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An approach and a tool for setting sustainable energy retrofitting strategies referring to the 2010 EPBD

Un procedimiento y una herramienta de ayuda a la decisión para desarrollar estrategias de rehabilitación energética sostenibles para la Directiva Europea (EPBD) 2010

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SUMMARY

The 2010 EPBD asks for an economic and social analysis in order to preserve social equity and to promote innovation and building productivity.
This is possible with a life cycle energy cost (LCEC) analysis, such as with the SEC (Sustainable Energy Cost) model whose bottom up approach begins with a building typology including inhabitants. Then the analysis of some representative buildings includes the identification of a technico-economical optimum and energy retrofitting scenarios for each retrofitting programme and the extrapolation for the whole building stock. An extrapolation for the whole building stock allows to set up the strategy and to identify the needed means for reaching the objectives.
SEC is a decision aid tool for optimising sustainable energy retrofitting strategies for buildings at territorial and patrimonial scales inside a sustainable development approach towards the factor 4. Various versions of the SEC model are now available for housing and for tertiary buildings.

RESUMEN

La directiva europea de 2010 sobre eficiencia energética en los edificios exige un análisis económico y social con el objetivo de preservar la equidad social, promover la innovación y reforzar la productividad en la construcción.
Esto es posible con el análisis del coste global ampliado y especialmente con el modelo SEC. El análisis "bottom up" realizado con la SEC se basa en una tipología de edificio/usuario y en el análisis de edificios representativos: la identificación del óptimo técnico-económico y elaboración de escenarios antes de hacer una extrapolación al conjunto del parque.
SEC es una herramienta de ayuda a la decisión para desarrollar estrategias territoriales o patrimoniales de rehabilitación energética. Existen diversas versiones del modelo: para edificios residenciales (unifamiliares y plurifamiliares, públicos y privados) y para edificios terciarios.

113-116

Keywords: life cycle energy costing, sustainable energy retrofitting strategies/policies, technico-economical optimum.

Palabras clave: *Coste global ampliado, estrategia de rehabilitación energética sostenible, optimo técnico-económico.*

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1. THE NEW SUSTAINABLE DEVELOPMENT APPROACH REQUIRED BY THE EPBD

According to the 2010 European Directive on energy efficiency in buildings (EPBD), "requirements for the energy performance of buildings and building elements should be set with a view to achieving **the cost-optimal balance** between the investments involved and the energy costs saved **throughout the lifecycle of the building…** Member States shall take account of the cost-optimal levels of energy performance when providing incentives" (art. 10). And "Should significant discrepancies, i.e. exceeding 15%, exist between these calculated cost-optimal levels of minimum energy performance requirements and the minimum energy performance requirements in force, Member States should justify the difference or plan appropriate steps to reduce the discrepancy" (art. 14).

2. FROM BEST PRACTICES AND AWARENESS TO BEST POLICIES OR STRATEGIES

Due to the first 2002 EBPD, local authorities, environmental public agencies as well as national regulation and programmes were focussing on demonstrative energy retrofitting operations named best practices on the one hand and on awareness (of the various actors including inhabitants) on the other hand. These best practices were focussed on energy savings for most of them (and not on energy efficiency).

With the common EU 3 x 20 objectives (2007) and since the 2010 EPBD (focussing on economic efficiency and no more only on energy efficiency), and especially in France because of the very ambitious objectives of the "Grenelle de l'Environnement", we have to take into account (also) both economic and social issues. So, now, awareness with best practices is no more sufficient and **priority should be given to sustainable territorial energy retrofitting strategies**. Best practices should be supported only in case of an important innovation or for testing the territorial strategy and these strategies have to take into account first the economic efficiency.

What is a sustainable energy retrofitting strategy for housing?
It is a strategy which takes into account social and economic issues as well as environmental and ecological ones TOGETHER (and not only social or economical impacts of actions on energy or on energy savings) and so it is a strategy which reduces energy precariousness, preserves the households' budget and does not improve inequity on the one hand and which improves the building sector productivity and local employment on the other hand.

3. LIFE CYCLE ENERGY COSTING WITH THE SEC MODEL FOR SUSTAINABLE ENERGY RETROFITTING STRATEGIES

What is a life cycle energy cost analysis?
The ISO/DIS 15686-5 norm gives the definition of "life cycle cost" and "whole life costing".

The main interest of a life cycle cost (LCC) analysis is to wonder about the long terms impacts of our present choices, of our policies, such as for example in terms of costs and benefits for each of the various actors. This cross cutting approach is really innovative in France as in other European countries (Only few energy experts are also experts in economics and so the economical approach of energy retrofitting in buildings and especially in private housing is often very poor or even wrong as we could see in France due to a research managed by La Calade for the French housing ministry).

As regarding energy performance in building retrofitting, a life cycle energy cost (LCEC) analysis allows to identify the technico-economic optimum which preserves social equity and improves building productivity (and so preserves local employment). It allows also identifying the level of the needed subsidies for reaching political objectives (such as the ones from the "Grenelle de l'Environnement" or the European 3 x 20) in order to preserve equity and the households budget.

So, the LCEC analysis is a way for answering the 2010 EPBD requirement on economic efficiency. It is a socio-economic and financial complement of the usual technical analysis focussed only on energy and it enables to integrate the EPBD in a sustainable development approach.

3.1. A LCEC analysis with the SEC model

The SEC model is a life cycle energy cost (LCEC) easy to use by a lot of actors: social owners, local authorities, building companies, consultants...

It can be used for the building scale but there are already a lot of more sophisticated tools for this scale. Its main objective is the territorial or patrimonial scale, the strategy (instead of the best practice focussed on the building scale).

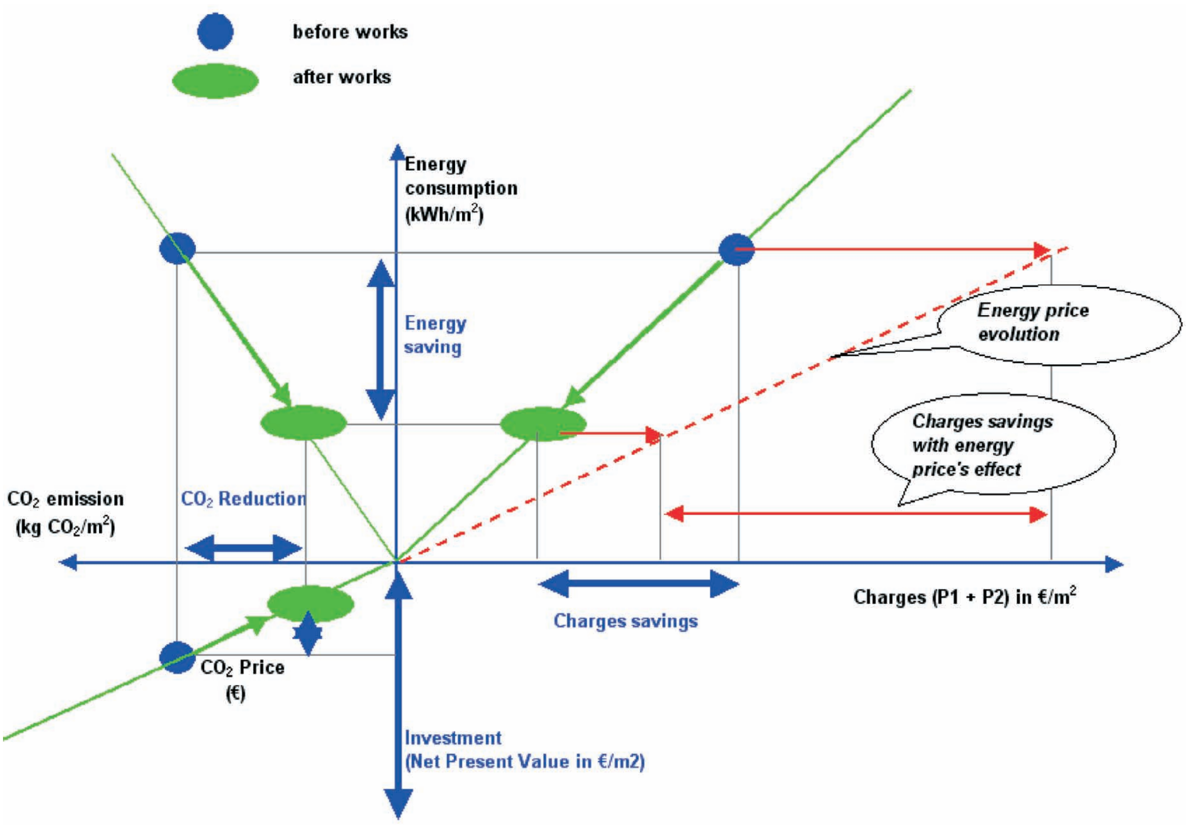
It allows setting up a lot of simulations in order to optimise the energy retrofitting programme of any building and especially any building type. These simulations allow a selection of the best technologies as regarding their economic efficiency and their impacts for the various actors (and especially the owner and the renter) or, if needed (in specific cases), their energy efficiency.

As required by the 2010 EPBD, the SEC model allows an economic efficiency approach. It allows to take into account simultaneously all the environmental (reduction of energy consumption), **ecological** (reduction of CO_2 emissions), **social** (reduction of charges for tenants or owners) **and economic** (investments optimisation, taking into account energy price increase) **issues in order to help all the actors concerned** (social owners, private owners, local authorities, banks…) **to make the best choice** *(Figure 1)*.

by a lot of actors on the one hand and **dealing with economic efficiency and social impacts as well as with energy and GES together** on the other hand.

The SEC model allows local authorities or building stock owners (and their partners, especially the financial ones) to set up **sustainable energy retrofitting strategies** at territorial or patrimonial (building stocks) scales as required by the 2010 EPBD and in coherency with their regulation documents as regarding both housing and land planning. For example the LCEC analysis managed with the SEC model is now used as one of the criteria for the attribution of the Feder founds.

1. Simultaneous integration of environmental, ecological, social and economic issues. *Source La Calade for the Factor 4 European project, 2007*[3].



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3.2. What is the SEC model?

We have seen that the SEC (Sustainable Energy Cost) model is a life-cycle energy cost tool easy to use and which can answer the 2010 EPBD requirements on economic efficiency.

The SEC model has been worked out by the authors (and especially Philippe Outrequin) according to the French context (technical regulation, laws, techniques, costs…)

3.2.1. *The SEC model's objective*

Energy retrofitting is complex and the energy existing tools are very sophisticated so there is a need for a sophisticated tool **easy to be used**

3.2.2. *The SEC model's origin: the European Factor 4 project focussed on social housing*

The first version of the SEC model has been worked out by La Calade[2] in 2006 during the European SAVE project Factor 4 coordinated by the non profit association SUDEN[1].

The Factor 4 project objective was to set out a sustainable energy retrofitting strategy for a whole social housing building stock.[3]

4 national versions of the model were worked out (SEC in France, BREA in Italy, ASCOT in Denmark and VROM in Germany) but only

[1] *SUDEN* (Sustainable Urban development European Network), a non profit association (www.suden.org) who coordinated the Factor 4 European project (see www.suden.org/Factor4).

[2] La Calade is a SME involved in research and consultancy in 2 main fields: sustainable urban development and energy strategies.

[3] The *Factor 4* deliverables (in various languages) are on the web site www.suden.org/Factor4.

2 of them (BREA and SEC) are dealing with a life cycle energy cost (LCEC) analysis.

The aim of Factor 4 project was to work out **a decision aid tool for optimising energy retrofitting programmes for social housing inside a sustainable development approach** (including a socioeconomic optimum) easy to be used by social owners themselves, facilitating the choice among energy efficient technologies (through the analysis of various scenarii), improving the dialogue with all the social owners'partners (and especially the financial ones and tenants) and useful **for setting up territorial (and/or building stock) energy retrofitting strategies towards a factor 4** (at the neighbourhood, city, regional or national scales).

The Factor 4 approach has the following steps:

1. the setting of **a building typology** (of the building stock) in order to select representative ones on which the analysis will be focussed on
2. **an energy diagnosis** of the selected representative buildings with the SEC model (with both Energy and Climate labels) and the analysis of available energy consumption data (such as data from the collective heating plants for example);
3. **various energy retrofitting simulations or scenarii for each representative building** with the SEC model, first without taking into account the potential incentives or subsidies and then with various potential ones in order to show and better understand their long term impacts (on energy consumption but also on CO_2 emissions and on charges for renters, etc.). These simulations (scenarios) also help for identifying the buildings to be demolished and those for which an important energy retrofitting programme is needed;
4. an **extrapolation** of the results on the representative buildings **to the building stock or to the territorial scale** (neighbourhood, city…);
5. recommendations (including for local authorities as regarding the subsidies criteria) and setting out **a sustainable energy retrofitting strategy.**

3.2.3. *The SEC model improvements*

Since 2008 (end of the Factor 4 project), the SEC model has been improved by La Calade due to various studies for local authorities and social owners as well as to researches for the French ministry. It is considered as one of the 5 French references including only 2 tools as regarding LCC approaches since May 2010. The main improvements were new versions of the model for single housing and for the private sector, the addition of more techniques dealt with by the model, the way of using it (it is now easier and quicker)…

A lot of actors such as banks (including the main public one, the Caisse des depots et Consignations) participated to the discussions on the numerous hypotheses needed for/by the model and some of them were modified or added.

3.2.4. *The SEC model: a decision aid tool for various actors*

The SEC model is **a decision aid tool:**

- **easy to be used,**
- facilitating the choice among energy efficient technologies (through the analysis of various scenarios),
- improving the dialogue among the actors (and especially financial ones with tenants or social owners),
- useful **for a long term assets' management** of a whole building stock,
- **useful for setting up territorial sustainable energy retrofitting strategies towards a factor 4** (at the neighbourhood, city, regional or national scales),
- which can also reduce energy precariousness, especially in the private housing sector.

So, SEC is a decision aid tool for various actors:

- **local authorities and their local partners (banks, local energy agencies…):**
  - for setting up their sustainable energy retrofitting strategy for housing, in coherency with their regulation documents as regarding both housing and land planning
  - for defining the subsidies criteria, either for social housing and for the private sector,
  - for fighting against energy poverty or precariousness;
- **social owners** for setting up the energy retrofitting strategy of their whole building stock,
- all the actors involved in a neighbourhood regeneration project including retrofitting of existing buildings;
- **building companies**, in order to improve their development strategy;
- **energy suppliers** because they are now involved in services for local authorities,
- **households.**

3.2.5. *A dialogue tool towards building productivity and local employment*

The SEC model **contributes to the dialogue between actors** (such as between local authorities and social owners or between households and building companies for example) and especially with financial ones such as banks.

These dialogues and the identification of the techniques which will be used tomorrow help building companies and especially the small local ones to be aware of the market needs and to engage themselves in the needed training courses. So at least this approach with the SEC model contributes to promote innovation and building productivity as well as local employment.

3.3. The various available versions and uses of the SEC model in 2011

The first versions of the SEC model were for social housing.

Due to specific studies for social owners or local authorities, the SEC model has been regularly improved by La Calade and various versions are now in use (some social owners wanted their specific version with their own building stock typology for example and with their own objectives as regarding energy performance or retrofitting costs/main issues).

Further more, due to subsidies from the French ministry (PUCA[4] through PREBAT, the national research programme on energy in buildings), La Calade has improved the initial version of the SEC model: SEC can deal now with more technologies/techniques and is adapted to the private sector (which has not the same financing rules nor the same costs) and another new version of the SEC model is now available for single family houses.

So it is now possible to use the SEC model for:

- **social housing,** including single family housing and regional energy retrofitting strategy (Picardie and Alsace asked for La Calade in order to use the SEC model and its LCEC approach). The SEC model is also used by the Picardie Region and the Caisse des Dépôts et Consignation (a national bank) for according the Feder subsidies (according to the level of the technico-economic optimum)
- **private housing,** including single family housing,
- **tertiary buildings**: offices, schools…

A lot of social owners and some local authorities (such as Paris for example) are now using the SEC model.

At least the SEC model has been used by La Calade for setting the scenarii towards the public regional strategy of Auvergne (in the framework of the regional schema for energy and climate (named SRCAE) worked out by the DREAL Auvergne, the regional public administration for environment, land planning and housing).

3.4. The methodological approach

3.4.1. *The SEC model hypotheses*

A lot of hypotheses have been validated with public administration and some other actors such as Caisse des Depots et Consignations (the official French bank for local authorities and social owners) and Ademe, such as:

- the energy prices data base and energy prices increase,
- the equipments and techniques data base with their life duration, cost and maintenance cost,
- the degree days data base,
- carbon tax and other energy certificates,
- the discount rate level,
- the duration of the evaluation (for example we usually select 25 years for social housing but only 15 years for the private sector),
- …

And all these hypotheses can be modified if needed.

3.4.2. *First step: a typology and the selection of representative buildings*

The first step is a typology of the buildings including their users (social or private sector, renter or owner, with financial possibilities or not…).

Then we select representative buildings on which an analysis with the SEC model will be managed. (It is better to select representative buildings with real data on energy consumption).

3.4.3. *The energy diagnosis of the representative buildings with the SEC model*

The SEC model allows calculating the energy consumption of any housing building for heating, sanitary hot water (SHW) and electricity (which is not included in the EPBD diagnosis but which is sometimes an important and increasing expense for house keepers) and **comparing this estimation to the real data** when they are available. This comparison allows adjusting the technical parameters describing the building and is a sort of guarantee on the results quality of the further simulations (this is not possible with the official EPBD diagnosis in France).

The following example illustrates this comparison between the real data and the calculated ones given by the SEC model. So, if there is an important difference (over 10 % or 15 %), you must try to understand why (perhaps you did not describe well the building or the climate conditions or the residents' behaviour is not usual…). (Tab 1).

[4] PUCA (for *Plan* or department of *Urbanism, construction and Architecture*) is a public structure focussed on research and demonstration in the fields of urban planning, building and architecture, linked to the *Energy, sustainable development, housing and transports French ministry.*

Tab 1
Final consumption - heating and HSW - in kWh / m²

	169		
	data	**Difference**	**Estimation with SEC**
Heating	132	+ 9 %	121
Sanitary Hot Water (SHW)	37	– 5 %	39
Electricity common lighting and auxiliaries	12,0		

At least, if you can't get the data, the SEC model calculates them, even if it is not the objective of the model (there are other sophisticated models dedicated to that). Energy and Climate labels are also given.

Tab 2
Example of energy diagnosis results for a 20 flats building
(1300 m², very simple bar built during the sixties)

1. In ratios	
Heating + SHW in kWh per m² . year (pec)	244,7
CO_2 emission in kg per m² . year	73,4
Expenses Heating + SHW in €/m² . year	14,8
Expenses for Electricity in the dwellings in €/m² . year	4,65
Expenses for cold water in €/m² . year	3,98
2. Results per dwelling	
Heating + SHW in kWh per year (pec)	16 650
CO_2 emissions in tons per year	5,0
Expenses for Heating + SHW in € per year	1 006
Expenses for electricity in dwellings in € per year	317
Expenses cold water in € per year	271
3. Results for the building	
Heating + SHW in MWh / year (pec)	333
CO_2 emissions in tons / year	100
Expenses for Heating + SHW in € / year	20 113
Expenses for electricity in the dwellings in € / year	6 332
Expenses for cold water in € / year	5 411
Expenses electricity in common areas in € / year	733

pec = primary energy consumption

3.4.3. *Third step: selection of the most efficient techniques and scenarios*

A-The techniques' hierarchisation: identification of the technico-economical optimum
The SEC model can compare around 70 technologies (types of work) for improving energy consumption in buildings. These techniques are upon the building envelop, the improvement of energy efficiency of energy equipments, renewable energy, alternative energy sources, residents' behaviour…

For each technique, the SEC model gives an investment cost, a maintenance cost, an usual technical life duration (due to a cost data base including maintenance) and the impacts of the technology on energy consumption and CO_2 emission (cf. Tab 3).

Then you get a hierarchy among the techniques and the technico-economical optimum (table 4). Going further (additional works or techniques) is not rational from an economic point of view. So, if there are political objectives (as in France with the Grenelle), subsidies or incentive measures should be necessary.

You can also elaborate many scenarios and have the results for each of them as shown in the table 4.

B - Scenarios / simulations
Various energy retrofitting scenarios can be set out by or with the various actors concerned, such as for example (cf. Tab. 4):

- a technico-economical optimisation with the life cycle energy cost analysis (so, based on economic efficiency) (called «**Optimum scenario**», in green in the table);
- a «**Grenelle scenario**», according to the requirements of the French Grenelle 1 Law, which consists in going towards an

Tab 3
Analysis component per component (for each technique)

	Primary energy consumption (pec)	Works for the social owner (€/m².year)	Energy charges (€/m².year)	Life cycle cost (€/m².year)	Invest/ dwelling (€)
Initial situation	244,67		21,50	21,50	244,67
Hygro ventilation type B	231,64	1,10	21,17	22,28	910
Central gas boiler with condensation	223,87	1,66	19,81	21,47	1 837
From fuel oil to gas for condensation	244,67	0,90	21,50	22,41	1 000
External walls insulation - 10 cm	185,37	3,25	16,29	19,54	4 296
Roof insulation	232,77	2,04	20,46	22,50	2 255
Heating system balance	223,08	0,35	18,51	18,86	272
Behaviour changes	233,72	0,69	20,54	21,24	136
Pipes insulation	238,72	0,07	20,98	21,05	68
Centralised SHW replaced by an independent system	244,67	1,56	21,59	23,15	1 225
Energy saving due to hot water saving	232,77	0,16	19,83	19,99	68

Tab 4

Hierarchisation among the potential techniques and main results for each scenario

Tab 4. Over all analysis (with all the techniques needed for reaching the various scenarios)	Primary Energy consump. Kwh/m²	Works for the social owner (€/m² · year)	Energy charges in €/ m² · year	Life cycle cost in €/m² · year	Invest/ Dwelling (€)	Scenario	Energy label	Climate label
Initial situation	244,67		21,50	21,50			E	F
Heating system balance	223,08	0,35	19,73	20,07	272		D	F
Energy saving due to sanitary hot water saving	211,18	0,51	18,05	18,55	340		D	F
External walls insulation - 10 cm	155,04	3,76	13,64	17,40	4 636	Eco-prêt	D	E
Pipes insulation	149,98	3,83	13,20	17,03	4 704	Grenelle	C	D
Central gas heating with condensation	130,40	6,40	8,93	15,32	7 541	Optimum	C	D
Changes in behaviours	125,97	7,09	8,62	15,71	7 677		C	D
Solar heat water	107,25	8,89	8,22	17,11	9 719		C	D
Hygro ventilation type B	95,93	10,00	8,25	18,25	10 629	BBC	C	D
Roof insulation	88,04	12,04	7,70	19,74	12 884		B	C

Tab 5

Energy characteristics for each scenario

Scenarios	Energy characteristics for each scenario
Eco-Prêt scenario	pec < 195 kWh/m² and minimum reduction of 80 kWh/m²
Grenelle scenario	pec < 150 kWh/m²
BBC scenario	pec < 80 kWh/m² (approx.)
Optimum scenario	where cep minimises the life cycle energy cost of the building

Pec = primary energy consumption for heating and SHW

energy consumption under 150 kWh/m² pe (primary energy) per year for heating and hot sanitary water for social housing or in a 38 % reduction of energy consumption for the private housing sector (in pink in table 4);

- an «**Eco-prêt scenario**», which consists in a reduction of at least 80 kWh/m² for energy consumption as well as going under 195 kWh/m² (for primary energy), allowing to get an attractive loan ("prêt");
- a «**BBC scenario**» (BBC means low energy building), which is a scenario allowing to reduce energy consumption until about 80 kWh/m² and per year (exactly: 80 (a+b) where a is a ratio depending on the area and b a ratio depending on altitude).

The end results for each housing building give ratios per m² of heated area and per dwelling. They give also the Energy and Climate labels.

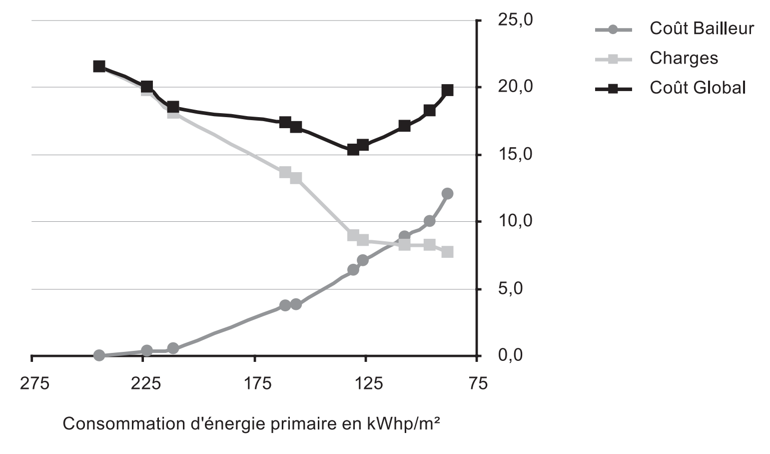
In this example, the 4 scenarios require various investment costs from 4 636 € / dwelling up to 12 884 €. The optimum is reached for a 7 541 € investment/dwelling.

These results can be illustrated by the following *figure n°2* showing the **evolution of the life cycle cost in €/m2.year** - technique (work) after technique - (the red curve in the life cycle cost, the pink one is for charges and the blue one for the social owner's cost):

In this example the optimum is near 125 kWhp/m². If there are political objectives (and incentives measures as required by the 2010 EPBD), you can go as far as possible (from a technical point of view, so in this example up to 80 kWhp/m²) but you must stay under the initial level if you don't want to loose money (some curves are going up very quickly, for old complicated buildings for example).

The following *figure n° 3* is showing the evolution of investment (in € per dwelling on the right part of the figure) on the one hand and of primary energy consumption on the other hand.

2. Evolution of the total cost in €/m² year and its various components according to the options for rehabilitation.



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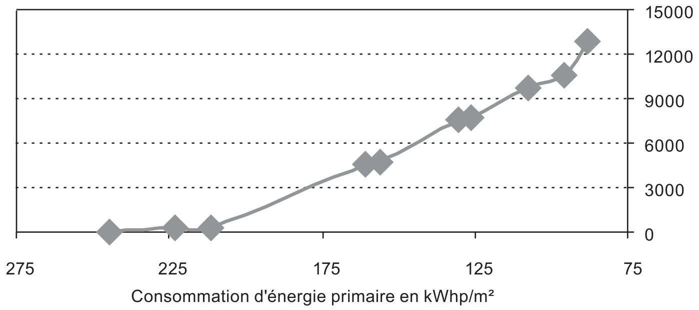

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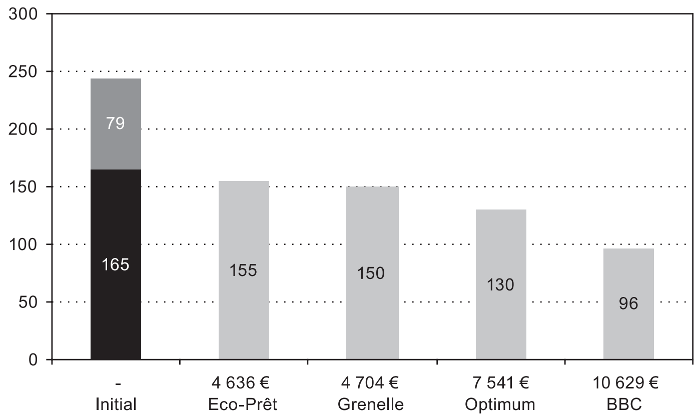
So energy consumption can be compared for each scenario as in the following *figure n° 4*.



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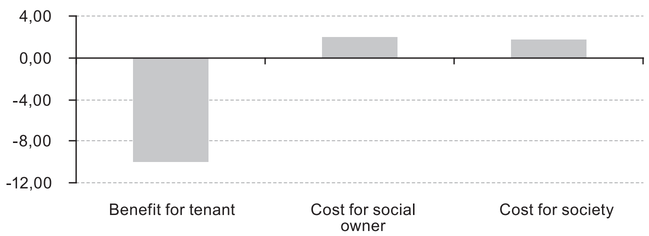
And we can also see for whom are the costs and benefits as shown in the following *figure n° 5*.



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3. Level of investment in € / housing.

4. Comparison of energy consumption and investments needed for each scenario with the initial situation of the building (before works).

5. Cost and benefits for the various actors (tenant, social owner and society because of the incentives measures) for the Grenelle scenario.

So for each scenario the results are presented as in the following tab 6.

Such a life cycle energy cost analysis can be done for private residential buildings at the city scale (or for a neighbourhood) or for social housing at the regional scale or for the building stock of a social owner for example. It can be done also for a larger scale such as a region in order to work out the territorial sustainable energy retrofitting strategy (including the definition of the incentives measures).

3.4.4. *Towards sustainable energy retrofitting strategies*

We could see for example that energy retrofitting costs for buildings with an Energy label E or F are very different according to:

- the typology: single housing buildings with electricity heating systems cost much more than buildings with a lot of dwellings as shown in the *figure 6*.
- the objective of energy savings as shown with the *figure 7*.

So when you see these results, you can select the typology you will focus on first and the subsidies needed for the various actors.

4. THE FIRST RESULTS IN FRANCE

4.1. Social equity, subsidies and incentive measures

Subsidies and incentives measures: for which buildings and how much to give?
The level of the needed subsidies can be defined for each building type and, since the study on the overall region with SEC, for the Feder funds (for social housing), the Picardie region is using SEC for identifying the buildings to support on the one hand and the level of subsidies on the second hand.

What about public subsidies and incentive means for private housing ?
The various life cycle energy cost analyses have shown that:

- **the most efficient techniques are different according to each building specificities and so specific technologies must not be supported by public subsidies** (as it is done in France);
- **energy retrofitting costs are sometimes very different according to:**

– the energy source,
– the building typology,
– the initial level of energy consumption,
– the scenario (the objectives and the way for reaching the objectives)
– …

and so **public subsidies should be given according the needed effort for reaching the energy efficiency political level instead of the energy efficiency itself** as it is in France up to now (and as it is also in the 2010 EPBD but in the EPBD both are required)…

Energy performance objectives should be defined after a LCEC analysis (and not first as it is done almost everywhere until now) **and should be according to the climate, to the existing building and to the available means in order to preserve social equity and to avoid to loose money** (from a national economic point of view).

Tab 6

Results of the life cycle energy cost analysis for one scenario

	€ / m² · year	€ / dwelling	€ / building
Charges for tenants (initial situation)	**21,50**		
Present value of the investment in € per year (1)	6,40	435	8 704
Yearly maintenance (2)	0,26	17	347
Energy savings with constant energy prices (3)	–8,98	–611	–12 221
Energy savings due to energy price increase (4)	–3,85	–262	–5 242
PV panels gains (5)	–	–	–
Subsidies (for solar heating) (6)	–	–	–
Life cycle cost evolution in present € per m² and per year – Sum from (1) to (6)	**–6,18**	**–4,21**	**–8 413**
Property taxes exoneration (7)	–1,25	–85	–1 696
White energy certificate (8)	–0,87	–59	–1 187
Average life cycle cost after retrofitting works for the whole period – Sum from (0) to (8)	**13,21**		
Financial participation of the renters	2,70		
Charges for tenants after retrofitting works	11,62		
Annual cost for the social owner	1,58		
Annual cost for society	2,12		

CO_2 factor (emission before/after)	2,4

6. Energy retrofitting costs in the Grenelle scenario for buildings with a E or F Energy label according to the building typology (multifamily building, single family house with gaz or with electricity…).
Source: La Calade, analysis of 22 000 social housings in the Picardie region with the SEC model.

7. Energy retrofitting costs for multi-family buildings with a E or F Energy label according to the energy consumption objective after works.
Source: La Calade, Analysis of 22 000 social housings in the Picardie region with the SEC model.

4.2. Regional or local authorities' strategies

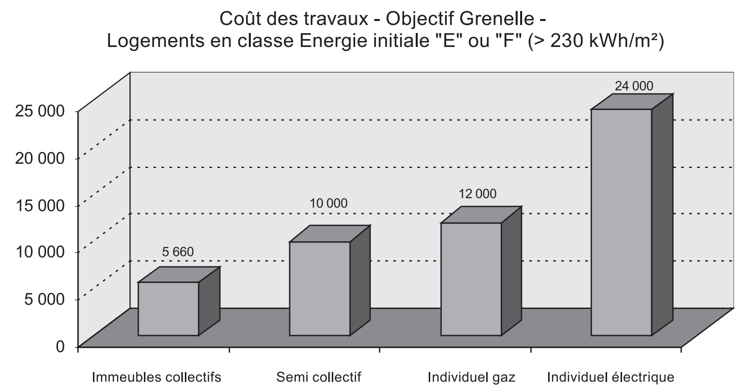
SEC has been used first for setting out regional strategies for social housing (in Picardie as shown in this paper and in Alsace it is still on going).

SEC has been used too for elaborating rational scenarios and working out the regional strategy of Auvergne (a rural region with many single family houses in the middle of France).

SEC has been used also by some local authorities for setting out their housing energy retrofitting strategy (the conurbation of Bayonne-Anglet-Biarritz for example) and SEC is also used for their strategy for public buildings (as by the municipality of Paris for example).

4.3. Promotion of innovation, building productivity and local employment

Such an analysis allows identifying the most efficient techniques and so helps building companies to be aware of them and, if necessary, to train their employees. It also shows where innovation is needed. So it can improve both the quality of work and local employment and at least it improves building productivity.



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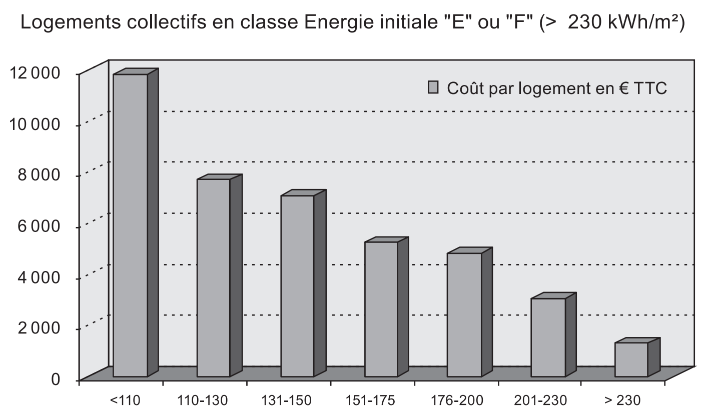

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CONCLUSION

The 2010 EPBD, the level of ambition as regarding energy performances in France and in Europe as well as the world financial crisis are requiring new approaches and tools not only focussed on energy and GES. SEC and the LCEC tools are a necessary complement of energy existing tools in order to take into account economical efficiency, to preserve social equity and local jobs and to improve the building sector productivity.

The researches and studies managed on housing (mainly by La Calade but not only) with the SEC model since 2008 have shown that:

- there is not a unique (universal) technical solution for all the buildings as it is often explained by energy experts, but the technical solutions must be chosen for each building according to its specificities and the household characteristics: budget, age, occupation type (renter or owner)…
- the potential level of energy savings for a building stock (such as the housing sector in a city for example) according to a technical point of view has to be compared with the potential level of energy savings including a social and economical analysis (which is often 30 % less than the first one);
- existing tools are far from perfection (in France) and, for energy consumption, it is necessary to compare the calculated data with the real ones, especially for old (single family) housing;
- the French law (Grenelle 1) asks for an energy retrofitting up to 150 $kWh/m^2 \cdot year$ and a lot of social owner manage their strategy according to this objective but for some buildings the technico-economic optimum is higher and they should manage to reach it and for others the technico-economic optimum is under this level and they should get subsidies for reaching this political level of energy performance;
- energy retrofitting is very expensive for housing with a heating system using electricity and, in order to preserve social equity, subsidies must be dedicated to these buildings (especially in social housing);
- energy retrofitting is very expansive for old single family housing where is the most important cases of energy precariousness, so specific means should be dedicated to this specific type of housing; (LCEC and the SEC model is an interesting tool allowing to better deal with energy precariousness);
- a LCEC analysis should be always managed in case of public subsidies in order to preserve social equity and to improve the building sector productivity;
- it is urgent to move from best practices (often focussed on energy performances) to best strategies/policies including economic efficiency and social equity (id est to sustainable development strategies, both at a territorial scale and at a patrimonial one);
- **subsidies should not be given according to the level of energy performances** as it is most often done in France as well as in other European countries **but according to the needed effort for reaching these performances** when they are over the technico-economic optimum.

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