Promoting bioclimatic and solar construction and renovation

Guide for a building energy label

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Graphism Atelier des grands pêchers

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Promoting solar and bioclimatic construction

Technically speaking, building experts have the knowledge to deal with thermal mass of buildings, solar gains, insulation, efficient ventilation, and daylighting… to get low energy buildings that provide comfort for the users. Buildings should always be designed in terms of the specificities of the local climate, according to a «solar and bioclimatic construction» approach.

It is not always possible to fully apply these principles, particularly in urban areas with high density.
However, this is unacceptable to keep building with such errors as insufficient insulation and direct electrical heating, single glazing, thermal bridges, low efficiency heating systems!

On the other hand, during the past centuries, the production and distribution of energy have been more and more concentrated leaving citizens, companies and local authorities the mere role of consumers. It is time to reverse this tendancy and decentralise energy production with renewable energies. This should rely on local stakeholders. This means to give more opportunities to the consumer: the opportunity to use efficiently energy and the opportunity to produce clean energy.

In this context, the PREDAC consortium wished to provide a comprehensive label to help the consumer in comparing buildings performances from a sustainable energy point of view. On the pedagogic level, such a simplified method would show essential criteria to enhance the building performances. The objective of such a label is twofold: on one side: to avoid the main errors, on the other side: to promote «energy plus buildings».

This guide is one step: the proposal. As you will read it, many questions still remain concerning the implementation of such an approach. The key issue is: how shall we proceed to get an energy label on new buildings, in a similar way as we are used to see them on our refrigerators?

One thing is certain: we will need the contribution from all kind of stakeholders. This guide is intended to you: ministries in charge of construction in the E.U. member states, agencies for energy and environment, professionals and professional associations (architects, social housing companies, consultants, contractors, manufacturers), consumers and environmental associations. During the next step in Automn 2003, we will have the opportunity to meet each other and discuss about this proposal in Paris and London.

We wait for your comments and ideas!

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General introduction

Implementation of the Energy Performance in Building Directive is on the agenda of every government Department or Agency in charge of energy in the E.U.
Among the various requirements of this text, building certification stands a particular place: it should be a new service –in most countries– for building owners or occupants and not only bring them information on their home or facility energy performance but also ways or recommendations on how to improve it. Thus it will contribute to a reduction of Greenhouse Gases emissions due to energy consumption. On top of it, it must be applicable both to new built constructions and to existing buildings, which makes it a real challenge.

On these general principles, everybody should agree now but when coming to practical application many obstacle is rising. In this prospect, the present study brings in a very positive contribution:

- first in providing a review and comparison of energy requirements for new residential buildings in several E.U. countries,
- secondly in suggesting a method to elaborate the certificate, method that should help to support a wider use of renewable energy in the domestic sector.

For these reasons, I recommend the reader to examine this document carefully because it is full of useful considerations regarding the work to be carried out for elaborating certification.

Although I am not a strong supporter of points based methods; I recognize they can in this case solve some of the difficulties from other simplified energy calculation methods.

There might be no perfect way to implement the certification in buildings, but the worst thing to happen would be not to implementing or simply postponing the decisions at National or local level.
So the sooner the scheme will start, the better, and I am sure that the know-how gathered in this document will contribute to that objective.

Hubert Despretz
Building Department
ADEME, French agency for environment and energy management

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This guide is downloadable on PREDAC website : www.cler.org/predac

Warning

This draft document has been prepared to constitute a discussion basis for workshops involving various partners concerned by building regulation and energy labelling : ministries in charge of construction in the E.U. member states, agencies for energy and environment, professionals and professional associations (architects, social housing companies, consultants, contractors, manufacturers), consumers and environmental associations. This guide will be updated according to the output of these discussions and an addendum will be published.

PART 1

CONSTRUCTION LABELS AND REGULATIONS IN THE FIELD OF ENERGY PERFORMANCE

REVIEW OF EUROPEAN EXPERIENCE

1.1 Context

European Commitment

In the context of the European commitment to reduce the greenhouse gases emissions, the building thermal regulations will have to be strengthened. Also, the European directive 2002/91/EC on the energy performance of buildings imposes that «an energy performance certificate is made available to the owner or by the owner to the prospective buyer or tenant, as the case might be».

The review of existing practice in E.U. countries shows that a European consumer is presently not well protected regarding the thermal performance of his dwelling: with similar climatic conditions, the primary energy consumption according to the national regulations is for instance 125 kWh/m²/y in the Netherlands, up to 400 in France (electric heating).

The European directive aims to improve this situation e.g. by informing buyers and tenants. The application of this directive leads to various comments:

- the evaluation methods are not harmonized, e.g. in France a simplified method has been developed, neglecting important parameters (e.g. only the thermal losses are accounted for and no solar gain),
- the persons in charge of the evaluation are not necessarily skilled (e.g. in France property agencies could do it, with a high risk of low precision and bias),
- there remain high differences between the national regulation thresholds (more than a factor 2),
- the presentation of the performance is not harmonized, and a common format like for domestic appliances would be very helpful.

In this context, an evaluation of this directive and proposals by non governmental organisations is very useful to promote the existing good practice, and protect both consumers and the environment.

Purpose of this guide

This guide proposes an energy rating and labelling process in order to facilitate the evolution of the energy performance in the residential sector, and the application of the above mentioned European directive. This proposal has been elaborated by reviewing existing methods in Europe and identifying good practice.

This first version is distributed among concerned actors :

- decision makers in the field of building regulation and labelling (member state ministries in charge of dwelling, technical centers, energy and environment agencies),
- professional associations (architects, social housing companies, consultants, contractors, manufacturers),
- consumers and environmental associations,
- concerned professionals.

Workshops will allow to get the feed back from professionals, to improve this guide and to disseminate the results.

The study concerns residential buildings in mid European climates. New construction will be considered in a first step, and the possibility to extend the results to existing buildings will be studied in a second step.

This work aims to contribute in an efficient application of the European directive 2002/91/EC, entered into force on 4 January 2003.

1.2 Review of existing regulation methods and labels

Existing labels are described according to a common format (cf. annex) providing information about: the indicator considered (U-value, heating load, primary energy,…), the aspects included (heating, hot water, ventilation, lighting,…), the variations of the threshold (according to the shape of the building, the climate, the type of energy,…), the key parameters (insulation, windows, equipment,…), the underlying model (standard EN 832, prEN ISO 13790, U-value, simulation tool,…), the form of the results (value, stars, letter like the energy rating of appliances,…).

In case the primary energy is considered, the conversion factor between electricity and heating energy is precised.

Three standard buildings are defined: a single family detached house, a terrace house and a small apartment building corresponding to the present regulation in each country. A value or an interval for the heating load or primary energy is given in kWh/m²/year.

The indicators considered in the different countries are not homogeneous: they can be expressed in terms of a load, end energy or primary energy; they include heating, sometimes also domestic hot water, lighting, domestic appliances. Therefore, the values provided at a national level have been transformed into a harmonised indicator, so that the different thresholds can be compared.

Assumptions

Deriving such harmonised thresholds is based upon several assumptions. To transform a **heating or domestic hot water load** into a delivered energy, a boiler efficiency of 75% is considered. The primary energy is approximated to the delivered energy for heating and hot water. For electricity, a factor 2.58 is considered in France, 2 in Switzerland. The conversion factor considereded by the International Energy Agency is 3. This factor should account for the electric production and distribution efficiency.

The domestic hot water load is obtained assuming that 4 persons live in the dwelling and use 30 l hot water per person and per day (or 40 if the hot water temperature is around 40°C instead of 55°C). The cold (resp. hot) water temperature is 10°C (resp. 55°C), which leads to an annual load of 2,500 kWh, assuming 300 days of presence. The end energy is derived: 1,900 / 0.75 (boiler efficiency) = 2,500 kWh. Considering a dwelling area of 100 m², the annual primary energy consumption per square meter is for domestic hot water about 25 kWh/m²/y. This figure is added if hot water is not considered in an indicator (e.g. Austria, Belgium).

The electricity consumption for **lighting** depends on the building design (use of daylighting) and it is thus useful to include it in the indicator. An electricity consumption of 400 kWh per dwelling is considered. Using the primary energy conversion factor (2.58) and dividing by the area (100 m²), the annual primary energy consumption per square meter is for lighting is derived: about 10 kWh/m²/y. This figure is added if lighting is not considered in an indicator (e.g. Austria, Belgium, France, Germany).

The electricity consumption for **domestic appliances** does not depend on the building design, but on the residents' behaviour. Therefore it is proposed not to include it in a building energy rating.

In most countries, the threshold expressed in kWh/m²/y depends on the shape of the building (compactness). Therefore, two values are provided (lower and upper threshold). In France, the threshold also depends on the energy type: it is higher in the case of electric heating (a supplementary line have thus been added). The northern part of France is considered here (the thresholds are lower in the mediterranean part).

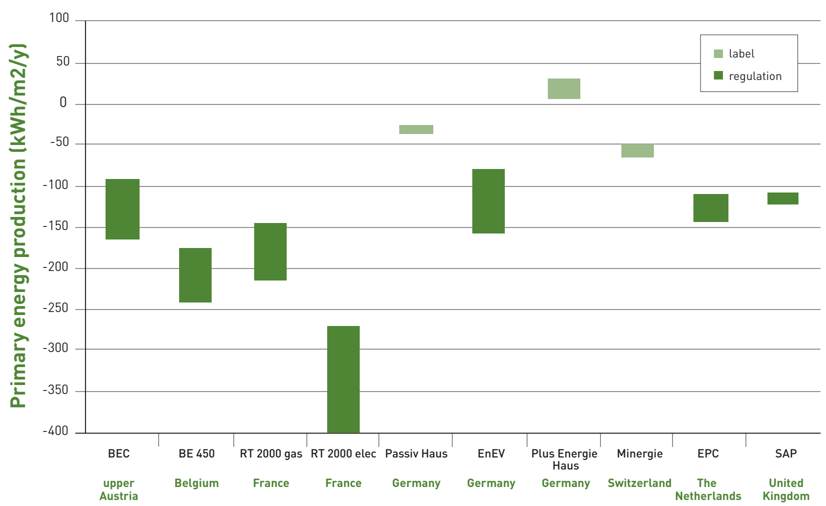
Results

The results are presented in the following table.

country	method (R= regulation, L= label)	indicator	harmonised threshold (4), (kWh/m²/y) Lower level	Upper level
(upper) Austria	BEC (R)	heating load	93 (5)	163 (5)
Belgium	K55/Be450 (R)	Heat loss coefficient	174 (5,7)	237 (5,7)
France (north)	RT2000 (R)	primary energy (1)	144 (5,6)	210 (5,6)
France (north), electric heating	RT2000 (R)	primary energy (1)	270 (5,6)	400 (5,6)
Germany	Passiv Haus (L)	primary energy (2)	30	
Germany	EnEV (R)	primary energy (1)	80 (5)	153 (5)
Switzerland	Minergie (L)	primary energy (2)	55	
The Netherlands	EPC (R)	primary energy (2)	110 (5)	140 (5)
United Kingdom	SAP (R)	Energy cost (3)	108 (5)	117 (5)

(1) without lighting (2) including lighting (3) including lighting
(4) derived order of magnitude of the primary energy including lighting, i.e. =(2), for a typical house
(5) depending on the shape of the building
(6) depending on the climate
(7) Two levels are possible (K55 for the U-value or Be450 for the heating load)

Considering only the national thermal regulations, the threshold values vary from 80 to 237 kWh/m²/y (and even 400 with electric heating), i.e. more than a factor 2 variation, though the climatic conditions are not so different (the figure for France corresponds to the northern part of the country). The German «Passiv haus» and «Plus Energie Haus», and the Swiss «Minergie» methods are labels and no regulations, and the corresponding performance is higher. The «Plus Energie Haus» label corresponds to a net energy production. A maximum has been evaluated assuming that the whole roof is covered with Photovoltaic (PV) panels (the local consumption for domestic appliances has been substracted from the PV electricity production).
We can visualise the results on the following figure (positive values correspond to energy production).



Primary energy production levels -regulations and labels- (including heating, domestic hot water, ventilation and lighting) in mid European climates (negative values correspond to a consumption)

PART 2

INDICATORS AND THRESHOLDS

MEASURING AND LABELLING THE ENERGY PERFORMANCE OF BUILDINGS

Measuring the energy performance

The design of a building, including its envelope and equipment, influences the energy consumption for heating, domestic hot water, lighting and ventilation. These aspects should thus be taken into account in the energy rating indicator, but not the consumption for domestic appliances which is only influenced by residents behaviour.

Precisions about the indicator :

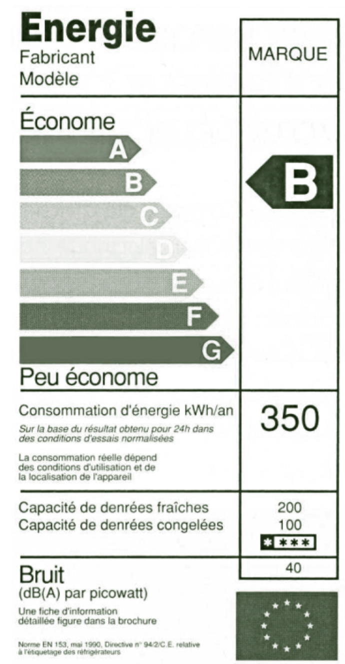
Because both heat and electricity consumptions are considered, and because more primary energy is needed to produce 1 kWh electricity than 1 kWh heat, the indicator should be expressed in primary energy and not in delivered energy. To transform electricity consumptions into primary energy, a conversion factor betwen 2 and 3 should be considered, which should correspond to a mean efficiency of an electricity plant (also accounting electricity losses in the grid). The International Energy Agency recommends a factor 3. A factor 2.58 is considered here, corresponding to the French regulation, but other values could be used.
The heating load and energy consumption values are transformed into a unique primary energy indicator by the equation: **P = C + 2.58 (L + EC - EP)**
Where P is the primary energy consumption (kWh/m²/y), C the primary energy consumption for space heating and domestic hot water (kWh/m²/y), L the lighting electricity consumption (default value = 4 kWh/m²/y), EC the electricity consumption for e.g. pumps or ventilators (not including domestic appliances) and EP the electricity production (in the case of a photovoltaïc system or cogeneration). If EP is high enough, P can be negative. In such a case, the building is a net energy producer (e.g. the «Plus Energie Haus» label).
If gas or fuel oil is used for space heating and domestic hot water: **C = (H + D) / eta**
Where H is the heating load (kWh/m²/y), D the domestic hot water energy load (default value = 30 kWh/m²/y), eta the heating equipment efficiency (mean annual value)
In the case of electric heating: **C = 2,58 (H+D)**
In the case of a heat pump: **C = 2,58 (H+D) / eta**
Such an indicator combines the rating of the envelope and of the equipment. The envelope may last much longer than the equipment, and it would perhaps be wiser to give a greater weight to the quality of the envelope compared to the equipment (e.g. 5 times greater if the expected life time of the envelope is 5 times higher than for the equipment).
The identified best practice is presented in the following table:

Bad practice	Good practice
Performance including limited aspects (e.g. only heat losses)	Performance including heating, DHW, ventilation and lighting, envelope and equipment
Final energy load or consumption	Primary energy consumption (e.g. IEA equivalence factor: 1 kWh electricity = 3 kWh primary energy), accounting for the quality of energy Energy cost could be an alternative, using a similar ratio (the cost of 1 kWh electricity is generally around 3 times higher than 1 kWh heat)
Either energy consumption or ratio per m²	Both primary energy consumption and ratio per m², to draw attention on the high consumption in large dwellings
Thresholds vary according to the shape of the building (compactness)	Fixed threshold, helping to promote low energy architectural design
Different thresholds in different climates	Same threshold (e.g. more insulation is needed in cold climates to reach the same level), possible adaptation according to a local economic optimisation
National formats	Same format in Europe : A to G classes, already known for domestic appliances, depending on the ratio (kWh/m²/y), + indication of the primary energy consumption (kWh/y)

Labelling the energy performance

The European energy rating is widely used for domestic appliances, and this could constitute a convenient format for the labelling of buildings. The A class could correspond to the best available technology. It is proposed to adopt the «Passiv Haus» threshold achieved e.g. in the European CEPHEUS project in which 3 apartment buildings have been built in Sweden, Germany and France, with a 15 kWh/m²/y heating energy consumption. This corresponds to 30 kWh/m²/y primary energy including domestic hot water and electricity consumption for lighting, ventilation and water pumps (considering a factor 2.58 to convert electric energy into primary energy) assuming low flow rate sanitary equipment, a solar water heater, and fluo-compact lighting. The G class would correspond to the present regulation (cf. values in the previous paragraph, e.g. 200 kWh/m²/y). Intermediate classes could then be derived.

Example proposal



A: <= 32 kWh/m²/y
B: from 33 to 65 kWh/m²/y
C: from 66 to 100 kWh/m²/y
D: from 101 to 135 kWh/m²/y
E: from 136 to 170 kWh/m²/y
F: from 171 to 200 kWh/m²/y
G: more than 200 kWh/m²/y

The estimated primary energy consumption includes heating, domestic hot water, ventilation and lighting.

In complement to the letter, the primary energy consumption is given in kWh/y, e.g.
12,000 kWh/y

Other characteristics might be added, e.g. regarding thermal and acoustic comfort, daylighting, air quality

Questions

Among the questions which can be discussed are:

Which is the most relevant indicator: primary energy, cost, CO2 emissions?
CO2 emissions would lead to differenciate oil and natural gas. This indicator is very difficult to assess in the case of electric heating because the electricity mix varies in time : electric heating causes high demand in winter and thermal plants are generally used to match such peak demands, leading to high CO2 emissions. The uncertainty of predicting the electricity mix over a long period makes the assessment of CO2 emissions difficult. Besides, electric heating may lead to other environmental impacts (e.g. in case of using nuclear plants) which makes the use of a unique global warming indicator problematic.
Cost and primary energy lead both to differenciate electricity and heat by a factor between 2 and 3. This reflects the higher «quality» of electricity as an energy, the quality being linked to thermodynamic considerations. The problem with cost is the variation of energy prices over time, which may induce a lack of credibility if the assessment is performed e.g. every 10 years. The primary energy equivalence factor (e.g. 1 kWh electricity=3 kWh heat) is arbitrary but reflects a mean energy efficiency of electricity plants and distribution, which is meaningful and might be more stable than prices. On the other hand it requires a rather technical information of the citizens.

Should the G value correspond to the regulation level or to the worst existing building?
The objective is to avoid low quality renovation , e.g. replacing a single glazed window with a low quality double glazing. Such actions would make financially impossible further improvement: replacing a low quality double glazing by e.g. a low-e glazing would not be economical anymore. Then, a high quality renovation is needed to be noted above G, low quality renovation does not bring any advantage in the proposed assessment.

Will the user complain if the energy consumption or cost indicated in the label does not correspond to the actual bill?
There could be a note on the label, e.g. «energy consumption corresponding to a standard use of the building, e.g. 20°C temperature set point of the thermostat». For a car, the oil consumption indicated (e.g. 7 liters per 100 km) does not correspond to the actual figure neither, but the consumers understand that the way they drive might influence this figure. A users guide of a dwelling should be part of such energy certification system.

Should the A to G levels vary in the different member states?
This would be a very important limitation of the label, leading to a low protection level of the users. The economic optimisation may differ a little in some countries, because manpower prices may differ, but European harmonisation is in progress. Using common A to G levels, it is easier to reach the A level in a warmer climate (e.g. a lower insulation level is sufficient) and this corresponds to an economic optimisation : a higher insulation thickness would not be economical if the heating load is low. Therefore, local adaptation of the A to G levels is not optimal and should be very precisely justified.

PART 3
RATING METHOD
ASSESSING THE ENERGY PERFORMANCE OF BUILDINGS

3.1 Different types of assessment methods

From the most detailed to the simplest, the existing evaluation methods can be grouped in 3 main categories:

3.1.1 Thermal dynamic simulation tools

A wide range of building energy dynamic simulation tools have been developed. These tools account for the dynamic behaviour of buildings and particularly the collection, storage and distribution of solar energy over time. Therefore they are more precise than simplified methods. But their use requires specific education. Detailed information about such tools can be obtained e.g. in the web sites given in the following table.

International Building Performance Simulation Association	http://www.ibpsa.org/
Department of Energy, building tools directory	http://www.eren.doe.gov/buildings/tools_directory/
APACHE	http://www.ies4d.com
COMFIE / PLEIADES	http://www.izuba.fr/
DOE2	http://simulationresearch.lbl.gov
ENERGY PLUS	http://www.eren.doe.gov/buildings/energy_tools/energyplus/
ESP	http://www.esru.strath.ac.uk/
SUNREL	http://www.nrel.gov/buildings/highperformance/software/sunrel.htm
TAS	http://ourworld.compuserve.com/homepages/edsl
TRNSYS	http://sel.me.wisc.edu/trnsys/downloads/download.htm
TSBI3	http://www.by-ogbyg.dk/english/publishing/software/tsbi3e/index.htm

A method of test for the evaluation of building energy analysis computer programs has been elaborated in the frame of the International Energy Agency (Solar Heating and Cooling of Buildings, task 12) and it is now an ANSI/ASHRAE standard (140-2001). The test consists in performing simulations for around 30 cases in order to evaluate the sensitivity of a tool when varying parameters, and the results are compared to a set of results obtained by 8 already tested tools (e.g. TRNSYS, SUNREL, ESP, DOE2, …).
These tools may be used to derive simpler calculation or points based methods. A label may also promote their use among professionals : compared to the simplified models described below, the simulation tools allow a more precise evaluation of heating and cooling loads because the dynamic behaviour of buildings is modelled. They provide temperature profiles in buildings which is useful to study the thermal comfort. They also integrate energy efficient techniques that are usually not taken into account in simplified tools, e.g. the preheating of ventilation air in a sunspace, active solar systems, transparent insulation etc.

3.1.2 Simplified calculation methods

These methods provide an estimation of monthly heating loads by balancing heat losses and heat gains. The European standard EN 832 and prEN ISO 13790 «Thermal performance of buildings - Calculation of energy use for heating - Residential buildings» propose such a method. This method is rather complex and requires in practice the use of a computer and specific education, like for simulation tools. Simplified methods do not model precisely the dynamic behaviour of buildings, and therefore the use of simulation tools may be more adapted to low energy buildings because the solar gains provide a more important contribution in space heating.

3.1.3 Points-based methods

Definition and advantages

The methods described above can be used only by professionals (consultants and possibly architects) with a specific skill. For single family houses and small scale residential buildings, detailed thermal studies and calculations are generally not affordable. Thus, it is useful to propose a tool to contractors and clients in order to improve the thermal quality of such constructions in an easy way. This is the objective of points based methods.
In this approach, key parameters are asked (insulation level, type of glazing, type of heating equipment,…). To each technical choice corresponds a number of points (e.g. 5 points for a low emissivity glazing compared to 0 point for a standard double glazing). A rating can be derived according to the total number of points.
In **Germany**, the use of a calculation method is compulsory. In this case, the energy rating can be based upon this evaluation, and the label proposed here can promote an evolution towards the best practice (A class). It could also be useful to encourage the use of simulation tools.
The use of a calculation basis like EN 832 is well-established in the **United Kingdom**, where a point-based system is unlikely to find favour. It is proposed that the professional surveyor already in charge of visiting the dwellings being sold performs such an assessment. But this requires sufficient skill.
In **Belgium** and **France**, the use of calculation tools may not become rapidly adopted by practitioners, particularly in the residential sector because the size of the projects is generally small. In this case, a points based method would be useful. Such a method allows also non professionals to identify the possible improvements of the performance, which would make easier to elaborate recommendations for the renovation of existing buildings.
Another advantage of points based methods is to spread information among a very large public including building owners. The energy efficient technologies can easily be identified according to the number of points they provide. The energy rating could thus constitute also an educational tool, promoting low energy systems.

Main parameters

These methods should account for the main parameters. Beyond the evaluation of a heating load or energy consumption, they also constitute a check list so that no important aspect is omitted (e.g. thermal bridges, quality of glazing,…). For each component (e.g. the glazing), a number of points is attributed according to a quality level (e.g. advanced glazing with a U-value lower than 1.2 correspond to 5 points). All points are added, and the total number of points allows the primary energy consumption for heating, hot water and lighting to be estimated. In this example, one point corresponds to approx. 10 $kWh/m^2/y$ primary energy saving. In a mid-European climate, a reference level can be set (e.g. around

250 kWh/m²/y primary energy for heating, hot water and lighting), corresponding to 0 point. The difficulty is that the different parameters are not independent: the total number of the points obtained with all best available techniques (high insulation + advanced glazing + high efficiency boiler + etc.) is higher than 25, leading to a negative energy consumption even without energy production. This is due to the fact that e.g. high insulation with a standard boiler provides more energy saving than with a condensing boiler. But the aim of a points based method is to be very simple, so it is only possible to add points. One solution is to set a maximum number of points. In the example provided here, the maximum number of points is 21 for the reduction of heating and domestic hot water energy consumption plus 1 point for lighting. This maximum number corresponds to the «passiv haus» standard (250 – 22 x 10 = 30 kWh/m²/y). More points can be obtained in the case of electricity production: in this case, the consumption can be negative.
Another possibility is to vary the number of points in order to account for interaction. For instance, the number of points given for higher insulation is lower for a compact building, in which thermal losses are lower. In a similar approach, the number of points for a high efficiency boiler is lower if the heat demand is low (i.e. if the addition of all points concerning the envelope is high).
The review of methods presented previously allowed the identification of main parameters, which should be considered in a points based method. Some key parameters are identified in all methods :

- the shape of the building (compactness),
- thermal insulation of walls, roof, floor and glazing,
- efficiency of the heating equipment,
- preheating of ventilation air,
- efficiency of lighting,
- solar water heating.

Other parameters depend on the local context, e.g.:

- In countries where natural ventilation is typical, the air tightness of a building is more important than if mechanical ventilation is used,
- The importance of solar aperture and thermal mass varies in terms of the climatic conditions,
- In France, thermal bridges are very important because the insulation layer is typically inside the masonry, inducing a high thermal bridge around floor slabs.

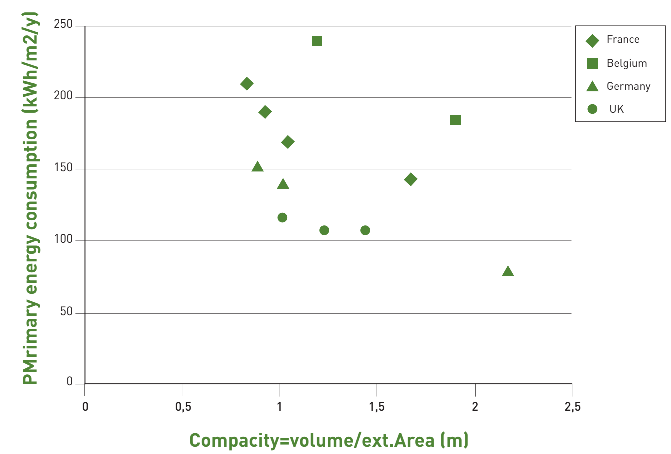
The reduction of the heating load should not lead to overheating in summer and mid-season. Thus, appropriate solar protection, ventilation and thermal mass should be planned and complement the aspects addressed in the method presented here.
Points based methods are less precise than more detailed calculations. The difficulty is to deal adequately with all permutations, which is a limit of points based methods. The use of e.g. dynamic thermal simulation tools should be promoted as much as possible among practitioners and points based methods should only be used if a more precise study is not affordable.

3.2 Proposed methodology to elaborate a points based method

Once the main parameters are identified, the first step is to evaluate the sensitivity of the energy performance to each parameter : the parameter is varied, and the primary energy consumption is calculated for each value. One important parameter is the derivative of the primary energy consumption curve. For instance, if this indicator is 170 kWh/m²/y for a standard insulation level (mean U-value of the opaque envelope = 0.3 W/(m².K)) and 140 for a higher insulation level (U = 0.15 W/(m².K)), the derivative is (170 – 140) / (0.3 – 0.15) =200. This means that a 1 W/(m².K) variation of the U value leads to 200 kWh/m²/y variation of the primary energy consumption.
The second step is to set an equivalence between energy consumption values and points. A point might correspond to e.g. 10 kWh reduction of the primary energy consumption. This will allow to evaluate a number of points provided by the main technical choices (e.g. reducing the U value by 0.15 W/(m².K) brings 3 points, replacing a standard boiler by a condensing boiler gives 2 points).
A corresponding rating system can be derived (e.g. 21 points or more corresponds to A class, less than 5 to G class).
An example rating procedure is proposed hereunder as an illustration.

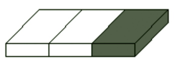
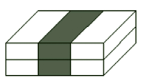
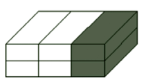
3.2.1 Compactness of the building

The compactness C of a building is defined as the ratio between its volume V and its external area A: **C = V/A.**
The compactness of a building influences its thermal losses, and thus its heating load. A two storeys house is more compact than a house with one level. The compactness of terrace houses is also higher compared to a detached house, and depends on the size of the connecting wall (length or width of the house).



The results obtained using various calculation methods are given in the following figure. In some cases, the area of the most compact dwelling is lower but the domestic hot water load does not vary (e.g. case of a lower income family living in an apartment versus a higher income family living in a larger detached house with the same number of persons). In such a case, the total primary energy per m² does not decrease in terms of the compactness, because the same hot water load is divided by a smaller area.
The mean slope is 70 kWh/m²/y (i.e. 7 points) per unit compactness variation. Therefore, the number of points obtained by a building is:
Number of points of the reference + 7 * (compactness of the building – compacity of the reference)
This obliges the user of the method to calculate the compactness of the building. One alternative is to evaluate the number of points for typical shapes, and to provide a table.

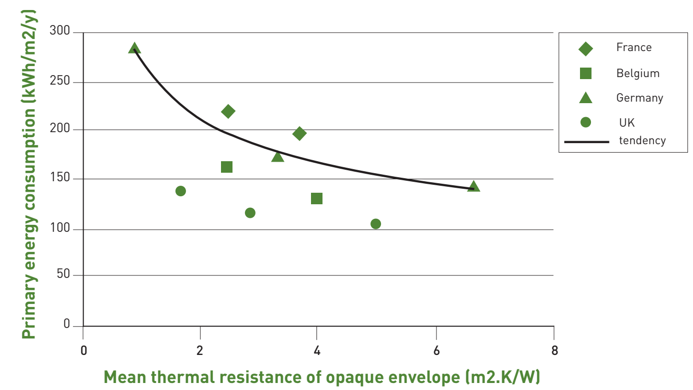
Considering that the reference corresponds to a single family detached house with a single level, the number of points is given in the following table for various configurations. The annual heat losses, heating load and primary energy consumption are given by example in the case of a typical meteorological year for Paris (2,625 heating degree days) and a 100 m² house.

Case number Number		Configuration	Compactness V/A	primary energy consumption [kWh]	Annual heating load [kWh]	Annual heat losses [kWh]	Annual of the primary energy consumption [kWh/m²]	Variation of points annual
1		Detached, single level	0.83	20079	12363	15796	0	0
2		Terrace (two width-walls)	0.95	17435	9935	13235	-26	3
3		Terrace (one width-wall)	0.89	18744	11142	14511	-13	1
4		Terrace (two length-walls)	1.04	15922	8559	11756	-42	4
5		Terrace (one length-wall)	0.92	18004	10458	13790	-21	2
6		Detached, two storeys	1	19705	13389	18355	-4	0
7		Terrace (two width-walls)	1.25	16502	10484	15121	-36	4
8		Terrace (one width-wall)	1.11	18088	11930	16740	-20	2
9		Terrace (two length-walls)	1.67	13443	7664	11892	-66	7
10		Terrace (one length-wall)	1.25	16502	10484	15121	-36	4

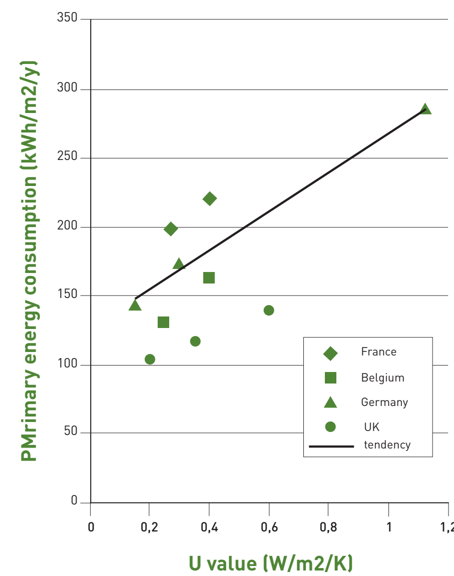
3.2.2 Thermal insulation and thermal bridges

Thermal insulation of walls, roof and floor

The thermal resistance R is often written on the packaging of thermal insulation (e.g. glass wool rolls). But the relationship between the energy consumption and R is not linear, as it is shown in the next figure.



It is thus advised to use the heat loss coefficient as a relevant parameter. A mean value for the opaque envelope (walls, roof, floor) can be considered. The sensitivity obtained using the different methods is shown below.

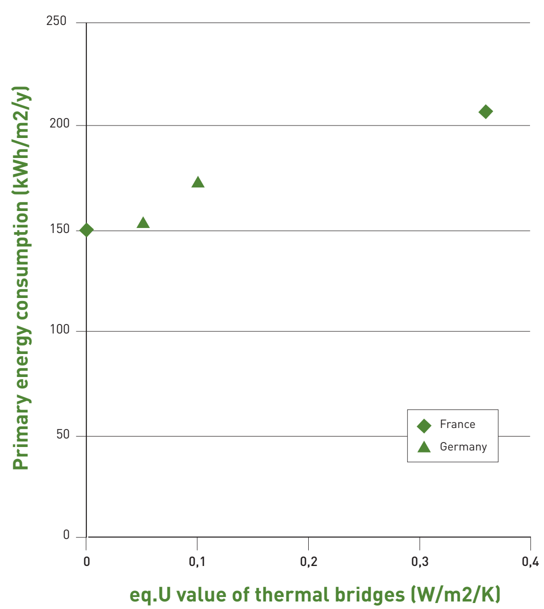


The mean derivative is 190 kWh/m²/y, or 19 points, per unit of U-value variation.
As the R value is more easily available data, points may be indicated according to this value, possibly distinguishing walls, roof and floor values. A number of points is given in the example following table according to the insulation level in walls, floor and roof, and to the compactness of the building: a higher number of points is given for less compact buildings (higher heat losses and thus higher saving).

	R (m^2.K/W)	R (m^2.K/W)	R (m^2.K/W)	R (m^2.K/W)
Walls	>= 2	>= 2,3	>= 2,7	>=3
Floor	>=2	>= 2,3	>= 2,7	>=3
Sloped roof	>=4,5	>= 4,5	>= 5	>=5
Other roof	>=4,5	>= 5	>= 5,5	>=6
Points if less than 4 points for compactness	1 point	2 points	3 points	4 points
Points if 4 points or more for compactness	1 point	2 points	2 points	3 points

Using such a table, three conditions must be satisfied (walls + floor + roof) in order to obtain the number of points indicated in the last lines. For instance if Rwalls =2.8 and Rsloped roof = 6, but Rfloor = 2.5, only 2 points are obtained.
The R-values are more accessible than U-value because they are written on insulation packaging, and they can be added if two insulation layers are superposed. On the other hand, such data is largely unknown in the case of existing buildings. If R-values are unknown, it is proposed to consider 0 point.

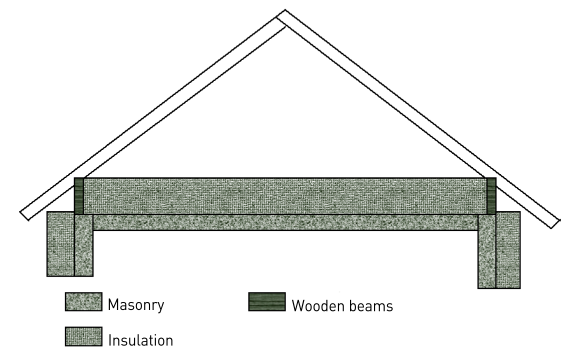
Thermal bridges
For example, the foundation of a building may interrupt the insulation layer, causing thermal bridges at the perimeter of the ground slab. Thermal bridges are evaluated by multiplying the length along which the heat loss occurs (i.e. the slab perimeter in the previous example) by a coefficient depending on the slab and walls characteristics. They are expressed in W/K. We propose to define an equivalent U-value by dividing the total of all thermal bridges in the building by the building envelope.This allows us to evaluate the sensitivity of the methods using the same parameter (the methods considered in the UK and Belgium do not include this parameter). The results are presented in the following graph.



The mean sensitivity is 280 kWh/m2/y per variation unit. Calculating an equivalent U value is not convenient for non professionals. Therefore, it is proposed to evaluate points in terms of informations that a non professional user of the method can provide, for instance :
- thermal bridges only occur in a masonry, thus a 0 value is considered in the case of light ceiling/floors,
- if the user of the method knows that a ceiling or slab has been properly insulated at its perimeter, some points can be given (it is advised to include schematics in order to clearly define what is meant by «propper insulation»).

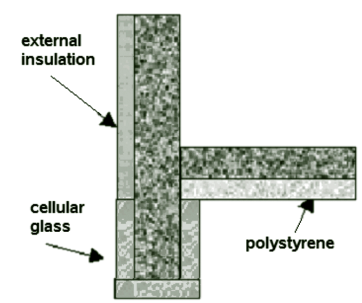
The insulation of walls can be internal, external or distributed in the whole wall (e.g. with cellular concrete or bricks). An external insulation avoids thermal bridges at the level of an intermediate floor, this is why some points are given in this case (cf. the following table). If a ceiling or a floor is light weight (e.g. wooden floor, cellular concrete floor), the corresponding thermal bridge is reduced. The cases named "treated" correspond to a masonry floor with a piece of insulation along its sides. In the case of an external insulation, the upper ceiling is considered insulated if there is no gap between the ceiling and walls insulation (cf. next figure).

Example of « treated » thermal bridge at an upper ceiling



The ground floor is considered insulated if thermal bridges are appropriately treated (e.g. by building the foundation using light weight concrete or insulating the foundation using foam glass, cf. next figure). In the internal insulation case, the ground floor is considered insulated if it is separated from the walls by a layer of insulation.

Example thermal bridge treatment at the foundation

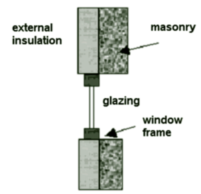


The total number of points is obtained by adding the numbers for the ceiling, the intermediate floor (if any, otherwise 0 point is considered) and the ground floor.

	Insulation						
	internal		distributed			External or cavity	
Upper ceiling	light	other	light	treated	other	insulated	other
Points	3	0	3	1	0	3	0
Intermediate floor	light	other	light	treated	other	Any case	
Points	2	0	2	1	0	2	
Ground floor	insulated	other	insulated		other	insulated	other
Points	1	0	1		0	1	0

Example: for cellular brick walls («distributed insulation»), if the upper ceiling is light (e.g. wooden ceiling), if the intermediate floor is treated and if the ground floor is not insulated from the walls, the number of points is 3 + 1 + 0 = 4.

The windows should be placed in the plane of the insulation layer of the walls, otherwise one point should be substracted.

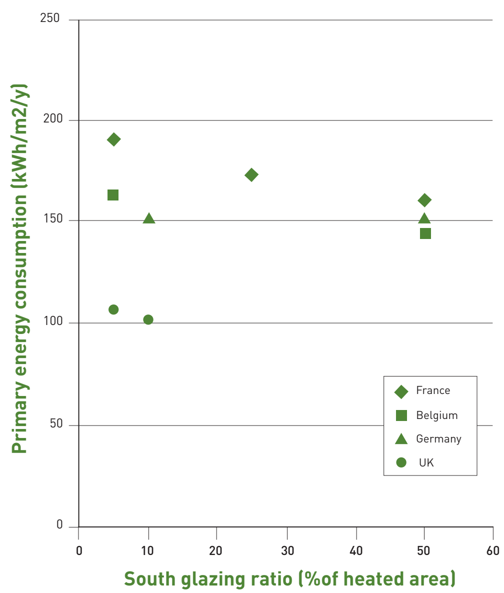


Partition walls may interrupt the insulation, at the level of a ceiling, a floor or a wall. For each partition wall interrupting the insulation at least along one side, one point should be substracted.

3.2.3 Glazing area, orientation and type

We consider two parameters in this paragraph:
- the south glazing ratio, defined as the south facing glazing area divided by the heated dwelling area,
- the heat loss coefficient U of the windows, expressed in W/(m².K).

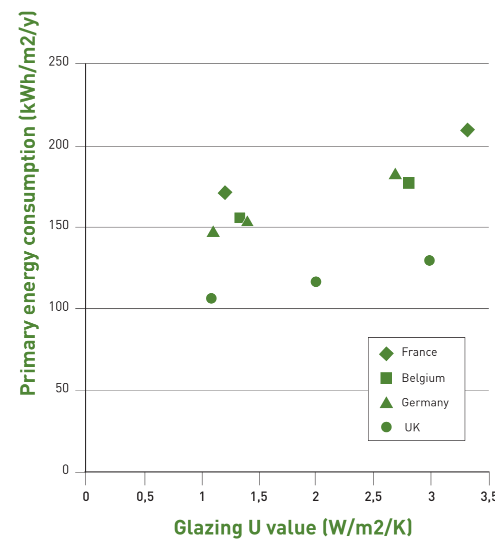
Several methods were used to study the influence of these parameters on the energy consumption. The results are the following.



The simplified method used by the German partner does not seem to take the south facing glazing area into account (the slope is zero). In the French method, the variation is 0.7 kWh/m²/y for each unit by which the ratio is altered. The slope is a little higher for the UK method and a little lower for the Belgian method. The sensitivity to the solar gains is certainly a difficult challenge for monthly balance methods, which may not account for the dynamic behaviour of the building (collection, storage and distribution of solar gains over time) as precisely as simulation tools with e.g. an hourly time step.
The following table gives the number of points in terms of the ratio of south facing glazing. For instance, 15 m² of south facing windows in a 100 m² house correspond to a 15% ratio, and thus to 1 point. The points are obtained only if the U-value of the glazing is lower than 1.9 W/(m².K) and if the thermal mass is medium or high (cf. § 3.2.5).
The second parameter deals with heat losses and the agreement between the different methods is easier (cf. the figure hereunder). The slope is around 20 kWh/m²/y per variation unit.

ratio of south facing glazing	7% or less	between 8 and 14%	between 15 and 24%	25% or more
Points	-1	0	1	2

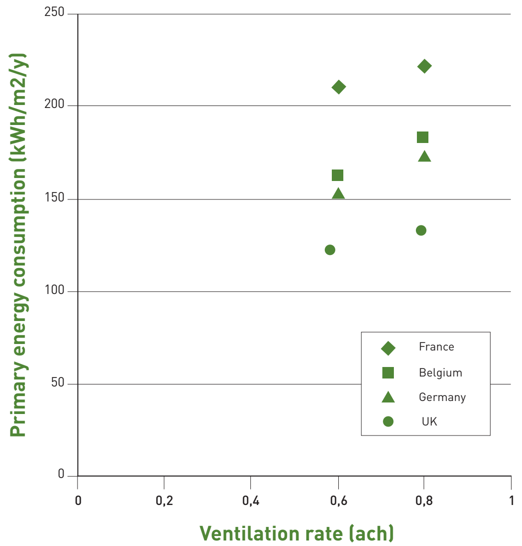
The points obtained are given in the table hereunder, in terms of the window heat loss factor (U-value), including the glazing, the frame and the possible roller blind if any.



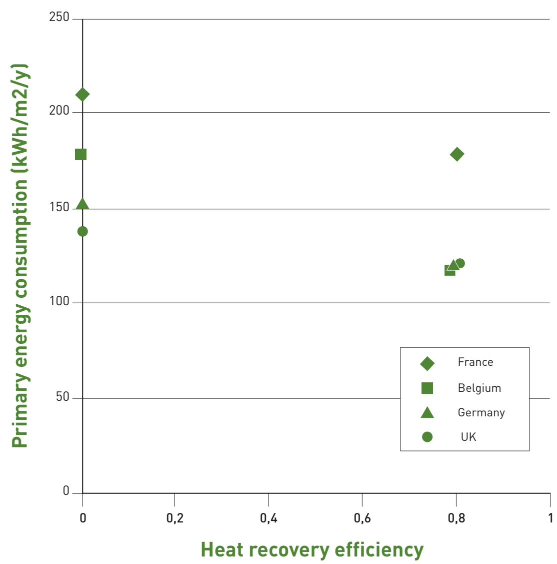
3.2.4 Ventilation

Heat loss factor (U-value)	› 2.9	2.21 to 2.9	1.81 to 2.2	1.61 to 1.8	1.21 to 1.6	‹= 1.2
Points	0	1	2	3	4	5

The methods have been compared regarding their sensitivity to the ventilation related heat losses. These heat losses vary in terms of the air flow rate. The primary energy variation is around 70 kWh/m²/y if the flow rate varies by 1 ach. This variation is easier to model in case of mechanical ventilation. For natural ventilation (e.g. in the U.K.), the air tightness of the envelope is considered having a limited impact on the air exchange rate because the occupants are assumed to open windows. All methods have a similar sensitivity for mechanical ventilation (cf. next figure).



In the heat recovery case, the fresh air is warmed by the exhaust air through a heat exchanger. The energy consumption varies in terms of the efficiency of this exchanger. The results are the following. The slope is around 40 kWh/m²/y per variation unit.



The number of points can then be proposed. If the air inlets are controlled in terms of the wind pressure, so that the air flow rate is as close as possible to the set point, 1 point is gained. If the air inlets are also moisture controlled (they are less open if there is no occupant in a room), 2 points are obtained.
In the case of mechanical ventilation, the electric power of the fan should be minimized. If the ventilation air is preheated in a sunspace, the number of points obtained is given in the following table in terms of the air tightness of the building. If it is preheated in a heat exchanger (by heat recovery from the exhaust air), the number of points depend on the air tightness and on the efficiency of the heat exchanger.

Preheating of ventilation air

	Exchanger			Sunspace	
Air tightness	Efficiency of the building consumption [kWh]	Variation of the energy	Points	Variation of the energy consumption [kWh]	Points
low	<0.15	0 <—>348	+0		+1
	0.15-0.47	-349<—>1045	+1	-679	
	>0.47	-1046<—>1742	+2		
high	< 0.10	0<—>348	0		
	0.10-0.31	-349<—>1045	+1	-1409	+1
	> 0.31	-1046<—>2439	+2		

If the total number of points obtained for the air inlets and the preheating of ventilation air is higher than 3, only 3 points are considered.

3.2.5 Thermal mass

SUNSPACE ATTACHED TO A HEAVY MASONRY CONSTRUCTION, SOUTH OF FRANCE (ARCHITECT : MICHEL GERBER.

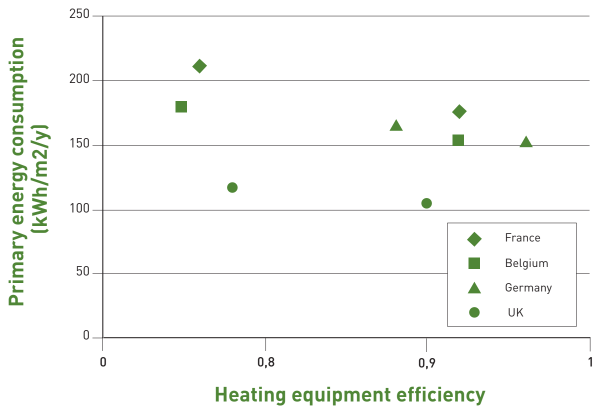
Thermal mass is more precisely accounted for by dynamic simulation tools than by monthly balance methods (cf. the previous comment regarding the south glazing ratio). Thermal mass influences the energy consumption if the solar gains are high, allowing the solar radiation to be stored and contribute to heating during the evening and possibly at night.
The overall thermal mass of a building depends on the type of floor and walls. A floor is considered heavy if it contains at least 7 cm of concrete. Walls are considered heavy if they contain at least 7 cm of concrete, heavy bricks or adobe or 11 cm of concrete blocks or 15 cm hollow bricks and if the insulation is placed on the external side of the masonry. The following table is proposed.

	Light walls	Heavy walls
Light floor	Low thermal mass = 0 point for south glazing ratio	Medium thermal mass = maximum 1 point for south glazing ratio
Heavy floor	Medium thermal mass = max. 1 point for south glazing ratio	High thermal mass = 2 points possible if high south glazing ratio

3.2.6 Heating and domestic hot water equipment

SOLAR DOMESTIC WATER HEATER.

3.2.6.1 Fuel or gas boiler



The main parameter is the boiler efficiency. The energy consumption decreases by around 2.3 kWh/m2/y if the efficiency increases by 1% (e.g. from 75% to 76%).
The pipes must be insulated and for pipes outside the heated rooms, the insulation thickness must be at least half the pipe diameter. The control system must include a thermostat in the heated rooms, and the temperature set point can be set by the users at different values in terms of the hour (day-night) and of the day (working days and week ends). There must be a control on each radiator except those in the same room as the thermostat. A floor heating can also be used. Points should be given according to the quality of the boiler and of the emitters (radiators or floor) : a floor heating requires a lower temperature, and thus the boiler efficiency is higher.
The energy saving obtained using a high efficiency heating system is lower if the heating load is lower, i.e. if the total number of points T for $3.2.1 to 3.2.5 is higher.

boiler If T ← 10	condensation	low temperature	standard
radiators	3 points	1 point	0 point
Floor heating If T →= 10	4 points	2 points	0 point
radiators	1 points	0 point	0 point
Floor heating	2 points	1 point	0 point

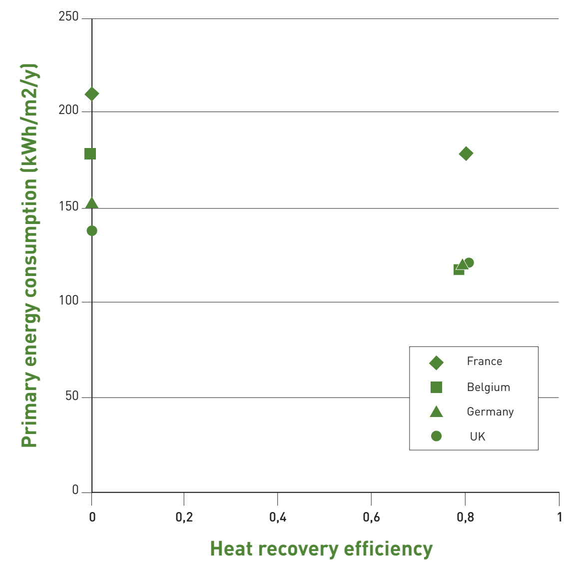
Where T = addition of all points for § 3.2.1 until 3.2.5.

Thermal zoning leads to energy saving according to the control system in a dwelling : for instance, bedrooms can be heated at a lower temperature than the living room. This is particularly efficient if the lower temperature zones are oriented on the northern side of the building, and the living rooms near the south facing façade. Reducing the dwelling temperature by 1° lowers the energy consumption for space heating by 7%. Thus one point can be given for thermal zoning, if T<10, assuming a 2° temperature reduction in half of the dwelling area (the space heating reduction is lower in the case of an energy efficient envelope).

3.2.6.2 Electric heating

The efficiency of such equipment is high but because 1 kWh electricity corresponds to 2.58 kWh primary energy, the primary energy consumption is high. Thus negative points can be attributed.
The «efficiency» of a heat pump can be up to more than 4 (this case corresponds to the use of ground as a cold source and low temperature heat distribution like floor heating). In this case, 7 points are obtained if T < 10, 3 points otherwise.

3.2.6.3 Use of renewable energies or other energy saving techniques



The methods were compared in the case of a solar domestic hot water system. The parameter considered is the solar fraction (% of energy need provided by solar). The results are the following.
The sensitivity is higher in the German method: a 50% solar fraction saves 50 kWh/m²/y, compared to 15 in the French method and about 20 in the U.K. method.
It is proposed to give supplementary points for the following techniques.
Low flow rate sanitary equipments (taps, showers): 1 point
Solar water heater + low flow rate equipment: 2 points
Solar floor heating or active solar heating with at least 50% solar fraction: 7 points if T < 10, 3 points otherwise

Trombe wall, air collector or transparent insulation : 4 points if T < 10, 2 points otherwise
Energy efficient wooden stove: 3 points if T < 10, 1 point otherwise
Energy efficient chimney: 1 point if T < 10, 0 point otherwise
Electricity production by photovoltaic or cogeneration could also be integrated in a points based method. Ten m² PV collectors provide around 1000 kWh electricity, which is equivalent to 25,8 kWh/m²/y primary energy for a 100 m² house. Three points might thus be given. Cogeneration can be accounted for regarding the efficiency of heat production, and the electricity production.
District heating should be promoted because it allows a wider use of renewable energies (e.g. geothermal energy, wood fuel in a large size boiler with a higher efficiency and less polluting emissions). Points might be given according to the energy mix of the district heating system.

3.2.6.4 Maximum number of points

Because it wouldn't make any sense to combine a condensing boiler + active solar + passive solar + a wooden stove, the maximum number of points for the whole §6 is 8 (including 2 points for domestic hot water) and the overall maximum number of points is 21 for §1 to 6 except PV: if a house has various low energy components, there are interactions and the points obtained for the envelope and for the equipment cannot simply be added. In case of a PV system, a higher total of points may be achieved because the energy consumption is negative if the building produces more energy than the amount consumed.

3.2.7 Lighting


Cristal palace, Madrid.

Low consumption lamps (e.g. fluocompact systems) allow a 70% reduction of the electricity consumption for lighting, e.g. 280 kWh/year for a 100 m2 dwelling. The corresponding primary energy saving, assuming a 2.58 equivalence factor, is thus 720 kWh/a, i.e. 7.2 kWh/m2/y which corresponds to 1 point.

3.2.8 Overall score

As mentioned in the introduction, the primary energy consumption for the reference case is 250 kWh/m²/y. This corresponds to 0 point, and to the G class.
The passive house standard corresponds to the following techniques, and the number of points can be derived:

- high compactness: 7 points
- high insulation: 3 points (because compactness points > 4)
- low thermal bridges: 6 points
- high solar aperture: 2 points (because high thermal mass)
- advanced glazing: 5 points
- air tight construction
  with preheating of ventilation air: 3 points
- boiler efficiency: 2 points (because T = 26 > 10)
- solar water heater: 2 points

TOTAL thermal: 30 points > 21, therefore 21 is considered
- low consumption lighting: 1 point

TOTAL 22 points

The corresponding primary energy consumption is thus 250 – 22 x 10 = 30 kWh/m²/y
Thus, the A class corresponds to a number of points equal or higher than 22.

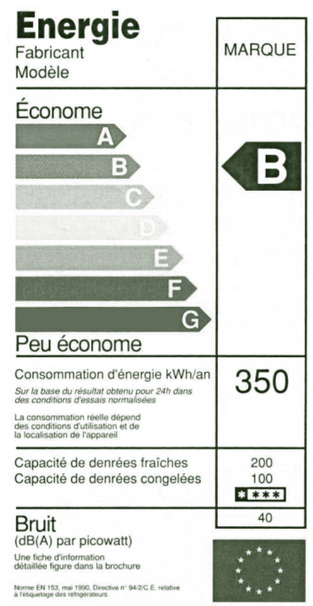
A typical house according to the French regulation corresponds to the following assessment:

- standard compactness: 0 points
- typical insulation: 1 point
- light ceiling (thermal bridges): 3 points
- standard solar aperture: 0 point
- typical glazing: 1 point
- standard ventilation: 0 point
- standard boiler efficiency: 0 point
- no solar water heater: 0 point

TOTAL thermal: 5 points
- standard lighting: 0 point

TOTAL 5 points

This leads to 200 kWh/m²/y consumption, which corresponds to the regulation standard.
The following definition is proposed for the different classes.



A: more than 21 points, less than 31 kWh/m2/y

B: from 19 to 21 points, from 31 to 60 kWh/m2/y

C: from 16 to 18 points, from 61 to 90 kWh/m2/y

D: from 13 to 15 points, from 91 to 130 kWh/m2/y

E: from 9 to 12 points, from 131 to 170 kWh/m2/y

F: from 5 to 8 points, from 171 to 210 kWh/m2/y

G: less than 4 points, more than 211 kWh/m2/y

The estimated primary energy consumption, including heating, hot water and lighting, is derived from the number of points N by: 250 – N*10 kWh/m²/y The primary energy consumption of the dwelling is derived by multiplying this value by the dwelling area.

Remark
Some equipment last a shorter time compared to the building envelope (e.g. 5 times smaller life span for a heating equipment, 20 times smaller for a lighting equipment). The number of points could be adapted for new construction, e.g. dividing by 5 the number of points given for heating equipment: it is wiser to invest in a long lasting energy efficient envelope rather than in a high efficiency boiler.

3.2.9 Aspects regarding thermal comfort

Thermal comfort is defined as a state of satisfaction of building occupants with reference to the thermal environment. It is defined by the dynamic equilibrium resulting of the thermal exchanges between the occupant's body and its environment.
Thermal comfort depends on 6 parameters:
1. The metabolism of the occupant, which ensures the human body maintains an average temperature of about 36,7°C.
2. The clothing of the occupant, which opposes a resistance to thermal exchanges between the occupant's skin area and the environment.
3. The ambient air temperature.
4. The temperature of surrounding building surfaces, characterised by a resulting dry temperature for the occupant.
5. The surrounding air relative humidity.
6. The surrounding air velocity, which influences thermal exchanges by convection. In housing, air velocity is generally limited to less than 0,2 m/s.

Human body autoregulation mechanisms let appear a zone where the variation of thermal comfort is small : it is called the thermal comfort zone.

Buildings have to be designed so as to guarantee thermal comfort conditions in as many situations as possible. To achieve this, two main solar passive architecture strategies have been developed:
1. The heating strategy aiming at maximum thermal comfort in winter time.
2. The cooling strategy aiming at maximum thermal comfort in summer time.

3.2.9.1 The heating strategy

To achieve thermal comfort in winter time, the heating strategy relies on 4 main principles:
1. Collect the solar heat
Collecting solar heat is mostly reached through opening large windows in south oriented walls so as to let solar radiation penetrate the building.
2. Store the solar heat
As solar radiation generally produces heat when it is not useful, solar heat has to be stored for use when necessary. This storage takes place in each building material, according to its heat capacity, high thermal mass materials are therefore of importance. Storing heat in building materials also is a very effective way of avoiding high variation of inner air temperature.
3. Prevent thermal losses
In cool or cold climates, all types of thermal losses have to be prevented. The shape (compactness) of the building, the air tightness and the insulation of the building envelope are the main tools used to limit thermal losses. Partitioning the building in different functional thermal zones can also help to reduce the total heat load.
4. Distribute the heat in the building
As solar heat gains are mainly localised on south oriented zones of the building, it is important to distribute this heat to other zones. This can be done either by natural thermocirculation or by mechanical ventilation coupled to a regulation system.

3.2.9.2 The cooling strategy

Erroneously the cooling strategy has long not been considered important in cool and cold climates. This resulted in a high number of buildings being constructed which perform well in winter but are affected by severe overheating problems in summer. Now that this has been pointed out, a number of recent thermal regulations in Northern Europe have integrated summer time comfort indicators.
To achieve thermal comfort in summer time, the cooling strategy relies on 4 main principles:
1. Protect the building from direct solar radiation
Building protection is especially important around glazed openings so as to limit direct solar heat gains. Protection of opaque roof and wall surfaces are also important as heat transmission to inside building air can prove important when surface insulation is insufficient.
Good building protection can be reached using permanent or mobile sunscreens, roof overhangs, or even (in the case of small buildings) surrounding vegetation.
2. Minimise internal heat gains
Minimising internal heat gains due to occupants (density) and equipment (artificial lighting, electrical appliances) helps to prevent summer overheating. Among possible measures, optimal daylight use design is most frequently listed.
3. Use ventilation when relevant
Surplus heat that reaches the building has to be dissipated as much as possible by natural ventilation, provided that the external temperature is cool enough. Building configuration is therefore of prime importance as it determines temperature gradients ("chimney effects") and possible air flow channels. A first way is to enhance ventilation (night cooling) or raise air velocity (wind towers, …). Another way is to lower air temperature in the direct surroundings of the building through contact with water (fountains), vegetation or ground (earthducts).
4. Use thermal mass
Thermal mass reduces the temperature swing and thus contributes to improve comfort. It is particularly efficient in combination with night cooling : the fresh night air (the flow rate being increased at night) lowers the temperature in the structure of the building (heavy walls and floors), and the indoor temperature remains moderate during the day thanks to the high thermal mass.
In conclusion, some supplementary measures have to be demanded in e.g. mediterranean climatic zones but also in mid European climates :
- appropriate solar protection (e.g. external shading devices, overhangs,…),
- if this first measure is not sufficient, thermal mass and night ventilation.

Questions

On the topic of assessment methods, questions worth discussing are:

- the level of complexity of the method (dynamic simulation, simplified calculation, points), and particularly the input (e.g. level of insulation, thermal bridges, ventilation),
- the possibility to use simplified calculation as a standard (e.g. EN 832) and dynamic simulation as an alternative, like in the Netherlands, in order to promote best practice in design and to encourage the evolution of assessment methods,
- the need to educate the persons in charge of the assessment,
- the «arbitrary» factors, e.g. equivalence between electricity and other fuels, between wood fuel and fossil fuels etc.
- the homogeneous rating of the envelope and equipment, though they have different life spans (e.g. 20 years for a boiler, 100 years for a house),
- the indoor temperature(s) considered, with a possible zoning of a dwelling (e.g. higher temperature in the living room than in the bedrooms) and a possible temporal variation (e.g. lowering the thermostat at night),
- the use of the method to derive recommendation for the renovation of existing buildings,
- specifically for point based methods, the ability to deal with all combinations of the parameters.

PART 4

CERTIFICATION PROCESS

ORGANISING A PROPER MANAGEMENT

4.1 Introduction

As one of the means of achieving the Kyoto protocol goal Council Directive No. 93/76/EEC obliges all EU Member States to draw up and implement programmes aiming at developing national energy certification schemes. The demands for the energy certificate set in the Directive are that it should provide:

- a description of the buildings' energy characteristics,
- information for prospective users concerning a building's energy efficiency; and
- recommendations for the improvement of these energy characteristics (where appropiate).

However, the Directive does not pay any attention to the technical contents and the appearance of the energy certificate. The implementation of energy certification in the Member States can therefore differ nationally.

Certification schemes and other informative instruments do not themselves have a direct influence on the energy consumption and related emissions caused by the building sector. It is, however, generally accepted that raising the awareness of the occupants and owners of buildings is one of the key issues in both reducing unnecessary energy use and also in boosting the market penetration of energy saving technologies. Increasing the amount of energy related information available for the decision-makers is thus of major importance. Building energy certification schemes are intended to provide a means for transferring this information from building professional to the procurement process.

The situation concerning energy certification of buildings varies considerably between the different member states of the EU. In certain countries, such as Denmark, energy audits and certification has been an established practice since 1970's and 1980's. There are also many member states in which first steps towards this direction have been taken quite recently.

4.2 Consumer and investor attitudes

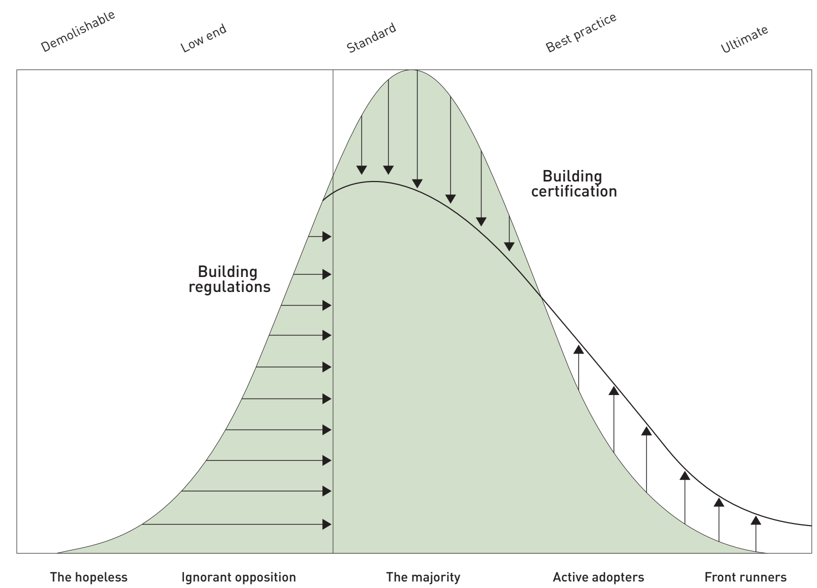
Many general purpose consumer attitide surveys have shown an increase (at least in principle) in public interest towards environmental issues. A large majority of the consumers interviewed were of the opinion that more information on the energy consumption of buildings should be made available. Energy consumption is seen as having a clear impact on individual decisions when purchasing an apartment or house. Consequently the bulk of those interviewed either fully or partially agreed on the usefulness of energy certification. Majority of the interviewed consumers also consider that energy certification should be mandatory for all buildings and that the certificate and the certification procedure should in some sense be officially approved.

At the same time it must be noted that even though consumers' general attitude towards energy issues in general and energy certification in particular is positive, their willingness to pay for energy certification is remarkably low.

Investors' interest towards energy management and energy certification seems to arise mainly from increased activities around environmental management. This leads to the conclusion that energy is not seen as an issue in itself but rather as an important element in improving the environmental profile of properties and of property companies. This, of course, has its implications both on the contents and procedures of energy certification as such and also on the approaches taken for marketing energy certification to the commercial sector. In practical terms this means that energy certification should be seen as an element in a wider spectrum of environmental management tools.

4.3 Energy Certification as a Market Transformation tool

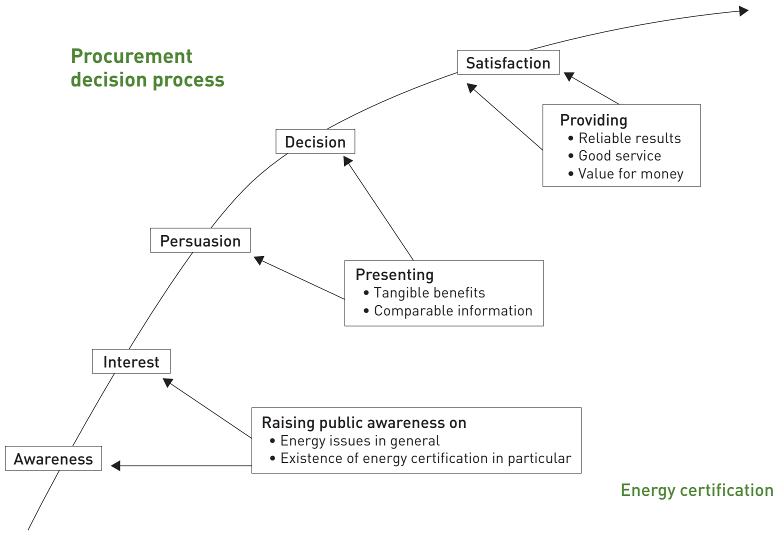
In order to understand the potential role of energy certification on the property market it is helpful to try to classify the market according to the technical performance of individual buildings and the characteristics of the individuals/organisations making building procurement decisions. An attempt to do this is presented in the following figure, which illustrates the role of energy certification on this market.



Potential impact of building certification on the property market

The comparative nature of building certification (i.e. enabling decision-makers to distinguish between "good" and "bad" buildings") implies that its potential impact is highest on the middle and high end of the market. This is the segment where individuals and organisations are already interested in energy and environmental issues and where property suppliers tend to compete and differentiate using a broader range of building performance characteristics. Here certification can help in directing both demand and supply from the "standard" performance levels towards buildings with better energy performance.

The requirements and possible expectations on certification can also be looked at from an individual client's perspective. From this point of view the role of and requirements imposed on energy certification (and related programmes in general) can be different, depending on the individual client's position within the procurement process (cf. next figure).



Different roles of energy certification in property procurement

There is a common agreement on the fact that the main purpose on energy certification is affecting purchase and renting decisions. (This applies on acquiring new apartments or office space as well as on decisions related to renovating or upgrading existing properties.)
In order to have an impact on decisions the certificate has to present tangible benefits arising from selecting one particular product over another. This in turn is possible only if certification enables (more or less) direct comparisons to be made between alternative products.
In order to preserve market credibility certification has to

• be reliable in the sense selecting a building with a «good» rating should also lead to good performance (i.e. lower energy bills, less emissions, etc) in practice and that this can be monitored and demonstrated; and

• provide «value for money» in the sense that the complexity and consequent price of certification is in balance with the actual benefits to the customer; this is especially vital in convincing owners of existing buildings to commission certification or auditing of their property.

4.4 Example: the building certification process in Germany

As an example of the Member States activities in the field of building energy certification, this chapter provides an overview of the development towards a standardised energy certificate for Germany.
The following facts describe the present situation in Germany:

• The EnEV (Energy Savings Ordinance) dictates that energy certificates are mandatory only for new or substantially refurbished buildings
• Numerous voluntary energy certificates, designed at regional or municipal level, exist for
• lder buildings
• Various sectoral software solutions
• No simple and user-friendly certificate has been widely accepted by consumers so far like for «white goods» or cars
• Energy efficiency is a marginal decision factor when buying or renting a house or flat

The newly developed prototype of a standardised energy certificate is based on the aspects presented in the table below:
The next steps aiming to introduce the building energy certificate comprise further discussion and development with market partners (advisory board) and a test run and search for disseminators (spring 2003) followed by a consumer campaign in 2004.

Certificate valid for	all normally heated residential, non-residential and public buildings (except with electrical cooling)
Criterium	primary energy demand
Calculation	and key figures based on the EnEv
Classification	8-10 classes A-(H)J (based on primary energy demand)
Other criteria	quality of insulation (heat use) quality of heating, hot water and ventilation systems (Anlagenaufwandszahl) energy use for space heating and hot water (final energy)
Contents	Folder cover pouch contains certificate Information for consumers Information for craftsmen and technicians List of renovation consultants
Integration	modular structure allows integration of existing energy certificates and software

4.5 Characteristics of building Energy Certification

Article 7 in the new Directive 2002/91/EC, on the Energy Performance of Buildings (04/01/2003) provides the following baseline related to energy performance certificates:

• Energy performance certificates for most new and existing buildings should be available when they are constructed, sold or rented out.
• The certificates should:
  ›not be > 10 years old, but should describe actual energy-performance situation.
  ›include reference values and advice on how to improve energy performance.
  ›be displayed in large publicly owned, occupied anf frequently visited buildings.
• The certificates may:
  ›use voluntary agreements if equivalent, supervised and followed up by the Member States.
  ›include the range of recommended and current indoor temperatures.

Based on that energy certification is essentially defined by following main elements:

A. Contents of the certification

• description of the energy characteristics of the building envelope/the components of the envelope and a calculation of the corresponding heat losses
• description of the energy characteristics of the fixed building installations and an evaluation of their performance
• on the basis of previous elements: an eveluation of the energy consumption
• (on the basis of the energy consumption: an evaluation of the energy costs)
• suggestions to improve the energy performance of the buildings and its installations:
• on the basis of general rules for RUE

- on the basis of a building typology indicating
  - ›the possible measures
  - ›the possible energy savings
  - ›the technical difficulty for each of the proposed measures
  - ›the cost of the measures
  - ›an indication of the payback time for each of the proposed measures
- on the basis of an audit of the specific building situation

B. Procedures for energy certification

Specific determination procedures (observations, calculations, etc) must be defined for all aspects of the certificate mentioned above. Auditors need to respect these predefined procedures.

C. Qualification of auditors

A qualification of the auditors is necessary in function of the technical content of the certificate and the chosen procedures.

D. Cost of the certification

The contents of the certificate and the chosen procedure will not only determine the needed qualification of the auditors but also the cost of the energy inspection. These two elements will give an impression of the total cost of the action.

E. Application area

On the basis of characteristics of the building sector specific priority areas can be defined for the introduction of certification (owner-occupied existing dwellings, sales or renting of dwellings, social housing,…).

F. Political decisions

Following scenarios could be considered:
- free working of market forces, voluntary introduction
- direct funding of the certification costs
- funding of renovation investments linked to presence of certificate
- certification linked to sale/rent
- mandatory introduction of certification

References

- *Market transformation: Building certification*, Ilari Aho
- *Energy certificates in Germany – an overview and assessment of the situation today*, Felicitas Kraus

Questions

The proposal of a certification scheme at European level is inevitably linked to the following questions to be taken into account:
- To what type of buildings is the certification applicable?
- Which key parameter(s) are used as basis for certification?
- Besides the overall key parameters (primary energy figure, heat demand,...), should international requirements be set e.g. related to the efficiency of single components?
- Whether and which different quality levels should be distinguished?
- Which type of certificate (including logo) is used?
- Who can do the building certifications?
- What control mechanisms are established?

PART 5

EXTENSION TO EXISTING BUILDINGS AND TO OTHER CLIMATES

PLANNING FURTHER PERSPECTIVES

5.1 Existing buildings

The application of the proposed energy rating system to existing buildings seems possible. The list of key parameters is the same. The energy consumption in existing buildings may be higher than the reference level considered above, thus negative points have to be defined, for instance:

- no insulation in walls, floor and roof: - 4 points
- single glazing: - 2 points
- high air leakage and ventilation flow rate: - 2 points
- old boiler: - 4 points

A total of – 12 points can be obtained, leading to a primary energy consumption of 420 kWh/m²/y.

The interest of a points based method is to help non professionals to identify possible improvement of the performance based on the number of points corresponding to various alternatives. It can constitute an educational tool to elaborate recommendations for the renovation of existing buildings.

5.2 Northern European climates

A possible application of the method to Northern European climates can be studied. One point may correspond to a higher energy consumption or alternately, more points should be given for energy efficient techniques for heating. This work should be performed if a point based method is relevant in the concerned countries: if calculations are compulsory like in Germany, a point based method is not needed.

5.3 Mediterranean climates

The major extension to apply the method in Mediterranean climates is the evaluation of the possible energy consumption for cooling. The indicator would then be:

- with an electric air conditioning system

$$= C + 2.58\ (Coo + L + EC - EP)$$

Where Coo is the electricity consumption for cooling.

$$Coo = CL / eta$$

Where CL is the cooling load (kWh/m2/y) and eta the cooling equipment efficiency (mean annual value).

- with a gas system (e.g. absorption heat pump

$$P = C + Coo\ \ + 2.58\ (L + EC - EP)$$

Where Coo is the energy consumption for cooling.

$$Coo = CL / eta$$

Additional main parameters are:

- solar protections,
- night ventilation.

A detailed study would be required to evaluate the possibility of a points based method, and the rating system. The sensitivity to some of the parameters may lead to modify the number of points, e.g. more points should be given for solar components (south facing glazing, active solar and PV) because the solar radiation is higher, leading to a higher productivity of such components.

Conclusions and perspectives

This document presents a review of existing regulation thresholds and labels for residential buildings in mid European climates, and proposes a contribution in the application of the European directive 2002/91/EC on the energy performance of buildings, regarding: the label format, the assessment method(s) and the certification process.

These proposals are presented to decision makers, professionals and non governmental associations in order to disseminate the results and to collect opinions during workshops.

Regarding the label, an A to G format similar to the one used for domestic appliances is proposed, A corresponding to e.g. the Passive House label, with the remaining questions:

- which is the most relevant indicator : primary energy, cost, CO2 emissions ?
- should the G value correspond to the regulation level or to the worst existing building ?
- will the user complain if the energy consumption or cost indicated in the label does not correspond to the actual bill ?
- should the A to G levels vary in the different member states ?
- which additional information should be included (e.g. renewable energy share, comfort, environmental issues) ?

Regarding the assessment method, the use of simplified calculation methods like the EN 832 or PrEN ISO 13790 standards is considered in most countries. It is proposed that the use of dynamic simulation tools should be allowed because they are more precise, particularly in the case of energy efficient buildings. The sensitivity of different assessment methods has been compared in order to identify the key parameters and a very simple points based method has been derived. Such methods can be used for small sized projects for which no budget is available for a calculation. They can help non professionals to identify possible improvement of the performance based on the number of points corresponding to various alternatives, and therefore can constitute an educational tool to elaborate recommendations for the renovation of existing buildings. Renewable energy systems can be integrated in an easy way. Among the questions to be discussed are:

- the level of complexity of the method (dynamic simulation, simplified calculation, points), and particularly the input (e.g. level of insulation, thermal bridges, ventilation),
- the possibility to use simplified calculation as a standard (e.g. EN 832) and dynamic simulation as an alternative, like in the Netherlands, in order to promote best practice in design and to encourage the evolution of assessment methods,
- the need to educate the persons in charge of the assessment,
- the «arbitrary» factors, e.g. equivalence between electricity and other fuels, between wood fuel and fossil fuels etc.
- the homogeneous rating of the envelope and equipment, though they have different life spans (e.g. 20 years for a boiler, 100 years for a house),
- the indoor temperature(s) considered, with a possible zoning of a dwelling (e.g. higher temperature in the living room than in the bedrooms) and a possible temporal variation (e.g. lowering the thermostat at night),
- the use of the method to derive recommendation for the renovation of existing buildings,
- specifically for point based methods, the ability to deal with all combinations of the parameters.

Regarding the certification process, experience has been collected in some more advanced countries. The remaining questions concern the procedures and their cost, the qualification of the auditors, and the link with possible incentives to support energy efficient techniques in construction and renovation.

This collaboration between institutions in charge of defining the certification process, research institutes and non governmental organisations brings a contribution in the present debates and aims to contribute in the improvement of energy performance in the European building sector.

Energy as a trendsetter

The implications of climate protection, like all essential challenges, constitute two indissociable facets, both a danger and a chance.

The danger would be to reduce construction to its energy dimension. As we could see after the oil crisis in the 70's, the effort put exclusively on energy saving has sometimes led to damages, particularly regarding air quality : some dwellings were transformed into «Thermos flasks», with related problems concerning residents' health and maintenance. Some purely energy efficient designs have neglected acoustic comfort, which could have been achieved at a low marginal cost. A building is a system and solving a problem separately is a strong mistake.

The chance is that a constraint is a driving force to evolution. The climate protection challenge constitutes an exceptional opportunity for the progress of construction techniques and building operation. Stabilising the greenhouse gases emissions is only a first step : we should prepare the next phase, their important reduction during the next decades. The new construction like the existing building stock will have to enter a new era with stricter and stricter objectives, which will, by a system effect, influence other aspects than energy and of course, beyond the building itself, the whole organisation of space, of our ways of life, and of our exchanges.

Measuring performances, assessing the qualities of a building constitute necessary conditions in this progress approach. References are useful in such a long term perspective. All concerned actors should also be involved, and particularly the residents, to contribute in this both social and technological venture. In this respect, the recognition through a certificate of the energy performance of a building is an unquestionable step forward. But the above mentioned danger should not be forgotten. A wider certification is necessary, integrating at the same time functional and environmental qualities, including of course energy performance. The energy assessment and the related labelling should thus be integrated in a broader environmental assessment. The experience gained in this first phase dealing with energy should lead the way towards assessment and information tools in all environmental aspects. Energy should pull all components of environmental quality like a locomotive pulling many carriages : indoor air quality, reduction of all kinds of polluting emissions, comfort, relevant choice of building materials and equipment, water saving etc.

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Annex : Synthetic presentation of the building regulation or rating methods considered in the review

COUNTRY	UPPER AUSTRIA	BELGIUM	FRANCE	GERMANY	GERMANY	SWITZERLAND	THE NETHERLANDS	UNITED KINGDOM
Method or label name	Building Energy Certificate	Be 450	RT 2000, technical solutions for single family houses	EnEV («Energieeinsparverordnung, Energy Saving Ordinance»)	Passiv Haus	Minergie	EPC	SAP - Standard Assessment Procedure for Energy Rating of Dwellings
Date	01/01/1999	1996	12/2000	01/02/2002	1996	2001	2001	version 9.7 introduced December 2001
Authors	OÖ Bautechnikgesetz, Environmental Department of the Upper Austrian Government	Ministry of the Walloon Region	Ministry of Transport and dwelling, CSTB	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	Institut Wohnen und Umwelt, Darmstadt	Minergie association	Nederlands Normalisatie-Instituut	DEFRA, BRE
Indicator	Heating load	Heating load	Primary energy consumption	Primary energy / U-value (existing buildings)	Primary energy consumption	Primary energy consumption	Primary energy consumption	Energy cost for heating and hot water
Aspects included	Heating and ventilation	Heating and ventilation	Heating, domestic hot water and ventilation	Heating, domestic hot water and ventilation	Heating, domestic hot water, lighting and ventilation	Heating, domestic hot water and ventilation	Heating, domestic hot water, lighting and ventilation	Heating, domestic hot water, and ventilation
Threshold variation	Compactness	Compactness	Compactness, climate (3 zones), type of energy (2)	Compactness	no	42 kWh/m^2/y if SIA 380/1 calculation method is used, 45 otherwise	Compactness	type of energy (3)
Key parameters								
Wall insulation	X	X	X	X	X	X	X	X
Roof insulation	X	X	X	X	X	X	X	X
Floor insulation	X	X	X	X	X	X	X	X
Thermal bridges	X	X	X	X	X	X	X	-
Type of equipment for heating		X	X	X	X	X	X	
Type of equipment for hot water		X	X	X	X	X	X	
Insulation of the piping				X	X	X		X
Type of ventilation	X	X	X	X	X	X	X	X
Type of windows	X	X	X	X	X	X	X	X
Compactness of the building	X	X		X	X	X	X	X
Area of glazing	X	X		X	X	X	X	X
Orientation of glazing	X	X		X	X	X	X	X
Active solar system				X	X		X	
PV system							X	
Lighting					X		X	

COUNTRY	UPPER AUSTRIA	BELGIUM	FRANCE	GERMANY	GERMANY	SWITZERLAND	THE NETHERLANDS	UNITED KINGDOM
Model	EN 832 standard (monthly balance)	Combination of global U-value and solar gains through windows (Walloon standard be 450, monthly balance)	Points system derived from EN 13790 standard	EN 832 standard (monthly balance)	Simulation tools	Swiss standard SIA 380/1 (monthly balance)	EN 13790 standard and simulation tools : NPR 5129 2002 Rekenprogramma	EN 832 standard (seasonal balance)
Result format	Heating load	Proportional to heating load	Points related to Primary energy consumption (rating between 18 and 31)	Primary energy consumption / U-value (existing buildings)	Primary energy consumption	Primary energy consumption (1 kWh electricity = 2 kWh heat)	Primary energy consumption (1 kWh electricity = 2.56 kWh heat)	Points related to energy cost (precise rating between 1 and 120)
Performance level (1) :								
Detached house	160 kWh/m^2/y (A/V = 0.8)	237 Wh/m^2/y(Be450), 178 (K55)	210 kWh/m^2/y, 400 (electric heating)	153kWh/m^2/y	30 kWh/m^2/y	42 to 45 kWh/m$_2$/y	140 kWh/m^2/y	117 kWh/m^2/y
Terrace house	130 kWh/m^2/y (A/V = 0.6)	183 kWh/m^2/y(Be450), 176 (K55)	170 kWh/m^2/y, 325 (electric heating)	140 kWh/m^2/y	30 kWh/m^2/y	42 to 45 kWh/m^2/y	125 kWh/m^2/y	108 kWh/m^2/y
Good practice	Valid also for existing buildings	Promotes better architectural design	Simple to use by non professionnals	Accounts for whole energy chain	Promotes a global quality (architecture and best available technologies)	Promotes a global quality (architecture and best available technologies)	Allows the use of various methods, including dynamic simulation	Simple to use by non professionnals
Limitations	Upper Austria only	Limited use because a simpler evaluation (U value) is allowed Only for new buildings Little precision on internal gains, ventilation, shading Use of simulation tools not possible	Does not account for architectural design No point for advanced glazing Use of simulation tools not possible	Requires a computer Use of simulation tools not possible	Remains marginal Only for new construction	Monthly balance is less precise than dynamic simulation		Use of simulation tools not possible
Other comments	Energy Certificate established and delivered by energy assessors for residential buildings with normal room tempereatures (> 20 °C) is obligatory	• Heating load level requirement is combined to a max. U-Value for envelope components. • Envelope components (glazing incl.) are considered proportionally to their contribution to the heating load.	1 kWh electricity = 2.58 kWh primary energy	The calculation considers the national standards DIN V4108/6 (calculation of the annual heat demand) and DIN V4701/10 (calculation of heating, ventilation and hot water requirements). The EnEV remains valid in case of any future adaption of these standard norms. On the basis of the requirements the EnEV foresees an Energy Certificate established and delivered by energy assessors for medium/large buil-dings (> 100 m^3) with normal room tempe-reatures (> 19 °C).		Envelope elements can also be labelled (e.g. Minergie roof or wall components)	• Envelope elements and equipment are certified • The threshold is 330 x floor area + 65 x heat loss area (MJ/m^2)	• This latest version of the model also provides a carbon index based on the amount of carbon dioxide emitted by the dwelling. Other emissions such as NOx, Sox are also taken into account. • Also for existing buildings (but not compulsory) : for changes such as use of building or major refurbishment.

(1) primary energy consumption including heating, domestic hot water, ventilation and lighting
(2) a building with electric heating is allowed to consume 2,58 more primary energy than with gas heating
(3) If a dwelling is assessed for regulations by this procedure, the CO2 emissions have to be the same for all fuels. If assessed otherwise, the delivered energy has to be 15% less for electricity.

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