	**- 5,60**	**- 5,98**	**- 5,34**	**- 5,25**	**- 3,72**
CO_2 factor	3,2	2,2	3,7	4,8	1,6

Source La Calade for Factor 4

In the scenario 1 we don't remove the heating system, we add insulation of walls and we remove the windows (reinforced double glazing with argon).

In the scenario 2 we remove the heating system without additional walls insulation nor the windows removal.

The scenario 3 is the 2 scenarii 1+2 together: a new heating system, additional wall insulation and new windows.

The scenario 4 shows the interest of solar heater water systems.

At least the scenario 5 is the business as usual scenario in France today.

- **Social owners policies**

We can notice that we reach the optimum with the scenario 2 with an investment similar to the usual one, around 5 000 €, but we reach only the factor 2.2, the energy labelling C and the CO_2 labelling D.

Now, if we imagine a voluntary policy with public subsidies for social owners, we will choose in this case the scenario 3 because it allows reaching the factor 3.7 and perhaps the scenario 4 in order to reach the factor 4.8…

At least, if we are able to anticipate some future retrofitting works and if we can manage them all along the next years, we will begin by the scenario 1 with additional walls insulation and the removal of windows (because if we first change the heating system, it twill not be at its optimal efficiency) in order to reach later on the scenario 3 (and the factor 3.7) or even the scenario 4 (and the factor 4.8).

- **The local enterprises know how**

At a local or regional scale, according to the building stock's technical and energy state and to the estimated price evolution (especially for energy), it would be possible to determine the needed works and the needed investments for reaching the (political) objectives.

This knowledge would allow also to set up the needed training courses (including for improving the workers know how in order to help people without any job to find one) and the needed local policies for improving the know how and technical possibilities of the local enterprises (which would be able to know the types of works they should deal with early enough to set up an investment plan if needed and to be ready and able to manage these works when needed).

- **Social owners financial long term strategies**

At least it is also possible to estimate the pay back return or profitability ratio without price increase for the scenarii selected (as for money invested in banks…):

Profitability ratio of the scenarii according to the price increase:
an example with some gas price increase on 25 years

Scenarii	Profitability ratio (en %) with a 2%/year Δp (gas)	Profitability ratio (en %) with a 4 %/year Δp (gas)
1	1,35	2,44
2	**3,05**	**4,18**
3	1,05	2,10
4	0,8	1,9
5	2,1	**3,22**

Source La Calade for Factor 4

We can compare these ratios to the potential ones on financial markets and compare the energy retrofitting needed investment to them for the same period…

- **Bank policies towards urban sustainability**

At least we could suggest that banks' sustainable development policies (especially for those linked to local authorities and to the State) should take into account the macroeconomic objective and support social owners in their efforts towards urban sustainability…

- **The need for partnerships involving all the actors concerned by energy retrofitting actions towards coherent strategies with common objectives**

All these figures and examples have shown how important are the partnerships in order to guaranty coherent strategies on the one hand and to reach the local objectives (climate action plan) but also the national and European objectives (3x20 and factor 4 for example) on the other hand.

This is particularly important for local authorities and social owners but this needs also price and cost transparency as well as training and a new way of working…

7. FROM THE BUILDING TO THE BUILDING STOCK ANALYSIS: THE MICROECONOMIC OPTIMUM OR THE OPTIMISATION FOR THE SOCIAL OWNER AND THE TENANT (TOGETHER)

The Factor 4 model and the Factor 4 approach allow answering this question**:**

How to go from the building scale to the building stock one and how to set up a sustainable strategy for energy retrofitting of the whole social housing building stock?

7.1. REMINDER OF THE STEPS OF THE BUILDING SCALE ANALYSIS WITH THE FACTOR 4 MODELS[30]

The energy consumption analysis of a building is done by joining data and estimations or calculations and the technical information available on the building.

At this first step, we have various objectives according to the context:

- to give the social owner a good information on energy consumption even without data (which is often the case in France and in Italy when there are individual heating systems)[31];
- to give social owners a technical description good enough to explain thermal losses in coherency with energy data available;
- to show coherency (or the lack of coherency) between theoretical calculation and real data as regarding energy consumption.

The starting point of the analysis with the Factor 4 model is the collection of data on energy consumption and on technical data on the building, both as regarding the envelop and heating and regulation systems.

Then scenarii are worked out (combining the various potential technical choices) and the life cycle cost analysis is done according to the choice of the most interesting techniques within iterative steps.

Reminder of the various steps of the energy audit at the building scale with the Factor 4 model

Phases	
1	Analysis of the building stock typology (of a social owner or at the territorial scale)
2	Choice of representative buildings (case studies)
3	Analysis of the energy consumption of each of the buildings
4	Elaboration of realistic scenarii (as regarding social, technical and architecture issues)
5	Evaluation of the scenarii impacts on thr microeconomic and macroeconimic issues
6	Selection of the best scenarii per each building type
7	Elaboration of the iteratif process aiming at the definition of the best optimised scenario according to various criteria
8	Elaboration of the optimised energy retrofitting programme for each building type

We want also to remind that various complementary tasks or things can then be suggested or tested with the Factor 4 model :

- the analysis with other complementary criteria (social ones for example)
- energy integration in the whole building stock management planning,

[30] See the deliverable 5 on the various existing tools and the deliverable 8 on each national model in national language and al least the deliverable 10

[31] In Denmark data are available and so the ASCOT model has not this objective

- looking for financial solutions in order to reach the optimum (within an improved dialogue with public administration for example).

The stages of the energy audit with the Factor 4 model towards a sustainable energy strategy/policy

1	Analysis of a social owners' building stock typology (of the overall building stock or on a territorial area)
2	Choice of representative buildings in the stock
3	Analysis of the energy consumption of these buildings
4	Elaboration of realistic scenarii for the building's retrofitting
5	Assessment of the impacts from the scenario on the three dimensions: energy, CO_2 or GEG emissions and socio-economy
6	Choice of the best scenario for each category of buildings
7	Elaboration of an iterative process defining an optimal strategy thanks to a multi-criteria analysis
8	Elaboration of a project or retrofitting programme

7.2. THE ANALYSIS AT THE BUILDING STOCK SCALE

An analysis has been done by La Calade for SAGECO (a French associated Factor 4 partner), a social owner from the important SNI Group located in Paris..

29 representative buildings have been selected by SAGECO and were analysed with the SEC model, building after building and then in the second step in their whole for working out an overall strategy for the whole building stock of SAGECO.

Then each building has been analysed and the scenarii worked out.

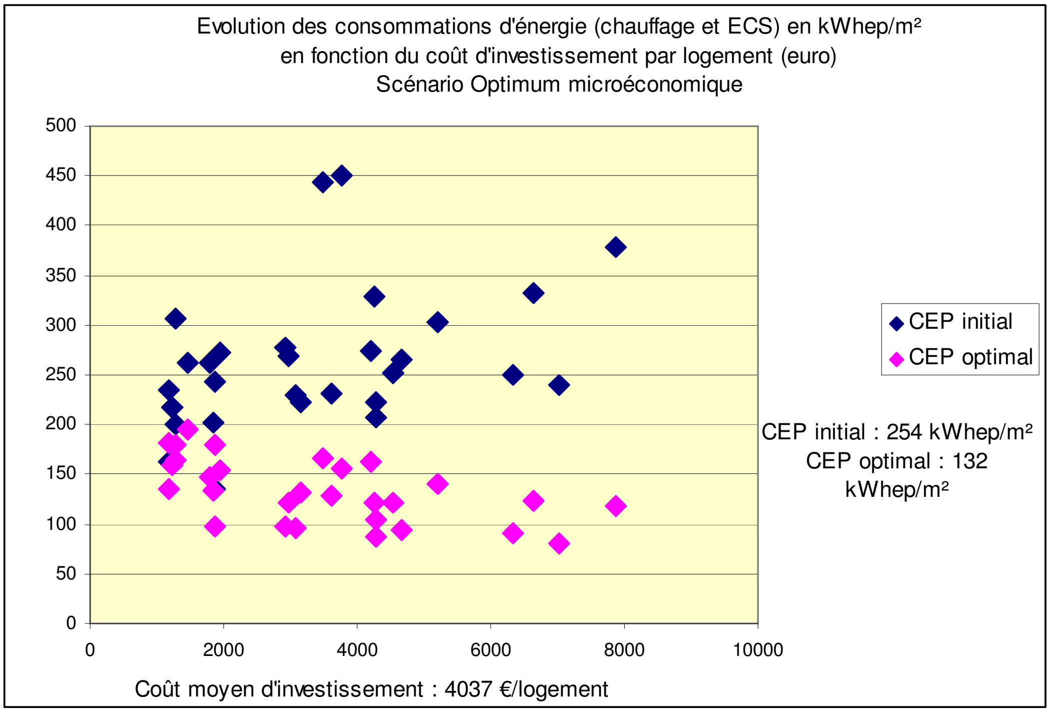
Then the results are gathered and represented for the 29 buildings together.

7.2.1. The micro economical optimum scenario or the profitability threshold for the social owner and the tenant together

The micro economical optimum is reached with an average investment of 4 000 € per dwelling. If so the primary energy consumption (PEC or CEP in French) for heating and sanitary hot water goes from 254 kWhpe/m² to 132 kWhpe/m², from the D to the C energy labelling as an average and CO_2 emissions are reduced with a factor 2,1.

The results of this scenario are shown in the following schema.

The evolution of energy consumption (CEP) (for heating and hot water) in kWpe/m² (kWep in French) **as regarding the investment cost per dwelling in € in the micro economical optimum scenario**



(average investment cost : 4 037 € per dwelling)

Source La Calade

7.2.2. A 80 kWhpe/m² scenario

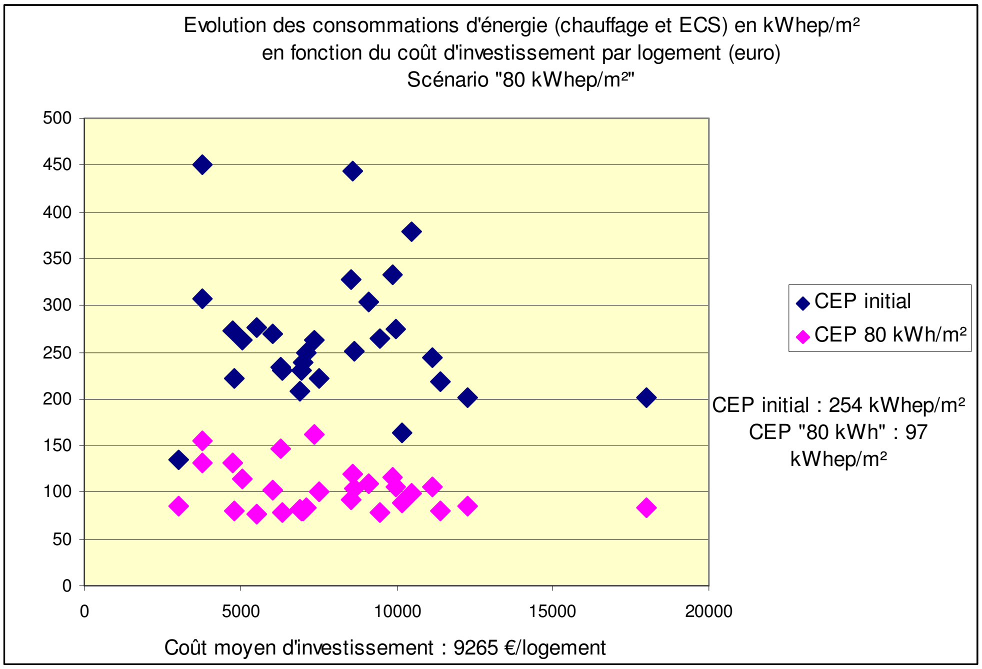
Various scenarii have been worked out among which one deals with the 80 kWhpe/m² objective because of the "Grenelle de l'Environnement" (an important public debate on environmental issues in France) and because of the Climate action plan of Paris (where the building stock of SAGECO is located).

By taking into account the various technical and social constraints which are indisputable for some of the buildings, especially in Paris (occupied dwellings, building position linked to another one, historical facades impossible to insulate with external techniques, solar heating systems rejected because of historic buildings nearby…) this scenario cannot go in fact until 80 kWhep/m² and it is possible to reach only an average consumption 97 kWhpe/m², id est a win of additional 35 kWhpe/m².

The needed investment is up to 9 300 € per dwelling and GES are reduced by a factor 2,7 as regarding the initial situation.

The results for the 29 buildings are shown in the next figure.

The evolution of energy consumption (for heating and hot water) (CEP) in kWpe/m² (kWep in French) **as regarding the investment cost per dwelling in € in the 80 kWhep/m² scenario**



Source La Calade

7.2.3. The scenarii comparison

This comparison can be done also for the whole building stock.

The microeconomic optimum gives the maximum profitability for both the social owner and the renter together.

If public administration asks for less than 100 kWhpe/m², the financial needs are increasing exponentially and the balance is becoming worse for the couple made of the social owner and the tenant.

If public administration wants social owners to go on with their social policy (as well as to avoid any financial strangulation risk), some subsidies or financial solutions must be found for an average of 28 % of the investment cost (which corresponds to additional subsidies of 2 600 € per retrofitted dwelling).

This can be shown in the following table.

Comparaison of the results obtained for each of the scenarii worked out

Scenarii	Investissement (M€)	Primary energy consumption for heating and hot water (kWhpe/m²)	Energy saving (GWh/year)	CO_2 avoided (tons/year)	Charges savings (M€/year)	Profitability M€/year (NPV or Net Present Value)[32]
'Microeconomic optimum'	18,5	132	32,6	5579	2,16	1,16
'Minimum energy consumption'	46,3	90	43,9	7040	2,61	0,42
'NPV > 0'	33,6	107	40,2	6590	2,46	0,79
'80 kWh/m²'	39,8	97	41,9	6728	2,56	0,61

Source La Calade

[32] Cf. the glossary

The life cycle energy cost analysis shows that charges savings are rather high for tenants. The « microeconomic optimum » scenario allows to reduce charges up to de 300 euro per year as an average in constant energy price (id est 0,42 € / m²- month).

7.2.4. Towards a sustainable energy retrofitting strategy for the whole building stock

The last step is to work out energy retrofitting strategies for the whole building stock.

In this case the objective will consist in the identification of the buildings or building families to retrofit in priority as well the definition of the optimal intervention level (how far to go for each energy retrofitting programme).

Four criteria have been used for this evaluation:

- **1. The first criteria can be the life cycle energy cost [33].**

According to this criteria the buildings or representative building types to be retrofitted are those for which the life cycle energy cost is the most decreasing due to the retrofitting programme[34].

The microeconomic optimum scenario can be used as a reference scenario (as shown in the following figure).

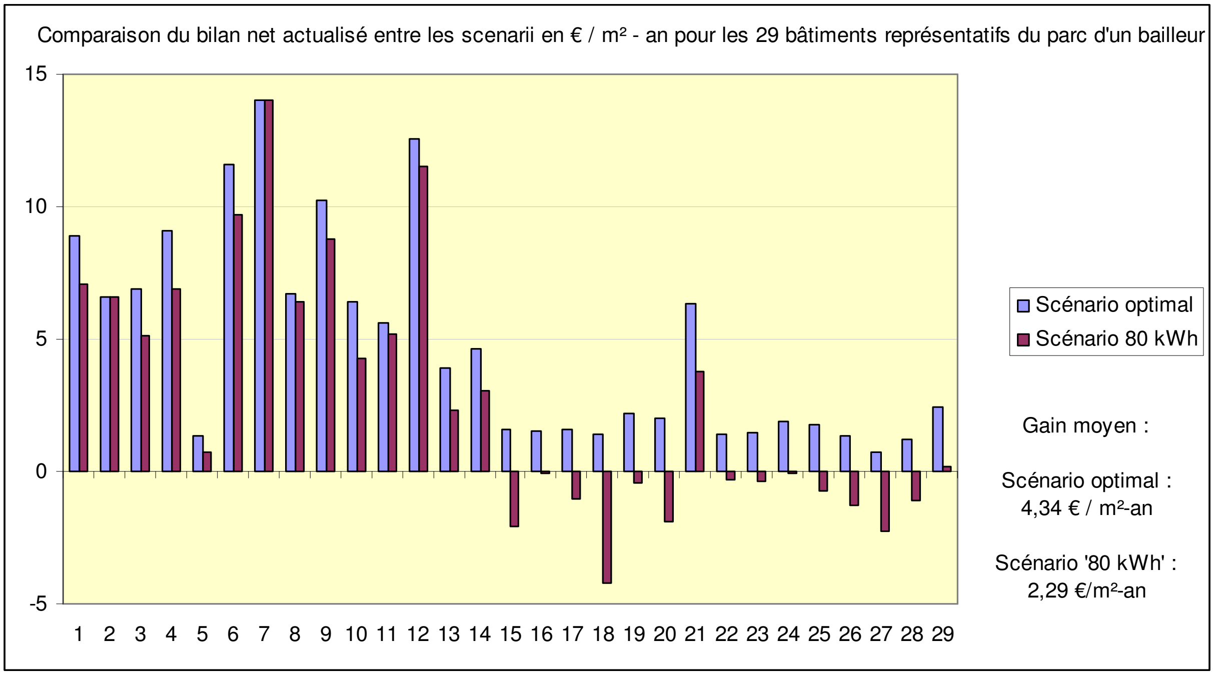
According to this scenario the buildings to retrofit are the 7, 12, 6, 9, 1, 4 and 21 because they have the best life cycle energy cost, as shown in the following figure. [35]

[33] Cf. the glossary

[34] This evaluation has been made with a 2 % discount rate for a of 25 years period and with the following hypotheses on the energy price increase in constant € : 4 % per year for gas and fuel oil, 2 % for district heating systems and 1 % for electricity. (Of course these hypotheses can be modifies in the Factor 4 model if needed)

[35] Of course the retrofitting strategy is not built only on energy issues. Energy is only one of the issues to deal with, beside technical obsolescence, the renters demand, regulation needs, etc.

Comparison of the Life Cycle Energy Cost for each building for 2 scenarii (the microeconomic optimum scenario and the 80 kWh objective scenario in €/m² – year for the 29 representatives buildings)



Source La Calade

The average Life Cycle Energy Cost is up to 4,34 € /m²-year in the microeconomic optimum scenario and up to 2,29 €/m² per year in the 80 kWh scenario.

- **2. The second criteria can be <u>the smallest investment needed for reaching the needed energy performances</u> (80 kWhpe/m²)**

This criteria measures the needed effort for reaching higher energy performances levels and so it is useful for minimising the extra costs due to some of these performance objectives.

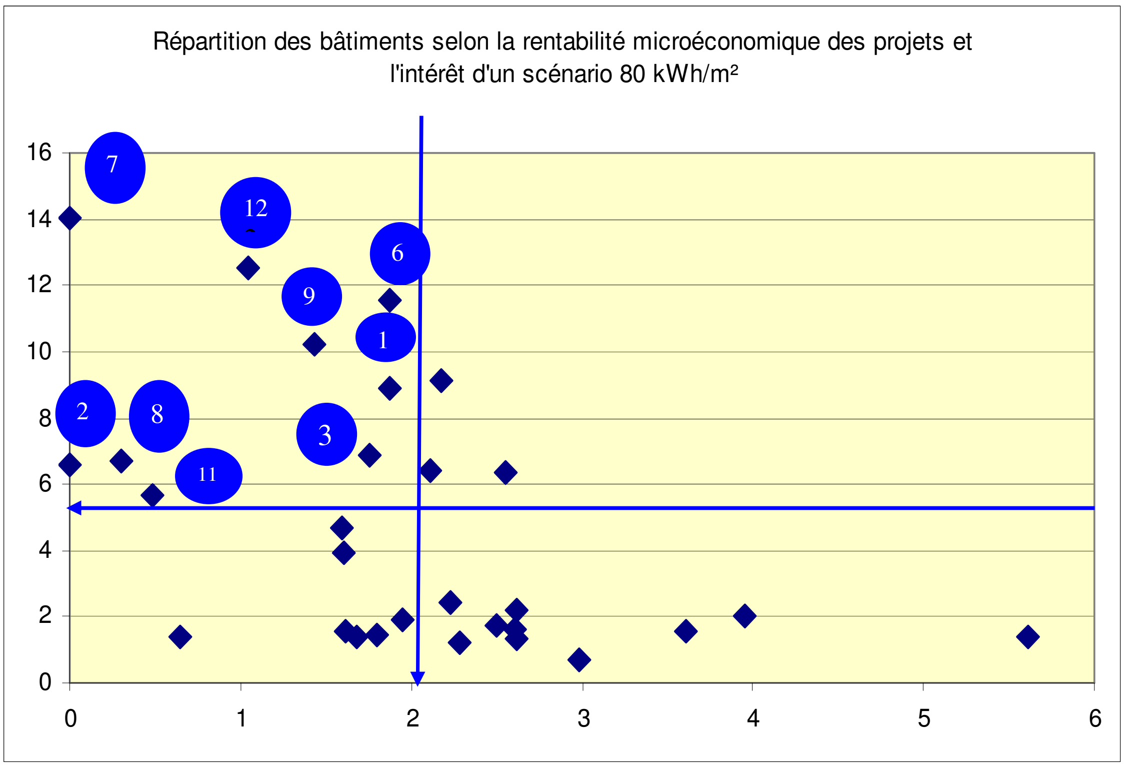
In the following figure, the upper left part shows the buildings with the best LCEC (over the average level i.e. 4.5 € /m²- year) and for which the extra effort for reaching the 80 kWh/m^2 – year is under the average of the whole building stock (2,0 €/m^2 – year as a benefit reduction from the LCEC).

The buildings results according to the second evaluation criteria

which is the smallest over investment (extra cost) needed for reaching 80 kWh/m^2

LCEC

in €/m^2 per year



Euro/m^2

Source La Calade

On this schema we compare the reference scenario with the first criteria (the LCEC of the optimised retrofitting programme, on the ordinate or y-axis) shown on the left and the extra cost or the LCEC reduction (in euro/m^2 per year on the abscissa or x-axis) due to the performance objective (80 kWh/m^2).

For example for the building 1 the LCEC with the optimised retrofitting programme is up to 9 €/m^2 per year and if we want to reach 80 kWh/m^2 the extra cost will reduce the LCEC by 1.8 €/m^2 per year

So, according to this criteria, the buildings to retrofit in priority are the those with the number 1, 2, 3, 6, 7, 8, 9, 11 and 12.

- **3. A third criteria can be a more conventional one which is the level of <u>CO_2 reduction and the energy consumption reduction</u>**[36].

This criteria is the usual one selected in European best practices an is shown in the chapter 5 of this Factor 4 Brochure as well as in the deliverable 5.

With this criterion the buildings 2 and 12 obtain together 52 % of the total potential needed investment and 62 % of the net present value expected.

- **4. A fourth criteria can be <u>the needed investment per avoided kg CO_2</u>** [37].

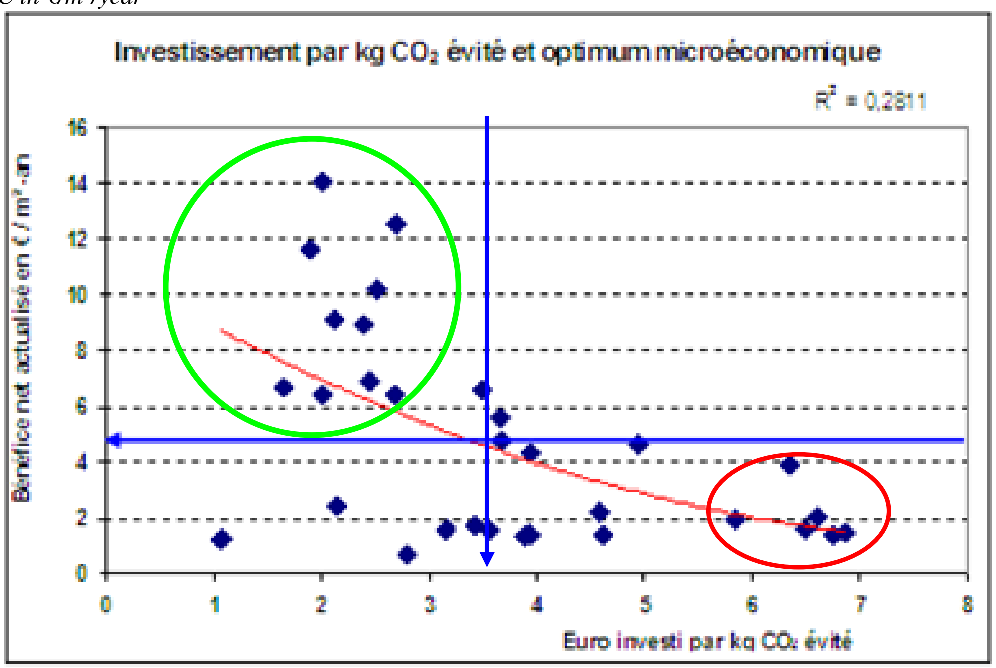
Some ones suggest using this criterion as the ONLY ONE now because it takes into account both the investment and the GES reduction objective.

For the 29 buildings analysed for Sageco, the results according to this criteria with the microeconomic optimum are presented in the following figure and in the table below for the first 12.

Selection of buildings to retrofit according the investment per avoided kg CO_2

and the microeconomic optimum

LCEC in €/m²/year



€ invested per kg CO2 avoided

Source La Calade pour Sageco

This figure underlines the link between the profitability for both the social owner and the renter together and the investment needed for reducing GES emission. As shown, many buildings (surrounded in green) have a good LCEC for the microeconomic scenario (over 5 €/m² - year) and a reasonable investment per avoided ton of CO_2 (less than 3 € invested per kg of CO_2 avoided per year).

These 10 buildings surrounded in green are those to retrofit according this criterion. They are the buildings with the numbers 12, 6, 9, 1, 4, 7, 3, 8, 10 and 21.

The 5 which should not be energy retrofitted are the buildings 23, 22, 21, 17 and 13 focussed in red on the figure above.

[36] Cf. This was the topic of the deliverable 7 and it is illustrated by the best practices presented in the chapter 5 in this Factor 4 brochure.

[37] Cf. This was the topic of the deliverable 7 and it is illustrated by the best practices presented in the chapter 5 in this Factor 4 brochure.

At least the red line in the above figure underlines the correlation between the microeconomic optimum and the cost of the avoided ton of CO_2. It shows also that

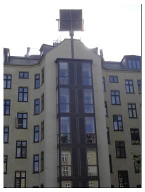
the energy retrofitting rule or regulation must not be the same for all the buildings… (even if it is recommended by a great number of experts in Europe...) and underlines the LCEC interest.

The results obtained for 1é buildings among the 29 with the LCEC analysis

Buildings	Investment per kg CO_2 avoided	Rank
1	2.39	8
2	3.50	16
3	2.45	9
4	2.13	6
5	4.63	22
6	1.91	3
7	2.01	4
8	1.66	2
9	2.53	10
10	2.69	11
11	3.67	18
12	2.71	12
Average for the 29 buildings	3.68	
Ponderated average	3 .96	

Source La Calade for Sageco

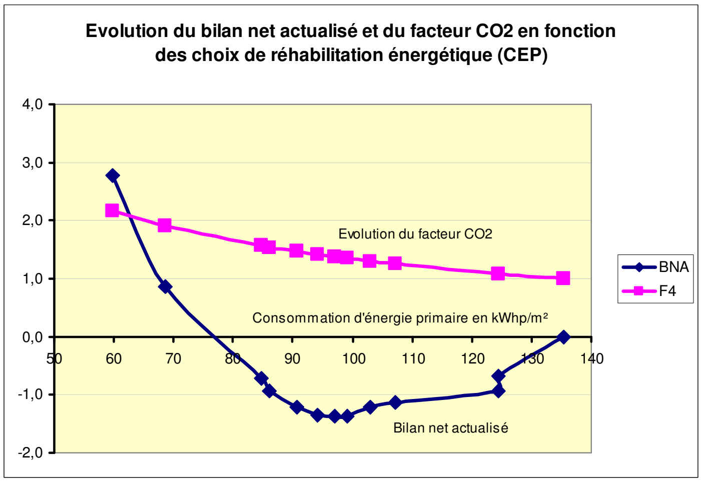
All these criteria can be used according to the priority objectives selected and then the other issues (social ones, the location attractivity, etc.) have to be taken into account and the dialogue with the partners and renters can go on…



8. THE SOCIAL OR MACROECONOMIC OPTIMUM FOR IDENTIFYING THE AMOUNT OF THE FINANCIAL SUPPORT

At the building scale the analysis consists in the definition of scenario one by one (as shown in the following figure) with the selection of the potential techniques (listed in the table below).

The LCEC and CO_2 factor evolution according to the retrofitting choice of techniques



Selection of techniques

1	Tenants behaviour change
2	Low energy consumption lamps (in dwellings)
3	Boilers/new heating system including CHP
4	Additional thermal insulation of floor
5	Hot water distribution lagging (insulation)
6	Hot water savings
7	Pipes insulation (heating)
8	Energy consumption control system
9	Roof or terrace insulation
10	Energy balance system
11	Additional thermal insulation of walls (exterior) - 20 cm
12	High performance windows Uw = 1,1

Source La Calade for Factor 4

For this building the microeconomic optimum is reached with the 6 first techniques. The LCEC is at its (97 kWhpe/m²).

If we add other techniques, the energy consumption is reduced but the LCEC is reducing.

When we choose the 10 first techniques, the LCEC is almost at 0, which means that it is neutral for the renter and the social owner together but not for each of them and so the question becomes on the repartition of the benefits among them.

After the 10 first techniques, the investments are not profitable according to a microeconomic point of view and they are profitable at the macroeconomic (for the society) point of view only according to the value given to externalities such as the CO_2 ton avoided. If we select the 11 first techniques, the energy retrofitting programme is profitable only if the ton of CO_2 avoided is up to … 494 €.

So we can say that if the LCEC value is positive, the energy retrofitting programme must not be selected or done because the incremental costs are increasing quickly.

With the SEC model it is possible to estimate the subsidies needed for reaching together the microeconomic optimum and the macroeconomic one at the same time.

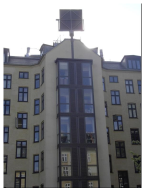
This estimation allows to define the justified level of public subsidies needed. This level or percentage is not the same fort all the building types and so it cannot be defined once. It depends on the energy consumption objective chosen (80 kWh/m² for example) or on the GES reduction objective (to reach the B labelling for example).

PART 4

TOWARDS SUSTAINABLE ENERGY RETROFITTING STRATEGIES FOR SOCIAL HOUSING

- FOR SOCIAL OWNERS BUILDING STOCKS

- FOR TERRITORIAL AREAS: FOR BOTH SOCIAL OWNERS AND LOCAL AUTHORITIES



9. TOWARDS A NATIONAL STRATEGY FOR ENERGY RETROFITTING OF SOCIAL HOUSING ?

9.1. DOES EACH BUILDING NEED TO GO TOWARDS THE FACTOR 4 IN RETROFITTING ACTIONS?[38]

For answering this question, we made simulations on 30 real buildings (which correspond to 170 representative building types as regarding the whole French social housing stock).[39]

In France this question is always coming for buildings built before 1975 in the H1 climatic area and using gas for a central heating system and these building are up to 36 % of the overall building stock of social housing to retrofit.

We worked out various scenarii for this type of building and the grey cells are the techniques selected in each scenario in the table on the next page.

These simulations show that :

- The first scénario, named « business as usual », are not difficult to manage for social owners even if the needed investment is up to 5 500 € per dwelling. It allows profitability with an hypothesis of 125 kWhpe per m² and per year[40]. This scenario is closer to the micro-economical optimum if we don't take into account any increase of energy price (cf. (3) in the next table). But it is far from this optimum and not interesting at all if we take into account the impact of the energy price increase (cf. (5)). This result reminds us the conventional calculation where this impact is never taken into account…

- The 2 other scenarii (micro-economical optimum and « factor 4 »)[41] need an external insulation of walls and the « 50 kWh/m² » scenario needs both the removing of the heating system and walls insulation.

- The life cycle energy cost optimum (or micro-economical optimum or profitability threshold for both the social owner and tenants) does not allow to reach the factor 4 (factor 3,3 only) but it allows to reach the B labelling.

- The « 50 kWh/m² » scenario is the only one which allows to reach the class A but with an important investment up to 15 000 € per dwelling so with a 20 to 50 % investment increase.

LCEC is over zero for the « 50 kWh/m^2 » scenario and so we estimated the subsidies needed for reaching profitability or the microeconomic optimum for both the renter and the social owner (and also for reducing energy consumption and CO_2 emissions).

The next table gives the results of the LCEC analysis for the building heated with natural gas, built before 1975 in a H1 climatic area : the needed investment for reaching the microeconomic optimum is up to 9 436 € and for reaching 50 kWh/m^2 it is up to 14 956 € (instead of 5 494 € usually spent in retrofitting programmes in France).

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[38] Cf. the first part of the deliverable 10 in French or the chapter II of the French part of the deliverable 10 in English

[39] Cf. the deliverable 9 in French

[40] kWhpe is the unit in kWh in primary energy (cf. glossary)

[41] Various examples of factor 4 scenarii (id est where reaching the factor 4 is the only one objective) are shown in the deliverable 7

Scenarii for a building built before 1975 in the H1 area and heated with natural gas

Comparison between scenarii	**initial situation**	**SCENARII**			
		« business as usual »	**Microeco. Optimum**	**factor 4**	**50 kWh/m²**
Technics used					
Heating system and equipements					
Hygroregulated ventilation (type B)		X	X		
Controlled Mechanical Ventilation with heat recovery				X	X
Double glazing Uw = 2,5		X			
Double glazing with low emission and argon			X	X	X
Insulation of roof		X	X	X	X
Thermal insulation of floor over non heated areas		X	X	X	X
Individual meters		X	X	X	X
Boilers/new heating system including CHP					X
Tenants recommendations		X	X	X	X
Insulation of external walls (e = 10 cm)			X	X	
Insulation of external walls (e = 20 cm)					X
Sanitary hot water					
Hot water distribution lagging (insulation)		X	X	X	X
Semi instantaneous system		X	X	X	X
Individual meters		X	X	X	X
Solar heater water					X
Electricity					
Daylight optimisation		X	X	X	X
Tenants behaviour			X	X	X
Hard white goods : grade A or A+			X	X	X
Closing audiovisual and electric equipment			X	X	X
Low energy consumption lamps			X	X	X
TECHNICO – ECONOMIC RESULTS					
Investment in € / dwelling	-	5 494	9 436	11 176	14 956
Primary energy consumption (heating and hot sanitary water) in kWhpe / m²	267	142	78	65	51
Energy labelling	**E**	**C**	**B**	**B**	**A**
CO_2 emissions in kg / m²	56,2	30	16,5	13,6	10,7
CO_2 factor	-	1,8	3,3	4,0	5,0
CO_2 labelling	**F**	**D**	**C**	**C**	**B**
Pay back return (in years)	-	12	12	13	17
(1) **Net present value of investments** in € /m² / year	-	4,5	7,5	9,2	12,0
(2) **Energy** savings in € / m² / year		- 4,9	- 8,9	- 9,4	- 9,9
(3) Life cycle energy cost in actualised € / m² / year = (1) + (2)	-	- 0,4	- 1,4	- 0,2	+ 2,1
(4) Impact of energy price € / m² / year		- 3,0	- 4,5	- 4,8	- 5,1
(5) **Life cycle energy cost** in actualised € / m² / year (including price impact) = (3)+(4)	-	- 3,4	**- 5,9**	- 5,0	- 3,0
Level of subsidies needed for keeping the micro-economic optimum (€/dwelling)		3 021	**0**	1 118	3 589
Level of subsidies needed for keeping the micro-economic optimum in %		55 %	**0**	10 %	24 %

Source Crdd La Calade for Factor 4 (cf. deliverable 10)

The next table shows how it is possible to reach the microeconomic optimum or the optimum for the « 50 kWh/m² » scenario, with various potential solutions.

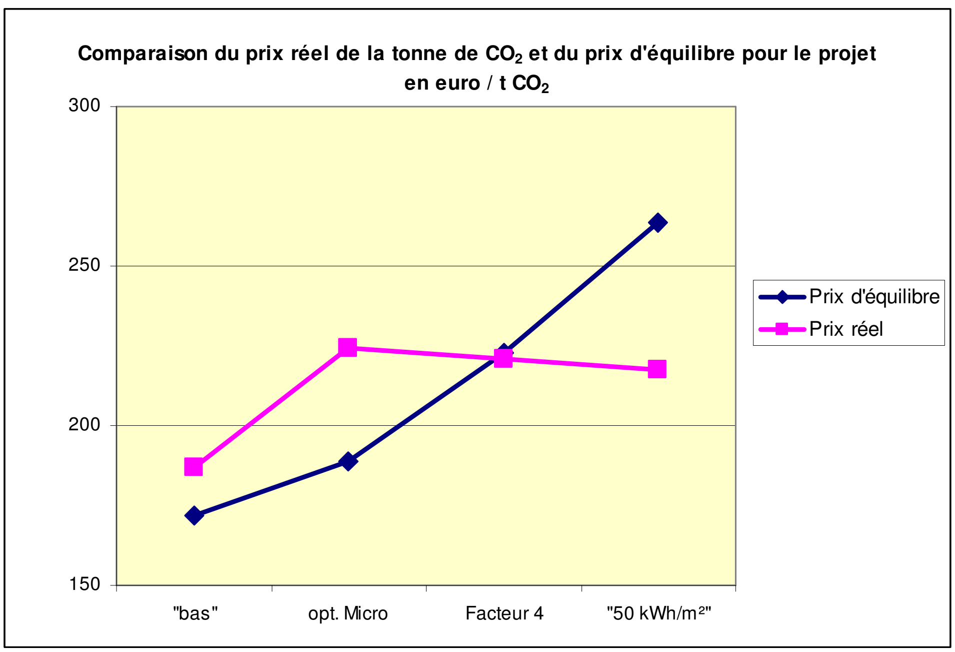
LCEC in €/m^2.year according to the various scenarii and options

	microeconomique optimum		« 50 kWh/m² » scenario	
	Without any contract (CPE) nor rent increase	With a CPE	Without any contract (CPE) nor rent increase	With a CPE
Investment (Net Present Value)	7,5	7,5	12	12
Social owner's investment	7,5	0	9,1	0
« Contrat de performance énergétique » (CPE)[42]	0	7,5	0	9,1
Subsidies	0	0	2,9	2,9
Charges for the renter	-13,4	-5,9	-15	-5,9
Balance Social owner + Renter	-5,9	-5,9	-5,9	-5,9

Source La Calade pour Factor 4

It is also possible to wonder what should be the price of a ton of CO_2 for reaching the optimum. For example for the building type selected (built before 1975 in a H1 climatic area and heated with gas) we can see on the following figure that we reach the optimum until the factor 4 scenario and then subsidies are needed (or a carbon tax).

Comparison between the ton of CO_2 real price (in pink)
and the price which allows to reach the optimum for the retrofitting programme (in black)
in €/t CO_2 for the various scenario analysed
(business as usual, microeconomic optimum, Factor 4 and 50 kWh/m^2)



Source La Calade for Factor 4

[42] This solution has been selected during the « Grenelle de l'Environnement » in order to find a solution for social owners when they cannot increase the rent. The reduction of charges is not given at once to the renter but is given to the social owner who made the investment..

> So, if the factor 4 is a good solution or objective for some buildings, **the factor 4 objective is not the optimal solution in any case** (cf. deliverale 10).
>
> The interest of a LCEC analysis is to show how different can be the microeconomic optimum and the macroeconomic one and how we can join both of them with justified subsidies when necessary and only when it is necessary…

9.2. ELEMENTS FOR A NATIONAL STRATEGY

The Factor 4 model cannot answer all the questions. Its aim is to be a decision aid tool for any building stock manager or financial partner by giving the optimised energy retrofitting programme for a building on the one hand and for any building of the building stock on the other hand. By doing that it is possible to manage energy retrofitting works in the long time, id est to select the first works to implement and those to implement later on.

This is possible for social or private housing and La Calade will now work another SEC model for private housing on the one hand and for single house on the other hand, in a research project supported by the French Ministry (PUCA) in the national energy research programme framework PREBAT). This should help local authorities to set up sustainable energy retrofitting strategies at territorial scales and to reduce energy precariousness.

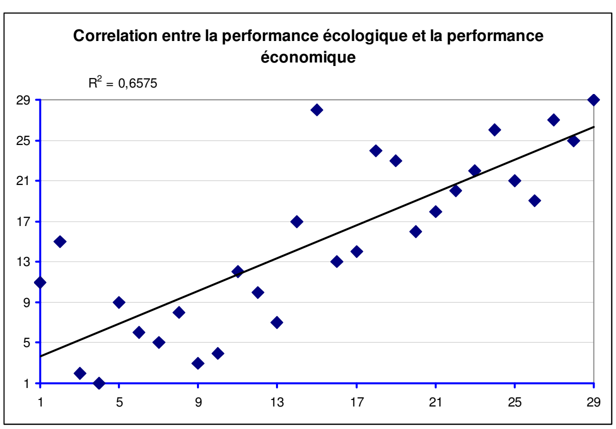
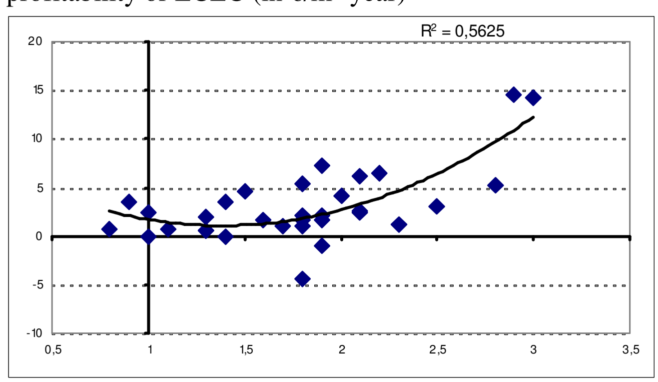
At least for social housing, the Factor 4 research and project conclusions are the following ones :

- **The buildings with the higher level of energy consumption are those to retrofit first for reducing GEG emissions up to a factor 4 objective**.

- **There is a correlation between LCEC (economic performance) and energy saving (as well as the CO_2 factor) (ecological performance).** That is to say that, in a way, energy saving bring additional savings…

This correlation can be shown with the 2 analyses (figures) below : the analysis of the 29 buildings of a social owner (Sageco) as well as the 32 case studies selected by various (French) social owners[43] :

Correlation between the economic performance (LCEC) and the ecological one (CO_2 factor)

<table>
<tr><th>LCEC or optimisation for the 29 representative buildings of a building stock (one social owner)</th><th>LCEC analysis of 32 case studies selected by 9 French social owners</th></tr>
<tr><td>
</td><td>Correlation between the CO_2 factor (abscissa) and profitability or LCEC (in €/m²-year)

</td></tr>
</table>

Source La Calade

[43] Cf. deliverable 9

- **In France the microeconomic optimum for the energy retrofitting programme of a building stock should reduce GEG emissions by 2 to 2,2** (with the same energy supply structure) ; this optimisation is closer to a factor 3 (and even 3.5) for building stocks with the most important GEG emissions (or CO_2).
- **Having an objective of reaching the factor 4 for any building is a political decision which can be a bad one in some cases, for some buildings**.

It is a bad idea to give the same threshold to all the buildings. Optimal or sustainable policies make differences between the buildings and are set up by taking account all the differences in the building typology, at any territorial scale as well as for social owner's building stocks.

As an example, for the 29 representative buildings of a social owner, the optimal CO_2 factor is up to 2.5 for the buildings heated with gas, 1.95 if they use electricity and 1.8 when they are connected to a district heating system.

Observed or estimated investment costs needed for social housing energy retrofitting are far from those estimated by the French CAPEB[44] which are up to 20 000 € per dwelling only for energy retrofitting. This estimation is mentioned by a lot of media as well as by public administration and experts from the French Ministry (such as Nathalie Kosciusko-Moricet), but it is wrong because it does not make any difference between social and private housing and in social housing price are lower because techniques are less sophisticated and there is a majority of multi-families housing.

Our estimations as regarding the factor 4 are very high, up to 15 to 18 000 euro per dwelling but we have shown that it is not the economical optimum, even with an important energy price increase. Reaching the factor 2.7 in social housing seems to us more realistic and this would need a smallest investment near 10 000 euro per dwelling (8 000 to 12 000 according to the representative buildings)[45].

Over this 2.7 factor there are questions on techniques to select : controlled mechanical ventilation with heat recovery, solar heater water, an additional thermal insulation of walls, triple glazing with argon… are the most appropriate ones for reaching the factor 4.

Must we always use these techniques due to a new regulation? If energy prices are not increasing, the answer is no as it was shown in all the French case studies, even if this can be positive in some cases.

As a conclusion, our **proposals for a national sustainable energy retrofitting strategy for social housing are** the following ones:

1 – ***For social housing in priority areas*** (concerned by the National neighbourhood regeneration programme such as ANRU in France), to use a LCEC analysis in order **to set up a territorial strategy for the neighbourhood and then for the city**

2 – ***For social housing***, to set up a Factor 4 approach with a LCEC analysis and to work on the building typology in order to select the representative buildings and **to retrofit first those with the higher energy consumption**

3 – ***For social owners and their partners*** (local authorities, banks…) ***and for public administration***:

- 3a: To work on building typologies and to build national and regional policies as regarding subsidies on the LCEC analysis results, introducing a distinction between the building types and also in supporting or promoting the most energy efficient techniques at each local level.

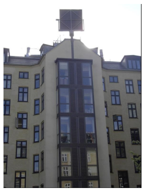
3b:To help social owners to take energy (including electricity consumption of tenants) into account when they set up their building stock strategy before any dialogue and contract with public administration and to choose techniques-equipments-products according to a LCEC analysis on their whole building stock.

4 – ***For public administration***:

4a: **To support replicable (without subsidies) demonstration retrofitting programmes** which bring a reduction of charges for tenants as well as a reduction of energy consumption and GEG emission (and not only those 2) and **which optimise the use of public subsidies**.

4b: **To promote or support LCEC analysis both for energy retrofitting and for new buildings**.

[44] The association of small building companies
[45] Cf. deliverable 10



10. THE VARIOUS BARRIERS[46]

The following table reminds the main obstacles in each country (Denmark, DK; France, F; Germany, D; Italy, I and Romania, Ro) for energy retrofitting in social housing (cf. deliverable 11).

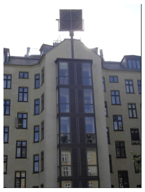
	DK	F	D	I	Ro
A. TECHNICAL BARRIERS					
- The lack of knowledge upon some new technologies		X		X	
Basic energy retrofitting measures are known but not enough required	X			X	
Insufficient warning of the users regarding the energetic performance of the new technologies					X
Lack of motivation/stimulant measures to use the technologies based on renewable resources					X
- Lack of manufacturers or installers and of know how in adapted technologies for retrofitting		X		X	
Lack of training		X			X
Lack of know how among installers especially for a correct thermal insulation				X	
Dominance of imported products/technologies (reduced number of local manufacturers)					X
Low offer/potential of the skilled workers due to the strong migration and the poor level of education					X
B. THE MARKET RISK					
- Structure of energy prices		X		X	
Economic precariousness of district heating networks		X			X
Distorsion of energy price due to monopolistic operators					X
Escalation of energy price due to the increasing of the imports dependency rate					X
- Blindness of decision makers : short term view		X			
Low energy price		X			
Extern cost not taken into account (no ecological tax...)		X		X	X
Low awareness on the market and on the local administration level				X	X
No long term perspective of the building stock	X		X		
High frequency of the framework modifications					X
The strong political interference					X
- The need of win – win systems		X			
Difficulty to link rent and charges and to have a overall approach of the housing cost	X	X	X	X [47]	
District heating contracts stop energy savings	X	X			
Need for life cycle calculation instead of ROI time	X		X		
Lack of the adequate instruments to make efficient the management task of social owners					X
Inefficient fiscal policy on the long term (mainly consumer – oriented)					X

[46] Cf. deliverable 11

[47] only in the public sector in Italy and not in the cooperative one

C. BEHAVIOURS					
Lack of dialogue between social owners and tenants about the housing management, especially as regarding energy		X	X		X
Lack of any overall approach including energy in the stratagic patrimony plan		X	X		
Lack of knowledge on the building stock as regarding energy: performance, energy indicators...		X	X		
Lack of social attractivity of energy for tenants (indoor comfort, safety, parking quality are more expected)	X	X	X		
Lack of dialogue between the management and construction services or departments of the social owner		X	X		
Lack of economical motivation for utility companies or ESCO and energy management companies		X			
Lack of demonstration operations which could be replicated		X			
Energy aspect is still not qualifying, clear and recognizable for the housing market			X	X	
The measurement system of energy consumption and regulation as regarding them are still not diffused			X	X	
Institutional campaigns for energy awareness are still insufficient			X	X	
No control of the systems efficiency of heating station			X		
Lack of accessible evaluation instruments					X
Resistance to changes					X
Wrong accent of the information process					X
D. INSTITUTIONAL BARRIERS					
European Commission barriers					
Lack of financial support for housing and for energy retrofitting works, especially in the European Regional Development Founds (2007-2013)		X		X	
Not enough instruments adapted to the specificities of the new EU countries and to their needs as regarding know-how and demonstration projects/actions					X
National institutional barriers					
Energy labelling is not encouraging		X	X		
Lack of financing of social owners which must above all give standard comfort to inhabitants and adapt their buildings stock to new regulations		X			
The calculation process for rents has a very obsolete way which does not enable to include any energy improvement	X	X	X		
Guidelines for certification not yet edited				X	
Lack of an energy integrated approach		X		X	
The risk of overregulation					X
The risk to feed the resistance to the improvements due to the too frequent modifications and to a perfectionist attitude					X
Local barriers					
Some of the energy efficiency retrofitting measures are not "regulated"				X	
Conflicts of interest between local utility and local housing company		X	X	X	
Charges of DH pipes using public rules			X		
Restriction from laws to protect historical buildings			X		
The lack of personnel					X
The poor professional background, especially in the rural areas					X
The weak spirit of initiative					X

E. ECONOMIC BARRIERS					
Lack of support to poorest households which can nor improve their housing neither pay more rent (regarding energy efficient investment) even if the charges reduce		X			
Interesting incentives for retrofitting works only on going				X	
High prices of energy conservation components due to low market competition	X	X	X		
High rate of the people with low income and the scarcity of the budgetary resources					X
Unsuitable fiscal policy instruments					X



11. THE LIFE CYCLE ENERGY COSTING INTEREST AND OVERALL RECOMMENDATIONS

11.1. THE LICE CYCLE COST AND LIFE CYCLE ENERGY COST INTEREST

The interest of a life cycle cost analysis is first **the optimisation of energy retrofitting programmes for any social housing building stock taking into account the couple rent + charges as well as hypotheses on energy price increase and various levels of taxes or subsidies.**

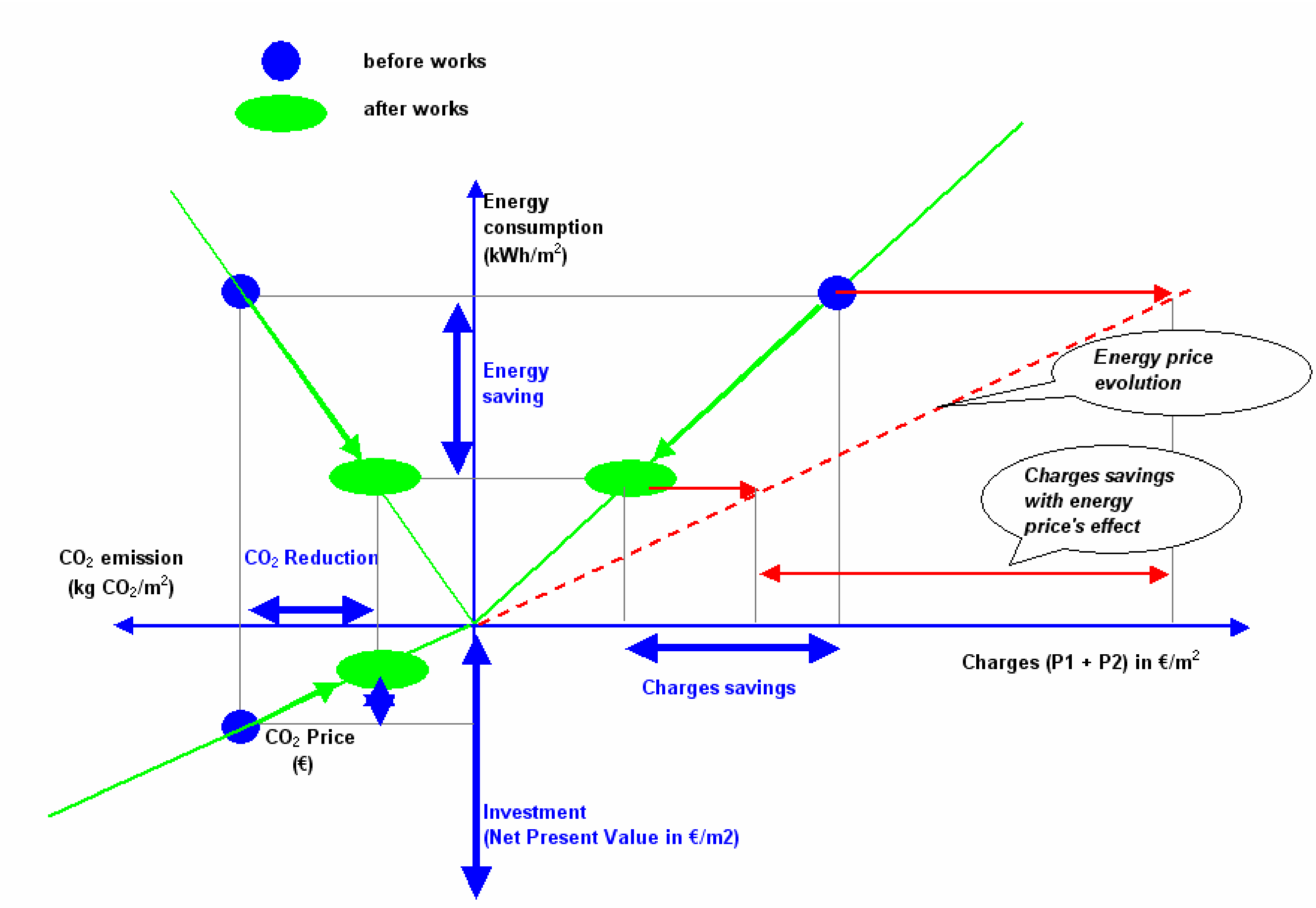
This sustainable development approach with various scenario or hypotheses has to be managed very early in the first step of any project before the energy expert who will finalise the energy retrofitting programme in details. In fact the Factor 4 objective is not this technical finalisation of the energy retrofitting programme (even if many people speak as if it was the case…) because if so the factor 4 model would be less useful than other very specific and technical tools.

The Factor model has to be used for building stocks. It can deal with all the representative buildings of the building stock of any social owner or in a territorial approach dealing with all the social housing buildings of a neighbourhood, a city or of a region. As for the building scale, it is possible to deal with all the existing techniques (even if they are not yet available in the country) and to give priorities, selecting some works for a first step and other works for a further step. The life cycle energy cost approach brings back something forgotten which is "time" and especially the long time approach which is a central element in any sustainable development approach.

Life cycle costing also allows giving **more transparency in cost approaches and subsidies policies** (which cannot be a progress for anybody…). The life cycle cost approach has to take into account step by step some social and environmental costs in order to justify public policies as regarding subsidies or taxes.

The Factor 4 model allows working in another way than with ratios, and it is the reason why we first work on the typology in order to identify representative buildings. This conventional approach with ratios for a building stock (inside a strategic analysis) in the first step and then with a technical analysis at the building scale is according to us not appropriate because it does not deal with any economic and technical analysis. If energy becomes a precious good, rare as well as dangerous for the planet survival, if energy is also an important part of the budget of any family and so an important element of any social policy, if energy brings important needed investments, so it is important and necessary to have a tool such as **the Factor 4 model which can deal with economic, environmental and social issues <u>together</u>** (which is the main characteristic of a sustainable development approach). The Factor 4 model participates to the decision optimisation process, as shown in the following schema.

The energy optimisation of a retrofitting programme with the Factor 4 model for setting up a sustainable strategy for a building stock



Source La Calade for Factor 4

11.2. OVERALL MAIN RECOMMENDATIONS

The Factor 4 project was built on for social owners but social owners are involved in urban sustainability and have many partners, so the results and our recommendations are for various actors.

1. – ***For social housing in priority areas*** (concerned by the National neighbourhood regeneration programme such as ANRU in France), to use a LCEC analysis in order **to set up a territorial strategy for the neighbourhood and then for the city**

2. – ***For social housing***, to set up a Factor 4 approach with a LCEC analysis and to work on the building typology in order to select the representative buildings and **to retrofit first those with the higher energy consumption**

3. – ***For social owners and their partners*** (local authorities, banks…) ***and for public administration***:

- 3a: To work on building typologies and to build national and regional policies as regarding subsidies on the LCEC analysis results, introducing a distinction between the building types and also in supporting or promoting the most energy efficient techniques at each local level.

- 3b:To help social owners to take energy (including electricity consumption of tenants) into account when they set up their building stock strategy before any dialogue and contract with public administration and to choose techniques-equipments-products according to a LCEC analysis on their whole building stock.

4. – ***For public administration***:

- 4a: **To support replicable (without subsidies) demonstration retrofitting programmes** which bring a reduction of charges for tenants as well as a reduction of energy consumption and GEG emission (and not only those 2) and **which optimise the use of public subsidies**.

- 4b: **To promote or support LCEC analysis both for energy retrofitting and for new buildings**.in order to always deal with energy or ecological objectives within sustainable development approaches as regarding

  - the EPBD implementation
  - the need for LCEC training for energy experts
  - European directives
  - the selection criteria in calls for tenders
  - …

11.3. NEEDED FURTHER STEPS

The main further steps needed could be as following:

- **LCEC models for other European countries**:

The Factor 4 project has concerned only some countries and so such an approach and LCEC models have to be set out for other countries

- **New rules for the attribution of public subsidies**

Public administration and European as well as national agencies must use the LCEC analysis which should become one of the indisputable selection criteria.

This is very important for urban renewal actors and national or local agencies such as ANRU in France.

At least this means also that the European Commission (DG Regio for example) should promote and use a LCEC approach.

- **LCEC analyses and models for other building types**

The Factor 4 project was dealing with social housing and we have now to deal with single family housing, tertiary buildings…

- **An important training need**

Energy expert have to be convinced of the interest of such an approach and all the actors and especially decision makers have to be informed and if necessary trained in order to understand the interest of a LCEC approach as well as the interest of sustainable urban development approches

- **Further researches towards various best policies**

It is important to disseminate these results and to show to various types of local authorities energy strategies included or integrated in urban planning and in urban development strategies…

GLOSSARY

Net Present Benefit	NPB = NPV(Inv) + NPV (others) – Eco (without price effect) – Price impact with : NPV (Inv) = net present value of the energy investments in €/m^2.year NPV (others) = net present value of the other investments which have an energy impact in €/m^2.year Eco (without price effect) = energy saving in courant money (€) without any modification or increase of the energy price
Primary Energy Consumption (PEC)	It is the needed energy to be produced and consumed for the delivery of final energy at the district heating sub station or at the heating system or at the electric counter of the building itself. The overall PEC is the sum of energy consumption for heating, hot water heating and electricity (measured in kWhpe par m²).
Final energy consumption	It is energy at the sub station or to the heating system before works (in kWh/m²)
Life Cycle Cost and Life Cycle Costing	The Life Cycle Cost (LCC) is the total cost of a building or its parts throughout its life, including the costs of planning design, acquisition, operations, maintenance and disposal, less any residual value. The Life Cycle Costing (LCC) is thus the technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. (*Source: ISO 158686 and ISO 14040 and Final report of the Task Group 4 upon Life Cycle Costs in Construction, November 2005*) Usually, conventional method don't take into account prospective and so potential price increase.
Enlarged Life Cycle Cost	Some researchers sometime speak about enlarged life cycle cost when externalities (such as greenhouse effect gas emissions) are taken into account
Shared life cycle cost	Some researchers sometimes speak about shared life cycle cost when the various actors concerned are distinguished, those investing and those with the benefits or advantages. (the SET-SHE model worked out by La Calade for the SHE project www.shecoop uses such an analysis)
Life Cycle Assessment or Analysis (LCA)	LCA assesses the environmental impact of a product or an equipment, from its manufacturing to its life end. It does not take into account any economic nor social issue but it gives the environmental indicators. Among LCA tools we can mention: BEAT 2000, Eco-Quantum, Envest, Green-Calc, Okoprofil…
Micro-economic optimisation	It aims at the solution for minimising the life cycle cost for both the social owner and the renter
CO_2 factor	It is the ratio of CO_2 emissions before the retrofitting works / CO_2 emissions after the retrofitting works
Macro-economic objective	It aims at the solution for reaching the « political » objectif (80 kWh/m^2 for example in France…)
Percentage of public subsidies really or truly needed	Part of the investment which could be paid by public subsidies in order to make the microeconomic optimum reach the macroeconomic one (or vice versa).

APPENDIX 1: SOME EXAMPLES OF RESULTS AFTER THE EVALUATION AND OPTIMISATION OF RETROFITTING PROGRAMMES FOR MULTI FAMILIES HOUSING WITH THE SEC MODEL (FRANCE)

We show in the following pages the result of a LCEC analysis of various social housing energy retrofitting programmes managed in July 2008 in the city of Rennes (Britany, France). The idea is to show to local authorities how they could manage for setting up sustainable energy management strategies at various territorial scales for existing buildings.

One of the criteria mentioned in the next pages is energy efficiency or energy saving but we also show how such an important criteria can be managed within a sustainable development approach together with other important criteria.

This is important in order to give an example and to show how to manage the EPBD inside a sustainable development approach towards the factor 4 (not only for some best practices or pilote retrofitting programmes but for all the buildings of a territory and so in order to show how to manage best practices inside best policies or strategies towards urban sustainability.

1. THE CONTEXT

This is a synthetic presentation of some case study (retrofitting programmes) analyses given or selected by all the social owners of a French city (Rennes) in July 2008. Each social owner gave one or two case studies to analyse.

The analyse has been done with the SEC model and was focussed only on the retrofitting programme given by the social owner (or his consultant) for its building. In some cases an optimisation has been done with the SEC model by La Calade.

Most of the technical solutions selected were selected by the social owner himself. The selection of each technology has been done according to 2 criteria : according to a decreasing profitability (with the best LCC) or/and according to energy productivity or efficiency (energy savings).

In some cases, if the scenario has only few technologies, both methods give rather the same result.

2. THE LCEC BUILDING ANALYSIS WITH THE SEC MODEL

2.1. Building A

76 dwellings	3 670 m²	District heating	Construction date : 1971 - 75

Technologies suggested by the social owner

1	Actions on tenants behaviour
2	Windows with high performances Uw = 1,6
3	Insulation of heating pipes
4	Regulation
5	Individual meters (for heating)
6	Insulation of Sanitary Hot Water pipes
7	Tenants behaviour (domestic electricity consumption)
8	Thermostatic valves
9	Common areas lighting
10	Lift engine with frequency variation
11	Roof insulation
12	Energy savings due to hot water saving
13	Thermo-hydraulic balancing
14	Additional insulation of walls - 10 cm
15	Controlled mechanical ventilation with hygroregulated ventilation

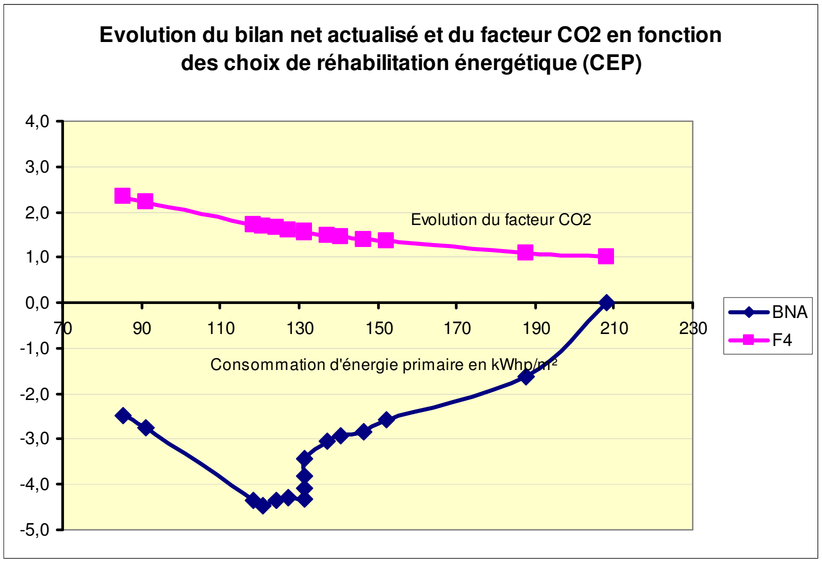
Remark : the number or rank of each technology is changing according to the selecting criteria (according to the LCC result for each technology) as seen on the figures.

Results of the LCEC analysis

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	123	32	58	
Hot sanitary water in kWh / m²	44	36	36	
Primar energy in kWh pe / m²	208	85	119	
CO_2 emission in kg CO_2 / m²	42	17	24	
Energy labelling	D	B	C	
CO_2 or climate labelling	E	C	D	
Technologies selected		1 à 15	1 à 13	
Investment in € / dwelling		9 446	3 893	
Tenants expenses without taking into account the energy price increase in € / m².year	16,1	8,8	10,5	
Energy price effect on 25 years in € / m².year	+ 7,9	+ 3,8	+ 4,9	
Total tenants expenses in € / m².year	24,0	12,6	15,4	
LCC in € / m².year		**2,5**	**4,3**	
CO_2 factor	1	1,7	2,4	

LCEC analysis

showing the CO_2 labelling evolution (in pink) and primary energy consumption in kWhpe/m^2 for each technology selected

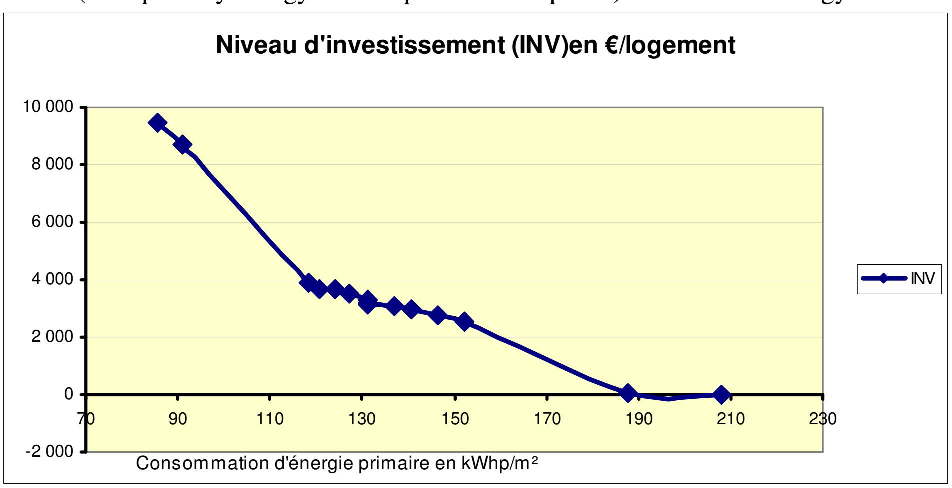


Source La Calade for the municipality of Rennes, July 2008

<u>Remark</u> **:** technologies are selected one by one according to the selection criteria (so here the best LCC).

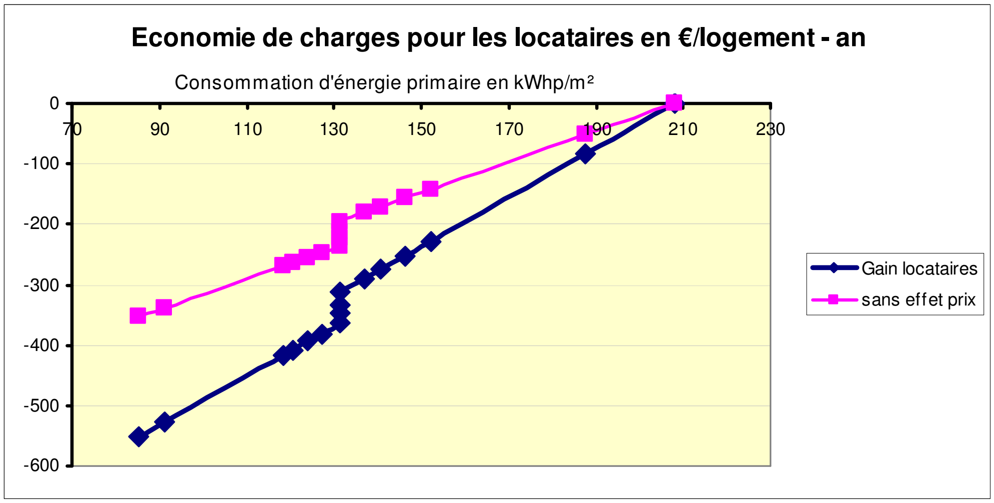
Investment needs in € / dwelling

(with primary energy consumption in kWhpe/m^2) for each technology selected



Source La Calade for the municipality of Rennes, July 2008

Evolution of tenants charges (in €/dwelling.year)
including the energy price increase (in pink) and without energy price impact (in dark blue)



Source La Calade for the municipality of Rennes, July 2008

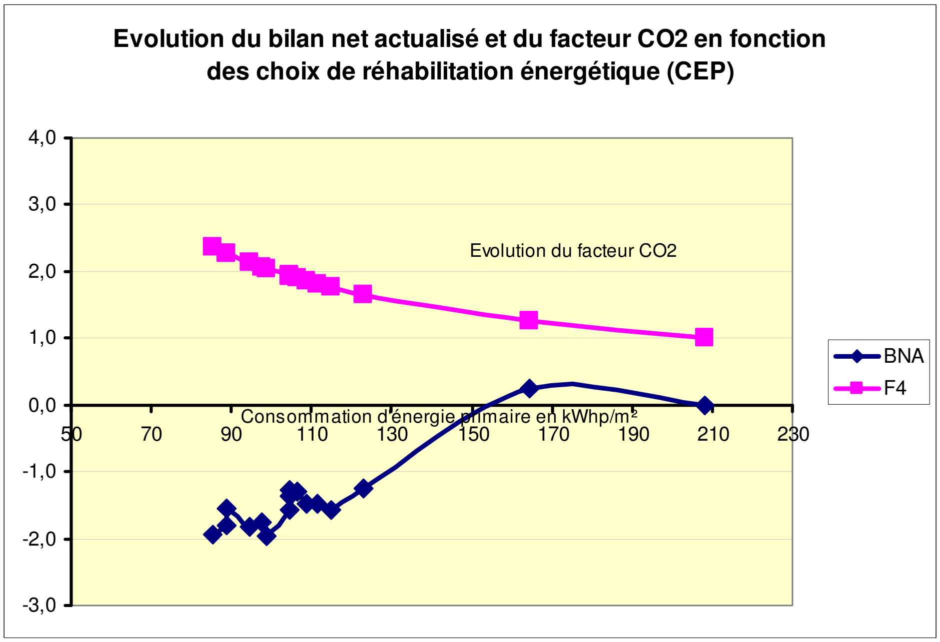
Additional scenario built by La Calade in maximising energy savings

Technologies suggested by La Calade

1	Insulation of walls - 10 cm
2	High performances windows Uw = 1,6
3	Changes in tenants behaviour
4	Regulation
5	Insulation of heating pipes
6	Thermostatic valves
7	Individual meters (heating)
8	Tenants behaviour (domestic electricity consumption)
9	Lift engine with frequency variation
10	Insulation of Sanitary Hot Water pipes
11	Thermo-hydraulic balancing
12	Roof insulation
13	Controlled mechanical ventilation with hygroregulated ventilation
14	Common areas lighting
15	Energy savings due to hot water saving

LCC analysis result

with the evolution of the factor 4 (in pink) and of the primary energy consumption in $kWhpe/m^2$ (in dark blue) for each additional technology

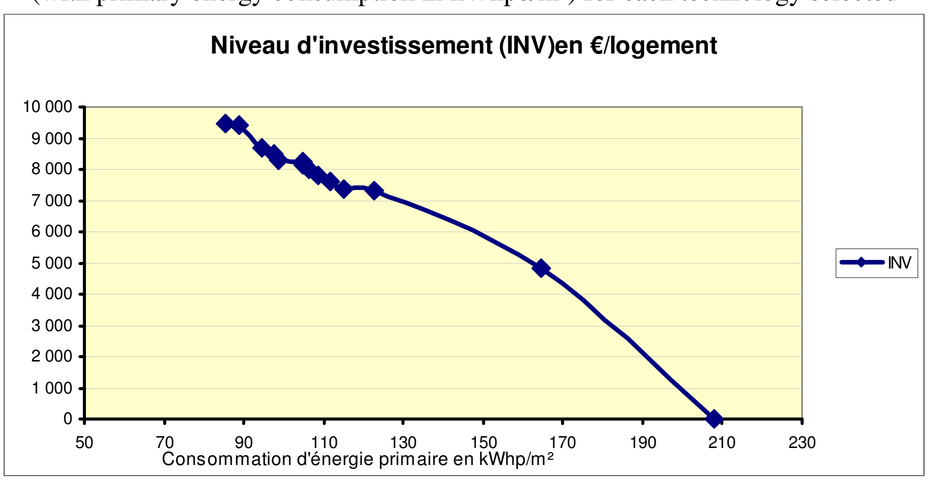


BNA= LCEC

Source La Calade for the municipality of Rennes, July 2008

Investment needs in € / dwelling

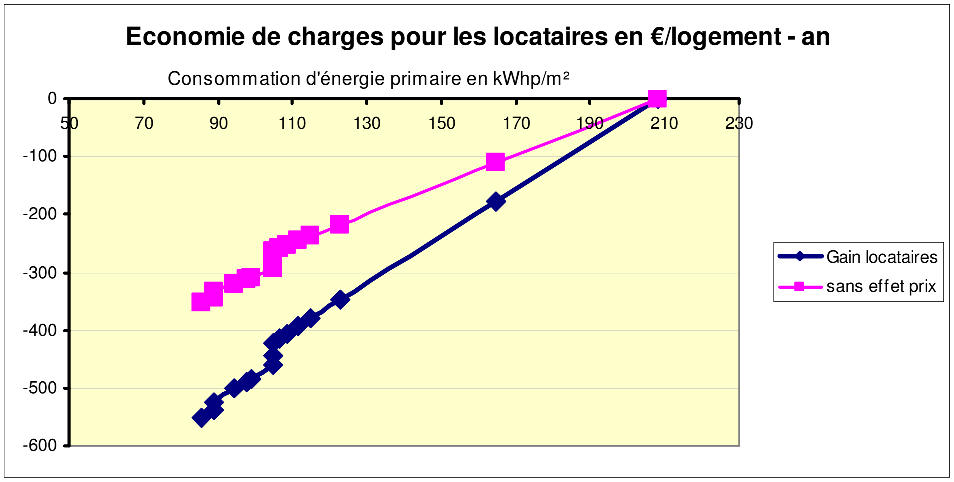
(with primary energy consumption in $kWhpe/m^2$) for each technology selected



Source La Calade for the municipality of Rennes, July 2008

Evolution of tenants charges (in €/dwelling.year)

including the energy price increase (in pink) and without energy price impact (in dark blue)



Comments

1. The retrofitting programme overseen by the social owner is profitable (with a positive LCEC)

   Primary energy consumption : 85 kWh primary energy / m²

   Investment per dwelling: 9 400 €

2. But for reaching the economic optimum with the LCEC approach we have selected all the technologies except insulation of walls.

   In this optimised scenario or potential energy retrofitting programme we get :

   Primary energy consumption 119 kWh primary energy / m²

   Investment per dwelling: 3 900 €

3. At least a scenario with the energy optimisation (maximum of energy savings) has been set up too.

2.2. Building B

102 dwellings	6 098 m²	Collective gas central heating	Construction date : 1956 - 70

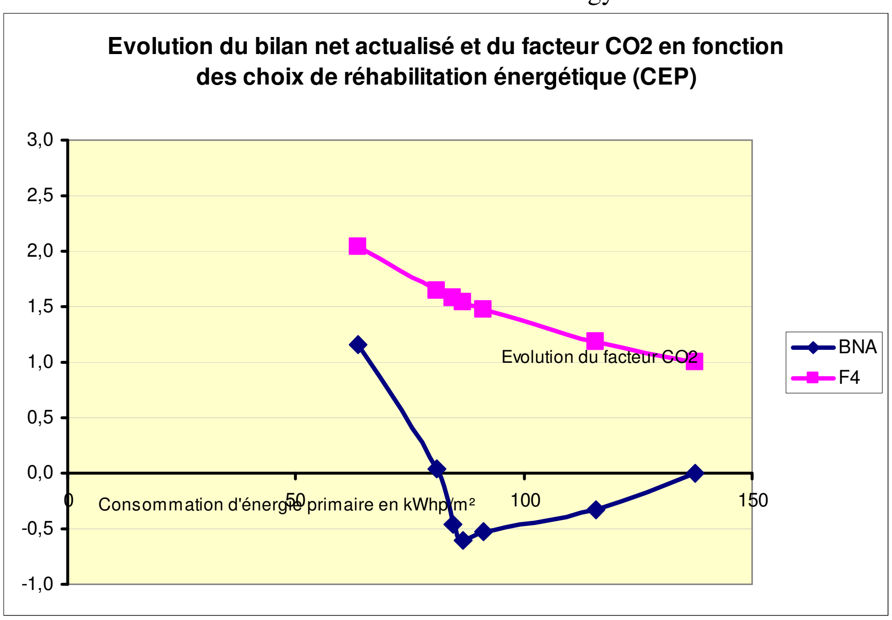
Technologies overseen or suggested by the social owner

1	Solar heater water
2	Double glazzing windows Uw = 2,5
3	Pipes insulation (heating)
4	Thermo-hydraulic balancing
5	Controlled mechanical ventilation with hygroregulated ventilation
6	Insulation of walls - 10 cm

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	100	48	68	
Sanitary hot water in kWh / m²	38	16	16	
Primary energy in kWh primary energy / m²	138	64	84	
CO_2 emissions in kg CO_2 / m²	28	13	17	
Energy labelling	C	B	B	
Climate or CO_2 labelling	D	C	C	
Technologies selected		1 à 6	1 à 4	
Needed investment in € / dwelling		8 600	4 130	
Tenants expenses without taking into account the energy price increase in € / m².year	11,7	8,4	9,3	
With energy price effect on 25 years in € / m².year	+ 4,4	+ 2,4	+ 3,0	
Total tenants expenses in € / m².year	16,1	10,8	12,3	
LCEC in € / m².year		**Loss of 1,2**	**0,5**	
CO_2 factor	1	2,0	1,6	

LCEC analysis results

with primary energy consumption in kWhpe/m^2 (in dark blue) and the factor 4 evolution (in pink) for each additional technology

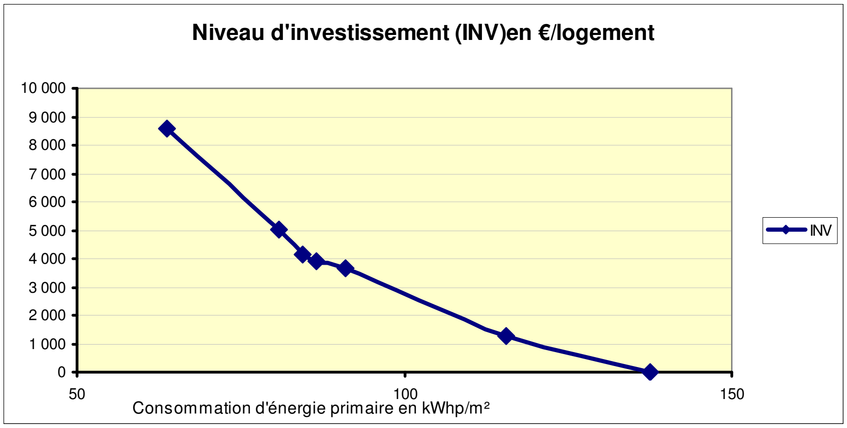


BNA= LCEC

Source La Calade for the municipality of Rennes, July 2008

Investment needs in € / dwelling

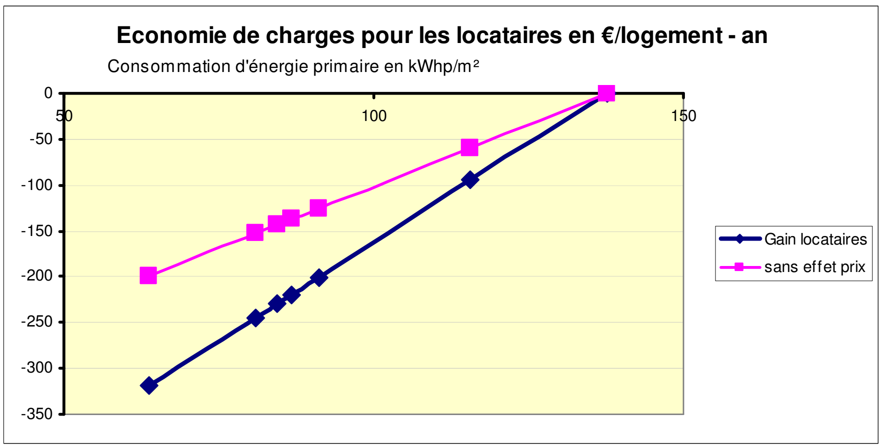
(with primary energy consumption in kWhpe/m^2) for each technology selected



Source La Calade for the municipality of Rennes, July 2008

Evolution of tenants charges (in €/dwelling.year)

including the energy price increase (in pink) and without energy price impact (in dark blue)



Source La Calade for the municipality of Rennes, July 2008

Comments

The energy retrofitting programme overseen by the social owner is not profitable (the LCC, both for the social owner and tenants, will be higher after works than before) .

Primary energy consumption : 64 kWh / m²

Investment per dwelling: 8 600 €

The economic optimum (reached within the LCEC approach) for this building needs all the technologies suggested except 2 : controlled mechanical ventilation with hygroregulated ventilation and insulation of walls.

In this optimised energy retrofitting programme :

Primary energy consumption 84 kWh / m²

Investment per dwelling: 4 100 €

2.3. Building C

52 dwellings	3 460 m²	Collective fuel oil central heating, electric water heater	Construction date : 1971 - 75

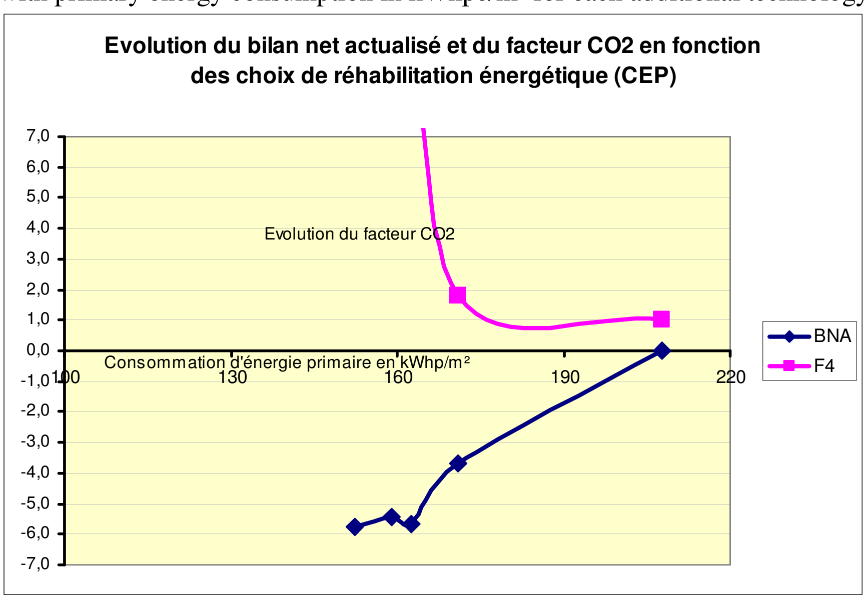
Technologies overseen or suggested by the social owner

1	Boiler change (for wood)
2	Double glazzing windows Uw = 2,5
3	Thermostatic valves
4	Energy savings due to hot water saving
5	Individual meters
6	Common areas lighting

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	120	71		
Sanitary hot water in kWh / m²	34	30		
Primary energy consumption in kWh / m²	208	148		
CO_2 emission in kg CO_2 / m²	33	1,2		
Energy labelling	D	C		
Climate or CO_2 labelling	D	A		
Selected technologies		1 à 6		
Needed investment in € / dwelling		7 800		
Tenants expenses without taking into account the energy price increase in € / m².year	17,8	10,7		
with energy price effect on 25 years in € / m².year	+ 7,3	+ 3,3		
Total tenants expenses in € / m².year	25,1	14,0		
LCEC in € / m².year		**6,1**		
CO_2 factor	1	14,1		

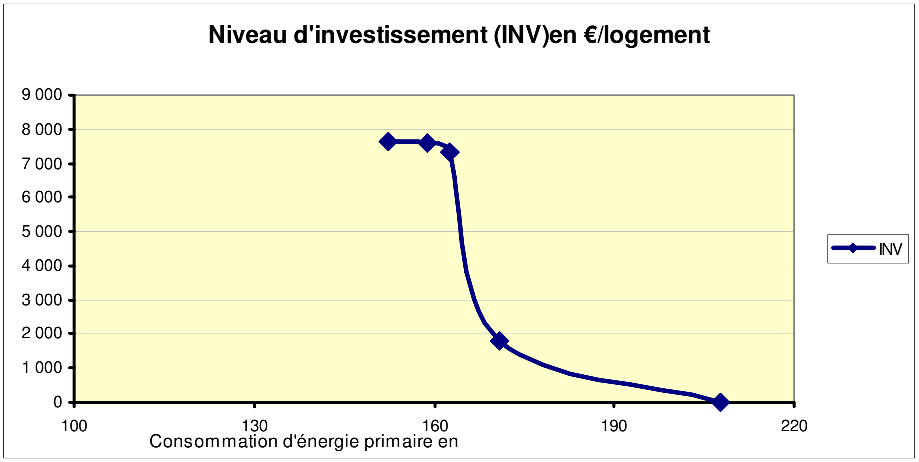
LCEC analysis results

with primary energy consumption in kWhpe/m^2 for each additional technology



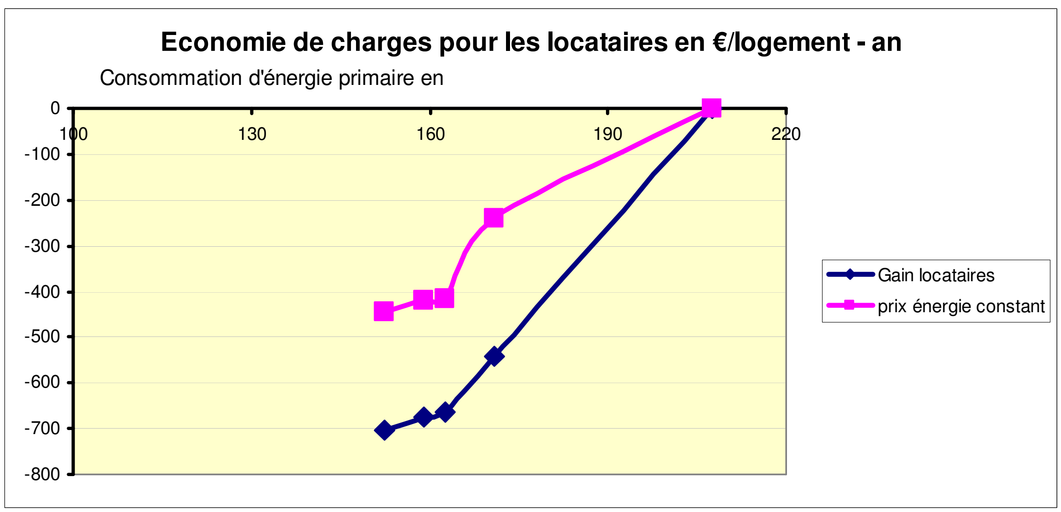
Source La Calade for the municipality of Rennes, July 2008

Investment needs in € / dwelling
(with primary energy consumption in kWhpe/m^2) for each technology selected



Source La Calade for the municipality of Rennes, July 2008

Evolution of tenants charges (in €/dwelling.year)
including the energy price increase (in pink) and without energy price impact (in dark blue)



Source La Calade for the municipality of Rennes, July 2008

Comments

The energy retrofitting programme overseen by the social owner is profitable

- Primary energy consumption : 148 kWh / m²
- Investment per dwelling: 7 800 €

In the optimised scenario or retrofitting programme, all the technologies can be selected too and so the results are the same or we can say that the energy retrofitting programme overseen by the social owner is the optimised one.

2.4. Building D

48 dwellings	2 235 m²	Collective gas central heating	Construction date : 1956 - 70

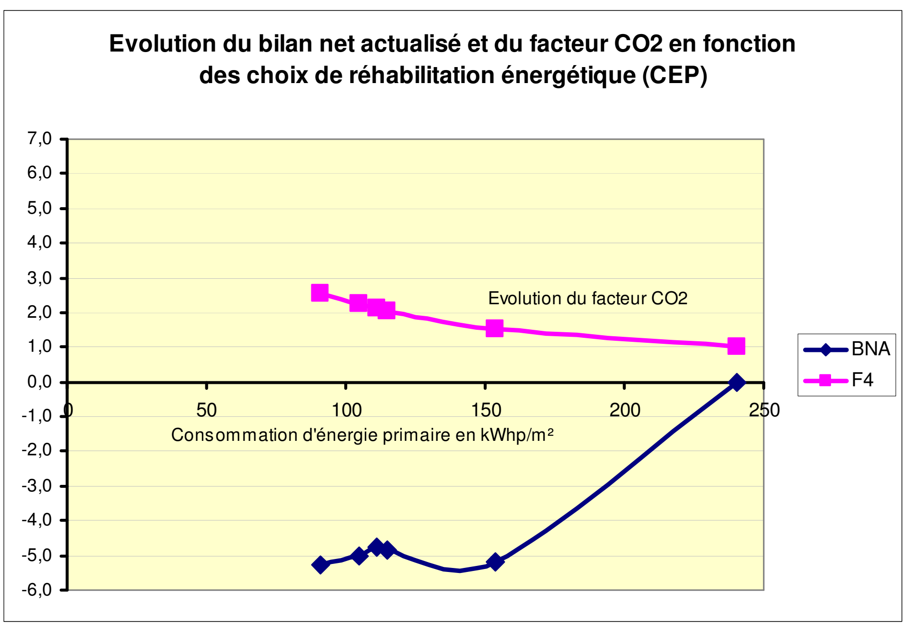
Technologies overseen or suggested by the social owner

1	Condensing boiler
2	Insulation of walls - 10 cm
3	Thermostatic valves
4	Energy savings due to hot water saving
5	Controlled mechanical ventilation with hygroregulated ventilation

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	205	66		
Sanitary hot water in kWh / m²	35	25		
Primary energy consumption in kWh / m²	240	91		
CO_2 emission in kg CO_2 / m²	48	18		
Energy labelling	E	C		
Climate or CO_2 labelling	E	C		
Selected technologies		1 à 5		
Needed investment in € / dwelling		5 913		
Tenants expenses without taking into account the energy price increase in € / m².year	14,4	7,7		
with energy price effect on 25 years in € / m².year	+ 7,5	+ 3,4		
Total tenants expenses in € / m².year	21,9	11,1		
LCEC in € / m².year		**5,3**		
CO_2 factor	1	2,6		

LCEC analysis results

with primary energy consumption in kWhpe/m² for each additional technology



BNA= LCEC

Source La Calade for the municipality of Rennes, July 2008

Comments

The energy retrofitting programme overseen by the social owner is profitable

- Primary energy consumption 91 kWh / m²
- Investment per dwelling : 5 900 €

In the optimised scenario or retrofitting programme, all the technologies can be selected too and so the results are the same or we can say that the energy retrofitting programme overseen by the social owner is the optimised one.

2.5. Building E

128 dwellings	8 744 m²	District heating	Construction date : 1971 - 75

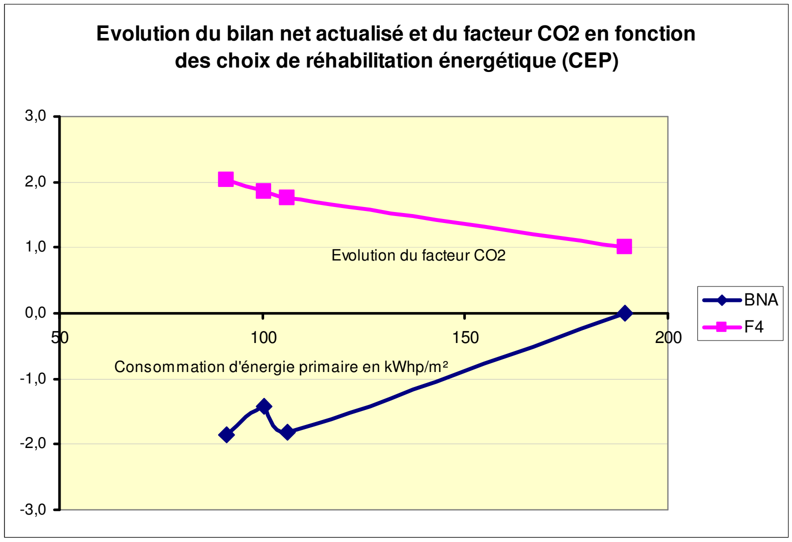
Technologies overseen or suggested by the social owner

1	Insulation of walls - 20 cm
2	Controlled mechanical ventilation with hygroregulated ventilation
3	Energy savings due to hot water saving

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	147	58		
Sanitary hot water in kWh / m²	42	33		
Primary energy consumption in kWh / m²	189	91		
CO_2 emission in kg CO_2 / m²	66	32		
Energy labelling	D	C		
Climate or CO_2 labelling	F	D		
Selected technologies		1 à 3		
Needed investment in € / dwelling		7 200		
Tenants expenses without taking into account the energy price increase in € / m².year	13,0	9,0		
with energy price effect on 25 years in € / m².year	+ 5,9	+ 3,6		
Total tenants expenses in € / m².year	18,9	12,6		
LCEC in € / m².year		**1,9**		
CO_2 factor	1	2,0		

LCEC analysis results

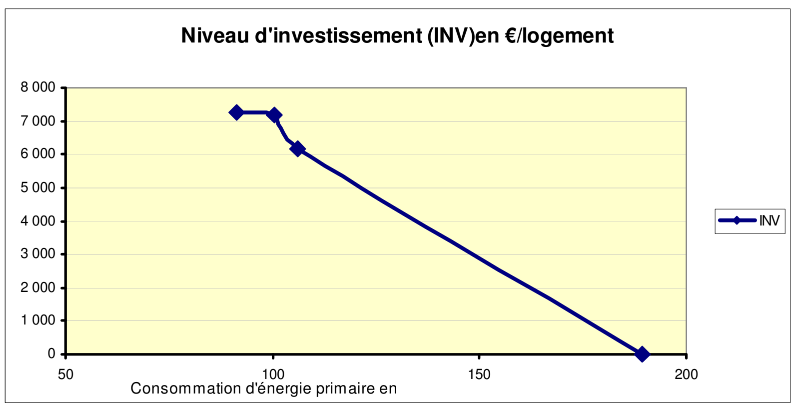
with the factor 4 and primary energy consumption in kWhpe/m² for each additional technology



Source La Calade for the municipality of Rennes, July 2008

Investment needs in € / dwelling

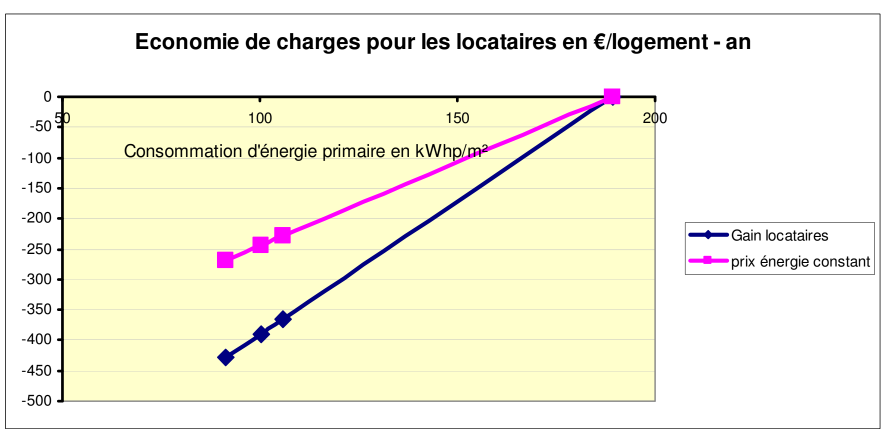
(with primary energy consumption in kWhpe/m²) for each technology selected



Source La Calade for the municipality of Rennes, July 2008

Evolution of tenants charges (in €/dwelling.year)

including the energy price increase (in pink) and without energy price impact (in dark blue)



Source La Calade for the municipality of Rennes, July 2008

Comments

The energy retrofitting programme overseen by the social owner is profitable

- Primary energy consumption 91 kWh / m²
- Investment per dwelling : 7 200 €

In the optimised scenario or retrofitting programme, all the technologies can be selected too and so the results are the same or we can say that the energy retrofitting programme overseen by the social owner is the optimised one.

2.6. Building F

83 dwellings	6 146 m²	District heating	Construction date : 1956 - 70

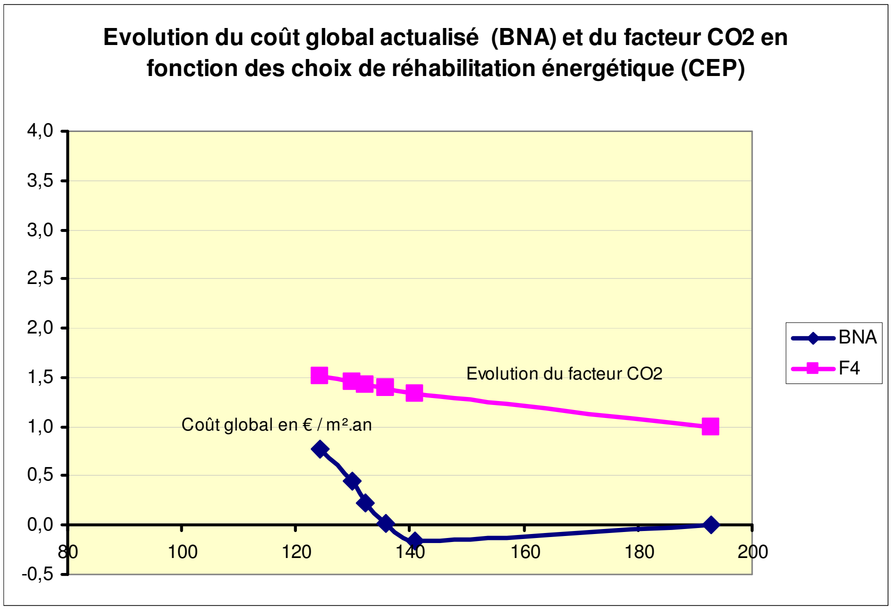
Technologies overseen or suggested by the social owner

1	High performances windows Uw = 1,6
2	Regulation
3	Thermostatic valves
4	Thermo-hydraulic balancing
5	Controlled mechanical ventilation with hygroregulated ventilation

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	109	54	68	
Sanitary hot water in kWh / m²	45	45	45	
Primary energy consumption in kWh / m²	193	124	141	
CO_2 emission in kg CO_2 / m²	28	18	21	
Energy labelling	D	C	C	
Climate or CO_2 labelling	D	C	C	
Selected technologies		1 à 5	1	
Needed investment in € / dwelling		5 405	3 628	
Tenants expenses without taking into account the energy price increase in € / m².year	11,8	9,6	10,1	
with energy price effect on 25 years in € / m².year	+ 2,2	+ 1,7	+ 1,8	
Total tenants expenses in € / m².year	14,0	11,3	11,9	
LCEC in € / m².year		**Loss of 0,8**	**0,2**	
CO_2 factor	1	1,5	1,3	

LCEC analysis results

with primary energy consumption in kWhpe/m^2 for each additional technology



BNA= LCEC

Source La Calade for the municipality of Rennes, July 2008

Comments

1. The energy retrofitting programme overseen by the social owner is <u>not</u> profitable
   - Primary energy consumption : 124 kWh / m²
   - Investment per dwelling : 5 400 €

2. In the optimised scenario or retrofitting programme there is only one technology which can be selected: the window change

   In this optimised scenario, we get:
   - Primary energy consumption 141 kWh / m²
   - Investment per dwelling : 3 600 €

2.7. Building G

23 dwellings (linked or row houses)	1 430 m²	Electric heating, electric sanitary hot water	Construction date : 1984 - 89

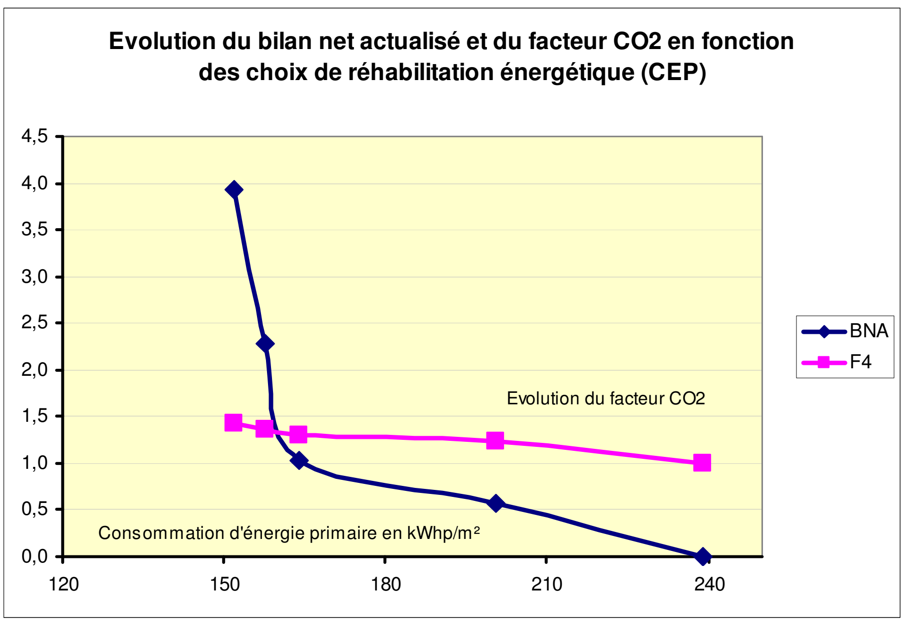
Technologies overseen or suggested by the social owner

1	High performances windows Uw = 1,6
2	Solar heater water
3	Insulation of doors
4	Insulation of livable attic

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	67	48		
Sanitary hot water in kWh / m²	25	11		
Primary energy consumption in kWh / m²	239	152		
CO_2 emission in kg CO_2 / m²	13	9		
Energy labelling	E	D		
Climate or CO_2 labelling	C	B		
Selected technologies		1 à 4		
Needed investment in € / dwelling		8 000		
Tenants expenses without taking into account the energy price increase in € / m².year	10,8	7,5		
with energy price effect on 25 years in € / m².year	+ 2,8	+ 1,9		
Total tenants expenses in € / m².year	13,6	9,4		
LCEC in € / m².year		**Loss of 3,9**		
CO_2 factor	1	1,4		

LCEC analysis results

with primary energy consumption in kWhpe/m^2 for each additional technology



BNA= LCEC

Source La Calade for the municipality of Rennes, July 2008

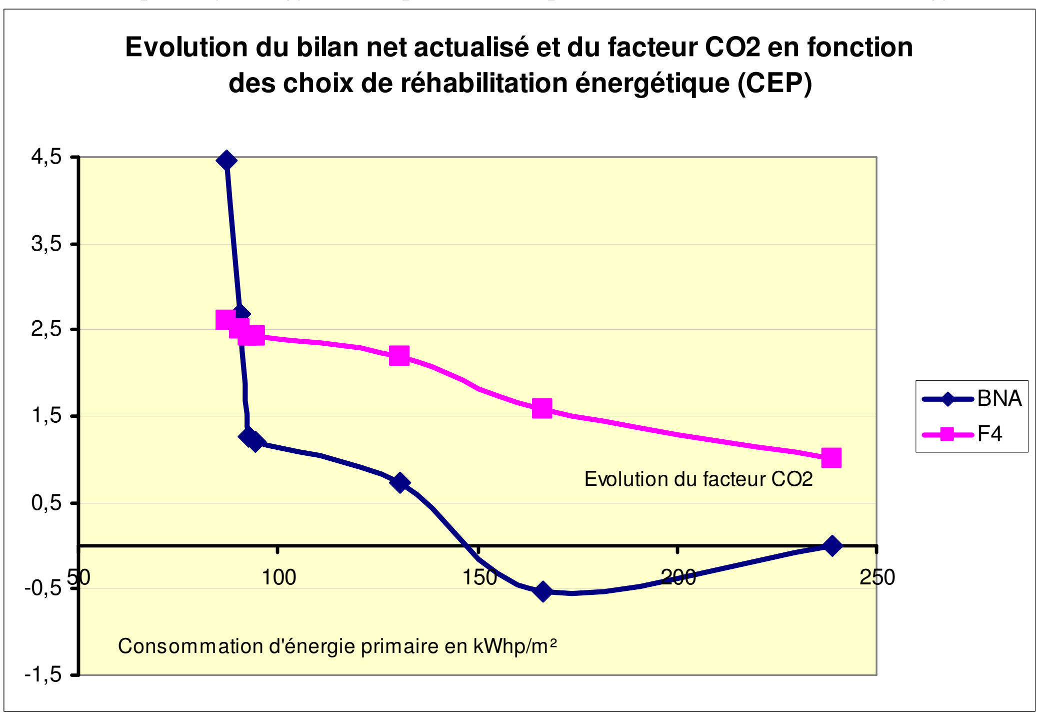
Other optimised scenario or potential retrofitting programme worked out by La Calade

1	Heat pumps
2	High performances windows Uw = 1,1
3	Solar heater water
4	Energy savings due to hot water saving
5	Insulation of doors
6	Insulation of livable attic

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	67	23	39	
Sanitary hot water in kWh / m²	25	11	25	
Primary energy consumption in kWh / m²	239	87	166	
CO_2 emission in kg CO_2 / m²	13	4,6	8	
Energy labelling	E	B	D	
Climate or CO_2 labelling	C	A	B	
Selected technologies		1 à 6	1	
Needed investment in € / dwelling		11 650	2 800	
Tenants expenses without taking into account the energy price increase in € / m².year	10,8	5,2	8,3	
with energy price effect on 25 years in € / m².year	+ 2,8	+1,3	+ 2,1	
Total tenants expenses in € / m².year	13,6	6,5	10,4	
LCEC in € / m².year		**Loss of 4,5**	0,5	
CO_2 factor	1	2,6	1,6	

LCEC analysis results

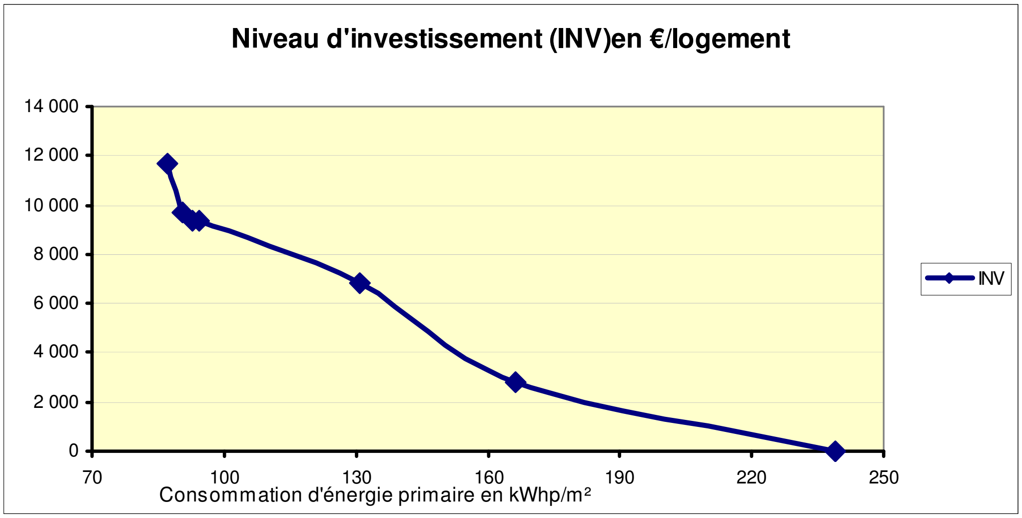
with primary energy consumption in kWhpe/m^2 for each additional technology



BNA=LCEC

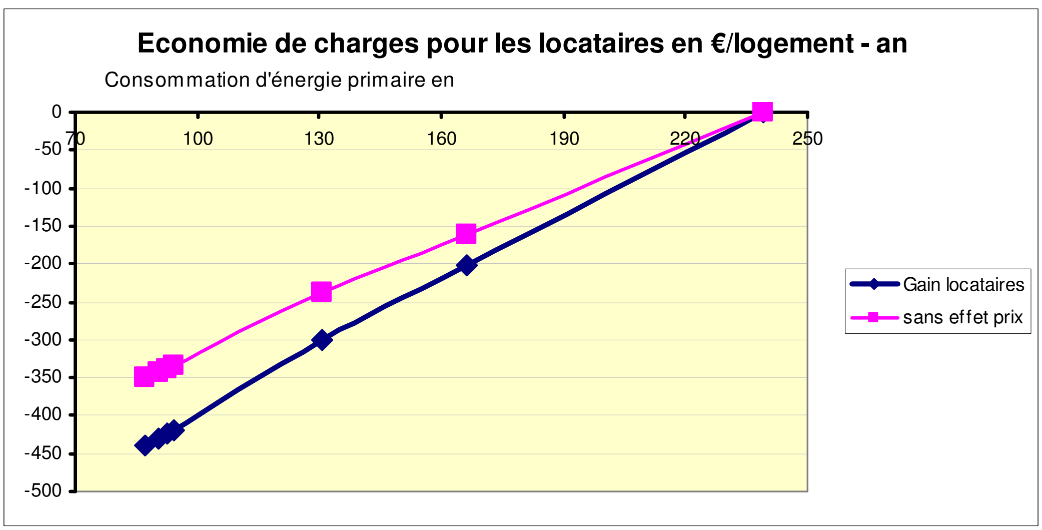
Source La Calade for the municipality of Rennes, July 2008

Investment needs in € / dwelling
(with primary energy consumption in kWhpe/m^2) for each technology selected



Source La Calade for the municipality of Rennes, July 2008

Evolution of tenants charges (in €/dwelling.year)
including the energy price increase (in pink) and without energy price impact (in dark blue)



Source La Calade for the municipality of Rennes, July 2008

Comments

1. The energy retrofitting programme overseen by the social owner is not profitable
   - Primary energy consumption : 152 kWh / m² (59 kWh / m² in final electric energy)
   - Investment per dwelling : 8 000 €

2. A profitable scenario with a heating pump and triple glazing is suggested. We must check the technical possibility of a Controlled mechanical ventilation with hygroregulated ventilation
In this case,

Primary energy consumption 87 kWh / m²
Investment per dwelling : 11 650 €

2.8. Building H

112 dwellings	6 450 m²	District heating	Construction date : 1956 - 70

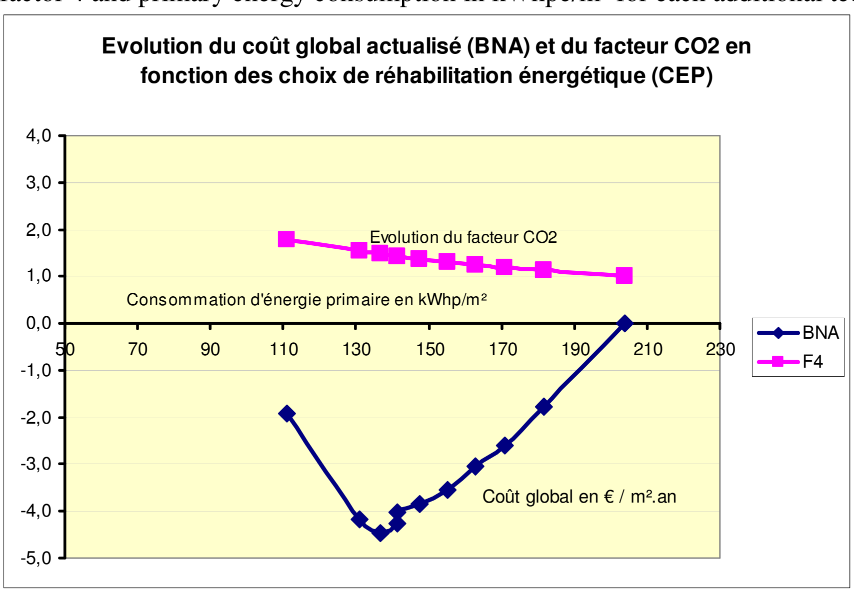
Technologies overseen or suggested by the social owner

1	Change of tenants behaviour
2	Insulation of floor
3	Insulation of pipes (heating)
4	Energy savings due to hot water saving
5	High performances windows Uw = 1,6 (17 % des vitres)
6	Thermostatic valves
7	Common areas lighting
8	Instantaneous sanitary hot water
9	Controlled mechanical ventilation with hygroregulated ventilation
10	Insulation of walls - 10 cm

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	132	67	88	
Sanitary hot water in kWh / m²	32	22	22	
Primary energy consumption in kWh / m²	204	111	137	
CO_2 emission in kg CO_2 / m²	42	24	27	
Energy labelling	D	C	C	
Climate or CO_2 labelling	E	D	D	
Selected technologies		1 à 10	1 à 8	
Needed investment in € / dwelling		7 964	1 342	
Tenants expenses without taking into account the energy price increase in € / m².year	16,1	11,0	12,3	
with energy price effect on 25 years in € / m².year	+ 7,8	+ 4,8	+ 5,7	
Total tenants expenses in € / m².year	23,9	15,8	18,0	
LCEC in € / m².year		**1,9**	**4,5**	
CO_2 factor	1	1,8	1,47	

LCEC analysis results

with the factor 4 and primary energy consumption in kWhpe/m^2 for each additional technology



Source La Calade for the municipality of Rennes, July 2008

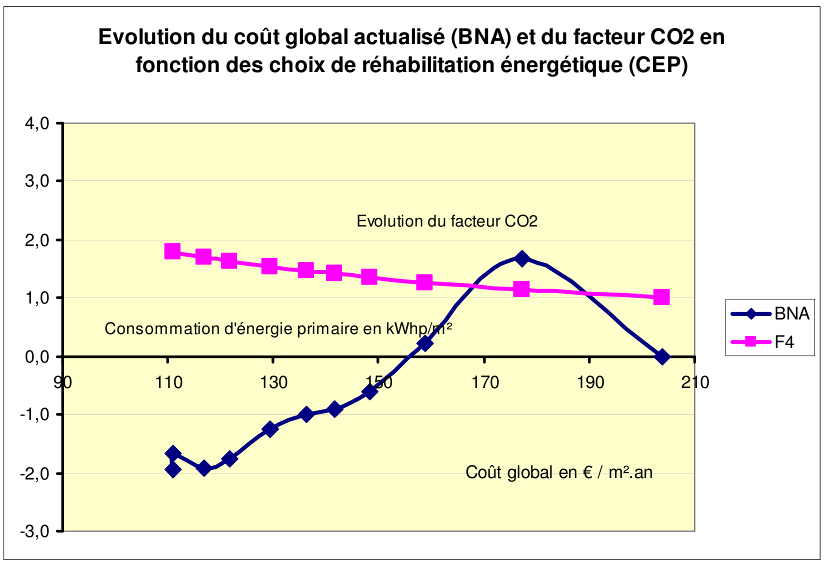
2. Scenario or energy retrofitting programme worked out in maximising energy savings

Technologies overseen or suggested by the social owner

1	Insulation of walls - 10 cm
2	Change of tenants behaviour
3	Insulation of floor
4	Insulation of pipes (heating)
5	Thermostatic valves
6	High performances windows Uw = 1,6 (17 % of windows)
7	Energy savings due to hot water saving
8	Remplacement accumulation par ECS semi instantanée
9	Controlled mechanical ventilation with hygroregulated ventilation
10	Common areas lighting

LCEC analysis results

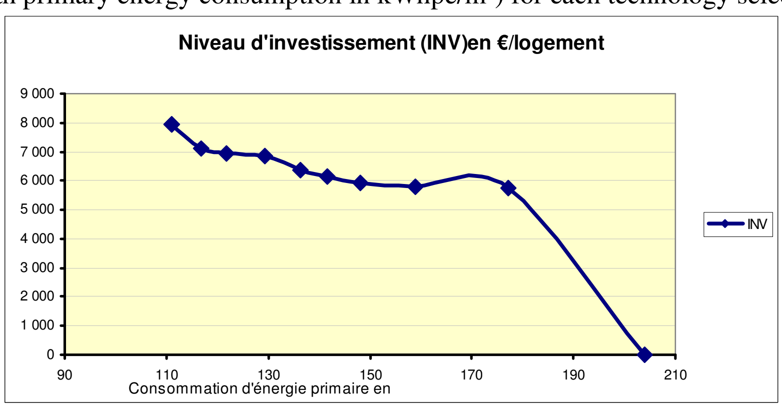
with the factor 4 and primary energy consumption in kWhpe/m² for each additional technology



BNA= LCEC

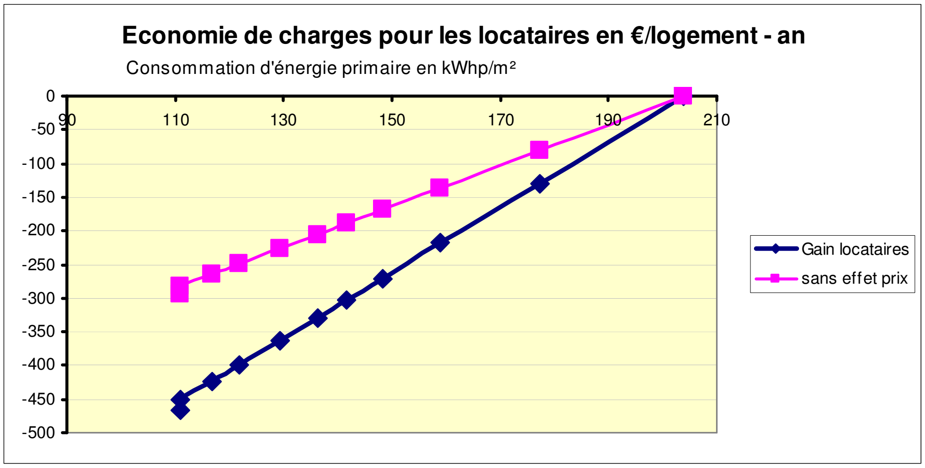
Investment needs in € / dwelling

(with primary energy consumption in kWhpe/m²) for each technology selected



Source La Calade for the municipality of Rennes, July 2008

Evolution of tenants charges (in €/dwelling.year)
including the energy price increase (in pink) and without energy price impact (in dark blue)



Source La Calade for the municipality of Rennes, July 2008

Comments

1. The energy retrofitting programme overseen by the social owner is profitable
   - Primary energy consumption : 111 kWh / m²
   - Investment per dwelling : 8 000 €

2. The economic or LCEC optimum retrofitting programme gathers all the technologies except one : insulation of walls. In this case we got:
   - Primary energy consumption 137 kWh / m²
   - Investment per dwelling : 1 400 €

3. Another profitable scenario or potential energy retrofitting programme has been suggested with an energy saving optimisation.

2.9. Building I

16 dwellings	1 041 m²	Collective gas central heating	Construction date : 1956 - 70

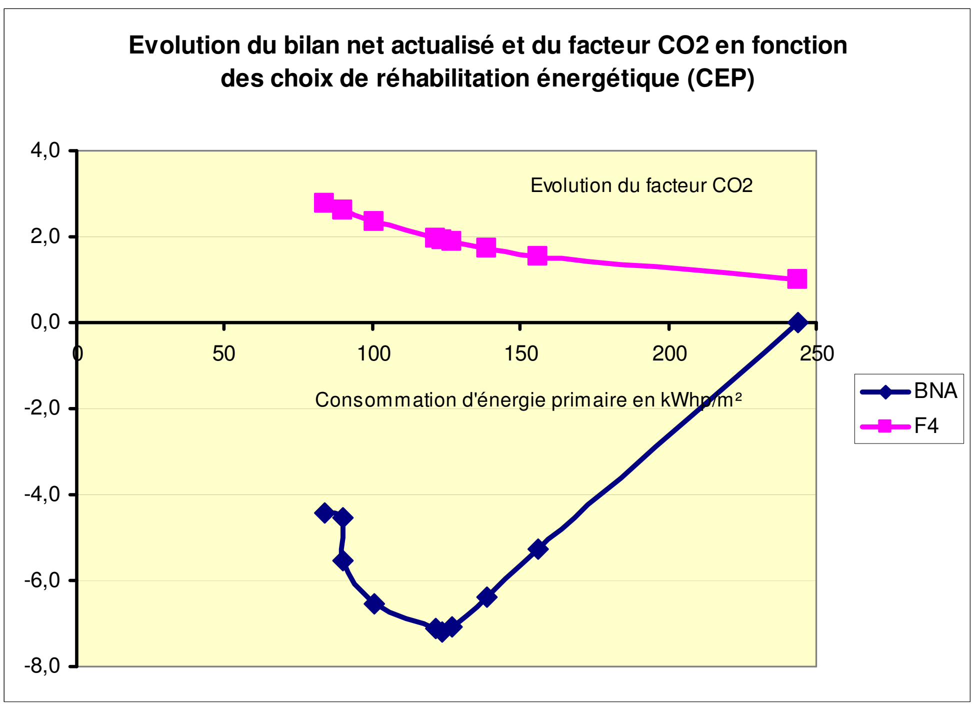
Technologies selected by the social owner

1	Condensing boiler
2	Energy savings due to hot water saving
3	Change of tenants behaviour
4	Regulation
5	Thermo-hydraulic balancing
6	High performances windows Uw = 1,6
7	Insulation of walls - 10 cm
8	Insulation of attic
9	Controlled mechanical ventilation

Energy consumption AFTER works	BEFORE	With all the technologies	Optimised LCEC	
Heating in kWh / m²	171	37	77	
Sanitary hot water in kWh / m²	73	46	46	
Primary energy consumption in kWh / m²	244	83	123	
CO_2 emission in kg CO_2 / m²	49	17	257	
Energy labelling	E	B	C	
Climate or CO_2 labelling	E	C	D	
Selected technologies		1 à 9	1 à 4	
Needed investment in € / dwelling		9 700	2 050	
Tenants expenses without taking into account the energy price increase in € / m².year	15,2	8,0	9,8	
with energy price effect on 25 years in € / m².year	+ 7,1	+ 2,7	+ 3,8	
Total tenants expenses in € / m².year	22,3	10,7	13,6	
LCEC in € / m².year		**5,1**	**7,2**	
CO_2 factor	1	2,8	1,9	

LCEC analysis results

with primary energy consumption in kWhpe/m^2 for each additional technology



BNA= LCEC

Source La Calade for the municipality of Rennes, July 2008

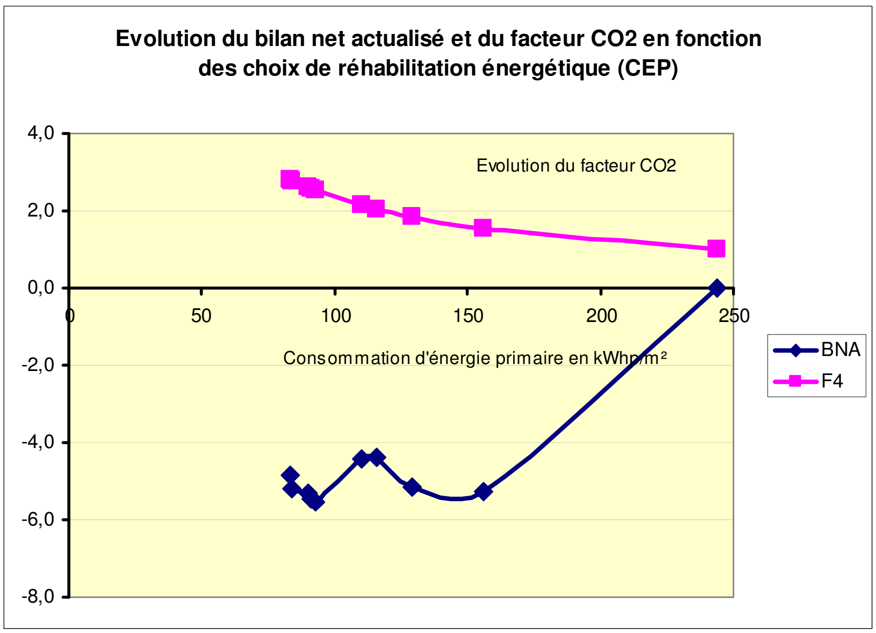
2. Scenario or energy retrofitting programme with an energy optimisation

Technologies selected

1	Condensing boiler
2	High performances windows Uw = 1,6
3	Insulation of walls - 10 cm
4	Change of tenants behaviour
5	Energy savings due to hot water saving
6	Regulation
7	Thermo-hydraulic balancing
8	Controlled mechanical ventilation
9	Insulation of attic

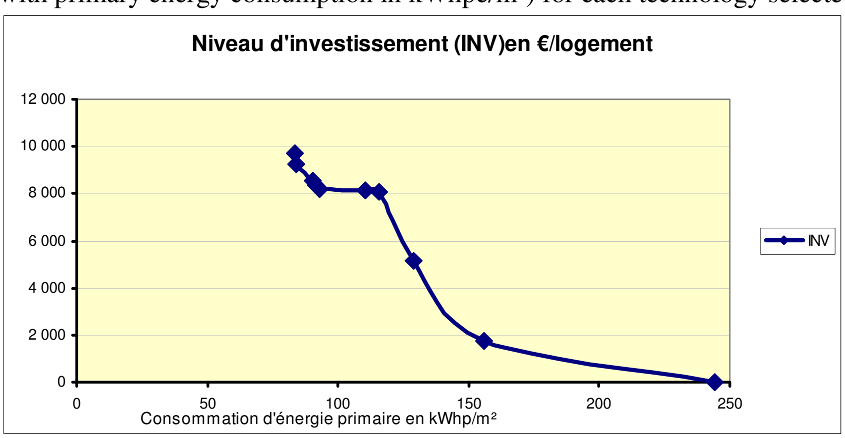
LCEC analysis results

with primary energy consumption in kWhpe/m^2 for each additional technology



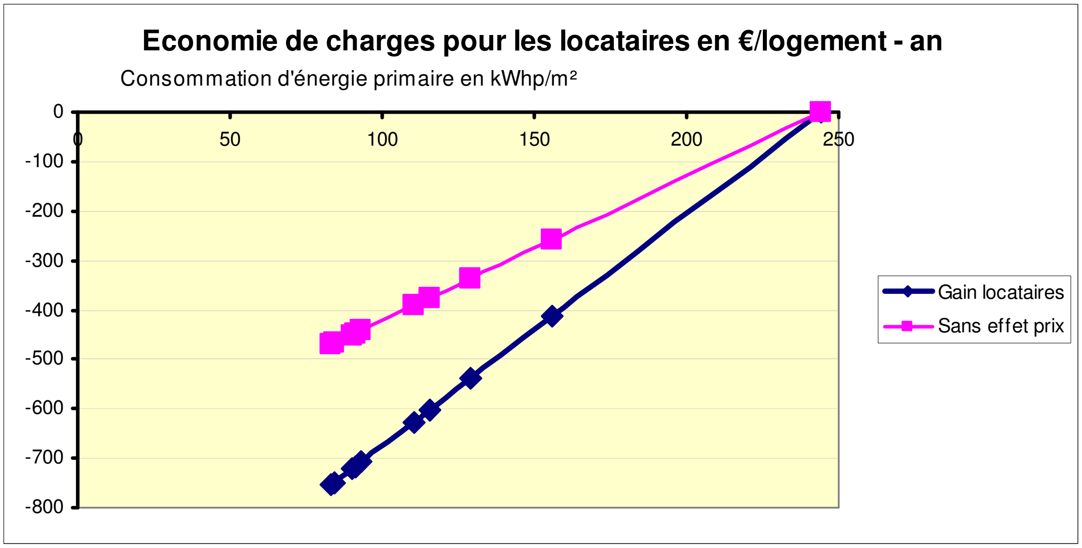
Investment needs in € / dwelling

(with primary energy consumption in kWhpe/m^2) for each technology selected



Source La Calade for the municipality of Rennes, July 2008

Evolution of tenants charges (in €/dwelling.year)
including the energy price increase (in pink) and without energy price impact (in dark blue)



Source La Calade for the municipality of Rennes, July 2008

Comments

1. The energy retrofitting programme overseen by the social owner is profitable

- Primary energy consumption : 83 kWh / m²
- Investment per dwelling : 9 700 €

2. In the economic or LCEC optimum retrofitting programme we selected only the condensing boiler, regulation, the change of tenants behaviour and Energy savings due to hot water saving. In this case we get:

- Primary energy consumption 123 kWh / m²
- Investment per dwelling : 2 100 €

3. Another profitable scenario or potential energy retrofitting programme has been suggested with an energy saving optimisation

3. SYNTHESIS AND COMMENTS ON THE 9 CASES STUDIES

Reminder : calculation has been done with the assumptions and data given by the social owners themselves.

For each energy retrofitting programme we can select various criteria as shown in the following tables. This analysis shows that the LCEC optimisation is the best criteria because it is in fact the sum of all the criteria together. But if some specific objectives are defined for a territory or a building stock it is possible with the LCEC analysis to take them into account as shown below.

HIERARCHY AMONG THE ENERGY RETROFITTING PROGRAMMES ACCORDING TO THE SELECTED CRITERIA

Les données du projet proposé par les bailleurs

Energy retrofitting programmes of the buildings n°	1. Maximum of profitability	**LCEC optimum**	2. CO_2 saving	3. Savings for tenants	4. Primary energy saving	5. Minimum of Investment/ avoided ton of CO_2
	€/m².an	€/m².an	Kg CO_2 / m².an	€ / m².an	kWh / m².an	€ / tonne CO_2
A	**4.3**	**2.5**	**25**	**11.4**	**123**	**103**
B	**0.5**	**1.2 perte**	**15**	**5.3**	**74**	**94**
C	**6.1**	**6.1**	**32**	**11.1**	**60**	**70**
D	**5.3**	**5.3**	**30**	**10.8**	**149**	**88**
E	**1.9**	**1.9**	**34**	**6.3**	**98**	**24**
F	**0.2**	**0.8 perte**	**10**	**2.1**	**69**	**88**
G	**0.5**	**3.9 perte**	**4**	**4.2**	**87**	**140**
H	**4.5**	**1.9**	**18**	**8.1**	**93**	**69**
I	**7.2**	**5.1**	**32**	**11.6**	**161**	**291**

Source La Calade for the municipality of Rennes, July 2008

Criteria n° 1 : Maximisation of profitability

RANK	Energy retrofitting project
+ + +	C
	D
	I
+	A
	H
	E
-	F
	B
- -	G

Criteria n° 2 : Reduction of CO_2 emissions

RANK	Project
+ + +	E
	I
	C
	D
+ +	A
+	H
	B
-	F
	G

Criteria n° 3 : Reduction of charges for tenants

RANK	Project
+ + +	I
	A
	C
	D
+ +	H
	E
	B
+	G
	F

Criteria n° 4 : Maximisation of primary energy saving

RANK	Project
+ + +	I
	D
	A
+ +	E
	H
	G
+	B
	F
	C

Criteria n° 5 : Minimisation of the investment for any avoided ton of CO_2

RANK	Project
+ + +	E
+ +	H
	C
+	F
	D
	B
	A
-	G
- - -	I

Hierarchy in the projects according to the various criteria

CRITERIA	Economic	Investment	Energy	Social	Carbon	FINAL (max 15)
Buildings						
A	+	+	+ + +	+ + +	+ +	**10**
B	-	+	+	+ +	+	**4**
C	+ + +	+ +	+	+ + +	+ + +	**12**
D	+ + +	+	+ + +	+ + +	+ + +	**13**
E	+	+ + +	+ +	+ +	+ + +	**11**
F	-	+	+	+	-	**1**
G	- -	-	+ +	+	-	**- 1**
H	+	+ +	+ +	+ +	+	**8**
I	+ + +	- - -	+ + +	+ + +	+ + +	**9**

Criteria :

Economic : maximisation of profitability

Investment : minimisation of investment per any avoided ton of CO_2

Energy : reduction of primary energy consumption

Social : reduction of charges for tenants

Carbon : reduction of CO_2 emissions

« Final » : this column is the arithmetic sum of « + » and « - »

Source La Calade for the municipality of Rennes, July 2008

Energy retrofitting projects/programmes with the most numerous best notations are those for the buildings D, C and E. They are also the best ones as regarding the LCEC approach.

The less interesting energy retrofitting projects/programmes according to energy criteria (if we don 't take into account social issues, obsolescence or attractivity…) would be for the buildings G, F and B. These 3 retrofitting programme are also less interesting as regarding the LCEC analysis.

At least we have to underline that such a table allows to select one or two criteria or to give more importance to one or two criteria (in case of a specific local strategy or of a specific area for example), and this can modify the hierarchy of the selected projects.

Appendix 2: The Factor 4 partners

1. The coordinator

SUDEN (Sustainable Urban Development European Network), a non profit association, is a European network for promoting sustainable urban development approaches and for facilitating their implementation, due to the close work of researchers with practitioners (www.suden.org).

2. Factor 4 partners

- **The European partners** (cf. Factor 4 Newsletter 1)

Pays	Partenaires de recherche	Bailleurs sociaux	Autres partenaires
France	La Calade	Moulins Habitat USH	HTC SUDEN
Denmark	Cenergia	KAB	
Italy	Ricerca & Progetto	Soc Coop ABITA ARL	
Germany		Volkswohnung	
Romania			Association of the Local Development Promotors (APDL)

- **The French associated partners**

In France and in Italy, social owners became associated partners in signing the factor 4 Consortium Agreement.

In France they are (with Moulins Habitat) the National Factor 4 Group. They participated to the SEC model test by giving some retrofitting programmes to analyse and in suggesting some specific improvements for the SEC model in order to make it as efficient as possible as regarding the social owners way of working.

Pour la France, il s'agit (en sus du partenaire Moulins Habitat) de :

The French associated partners (National factor 4 Group)	
Groupe CMH	OPAC 38
EFIDIS, groupe SNI	OPIHLM d'Arcueil – Gentilly
La Maison du CIL, Groupe UNILOGI	OSICA, Groupe SNI
La Maison Girondine	SAGECO, groupe SNI

SAGECO has asked for a specific additional analysis of 30 of representative buildings in order to get some recommandations for setting up the energy retrofitting strategy for the whole building stock.

- **The Italian associated partners**

Cooperatives (associated to ANCAB) of the Lombardian Region have been involved by providing case studies and by giving information about retrofitting actions planned.

Another cooperative (also associated to ANCAB) has been involved for setting up best process or policies in energy retrofitting using a life cycle cost analysis.

Cooperatives involved in the Factor 4 case studies	
Coop. DEGRADI	Coop. NIGUARDA – ANCAB
Coop. LA BENEFICA – ANCAB	
Best process or policies in energy retrofitting using a life cycle cost analysis	
Cooperativa edificatrice Murri per l'abitazione	

APPENDIX 3: THE AVAILABLE FACTOR 4 DELIVERABLES

DELIVERABLES IN ENGLISH

Phase 1 : the initial building stock analysis and the building typology

- ***Deliverable 3***: **Typological analysis and energy diagnosis for the "2050 buildings**", Jean-Alain Meunier and Julien Ciron (HTC) with Philippe Outrequin (La Calade) for France, Ole Balslev-Olesen (Cenergia) for Denmark, Roberto Fabbri for Italy (Abita), Reinhard Jank (Volkswohnung) for Germany, Jana Suler and Irina Botez (APDL) for Romania, November 2006

This deliverable gives the main figures on each national social housing building stock and the first elements of each national building typology requested for the Factor 4 project (id est with social and economical aspects as well as the usual technical and energy ones).

This deliverable has 4 files: the deliverable itself (with 3 files including 2 on France) and an appendix[48].

- ***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**, P. Outrequin (La Calade) for France, O. Jansen (Cenergia) for Denmark, R. Fabbri (Abita) and S. Bottiglione (Ricerca & Progetto) for Italy, R. Jank (Volkswohnung) for Germany and J. Suler with Violeta Balica (APDL) for Romania, March 2007

*This deliverable (**1 file**) gives*

- *the results of the analyse of each building stock typology: energy consumption and GES emissions for each national building stock showing the gap or efforts to be done for reaching the factor 4,*
- *the main criteria for the case studies selection in each national typology and a first idea of the representative cases studies which will be analysed in the Phase 2(building scale analysis) in order to build up the national strategy (Phase 3).*

The part on France is also in French (2 files, the deliverable itself and an appendix).

The Factor 4 models and the Energy Efficient Technologies data base

- ***Deliverable 5*: A life cycle energy costing model for optimising retrofitting programmes of existing social housings towards a factor 4,** O. Balslev-Olesen (Cenergia, DK), S. Bottiglioni (R & P, I), P. Outrequin (La Calade, F), R. Jank (Volkswohnung,D), C. Charlot-Valdieu (SUDEN, F), August 2007

This deliverable presents the state of the art on existing tools in Europe as regarding energy retrofitting issues and the Factor 4 project objective and describes the philosophy of the Factor 4 models which have been worked out in order to reach these Factor 4 project objectives.

*This deliverable(**1 file**) presents the Factor 4 model an its various national forms : ASCOT, BREA, SEC and VROM.*

- ***Deliverable 8*** (in national languages): description of each national Factor 4 model, May 2007

The German Deliverable 8 is the only one in English: **The German VROM model: establishing a tailor made "VoWo Retrofit Optimisation Model"**, Reinhard Jank, December 2007 (**1 file**)
(4 additional files in national language)

[48] The deliverables or newsletters available on the web www.suden.org are in bold green in this appendix

- ***Deliverable 6*: Energy Efficient Technologies in Europe**, S. Bottiglioni (R & P, I), P. Outrequin (La Calade, F), O. Balsev-Olesen (Cenergia, DK), J-A Meunier (HTC, F), C. Charlot-Valdieu (SUDEN, F), July 2007 (**2 files: the introduction and the data sheets**)

This deliverable is the first step of the Factor 4 data base with energy efficient technologies (and has 2 files: the introduction and the sheets).

Phase 2: The building scale analysis: the retrofitting programme optimisation

- ***Deliverable 7*: Potential energy savings for some representative buildings by using only the ecological objective of a LCEC analysis**, O. Balsev-Olesen (Cenergia, DK), P. Outrequin (La Calade, F), S. Bottiglioni (Ricerca & Progetto, I) and C. Charlot-Valdieu (SUDEN), August 2007

Part 1: **Danish analysis** by Ole Balslev-Olesen, October 2007 (**1 file**)

Part 2: **France** by Philippe Outrequin and Catherine Charlot-Valdieu, October 2007 (**1 file**)

Part 3: **Italian analysis** by Roberto Fabbri, Rossana Zaccaria, Sergio Bottiglioni and Angelo Mingozzi, December 2007 (**1 file**)

Part 4: **German analysis** by Reinhard Jank , March 2008 (**1 file**)

This deliverable deals with the "technical and energy/GES" usual optimum (best practice) and shows for some case studies (buildings) in each country ***how to reach the GES optimum towards at least the factor 4****.*

- ***Deliverable 9*** in national languages (**4 files**) deals with **a first optimisation at the building scale**

This deliverable describes in national languages all the case studies analyses managed in each country for validating the Factor 4 model and for reaching the optimisation of energy retrofitting programmes at the building scale including (each by each or together) the following optima:

- *the energy consumption optimum*
- *the CO_2 optimum*
- *the social or macroeconomic optimum*
- *the economical or microeconomic optimum.*

The number of case studies are non the same in each country. In Denmark there are not many building typologies and so it is not useful to analyse a great number of case studies. In France and Italy there is a great number of typologies and so the case studies are numerous.

This deliverable shows also what is called best practices in social housing energy retrofitting in each country*.*

The Romanian case studies *by Jana SULER, September 2007. This deliverable 9 is the only one in English because there is not any Factor 4 model worked out for Romania (this deliverable 9 can be considered in a way as a deliverable 7).* (**1 file**)

Phase 3: The building stock scale or territorial analysis: the building stock strategy

- ***Deliverable 10*: Elements for strategies for social housing energy retrofitting towards a factor 4 at territorial scales (from the neighbourhood to national ones) and for building stocks,** April 2008

This deliverable shows the second phase of the analysis which is the building stock analysis or approach in order to build up a sustainable strategy for a whole building stock, at a territorial stock or for a social housing building stock. (**1 file**)

The part on France is also in French. (**1 file**)

The barriers analysis

- ***Deliverable 11***: **Barriers analysis for social housings energy retrofitting towards a factor 4,** March 2008

This deliverable describes the various barriers against an improvement of social housing energy retrofitting in each country as well as a European synthesis. (**1 file**)

The overall synthesis and final Factor 4 Brochure

- ***Factor 4 Brochure***: **From the optimisation of energy retrofitting social housing programmes to energy retrofitting strategies for whole building stocks**, May 2008 with versions in national languages.

This document is a short synthesis on the work done showing the main results and the interest of a life cycle cost analysis. (**1 file in English**)

DELIVERABLES IN ITALIAN

Deliverable 8: **Programmi di calcolo delle prestazioni energetiche dell'edifici, il modello BREA,** Sergio Bottiglioni and Alain Mingozzi (Ricerca & Progetto), December 2008 (**1 file**)

Deliverable 9: **Ottimizzazione dei programmi di riqualificazione energetica attraverso il modello BREA,** Roberto Fabbri and Sergio Rossi (ABITA), Angelo Mingozzi and Sergio Bottiglioni (Ricerca & Progetto), December 2007 (**1 file**)

Final Factor 4 Brochure: **Dall'ottimizzazione dei programmi di miglioramento dell'efficienza energetica del patrimonio edilizio dell'allogio sociale alla definizione di strategie per l'intero patrimonio edilizio**, Roberto Fabbri and Sergio Rossi (ABITA), Angelo Mingozzi and Sergio Bottiglioni (Ricerca & Progetto), July 2008 (**1 file**)

DELIVERABLES IN ROMANIAN

Deliverable 8: **Un model CECV pentru optimizarea programelor de reabilitare a locuintelor sociale existente catre atingerea obiectivului factor 4**, Philippe Outrequin (La Calade) con la traducione di Jana Suler for APDL, December 2008 (**1 file**)

Deliverable 9: **Studiile de caz din fiecare tara. Acesta descrie ceea ce se numeste « best practices » in proiectele de reabilitare energetica in fiecare tara,** Jana Suler (APDL), December 2007 (**1 file**)

Brosura Factor 4 **: De la optimizarea programelor de reabilitarea energetica a locuintelor sociale la strategii de reabilitare energetica a fondului de locuinte sociale, Mai 2008 cu versiuni in limbile nationale**, Philippe Outrequin (La Calade), Catherine Charlot-Valdieu (SUDEN), Roberto Fabbri and Sergio Rossi (ABITA), Angelo Mingozzi and Sergio Bottiglioni (Ricerca & Progetto), Jana Suler (APDL), July 2008 (**1 file**)

DELIVERABLES IN FRENCH - DELIVERABLES EN FRANÇAIS

Phase 1 : L'analyse initiale du parc national et l'identification des bâtiments représentatifs (typologie)

- *Deliverable 4 sur la France*: 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, Philippe Outrequin (La Calade) et Catherine Charlot-Valdieu (SUDEN), Décembre 2006

Ce deliverable est une version sur la France un peu plus détaillée que la version en anglais. Il fournit :

- *les résultats de l'analyse de chaque type de bâtiments identifies dans le deliverable 3 en ce qui concerne: les consommations d'énergie et, les émissions de gaz à effet de serre en soulignant l'importance des efforts à fournir pour atteindre le facteur 4 ;*
- *les critères de sélection de la typologie Factor 4 et les différents types de bâtiments à sélectionner pour la validation du modèle, pour l'analyse à l'échelle du bâtiment (Phase 2) et surtout pour l'élaboration ultérieure de la stratégie nationale (Phase 3).*

Ce deliverable comprend le deliverable lui-même et des annexes (**2 files**)

Le modèle SEC (Sustainable Energy Cost) d'analyse en coût global énergétique

- *Deliverable 8* Le modèle SEC d'analyse en coût global: un outil d'aide à la décision pour la réhabilitation énergétique, Philippe Outrequin, Mai 2007 (**1 file**)

Le modèle SEC (Sustainable Energy Cost) élaboré par La Calade pour la France est différent du modèle danois initial (lequel aurait du être conformément au cahier des charges le modèle unique européen) car les bailleurs sociaux français ne connaissent souvent pas les données nécessaires pour utiliser le modèle danois (coefficients de déperdition par exemple). Le modèle SEC propose donc une estimation à partir des données disponibles.

Le permet SEC permet une analyse à l'échelle des bâtiments : étiquettes énergie et émissions de gaz à effet de serre puis l'optimisation du programme de réhabilitation au regard des différents optima pris en compte(par itération) : réduction des consommations d'énergie, minimisation des émissions de gaz à effet de serre, réduction des charges, retour sur investissement pour le bailleur, calcul de la subvention d'équilibre nécessaire…

Remarques :

- *Ce modèle a vocation à évoluer et il a été amélioré avec les bailleurs et leurs partenaires. Par ailleurs des versions régionales sont aujourd'hui disponibles.*
- *Une adaptation de ce modèle pour le logement privé est aujourd'hui en cours dans le cadre d'une recherche financée dans le cadre du PREBAT par le PUCA.*

Phase 2: L'analyse à l'échelle du bâtiment

- *Deliverable 9* L'optimisation des programmes de réhabilitation grâce à une analyse en coût global énergétique, Philippe Outrequin et Catherine Charlot-Valdieu, juin 2007 (**1 file**)

Ce document décrit les 32 études de cas françaises proposées par 9 bailleurs. Celles-ci ont permis également de valider et de finaliser le modèle SEC.

L'analyse présentée dans ce deliverable est de 2 types :

- *pour Moulins Habitat, l'analyse a porté sur l'identification des bâtiments représentatifs du parc concerné par le projet ANRU sur 2 quartiers de Moulins-sur-Allier puis sur l'optimisation du programme de réhabilitation de chacun de ces bâtiments (Partie 2)*
- *pour les partenaires associés l'analyse a porté sur le programme de réhabilitation proposé par le bailleur social (analyse des bonnes pratiques françaises) (Partie 3).*

La synthèse de l'ensemble de ces analyses à l'échelle du bâtiment est présentée dans le deliverable 10.

Phase 3: L'analyse à l'échelle d'un parc (analyse patrimoniale ou territoriale)

- *Deliverable 10*: Eléments de stratégie nationale, territoriale et patrimoniale de réhabilitation de logements sociaux pour intégrer l'énergie et les émissions de gaz à effet de serre dans une démarche de développement durable vers un facteur 4, Philippe Outrequin (La Calade) et Catherine Charlot-Valdieu (SUDEN), Septembre 2007 (**1 file**)

Ce document présente tout d'abord

- *une synthèse de l'analyse des outils existants (en anglais dans le deliverable 5)*
- *une synthèse des études de cas effectuées en France entre 2006 et septembre 2007.*

Puis il propose des éléments :

- ***pour élaborer une stratégie nationale*** *:*
  - *élaboration de la typologie du parc,*
  - *identification des bâtiments représentatifs,*
  - *analyse de ces cas représentatifs de l'ensemble du parc national français (étiquettes énergie et émissions de gaz à effet de serre et dépense des ménages liée à la consommation d'énergie, y compris électricité) et optimisation de la réhabilitation énergétique*
  - *optimisation des programmes de réhabilitation de chacun des cas représentatifs à l'aide de scenarii*
  - *identification du parc à réhabiliter en priorité*
  - *comparaison des résultats avec un scénario de référence (élaboré à partir des bonnes pratiques analysées en Phase 2)*
  - *analyse d'un cas type représentatif de 36 % du parc à réhabiliter*
  - *synthèse et éléments de stratégie nationale, notamment afin de maximiser les investissements (et fonds publics) disponibles*

- ***pour l'élaboration d'une stratégie territoriale*** *avec l'exemple des 2 quartiers concerné par le dossier ANRU de Moulins-sur-Allier*

  Cette partie est la synthèse de l'analyse à l'échelle du bâtiment effectuée en Phase 2 et l'analyse puis la comparaison des différents scenarii élaborés à l'échelle du territoire, pour l'ensemble des 63 bâtiments concernés par le dossier ANRU.

  Cette analyse présente également la subvention nécessaire pour atteindre l'optimum pour chacun des bâtiments représentatifs du parc analysé.

  La conclusion porte sur des recommandations pour les différentes échelles territoriales : quartier, ville, département ou région.

- ***vers une optimisation patrimoniale*** *(en commençant par la recherche de l'optimisation à l'échelle du bâtiment).*

  Cette dernière partie présente l'optimisation d'un programme de réhabilitation pour un bâtiment et amorce l'optimisation à l'échelle d'un patrimoine pour un bailleur social

Une courte synthèse de ce document rédigée avec Brigitte Brogat de l'USH (à destination des bailleurs sociaux notamment) est également disponible sur le site web.

Brochure finale de synthèse

- *Brochure Factor 4* : Vers une stratégie « durable » de réhabilitation énergétique pour un parc de logements sociaux (stratégies patrimoniales des bailleurs sociaux ou territoriales des collectivités territoriales), Philippe Outrequin (La Calade), Catherine Charlot-Valdieu (SUDEN) et Sergio Bottiglioni, Avril 2008 (**1 file**)

NEWSLETTERS
IN ENGLISH AND NATIONAL LANGUAGES
(FRENCH, ITALIAN AND ROMANIAN)

The newsletter 1 deals with the Factor 4 project's objective and partners (**1 file**)

La première newsletter présente le projet et ses partenaires (**1 file**)

La newsletter 1 presenta il Progetto e i partners (**1 file**)

Newsletter 1 prezinta proiectul si partenerii (**1 file**)

The newsletter 2 describes the 3 first Factor 4 models: ASCOT (Assessment of Sustainable Construction and Technologies cost)for Denmark, BREA (Building Retrofitting Efficiency Assessment) for Italy and SEC (Sustainable Energy Cost) for France (**1 file**)

La newsletter (lettre) 2 décrit les 3 premiers modèles Factor 4 élaborés: le modèle ASCOT pour le Danemark, le modèle BREA pour l'Italie et le modèle SEC pour la France (**1 file**)

La Newsletter 2 descrive i primi modelli di calcolo elaborati nell'ambito del progetto Factor 4 ASCOT per la Danimarca, BREA per l'Italia e SEC per la Francia. (**1 file**)

Newsletter 2 descrie modelele de analiza elaborate in cadrul Proiectului Factor 4: ASCOT pentru Danemarca, BREA pentru Italia si SEC pentru Franta (**1 file**)

The newsletter 3 is focussing on the building stock energy analysis for setting up building stock energy retrofitting strategies and shows to social owners the interest of a life cycle cost analysis. (**1 file**)

La newsletter 3 souligne l'intérêt pour les bailleurs sociaux de l'analyse énergétique en coût global pour l'élaboration de stratégies patrimoniales de réhabilitation énergétique. (**1 file**)

La newsletter 3 mettre in evidenza l'importanza delli analysi di ciclo di vita del costo energetico per la definizione di strategie di riqualificazione energetica di edifici e per la gestione dei patrimonii di allogio sociale (**1 file**)

Newsletter 3 pune in evidenta importanta analizei costului energetic pe ciclul de viata pentru definirea strategiilor de reabilitare energetica a patrimoniului de locuinte sociale (**1 file**)

The newsletter 4 is an overall synthesis of the Factor 4 results focussing on how to set up energy retrofitting strategies for building stocks (**1 file**)

La newsletter 4 résume le projet Factor 4 et souligne les principaux résultats du projet Factor 4 et l'intérêt de l'analyse en coût global énergétique. (**1 file**)

La newsletter 4 è una sintesi dei vari risultati del Progetto Factor 4 con particulare riferimento alla metodologia per l'elaborazione di strategie di recupero energetico per un patrimonio di allogio sociali. (**1 file**)

Newsletter 4 este o sinteza a principaleleor rezultate obtinute in cadrul proiectului Factor 4, cu accent pe importanta analizei costului energetic pe ciclul de viata (**1 file**)

Deliverables according to the Facror 4 project's phases

Phase 1 : typology	Deliverable 3 (English) Deliverable 4 (English and French)
Phase 2: the building scale analysis	Deliverable 7 : towards the factor 4 (English) Deliverable 9 : best practice (or representative case studies) analysis Newsletter 3 (English and national languages)
Phase 3 : the building stock analysis	Deliverable 10 (English and French) Newsletter 4 (English and national languages)
The Factor 4 model	Deliverables 5 (English) and 8 (national languages) Newsletter 2 (English and national languages)
Energy efficient technologies data base	Deliverable 6 (English)
Barrier analysis	Deliverable 11 (English)
Synthesis – **Factor 4 Brochure**	Factor 4 Brochure (English and national languages)