Towards very low energy buildings

Energy saving and CO2 emission reduction by changing European building regulations to very low energy standards

Jensen, Ole Michael; Wittchen, Kim Bjarne; Thomsen, Kirsten Engelund; Dyrbøl, Susanne; Albæk, Trine; Eriksen, Kurt Emil; Wilberforce, Rick; Baes, Marleen; Levy, Monique; Delpino, Efren

Publication date:
2009

Document Version
Publisher's PDF, also known as Version of record

SBi 2009:03

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Statens Byggeforskningsinstitut
AALBORG UNIVERSITET

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Ole Michael Jensen
Kim B. Wittchen
Kirsten Engelund Thomsen
EuroACE[1]

[1] The WG in EuroACE following the project consists of Susanne Dyrbøl, Rockwool International (DK), Trine Albæk, Danfoss (DK), Kurt Emil Eriksen, Velux (DK), Rick Wilberforce, Pilkington (UK), Marleen Baes, Huntsman (BE), Monique Levy, Saint Gobain Isover (FR) and Efren Delpino, Uralita (Spain) .

SBi 2009:03
Danish Building Research Institute, Aalborg University · 2009

Title	Towards very low energy buildings
Subtitle	Energy saving and CO_2 emission reduction by changing European building regulations to very low energy standards
Serial title	SBi 2009:03
Edition	1 edition
Year	2009
Authors	Ole Michael Jensen, Kim B. Wittchen, Kirsten Engelund Thomsen, EuroACE[1]
Language	English
Pages	40
References	Page 31
Key words	Energy saving, CO_2 emission reduction, European building regulations, very low energy standards
ISBN	978-87-563-1361-2
Cover	Colourbox
Publisher	SBi, Statens Byggeforskningsinstitut Danish Building Research Institute Dr. Neergaards Vej 15, DK-2970 Hørsholm E-mail sbi@sbi.dk www.sbi.dk

[1] The WG in EuroACE following the project consisting of: Susanne Dyrbøl, Rockwool International (DK), Trine Albæk, Danfoss (DK), Kurt Emil Eriksen, Velux (DK), Marleen Baes, Huntsman (BE), Monique Levy, Saint Gobain Isover (FR) and Efren Delpino, Uralita (Spain)

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Foreword

The project continues the work carried out for EuroACE concerning European strategies to move towards VLEB (Thomsen, Wittchen & EuroACE, 2008). In this previous report an overview of current national strategies to change towards VLEB in Europe is given.

The political context for looking further into this subject is that the EU Commission's proposal for recasting the Energy Performance Directive requires Member States to actively promote the higher market uptake of buildings where both CO_2 emissions and primary energy consumption are low or equal to zero. Member States should assume the leading role of public authorities in the setting up of specific targets for buildings occupied by them. Based on the Member States' information, the Commission should establish common principles for defining such buildings. The Commission will report on the progress of Member States, and on the basis of this develop a strategy, and, if necessary, develop further measures. In this context the impact on energy and CO_2 emissions has been analysed with a focus on the plans already announced by the considered MS.

A questionnaire survey was developed to investigate the issue, and this document reports the findings of the survey. The survey was conducted in a limited number of EU Member States, namely Denmark, France, Germany, The Netherlands, and United Kingdom. The questionnaire was circulated in late spring 2008 to official representatives from the selected MS, and the information was updated in early 2009.

In the questionnaire, the term VLEB is used. In the context of this survey, this term covers different kinds of low energy buildings and passive houses as well. The term incorporates the national definitions of buildings that are designed to a significantly higher standard of energy efficiency than the minimum required in national building regulations.

From the responses it was possible to get an overview of the current status regarding the amount of energy saved in buildings if going from current building regulations' minimum energy performance requirements to a very low energy standard. The answers have been analysed in the best possible way and supplemented with knowledge from the WG.

The authors would like to express their sincere thanks to all the persons who kindly helped us with national information for this survey.

Danish Building Research Institute, Aalborg University
Energy and environment
February 2009

Søren Aggerholm
Head of department

Introduction

This survey was initiated by EuroACE (www.euroace.org) and conducted by the Danish Building Research Institute to support and inspire the European Institutions as well as Member States in their future work to develop a strategy for very low energy buildings (abbreviated to VLEB for the purpose of this report). The report is intended to provide information for the European Institutions and Member States (MS) in their work to recast the Energy Performance of Buildings Directive (EPBD).

The main purpose of this survey is to investigate the impacts associated with a wider introduction of VLEB in five selected European MS (Denmark, France, Germany, The Netherlands, and United Kingdom).

Denmark, France, Germany, The Netherlands and United Kingdom were selected as today they have a national strategy for all new buildings to comply with a national standard for VLEB. The calculations referred in this report use the proposed national definitions that new buildings should comply with as stated by the official sources in the five countries.

In the report first the energy and CO_2 savings per m^2 were estimated from current requirements to future national standards on VLEB. Based on the estimated savings per m^2, two different scenarios have been calculated, one moving stepwise towards VLEB for new buildings and one moving directly to a very low energy standard for all new buildings.

However, it proved to be much more difficult than expected to find the needed national information, so the data given in this report can only be taken as indicative estimates. In many cases, the required data does not exist.

Finally, an overview of established promotion instruments for VLEB in the analysed MS is presented with some pro and cons.

Conclusion and recommendations

Many countries have announced their plans for the coming revisions of their energy requirements, and several countries have targets for new energy requirement up to year 2020. A long-term objective is an effective instrument to achieve highly energy-efficient buildings, resulting in energy and CO_2 emission savings. Another objective is to provide a valuable tool and guideline for the construction sector to prepare for the further development and implementation of the strategy.

It is important to stress the need for all MS to develop a national strategy towards making the VLEB level the standard for new buildings, as recently proposed in the Commission proposal for the EPBD recast.

A proper market transformation to VLEB is a challenge for all stakeholders in the building sector. However, more and more MS have started this process as they realise that this is one of the solutions needed to tackle the current and future challenges like climate change, energy supply and fuel scarcity.

In order to speed up the transformation process, it is essential to learn from those countries that have already gone far in this process.

It is important that the European Institutions continue to guide this development through EU legislation like the current EPBD recast, and require the MS to develop a national strategy towards this level of energy performance to become the standard as fast as possible as well as setting up ambitious plans for how to manage that the existing building stock becomes equally efficient.

A clear and ambitious strategy for improved energy efficiency of existing buildings is necessary if energy consumption is to be reduced significantly in the near future. The lifetime of buildings ranges between 50 and 100 years, and improvement of the existing building stock will thus have a much higher impact than tightening the requirements only for new buildings. However, the experience gained from the new VLEB will help move the existing building stock in the same direction, as the technologies and way of constructing VLEB becomes the natural reference.

The experience gained from Austria, which has been one of the leading countries in the development of low energy buildings, shows that economic and financial incentives to drive the development towards low energy buildings are a very efficient and needed political instrument.

In many cases, the required data for calculating the energy and CO_2 savings does not exist or are very difficult to access. Better and more consistent data collection on the building sector is highly recommended.

Summary

The definition of VLEB varies significantly across Europe, even though the EPBD (Energy Performance of Buildings Directive) gives guidelines for energy performance calculations. The variation exists not only in terms of the allowed absolute level of energy consumption in a low energy building, but also in the parameters included in the minimum requirements. Further the national calculation methods vary from country to country, which makes it almost impossible to compare the absolute values of the energy requirements.

In the European Commission's proposal for recast of the EPBD[2], Article 9 states:

Member States shall draw up national plans for increasing the number of buildings of which both carbon dioxide emissions and primary energy consumption are low or equal to zero. They shall set targets for the minimum percentage which those buildings in 2020 shall constitute of the total number of buildings and represent in relation to the total useful floor area.

Separate targets shall be set for:

- *new and refurbished residential buildings;*
- *new and refurbished non-residential buildings;*
- *buildings occupied by public authorities.*

Member States shall set the targets referred to in point (c) taking into account the leading role which public authorities should play in the field of energy performance of buildings.

The standard energy saving potential in Denmark, France, Germany, The Netherlands and United Kingdom combined is 33 PJ per year, if changing from formal building regulation minimum requirements to VLEB requirements. This saving potential is represented by 226 million inhabitants in the five countries. This number represents approx. 50 % of the inhabitants in the European Member States (458 million). If this saving potential can be assumed to be representative for the whole European Union, the total energy saving potential would be in the order of magnitude of 67 PJ per year. The total European energy and CO_2 emission saving in 2020 is estimated at 568 PJ and 36 Mt CO_2 per year respectively if all new buildings are constructed as VLEB from 2012. This figure may prove to be a conservative estimate as some Eastern European countries currently have just changed from a situation with no energy performance requirements to its introduction due to the EPBD.

According to the Impact assessment report (2008), the total impact of introducing an EU-wide low or zero energy/carbon building/passive house requirements is:

The benefits to the decrease of energy consumption, CO_2 emission reductions can be considerably high, roughly estimated at 15 Mtoe energy savings (approx. 636 PJ) and 41 Mt CO_2 savings per year by 2020 (if a full uptake is considered to start in 2012 for all new buildings.

The energy and CO_2 saving potential given in the impact assessment report, is in the same order of magnitude as the savings estimated in this study.

2 COM(2008)780 final, Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast)

As for the potential energy savings, the annual potential CO_2 emission reductions in the five MS have been estimated at 2.0 Mt CO_2 per year. If this can be assumed as an average for the entire European Union, the total annual saving potential will account for approx. 4.0 Mt per year using the present energy mix for the five MS. As for the energy saving potential, this might prove to be a conservative estimate.

The construction industry may be ready for a general shift towards VLEB. However there is an urgent need for education and training of designers (architects and engineers) as well as craftsmen. VLEB require new skills and new construction types that are easily implemented. The needed products already do exist, but further development is needed to be able to increase the energy performance further than already stipulated.

Some studies about the consequences related to the introduction of higher energy performance requirements have been conducted in the MS. Especially in United Kingdom, many studies exist.

One of the most important factors for promoting VLEB in the five MS is judged to be the long-term strategy and announcement of future requirements for new buildings and the expected dates for their introduction. This will encourage the building industry to prepare and investigate the possibilities for constructing VLEB before it becomes required by the authorities.

Among the barriers to implementing VLEB in the five MS is the lack of experience and standard solutions and also education of craftsmen, who actually have to construct the new buildings.

The annual construction activity for new buildings only accounts for about 1 % of the total heated area in broad terms. This means that a change in energy performance for new buildings will take more than 100 years before all existing buildings have been replaced. Therefore it is crucial to look on energy upgrading of the existing buildings stock, as the largest energy saving potential lies there.

A Danish study [Wittchen, 2004] proved that it is possible to save about 30 PJ annually by upgrading all existing residential buildings. This can be done by improving only 50 % of the constructions with the poorest energy performance and upgrade them to a quality close to today's standard. Compared with the annual savings by changing all new Danish buildings to VLEB (771 TJ as shown in table 9), the potential savings in existing buildings are about thirty-nine times higher. If this potential can be taken as representative of the whole European Union (by means of inhabitants), there is an annual energy saving potential in the existing residential sector in the magnitude of 2 500 PJ.

Energy savings

One of the pieces of information asked for in the questionnaire was an estimate of the energy consumption in buildings meeting the minimum requirements in the building regulations and in VLEB, both for residential and non-residential buildings. Two different energy consumptions were asked for:

– the minimum energy performance requirements as stated in the building regulation (standard energy consumption) and
– the estimated total energy consumption in a new building (including appliances etc.).

For some MS it was further possible to provide data for different building types, e.g. offices, educational buildings, hospitals, etc.

However only the ***formal*** requirement in the national building regulation was used to calculate the energy and CO_2 emission savings as this is what can be regulated by the MS. The energy savings are therefore calculated as:

– energy savings based on ***formal*** energy consumption – this is when moving from buildings meeting minimum energy requirements stipulated in present building regulations to buildings meeting the national standards for VLEB

The calculated energy savings on the formal energy consumption can only be considered as an estimate as national building regulation do not include energy performance of the actual occupants' behaviour.

Definition of current minimum energy requirements and low energy buildings

The low energy building definition was introduced at various times across Europe. Some countries have even had different definitions of low energy buildings at different times. Table 1 describes the minimum energy requirements in the current building regulations and table 2 lists the national definition of VLEB in the five MS. Among others, energy flows included in the requirements vary from country to country and consequently a direct comparison is not possible.

Table 1. Description of current energy requirements in selected countries. The energy requirements listed in this table are not directly comparable as the calculation methods differ between the countries.

Country	**Definition of current building regulation minimum energy requirements for new buildings**
Denmark	The minimum requirement for new residential buildings is: 70 + 2200/A kWh/m² per year (A is the heated gross floor area). For new non-residential buildings the minimum requirement is: 95 + 2200/A kWh/m² per year. The calculated energy performance of a building includes energy for heating, ventilation, cooling and domestic hot water. For non-residential buildings the requirements include electricity consumption for lighting. Furthermore, energy consumption of electricity for running the building (pumps, fans) is multiplied by a factor 2.5 before being included in the consumption. Additionally, a fictive cooling energy consumption is included in the energy performance as a penalty for having a too high (+26 °C) indoor temperature in the building. This fictive amount of energy is calculated as the energy needed to bring the indoor temperature down to 26 °C using a mechanical cooling system with a COP of 2 multiplied with the electricity factor of 2.5.

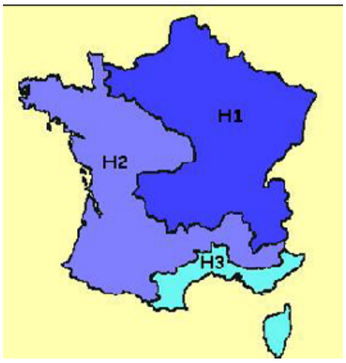
Country	Definition of current building regulation minimum energy requirements for new buildings
	The energy frame is supplemented with specific requirements for U-values, minimum boiler efficiency, pipe insulation, heat recovery, fan power efficiency etc. The supplementing requirements are normally not crucial to the design, but set only an outer limit for what is possibly.

France

The calculation procedures includes in particular:

- Influence of climate;
- Position and orientation of buildings, including outdoor climate
- Passive solar systems and solar protection;
- Indoor climate conditions, including the designed indoor climate;
- Active solar systems and other heating and electricity systems based on renewable energy sources;
- Natural lighting.

Maximum consumption expressed in primary energy for heating, cooling and production of sanitary hot water		
Type of heating	Climatic zone*	Maximum consumption
Fossil fuels	H1	130 kWh primary/m²/year
	H2	110 kWh primary/m²/year
	H3	80 kWh primary/m²/year
Electric heating (including heat pumps)	H1	250 kWh primary/m²/year
	H2	190 kWh primary/m²/year
	H3	130 kWh primary/m²/year



* the climatic zones are defined in the Decree (H1: North, to H3: Mediterranean zone).

In France, it is considered that :

- 1 kWh primary = 2.58 kWh final, for electric energy;
- 1 kWh primary = 1 kWh final, for other energy sources.

Germany

The current requirements (EnEV2007) for new residential buildings depend of the surface-volume-ratio (A/V) and – in case of central hot-water supply – of the buildings floor area (AN). The table below shows the table from annex 1 of the ordinance.

Surface-volume- ratio A/V	Primary energy demand per square meter useful floor area [kWh/(m² a)]	
	Residential buildings except those in column 3	Residential buildings primarily with electric hot water supply
≤ 0.2	66.00 + ΔQ_{TW}	83.80
0.3	73.53 + ΔQ_{TW}	91.33
0.4	81.06 + ΔQ_{TW}	98.86
0.5	88.58 + ΔQ_{TW}	106.39

Country	Definition of current building regulation minimum energy requirements for new buildings		
	0.6	$96.11 + \Delta Q_{TW}$	113.91
	0.7	$103.64 + \Delta Q_{TW}$	121.44
	0.8	$111.17 + \Delta Q_{TW}$	128.97
	0.9	$118.70 + \Delta Q_{TW}$	136.50
	1.0	$126.23 + \Delta Q_{TW}$	144.03
	≥ 1.05	$130.00 + \Delta Q_{TW}$	147.79
	$\Delta Q_{TW} = \frac{2600\,kWh/a}{100m^2 + A_N}$		
	The requirements refer to the primary energy demand per square metre and year depending on the surface-volume-ratio, which has been used as an indicator for the compactness of a building in Germany since 1978.		
The Netherlands	The Dutch energy target is expressed as a dimensionless constant (EPC) which is the characteristic energy use of a building divided by the energy use of an average sized Dutch terraced house[3]. The current requirement to the EPC value is 0.8 equal to 800 m^3 natural gas (0.8*39GJ)[4]. Residential: Examples for row-houses, end-row houses, free standing and apartments result in a range of 100-130 kWh/m².a for epc 0.8. Non-residential: EXAMPLES (!) ranging from approx.: – 400 kWh/m².a for a shop (epc 2.5 with requirement 3,40) – 200 kWh/m².a for a school (epc 1.40-1.80) – 170 kWh/m².a for an office (epc 1.23 with requirement 1.50) Non-residential buildings are sub-classified into 13 different categories (e.g. schools, hospitals etc) The maximum allowed EPC value varies according to the category. As of January 1 2009 EPC requirements for non-residential buildings have been tightened. EPC depends on building function. Between brackets is the former EPC: – gathering function: 2.0 (2.2) – prison: 1.8 (1.9) – health care, non-clinical: 1.0 (1.5) – health care, clinical: 2.6 (3.6) – office: 1.1 (1.5) – hotel: 1.8 (1.9) – school: 1.3 (1.4) – sports: 1.8 (1.8) – shop: 2.6 (3.4)		
United Kingdom	The requirements for new buildings came into force in April 2006 – see Approved Documents ADL1A and ADL2A[5] : The building complies with the regulations if it satisfies the following tests: – CO_2 emissions per m^2 lower than the target (The building design is acceptable if the emissions are below a target level which is set at between 20 % and 28 % below the notional building standard, depending on the type of building and the level of servicing provided. The more intensely the building is serviced, the greater the improvement required (20 % for dwellings, 28 % for air conditioned buildings)). This approach provides maximum flexibility to the designer but focuses attention on energy efficiency to reduce CO_2 emissions as the main compliance target. – Limits on design flexibility for building fabric and energy systems. – Limits on solar gains for non air-conditioned buildings (the cooling load calculation procedures address solar gain in air conditioned buildings)		

[3] SenterNovem Referentiewoningen nieuwbouw, 2006
[4] Fabric Insulation – ways of further rising performance standards for all types of buildings BD2428.
[5] *www.planningportal.gov.uk/england/professionals/en/1115314110382.html.*

Country	Definition of current building regulation minimum energy requirements for new buildings
	– Construction quality - including air tightness and commissioning tests – Satisfactory provision of operating and maintenance instructions In order to estimate the savings in kWh/m^2/a the example from BD2428[4] – (Regulation ADL1 (2002) – SPA carbon emissions method) is used as basis for the further calculation the example is a: terraced houses 108 kWh/m^2/a – detached houses 117 kWh/m^2/a. As the requirements in 2006 were strengthened with 20 % for dwellings and 27 % for buildings other than dwellings the energy consumption equal to the requirements in 2006 is for dwellings estimated to 85-95 kWh/m^2/a (including lighting and hot water) according to the ADL1-2006 method which gives a relative low energy consumption compared to other countries due to used input data e.g. an indoor temperature of 18˚C.

Table 2. Description of low energy building definitions in selected countries. The energy performance limits stated in this table are not directly comparable as the calculation methods differs between the countries.

Country	Definition of low energy buildings
Denmark	Rules for two low energy classes are already in force as optional possibilities. In 2010 it is planned that low energy class 2 (25 % lower energy consumption than the minimum energy performance for new buildings introduced in the energy provisions implemented in the building regulations from 2006) will be the new energy performance limit in the building regulations. In 2015 it is announced that low energy class 1 (50 % lower energy consumption than the minimum energy performance for new buildings stated in the current building regulations) will be the minimum requirement of the building regulations. It is the government's target that by 2020, all new buildings use 75 % less energy than new buildings constructed according to the current building regulations.
France	The “arrêté ministeriel” from 8th May 2007 defines regulatory requirements for energy performance of buildings. This arrêté defines five levels: HPE, HPE EnR, THPE, THPE EnR, and BBC. BBC means "Low Energy Consumption Building". For new dwellings: the annual requirement for heating, cooling, ventilation, hot water and lighting must be lower than about 50 kWh/m² (in primary energy) (40 kWh/m² to 65 kWh/m² depending on climatic area and altitude) as defined in Effinergie. For other buildings: the annual requirement for heating, cooling, ventilation, hot water and lighting must be at least 50 % lower than what required by the current building regulation for new buildings. Optional requirements: For renovation, the Grenelle de l’Environnement is likely to adopt a BBC label of 80 kWh/m^2 per year for heating, cooling, ventilation, hot water, and lighting, starting in 2009. To obtain the "Low Consumption Building" label a building have to respect on the one hand requirements of the thermal regulation for new buildings and on the other hand a specific requirement on consumption. Law Grenelle 1 has been voted by the National Assembly on 21st October 2008. The Senate still needs to vote on it. However, the new law states that "*By 2012, all new buildings built in France will have to comply with the so-called "low-consumption" standards (Effinergie); and by 2020, all new buildings should be energy positive, that is, they should produce more energy than they consume*".
Germany	Official definitions concerning the public subsidies for (residential) Low Energy Buildings are subject of the programs run by the (state-owned) Kreditanstalt für Wiederaufbau Frankfurt (KfW). These programs are mainly fed by public sources. The current requirements are 60 % (KfW60) or 40 % (KfW40). In addition, there is also a subsidy program for "Passiv-Häuser", which is defined in accordance with the Passiv-Haus-Institute as "KfW-40-buildings with an annual heat demand lower than 15 kWh/m^2".This figure can not be directly compared with the low energy classes from the other countries as passive houses only have requirement to energy for heating combined with a requirement to the overall use of energy to be less than120 kWh/m^2 including energy for appliances. The recommendation for passive

<table>
<tr><td></td><td>house standard for any type of building is to have the delivered energy consumption below 42 kWh/m^2 (industry estimate).

Planned: The energy requirements will be generally amended in 2009 (time schedule: expected autumn 2009 to a 30 % lower level. Next step of enforced requirements in 2012 will be another 30 % reduction for both residential and non-residential buildings. In 2020 new buildings shall be operated without using any fossil energy supply.</td></tr>
<tr><td>The Netherlands</td><td>Report from the Minister of Housing, Districts and Integration to Parliament (d.d. January 14 2009):

Planned tightening of the EPC value for residential buildings:
– present (2008-2009): EPC = 0,8
– in 2011: EPC = 0,6
– 2015: EPC = 0.4
– 2020: residential buildings are energy neutral

For non-residential buildings a similar tightening is applicable:
– 2008: EPC = 1,5 – 3,6
– 2009: EPC = 1,0 – 2,6
– 2011: 25% reduction (if the market did not make sufficient progress in improving the energy efficiency of new buildings)
– 2017: 50% more energy efficient non-residential buildings
– The final target in 2020 is to have energy neutral buildings.</td></tr>
<tr><td>United Kingdom</td><td>Definitions are given in "Code for Sustainable Homes" (CSH). There are six levels of the Code, with mandatory minimum standards for energy efficiency and water efficiency at each level. For example. Code Level 1 represents a 10 % improvement in energy efficiency over the 2006 building regulations. Code Level 6 would be a completely zero carbon home (heating, Lighting, Ventilation, hot water, and all appliances).

Currently the Code is voluntary for private sector housing. Government is considering whether, from April 2008, all new homes should be required to have a rating according to the Code.

Timetable for strengthening the energy regulations.
<table>
<tr><th>Date</th><th>All new dwellings</th><th>All new non-residential buildings
(unless otherwise indicated)</th></tr>
<tr><td>2010</td><td>2006 – 25 %</td><td>2006 – 25 %</td></tr>
<tr><td>2013</td><td>2006 – 44 %</td><td>2006 – 44 %</td></tr>
<tr><td>2016</td><td>Zero carbon</td><td>2006 – 100 %
Schools; Zero carbon</td></tr>
<tr><td>2018</td><td></td><td>Hospitals and other public services buildings; Zero carbon</td></tr>
<tr><td>2019</td><td></td><td>Zero carbon</td></tr>
</table></td></tr>
</table>

Table 3. Planned introduction of low energy standards as minimum requirements in MS building regulations. *LEB*: Low Energy Buildings. *E+*: Energy positive buildings. *NFFB*: Buildings to operate without fossil fuels. *ENB*: Energy Neutral Buildings. *NZEB*: 0 net. CO_2, incl. heating, lighting domestic hot water and all appliances.

Country/year	2009	2010	2012	2013	2015	2016	2020
Denmark		- 25 % 1)			- 50 % 1)		- 75 % 1)
France			LEB 2)				E+
Germany	- 30 %		- 30 % 3)				NFFB
Netherlands		- 25 %			- 50 % 4)		ENB
United Kingdom		- 25 %		- 44 % 4)		NZEB	

1) Percentage of the 2006 minimum level.
2) Effinergie standard.
3) Percentage of the 2009 minimum level.
4) Passive House level.

Scenarios for energy savings

Energy and CO_2 savings per m^2 have been estimated from current requirements to the future national standard of VLEB. Based on the estimated savings per m^2, two different scenarios have been calculated, one moving stepwise to VLEB for new buildings following the path illustrated in table 3 and one moving directly to the very low energy standard for all new buildings.

The first scenario has been calculated under the assumption that all new buildings from January 2009 are constructed according to the national standard for VLEB. The energy savings per m^2 is estimated in table 6 and comes by subtracting the energy requirements in the current building regulation by the energy requirements for VLEB. The savings are accumulated to 2020 in table 10.

The second scenario is the savings potential resulting from MS implementing the announced national strategy towards VLEB in their building requirements in steps as described in table 3. Savings are accumulated to 2020 in table 10.

Finally, the energy savings potential and CO_2 emissions reduction have been extrapolated to the whole of Europe.

Standard energy savings when moving from building regulation minimum requirements to VLEB

All European Member States have building regulation requirements setting the minimum energy standard for new buildings. In addition some MS lay down requirements for low and VLEB as well.

The definition of VLEB varies significantly across Europe, even though the EPBD (Energy Performance of Buildings Directive) gives guidelines for the calculations. The variation exists not only in terms of the absolute level of energy consumption in a low energy building, but also the deviation from the minimum requirements as stated in the national building regulations. Further the national calculation methods vary from country to country, which makes it rather complicated to compare the absolute values of the energy requirements.

For each of the MS that have filled in the questionnaire (Denmark, France, Germany, The Netherlands, and United Kingdom) data is compiled to make a calculation of the energy savings if changing from buildings meeting the present minimum building regulation requirements to VLEB according to the national definition. See table 6.

The minimum requirements as stated in the national building regulations of each MS are not the same. Calculation methods in building regulation concerning minimum requirements to VLEB do not always include the same energy flows; in France, for example, artificial lighting is included in the requirements for VLEB and not for buildings meeting the current building regulation. It is thus not possible always to make a direct comparison of the energy consumption in the two different building types, and the savings estimated can only be considered as the best possible estimate. No adjustments have been made to the figures given by the MS. What is included in the consumption is shown in table 1 and table 2.

In the table below the raw input from the five MS is given.

Table 4. Delivered energy consumption, following the national building regulation minimum requirement, for different kinds of new buildings in kWh/m². The values are expressed in terms of primary energy with a factor of 2.5 – 2.7 for electricity and 1 for all other energy sources.

Building type	**Denmark**	**France**	**Germany[1)]**	**Netherlands**	**United Kingdom**
Single family houses of different types	90	90-180	80-150	100-130[2)]	85-95[4)]
Block of flats	75	80-150	n/a	95-100	n/a
Non-residential buildings - excluding hospitals	80-150	75-180	80-150	120-315[3)]	170-270[5 & 6)]

1) There is no requirement in the EnEV for "delivered energy consumption", just for the primary energy consumption. And even this cannot be given in a range as it depends on the A/V-ratio for residential buildings (see table 1) and on reference buildings for non-residential buildings. For both types, Qp can be between 80 and 150 kWh/m².
2) Annually used primary energy (Source: Rockwool Netherland).
3) For the tightened EPC as of 1 January 2009: 120 – 315 kWh/m².
The highest values are for the building function 'shop'.
4) 85-95 is the level for design value according to ADL1-2006- but an over optimistic method is used in the UK. The 170 kWh/represent the actual use
5) Requirements are based on the building having a CO_2 emission rate (DER) less than a target emission rate (TER) specified for that building.
6) www.aecb.net/PDFs/conference07/AECB%202007%20AGM%20Workshop%20Pres%20070707.ppt (including appliances, lighting, cooking, HVAC fans/pumps, DHW and space heating)

Table 5. Delivered energy consumption following the national VLEB definition, in kWh/m² per year according to table 2 and table 3. In cases where an interval have been given the average values has been used in the further calculation.

Building type	**Denmark**	**France**	**Germany[1)]**	**Netherlands**	**United[2)] Kingdom**
Single family houses of different types	45	40-65	42	50-65	50
Block of flats	37	40-60	42	50	n/a
Non-residential buildings - excluding hospitals	37-50	30-75	42	60-158	95-151

1) The values are approximately the same as stated in the KfW40 standard.
2) The values for UK might be too low as the calculation method in the UK is too optimistic in the prescribed assumptions according to:
www.aecb.net/PDFs/conference07/AECB%202007%20AGM%20Workshop%20Pres%20070707.ppt (including appliances, lighting, cooking, HVAC fans/pumps, DHW and space heating).

Table 6. Standard energy savings per m² heated area annually in Member States as a consequence of changing to VLEB, calculated a difference in energy requirement of current building regulation and national very low-energy building standard, in kWh/m² per year.

Building type	**Denmark**	**France**	**Germany**	**Netherlands**	**United Kingdom**
Single family houses of different types	45	83	38-108 (73)	50-65 (57)	40
Block of flats	37	65	38-108 (73)	50	n/a
Non-residential buildings - excluding hospitals	42-50 (46)	45-105 (75)	38-108 (73)	60-158 (109)	75-119 (97)

Numbers in bracket are the average values which have been used in the calculation.

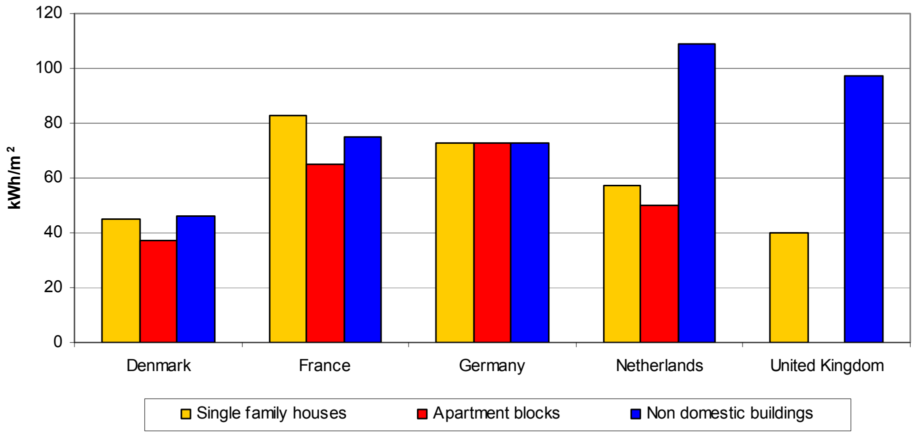


Figure 1. Energy savings if moving from the formal building regulation requirement to the formal requirement for VLEB in MS. Comparison from country to country is not directly possible as different conditions and calculation methods apply.

Total energy savings per year

The total energy savings in kWh per year are obtained by multiplying the savings per m^2 with the construction activity in m^2 for each MS, and if possible distributed on building types.

Construction activity

In order to bring energy saving per m² heated area into the total energy saving, valid figures on construction activity are needed. For this purpose the respondents have looked carefully at National Statistics concerning annual construction activity distributed on type of new buildings. Taken together, table 7 gives an overview of the figures as received.

Table 7. Average construction (m²) activity based on the annual activity over the past three years in the five MS.

Building type	**Denmark**	**France**	**Germany**[1)]	**Netherlands**	**United Kingdom**
Single family houses of different types	2 467 588	24 274 047	4 675 250	6 224 530[2)]	18 130 133[4)]
Block of flats	740 723	10 001 600	2 026 500	2 658 180[2)]	n/a
Non-residential buildings - excluding hospitals	1 394 107	9 400 001	25 789 250	1 972 500[3)]	18 000 000[5)]
Total	**4 849 888**	**44 975 647**	**32 491 000**	**10 855 210**	**36 130 133**

1) The German figures indicate that the German construction market in the period considered has been very low,
2) Source: CBS (PB08-021, 25 March 2008. Figure is derived from number of buildings constructed (averaged for the years 2005-2006-2007) multiplied by average floor area per building: single family house: 130 m² (averaged number of houses per year = 47 881); multi family house: 105 m² (averaged number of apartments per year = 25 316). It is expected that building production will go down dramatically as result of the economical crisis.
3) Source: CBS Statline. Figures are based on the floor area of submitted building permits, averaged for the years 2005 and 2006 and only for building categories office, shop, school.
4) Industry estimate: UK has no statistic showing the actual constructed m² the number stated for single-family houses is based on the numbers of completed dwellings and an average size of 87 m².
5) Prior to the recent 'credit crunch', the UK Government predicts that 9 000 non-residential buildings will be built in 2008. The average size of these buildings is estimated to be 2 000 m² equal to a total of 18 000 000 m².

Table 8. Average construction activity (m²/capita) based on the annual activity over the past three years in the five MS.

Building type	Denmark	France	Germany	Netherlands[1)]	United Kingdom[2)]
Single family houses of different types	0.45	0.38	0.06	0.38	0.30
Block of flats	0.14	0.16	0.02	0.16	n/a
Non-residential buildings - excluding hospitals	0.26	0.15	0.32	0.12	0.30
Total	**0.89**	**0.71**	**0.40**	**0.66**	**0.30**

1) Number of inhabitants on 1 January 2008: 16.405.000 (source: CBS Statline).
2) Industry estimates.

Energy savings in MS for total construction activity

The energy savings per unit constructed VLEB can be extrapolated to the entire country and with some caution to the whole of Europe. The construction activity in the MS is thus an important figure to be able to extrapolate. Energy savings per m² is simply multiplied with the average construction activity in the MS for the different building types, see table 9.

This may not necessarily give a correct picture as the construction activity in some MS has been anything, but "normal" over the past years. In Germany the construction activity has been below the normal level.

Table 9. Potential energy savings if moving from ***formal*** building regulation minimum requirements to VLEB requirements in TJ per year.

Building type	Denmark	France	Germany	Netherlands	United Kingdom
Single family houses of different types	400	7 253	1 229	1 277	2 628
Block of flats	99	2 340	533	478	n/a
Non-residential buildings - excluding hospitals	272	2 538	6 777	774	6 286
Total	**771**	**12 131**	**8 539**	**2 529**	**8 914**

The annual energy savings if moving from formal building regulation minimum requirements to VLEB in the five MS is 33 PJ.

The following table shows the accumulated energy savings in 2020 in the MS by introducing a stepwise and one-step transition to constructing all new buildings as VLEB.

Table 10. Accumulated energy savings (TJ) in 2020 in Member States as a consequence of stepwise or one-step change to VLEB using the data in table 9 and table 3.

Building type	Denmark	France	Germany[1]	Netherlands	United Kingdom
Residential buildings					
stepwise	17 213	343 792	66 798	61 425	112 773
one step	32 895	630 285	116 241	115 829	171 732
Non-residential bldgs.					
stepwise	9 515	91 368	257 050	27 010	271 862
one step	17 942	167 508	447 309	50 967	413 994
Additional energy savings by changing to VLEB standard, January 2009 instead of a stepwise change					
	24 109	362 633	239 702	78 362	201 091

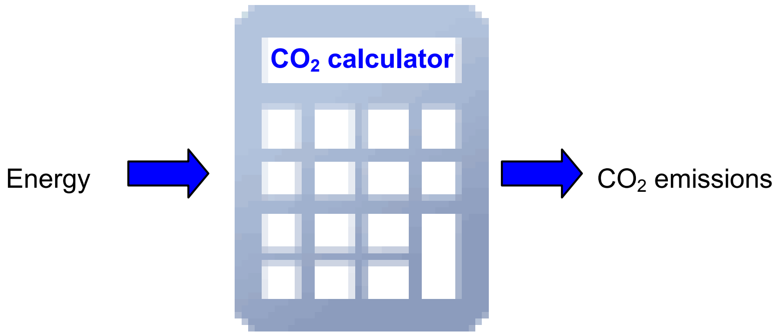
1) For Germany the standard savings in table 6 have been used to calculate the accumulated "one step" saving where the "stepwise" saving are calculated based on the planned tightening described in table 3.

If the five MS were able to implement the standard for VLEB for all new buildings from January 2009 instead of following the announced path described in table 3, the additional energy savings in 2020 for all five MS (assuming the current construction activity is unchanged) will be 906 PJ.

The standard energy saving potential in the five MS, if changing from formal building regulation minimum requirements to VLEB requirements, is 33 PJ per year. This saving potential is represented by 226 million inhabitants in the five countries. This number represents approx. 50 % of the inhabitants in the European Member States (458 million). If this saving potential can be assumed to be representative for the whole of the European Union, the total energy saving potential will be in the order of magnitude of 67 PJ per year. To be able to compare with the EU impact assessment report, 2012 have been used as a starting point for calculation of the savings by 2020. The total European energy saving in 2020 is estimated to 568 PJ per year if all new buildings are constructed as VLEB from 2012. Over the same period of time the accumulated energy saving accounts for approx. 2 650 PJ. This number may prove to be a conservative estimate as some Eastern European countries currently have just changed from no energy performance requirements to the introduction of this due to the EPBD.

Potential CO_2 emission reduction

When the energy saving potential has been estimated, the CO_2 emission consequences can be estimated as well. In order to do this a CO_2 "calculator" that is adjustable for the national energy mix must be available. The Danish Building Research Institute has developed such a calculator for use within the Danish energy supply system. This calculator can be extended to represent the mixture of energy consumption in other MS, as long as the primary energy sources are known. Thereby the calculator makes it possible to transform any energy consumption and savings to CO_2 emissions and reductions, respectively.



In this chapter CO_2 calculations are made in order to analyse the consequences of a change from building regulations minimum energy requirements towards VLEB for the five MS.

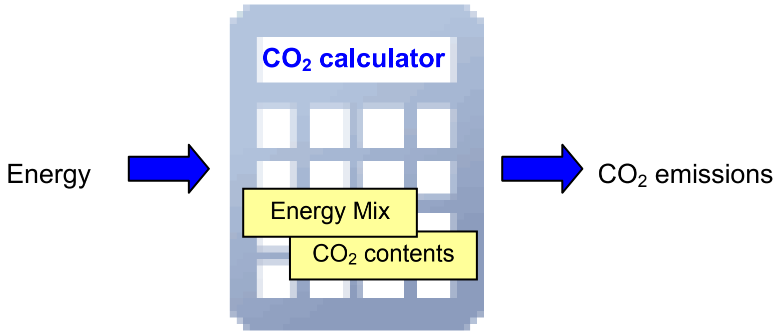
First, the principles of the calculation and the knowledge required for calibrating the calculator according to the energy breakdown of each MS are explained.

Second, the inputs needed for the CO_2 emission calculation are discussed. These are building regulation requirements for standard buildings and the expected future requirement for VLEB, as described in the previous section.

Third, calculation is executed in order to find the CO_2 emission for the defined scenarios.

CO_2 emission calculation

To adjust the CO_2 calculator according to each MS i.e. the national energy breakdown must be known. Additionally, the CO_2 content of each of the energy deliveries must be known. Due to this requirement, these questions were included in the questionnaire.



The energy volume corresponding to each fuel delivery in the national energy breakdown makes in possible to establish an energy mix. This energy mix can be due to energy breakdowns of the total (transport, industry, buildings, etc) energy consumption in the MS. Even better, the energy mix can be due to the energy used in the building sector or energy delivery for space heating. However, not all national statistics contain this breakdown of the energy consumption.

The questionnaire also requested information on the expected energy mix in a future when all new buildings are constructed as VLEB. Thus, we expect that the reduced need for energy for each building will influence the national energy mix for energy used in the building sector (e.g. today it is not allowed to use electricity for heating in Denmark, but the majority of VLEB are expected to be installed with heat pumps, which will cause a higher share of electricity in the energy mix compared with the current situation in 2008).

To set up a scenario of the future CO_2 emission reductions, a qualified estimate of the future energy mix was set up as if all new buildings in principle were constructed as VLEB. In this way the estimate of the future CO_2 emission reduction might be more reliable.

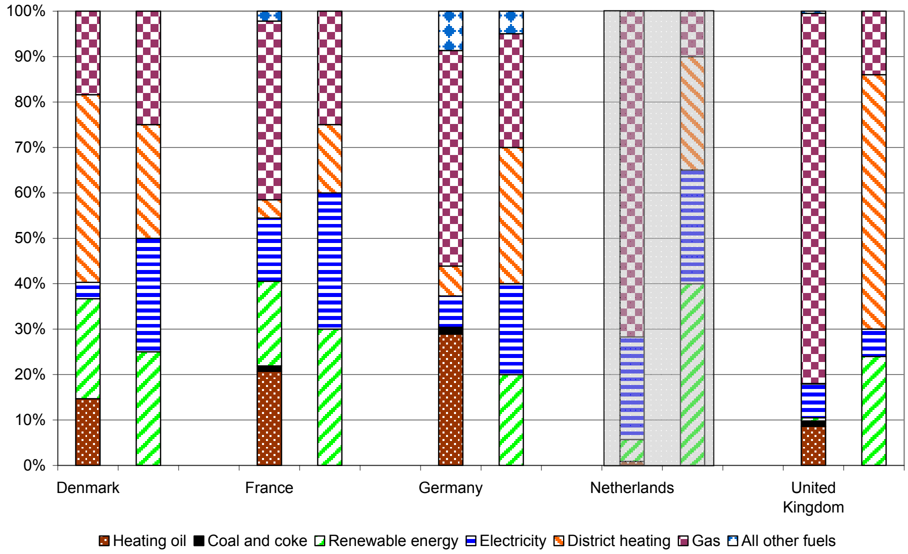


Figure 2. Present (left) and future (right) energy mix for space heating in residential buildings in the five MS. The energy mix for The Netherlands is based on the average energy mix for the country, e.g. including industry, transport, space heating and cooling, light etc.

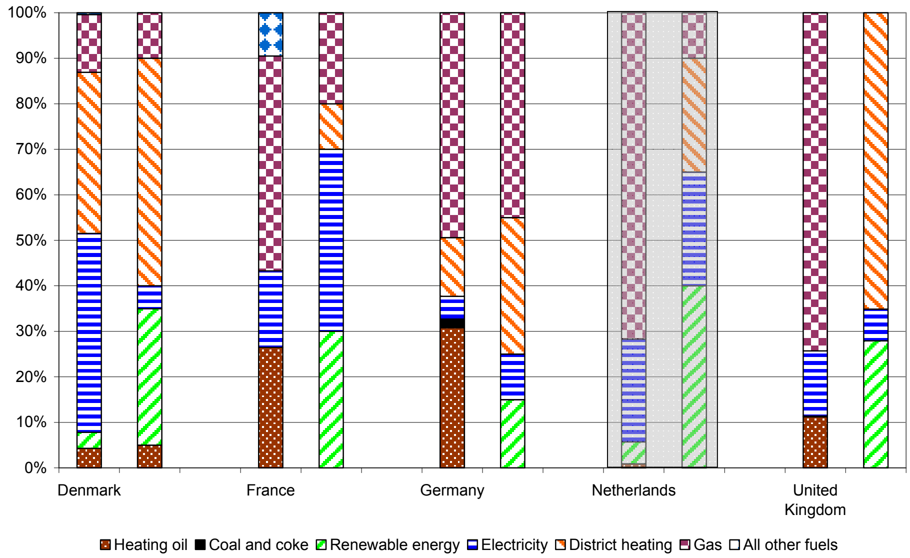


Figure 3. Present (left) and future (right) energy mix for space heating in non-residential buildings in the five MS. Neither future nor present mix for non-residential buildings in The Netherlands exists, but the energy mix for residential buildings have been used in The Netherlands is based on the average energy mix for the country, e.g. including industry, transport, space heating and cooling, light etc.

In order to fill in the table, the respondent was asked to examine the National Energy Statistics carefully for energy breakdowns concerning both residential and non-residential buildings. As the scenario was set up, VLEB were considered being constructed on a broad scale starting from tomorrow, substituting new buildings just meeting the minimum requirements in the building regulations of the MS.

Additionally, the respondent was asked to investigate their national Energy Statistics or other sources for the average CO_2 emissions concerning the different energy supplies. Among these the CO_2 emissions for heating oil, natural gas and coal are general known whereas the CO_2 emissions for electricity and district heating are determined by the national energy system. By definition renewable energy has no CO_2 emission.

Loaded with the energy mix and CO_2 emissions, the CO_2 calculator can transform different kinds of energy inputs into CO_2 emissions. For instance feeding the calculator with energy saving per m^2 will result in CO_2 emission reduction per m^2 whereas feeding the calculator with a total energy saving will give the total CO_2 emission reduction. This can, for example, be due to a change towards VLEB.

If different buildings for instance residential and non-residential buildings have their individual future energy mix, this can also be included in the calculation.

CO_2 emission reduction per m^2

Based on the energy consumption in new, standard residential buildings and the expected energy consumption in VLEB, the CO_2 emission reduction per m² was calculated for each MS.

The calculated energy savings and CO_2 emission reductions will of course depend on a number of parameters and conditions:

– different level of energy efficiency in the new building stock,
– different level of energy efficiency in the VLEB stock,
– differences in energy mix and thus average CO_2 emissions,
– different climate conditions.

All together, these parameters and different conditions make up rather big differences in the potential CO_2 reduction from MS to MS. See figure 4.

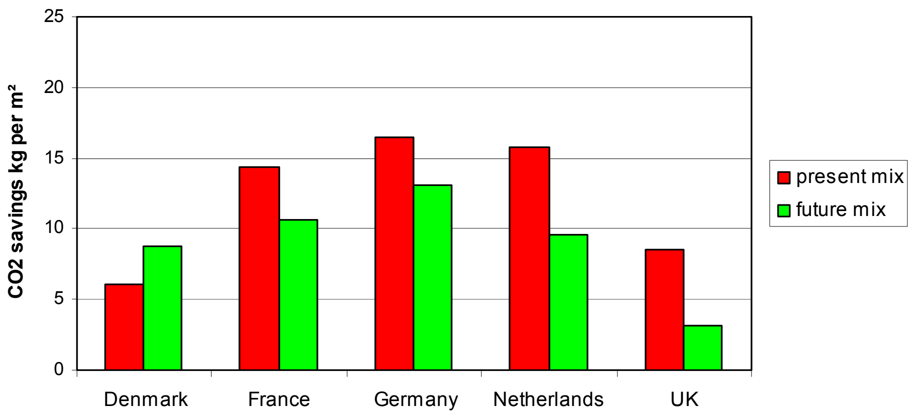


Figure 4. CO_2 savings per constructed m² of residential VLEB in selected MS and compared with buildings constructed according to provisions in the present building regulations.

In the residential sector, France, Germany and the Netherlands will experience a larger reduction in CO_2 emissions per newly constructed m² of VLEB compared with Denmark and the UK. This is due to the starting point where the current energy requirements in the French, Dutch and German building regulations are lower than in the other countries, while the energy consumption in future VLEB is of the same order of magnitude.

The increase in CO_2 emission for future Danish VLEB compared with the present mix of energy sources/carriers is due to the assumption that future buildings will have a higher ratio of electrically based heat pumps for space heating and thus increased electricity consumption compared with the present energy mix. This is realized even though the ratio of renewable energy for electricity production is expected to increase to 30 % in a future Danish energy mix.

Following the principles for data capture and CO_2 emission calculation, energy consumption and energy sources/carriers breakdown in non-residential buildings in the selected MS were derived as well.

Still following the principles used for CO_2 emission calculation in residential buildings, the energy content and national energy mix are being used in the calculation of CO_2. And again, the future energy mix in a scenario where all new non-residential buildings are constructed as VLEB was estimated. This information is being used in the calculation of the future CO_2 emissions from this category of buildings.

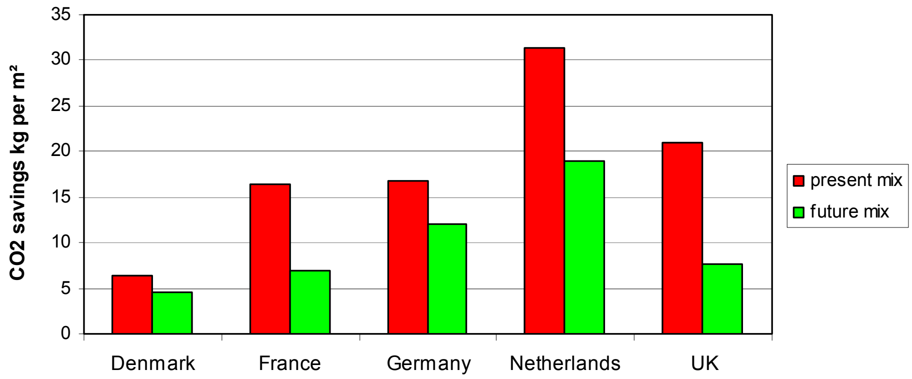


Figure 5. CO_2 savings per constructed m² of non-residential VLEB in selected MS and compared with buildings constructed according to provisions in the present building regulations.

In the non-residential sector Netherlands and United Kingdom will experience the largest reduction in CO_2 emissions per newly constructed m² of VLEB compared to Denmark and France. This is due to a rather low starting point compared with that of the other countries. However, their future requirements to energy consumption in VLEB are at the same order of magnitude. In this comparison Germany takes a middle position (see table 4, table 5 and table 6 for details).

CO_2 emission reduction

Using the CO_2 calculator either the total energy saving or the energy saving per constructed m^2 can be used as input. Using the energy saving per constructed m^2 (see figure 4 and figure 5) the CO_2 calculator will deliver the CO_2 reduction per constructed m^2. Multiplying this result with an estimate of the future construction activity in m^2 the result will be the estimated total CO_2 emission reduction per year.

The calculation of the savings potential for the residential building sector is based on the CO_2 calculation calibrated according to the individual MS energy mix, CO_2 content of fuels and the average annual construction activity. Concerning residential buildings, the future mix of this building segment is used.

The same method was applied to the non-residential building sector in the five MS.

Table 11. Annual CO_2 emission reduction per m^2 distributed on the five MS if changing all building activity from standard minimum building regulation requirements to VLEB (future energy mix).

	CO_2 emission reduction (Future mix) kg/m^2	Construction activity 1) annually m^2	Annual CO_2 emission reduction (Present mix) Tonnes	Annual CO_2 emission reduction (Future mix) Tonnes
Denmark				
residential	8.8	3 208 311	19 000	28 000
non-residential	4.5	1 641 577	10 000	7 000
total			29 000	35 000
France				
residential	10.7	34 275 647	497 000	368 000
non-residential	6.9	9 400 000	154 000	65 000
total			651 000	433 000
Germany				
residential	13.1	6 701 750	110 000	88 000
non-residential	12.1	25 789 250	431 000	313 000
total			541 000	401 000
Netherlands				
residential	9.5	8 882 710	140 000	85 000
non-residential	18.9	1 972 500	62 000	37 000
total			202 000	122 000
United Kingdom				
residential	3,2	18 252 000	155 000	58 000
non-residential	7.7	18 000 000	378 000	139 000
total			533 000	197 000

1) For the construction activity the average of the recent 3-5 years construction activity have been used.

The future energy mix has been used to estimate the total annual CO_2 emission reduction. The total annual CO_2 emission reduction for the five MS becomes 1.2 Mt. In case the present energy mix is used the annual CO_2 savings for the five MS becomes 2.0 Mt.

Table 12. Accumulated CO_2-emission savings Mt in 2020 in Member States as a consequence of stepwise or a one-step change towards VLEB using the data in table 3.

Building type	Denmark	France	Germany	Netherlands	United Kingdom
Residential buildings					
stepwise1)	0.8	15.9	3.9	4.0	5.2
one step2)	1.6	28.4	6.5	7.4	7.0
Non residential bldgs.	0.3	4,2	14.9	1,8	12.8
stepwise	0.6	7,2	24.6	3.3	17.0
one step					
Additional energy savings by changing to VLEB standard, January 2009 instead of a stepwise change					
	1.0	15.3	12.3	4.8	6.0

1) In the stepwise calculation the shift between present and future energy mix is assumed to take place in 2015.
2) In the "one step" calculation the average value based on pre-sent and future energy mix is used.

Political issues regarding VLEB

Information on relevant studies on VLEB, including measures and programmes to promote such buildings and to remove barriers to their future development has been collected. Education, training, and the public sector are other areas of special interest.

National studies regarding VLEB

Information about the existence of national studies showing evaluations of the impacts of a wider introduction of low energy buildings was collected.
Some studies have been identified which are shown in the following table.

Table 13. National studies evaluating the impacts of a wider introduction of VLEB in five MS and link to relevant documents in English focusing of the cost-effectiveness, expected costs, potential for energy savings and CO_2 emission reduction and job creation.

Country	National studies of low energy buildings
Denmark	Some studies, but only in Danish.
France	Yes, but no one in English written text.
Germany	In proceedings of the International Conferences on Passive Houses: www.passivhaustagung.de/elfte/english/01_start_home.html www.passive.de
Netherlands	a cost effectiveness study was carried out already in 2005[1)] (only available in Dutch) The excuse why it was not implemented already in 2005 was quite oriented on the available measures, like a heat pump combined with aquifer (earth heat/ground water): the regulations on groundwater did not allow the application of this solution. The problem with the heat pump was also, that at that time people were reluctant to be dependent on 1 measure (heat pump) to meet the requirements. Heat pumps are broader available and accepted now for non residential.
United Kingdom	Code for Sustainable Homes - Technical guide can be found at: www.planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide.pdf There have been several studies. One of the most useful documents is "Cracking the Code - How to Achieve Code Level Three and Above" and can be found at: www.housingcorp.gov.uk/upload/pdf/Cracking_the_Code.pdf

1) E.2005.0139.00.R001, Aanschrerping EPC eisen utiliteitsbouw – Haalbaarheidsstudie.

Promotion of VLEB

Furthermore the existence of instruments used to promote VLEB was identified in the selected countries. In those countries that have adopted some approach and promotion instruments for VLEB, a list of measures with pros and cons was given.

Instruments and programmes used

Table 14. Promotion instruments in the five MS for implementation of VLEB.

Promotions instruments	Pros	Cons
Denmark		
Code for two low energy classes in the building regulations	Complying with the requirements in the two classes enables the contractor to avoid connecting to the collective energy supply system.	
Low energy classes announced as future minimum requirements	The two low energy classes represent planned tightening of the minimum requirements for new buildings in 2010 and 2015 respectively. This means that the future standards are already known and builders can prepare their buildings accordingly.	
Energy certification	The low energy classes have their own classes in the energy certification scheme.	The scale of the energy certification might change over time and thus slide low energy buildings down the scale.
Demonstration project	Numerous demonstration projects show how low energy buildings of the future can be constructed and constructions designed	Demonstration projects may not penetrate to a broad marked and are generally costly.
Local planning	Some municipalities have put requirements for low energy class 1 or 2 on all new buildings in their area (parts of the municipality, the whole municipality or some selected building types).	
France		
Tax incentives	Well known and published.	Limited amount, no evaluation.
Quality certificates	For those who are willing to take the lead, useful to test ability of professionals, and financial supports schemes.	Still complex to understand, no incentive for professional stakeholders.
Announcement of the “class A” as future regulatory minimum requirement from 2012		
Possible financial schemes: – Low VAT rate for renovation works (both on materials, equipments and installation) – Income tax reduction (25 to 50 % of the purchase and installation costs for insulation or high performance heating equipments or renewable energy producing devices – Zero interest rate loans for renovation projects in the residential sector	 – For all renovation works, not limited to energy efficiency. – Installation costs are included. – New in 2009 ; significant amounts of money available: 20 or 30 k€ per housing unit; can be cumulated with the in-	 – No minimum performance requirements. – Minimum performance requirements are too low. – Minimum performance requirements are too low.

Promotions instruments	Pros	Cons
	come tax reduction; 2 or 3 different works to be chosen out of a list of possible renovation works.	
– Zero interest rate loans for acquisition of very low energy buildings (BBC-Effinergie level) – Lower tax on property, or complete exoneration for the construction of a very low energy building (amount on the local authorities) – Low interest rate loans for renovation works (bank offers subsidised by the money collected through the Livret Développement Durable) – Local subventions and/or low interest rate loans by some local authorities (cities, regions or departments)		
Germany		
CO_2 refurbishment programme (residential)	Mass-market programme, based on low interest loans, with added incentives for refurbishments achieving better than new-build standards.	Entirely voluntary; and in most cases very low energy standards are too tough to meet, given the size of the incentive.
Energy efficient new-build programme (residential)	Incentives for new-build dwellings to achieve passive house or very low energy standard. Aim is for 40 % of new-build to be passive house, and 18 % of new-build to be very low energy in 2016.	No obvious downsides. Just needs to stay well ahead of minimum standards.
Tertiary sector loans scheme (private commercial buildings)	Low-interest loans for commercial sector low energy refurbishments.	No additional incentive for achieving very low energy standard.
CO_2 refurbishment programme (public sector stream)	Good potential for low-interest loans being used to achieve very low energy standards, given the recognition that the public sector must play an exemplary role in energy efficiency.	No compulsion.
Netherlands		
National subsidy programme for renewable energy measures in privately owned houses ('Duurzame Warmte').	Very well appreciated by house owners (direct funding of part of their investment).	Cost for national government.
Green mortgages / soft loans		
Local planning	Direct agreement between the one selling (mainly municipalities) the ground and the one buying the ground.	Only possible to set higher energy efficiency standards by those owning the ground. There are no other legal options to set requirements higher than national Building Regulation.

Promotions instruments	Pros	Cons
Timely announcement of further tightening of energy performance requirements	The market can prepare for the announced tightenings. If the market takes this up actively then improvements go by itself (and market parties follow each other for reasons of competition).	Dependency of the actions by the market.
United Kingdom		
Code for Sustainable Homes	The Code uses a 1 to 6 star rating system to communicate the overall sustainability performance of a new home, with minimum standards for energy and water use at each level. New build will be required to comply with higher levels, with Code level 6 required by 2016.	The code is not yet mandatory (but should be by 2009).The energy part of the code is based around the heat loss parameter (HLP) of the building. This failure to take into account solar gain will put the premium on flats with smaller window areas.

The instrument used in all the five considered countries includes the timely announcement of further tightening of energy performance requirements. This is very valuable for the industry as it is used to prepare for and develop solutions in good time. Demonstration projects are also used to show the development and these are very valuable in order to learn more about low-energy and CO_2 neutral buildings.

A very important measure to drive towards low energy and zero CO_2 buildings is tax incentives and soft loans, which is used in several countries except Denmark. It is worthwhile to point out that such measures have been used in countries like Germany, Austria and Belgium to drive low energy and passive housing. Today such measures have made low energy buildings and low CO_2 buildings standard in Austria.

Local planning where regions are taking the lead and go further than required in building regulation is also seen as a promotion instrument in the same way as demonstration projects. A summary of the promotions instruments are shown in table 15 below.

Table 15. Promotion of low energy buildings.

	Denmark	France	Germany	Netherlands	United Kingdom
Announcements[1)]	X	X	X	X	X
Demonstration projects	X		X	X	
Tax incentives		X			X
Soft loans		X	X	X	X
Local planning	X			X	

1) Timely announcement of further tightening of energy performance requirements.

Another promotion instrument is policy instruments based on communication that try to persuade people to engage in VLEB by providing information about energy- and CO_2 savings or by trying to change opinion and attitudes.

Education and training

It was also investigated how the education and training challenge is dealt with in the selected countries. Information about programmes for education or training programmes for contributors to the construction process (e.g. architects, engineers, craftsmen. etc.) to meet the VLEB standards was listed. Special initiatives for the public sector were also investigated.

Table 16. Education and training challenge in the five MS to change towards VLEB.

Country	Education and training challenge
Denmark	The education is non-obligatory for the Danish building industry. As the planned low energy classes have already been announced, there is a possibility of gaining experience of constructing this kind of buildings without being obliged to do so. Certain craftsmen need training or change of focus, e.g. to obtain the required airtightness of new buildings (this requirements is new in the Danish building regulations). In some areas with demonstration buildings there are special training courses for craftsmen that are going to construct VLEB.
France	The efforts are principally focusing on craftsmen (because the retrofit of existing buildings is the major challenge (and not new construction). Most of the works in existing buildings are "designed" and implemented by craftsmen but they are not numerous enough neither skilled sufficiently. A large training programme funded (1 M€) with the "white certificates scheme" is started. There are no special initiatives for the public sector, but a similar requirement (all public buildings in class A from 2012 on) has been announced by the Government as one of the outcomes of the recent "Grenelle de l'Environnement".
Germany	There is considerable sharing of best practice (see www.zukunft-haus.info/de/projekte/niedrigenergiehaus-im-bestand.html for the residential sector, and www.zukunft-haus.info/de/projekte/niedrigenergiehaus-im-bestand-fuer-schulen.html for the schools sector). Both 'Zukunft Haus' and DENA (German Energy Agency, www.dena.de; managing agent of 'Zukunft Haus') run training, skills and best practice programmes for VLEB. However, the emphasis is still firmly on the residential sector. There are no special initiatives for the public sector.
Netherlands	The builders have promised in their "Spring Agreement" to do a lot on education. There are many courses, seminars etc about energy saving. But there is no information on how many craftsmen attend this, but the medium and large building companies do. The education of Architects is not addressed. However there is a certain and growing group of architects who is aware of the topic. All education it is voluntary.
United Kingdom	To meet the requirements under the EPBD, the government set a target of having 2,000 Domestic Energy Assessors, accredited by various UK bodies. A similar training scheme has been established to enable people to assess using the Code for Sustainable Homes. For the public sector housing associations are already required to meet Level 3 for the Code for Sustainable Homes (see above) for new build.

Barriers to constructing VLEB

Known barriers towards VLEB were listed in prioritised order, and how these are addressed in the national activities. In this context barriers mean obstacles and hindrances that prevent investors and potential owners of new buildings to construct VLEB.

Table 17. Recognised barriers (prioritised) in the MS for a change towards VLEB.

Barrier	Description
Denmark	
1. Lack of expertise	Some traditional construction companies have neither engineers nor craftsmen expertise
2. Lack of technology	When the low energy standards were announced in 2005, many building component manufacturers were not able to deliver components for low energy building. This has changed and now a large diversity of low energy components is available on the Danish market.
3. Lack of standard solutions	Standard solutions ready for low energy buildings are needed.
4. Lack of legislation requirements	In Denmark there are requirements for two low energy classes, which are assumed to become the minimum requirements for new buildings by 2010 and 2015. This has been an encouragement for the development of new products by the building component manufacturers. Lack of compliance targets will potentially have the opposite consequences.
France	
1. Lack of expertise	Most traditional building companies have neither engineers nor workman expertise and this is the reason for the large training program.
2. Lack of standard solutions	Solution packages are under development (PREBAT, Building Energy Foundation, EFFINERGIE).
3. Lack of legislation requirements	Announced within the recent “Grenelle de l’Environnement”, the regulatory framework Law Grenelle 1 has been voted by the National Assembly on 21st October 2008. The Senate still needs to vote on it.
4. Lack of technology	The PREBAT research call for tender is also focusing on low energy building components both for new and existing buildings.
Germany	
1. Motivation	Found to be a greater barrier than cost.
2. Finance	Perceived cost.
3. Information	Knowledge about benefits.
4. Skills	Lacking cooperation between different segments of the construction industry.
5. Coordination	Coordination between the myriad of institutions promoting VLEB could be better - to ensure more consistent messages to the target audiences.
6. Split incentives	Investor not beneficiary.
The Netherlands	
1. Costs	Perceived to be much higher.
2. Lack of expertise/skills	-
3. Motivation / lack of legislation	Prefer business as usual, not doing more than necessary.
4. Lack of standard solutions	-
5. Split incentives	Split incentives are possible to use for the housing associations, (about 60 % of the Dutch dwelling stock is owned by them), particularly for new buildings. For new buildings, it appears to be much more difficult to make investments in energy efficient measures and earn this investment back by the rent. For existing buildings housing associations are allowed to raise the rent to a 'reasonable level' to make up for the extra investment for improving the energy performance of a dwelling. Thus the total living costs for the renter should decrease or remain equal: a decrease of the energy costs should make up for an increase of the rent.

Barrier	Description
United Kingdom	
1. Costs	Builders perceive the costs of energy efficiency and renewable technologies to be high, and of little value to their customer base. This is despite the low marginal cost of energy efficiency if incorporated early in the planning process
2. Skills & Knowledge base	Lack of awareness from builders, and the division of labour between a roofer to install a solar hot water system, and a plumber to connect it, means they rarely promote such solutions, and become more costly when they do. A lack of knowledge also means they probably don't have rapid access to the technologies. Similarly, a lack of demand for technologies due to a lack of knowledge fails to drive the required improvement in the construction trade.
3. Regulatory Issues	It can be difficult to get planning permission for some renewable technologies, especially in conservation/historic areas.

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Annex 1 – Questionnaire

Danish Building Research Institute
AALBORG UNIVERSITY

EuroACE

Questionnaire concerning

European energy savings and environmental aspects when moving towards very low energy buildings

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Contact person: Kirsten Engelund Thomsen
e-mail: ket@SBi.dk; phone direct: +45 4574 2374

Danish Building Research Institute (SBi), AALBORG UNIVERSITY

This questionnaire is initiated by EuroACE (www.euroace.org), conducted by the Danish Building Research Institute and will support the European Commission to develop a strategy for very low energy buildings. Your answers are crucial to establish reliable figures on energy savings and CO_2 reduction potential in the European Member States (MS) regarding an early implementation of very low energy buildings in the national legislations. Your answers will provide important information for the European Commission in their work on recasting the Energy Performance Building Directive (EPBD).

In this questionnaire, the term very low energy building is used. In the context of this survey this term covers different kinds of low energy buildings and passive houses as well. The term indicates buildings which are designed to a significantly higher standard of energy efficiency than the minimum required by national Building Regulations.

We would be very grateful if you could fill in the questionnaire and return it to Kirsten Engelund Thomsen not later than June 20th 2008. If you have any questions regarding the questionnaire, please do not hesitate to contact Kirsten Engelund Thomsen (ket@sbi.dk) or Ole Michael Jensen (omj@sbi.dk).

If you have more than one region in your country please fill in a questionnaire for each region. If necessary please forward the questionnaire to a colleague.

All personal data will be kept confidential and anonymous in any publication!

Thank you in advance!

General information

- Country: Region:

Filled in by:
- Name:
- Organisation:
- e-mail:
- Phone:
- Date:

1

1. Energy consumption in residential buildings

1.1 Actual energy consumption. Please look carefully in your Energy Statistics for energy breakdowns concerning the actual energy consumption in residential buildings and fill in the form. If possible, fill in total Energy consumption (1. column), Heat consumption (column 2) and Electricity consumption, heating excluded (column 3). Column 1 includes heating, cooling and ventilation. Column 2 includes space and hot water heating and excludes cooling. Column 3 only take in electricity for light and appliances, included cooling. Mark above the columns whether the figures refer to final consumption (delivered to the building) or net consumption (utilized in the building, i.e. excluded converging loss by heat production).

Year of statistics :choose
The figures are climate adjusted: Yes (preferred) ☐ No ☐

Actual	Energy consumption		Heat consumption: space and hot water		Electricity for light and appliances (heating excluded)	
Energy supplies	final ☐ net ☐		final ☐ net ☐		final ☐ net ☐	
		unit		unit		unit
Heating oil						
Natural gas						
Coal and coke						
Renewable energy						
Electricity						
District heating						
Town gas						
Other, specify here!						
Total						

1.2 Estimate of future energy mix in very low energy buildings?
Please make an estimate of the future energy mix in very low energy residential buildings. Consider very low energy buildings being constructed on a broad scale starting from tomorrow and the nation wide energy mix for such buildings in your country.

Estimate	Energy consumption		Heat consumption: space and hot water	
Energy supplies				
Heating oil		%		%
Natural gas		%		%
Coal and coke		%		%
Renewable energy		%		%
Electricity		%		%
District heating		%		%
Town gas		%		%
Other, specify here!		%		%
Total	100	%	100	%

Comments:

1.3 Please inform about national Internet and other links that inform about relevant energy statistics.

Energy statistics	
Building statistics	
Other links	

2. Energy consumption in trade and service buildings

2.1 Actual energy consumption. Please look carefully in your Energy Statistics for energy breakdowns concerning the actual energy consumption in trade and service buildings and fill in the form. If possible, fill in total Energy consumption (1. column), Heat consumption (column 2) and Electricity consumption, heating excluded (column 3). Column 1 includes heating, cooling and ventilation. Column 2 includes space and hot water heating and excludes cooling. Column 3 only take in electricity for light and appliances, included cooling. Mark above the columns whether the figures refer to final consumption (delivered to the building) or net consumption (utilized in the building, i.e. excluded converging loss by heat production).

Year of statistics ☐
The figures are climate adjusted: Yes (preferred) ☐ No ☐

Actual	Energy consumption		Heat consumption: space and hot water		Electricity for light and appliances (heating excluded)	
Energy supplies	final ☐ net ☐		final ☐ net ☐		final ☐ net ☐	
		unit		unit		unit
Heating oil						
Natural gas						
Coal and coke						
Renewable energy						
Electricity						
District heating						
Town gas						
Other, specify here!						
Total						

2.2 Estimate of future energy mix in very low energy buildings?
Please make an estimate of the future energy mix in very low energy service and trade buildings. Consider very low energy buildings being constructed on a broad scale starting from tomorrow and the nation wide energy mix for such buildings in your country.

Estimate	Energy consumption		Heat consumption: space and hot water	
Energy supplies				
Heating oil		%		%
Natural gas		%		%
Coal and coke		%		%
Renewable energy		%		%
Electricity		%		%
District heating		%		%
Town gas		%		%
Other, specify here!		%		%
Total	100	%	100	%

Comments:

2.3 Please inform about national Internet and other links that inform about relevant energy statistics.

Energy statistics	
Building statistics	
Other links	

3. CO_2 emissions

3.1 Please look carefully in your Energy Statistics or other places for the average CO_2 emissions concerning energy supplies.

	Unit	
Heating oil		
Natural gas		
Coal and coke		
Renewable energy		
Electricity		
District heating		
Town gas		
Others		

3.2 Please inform about national Internet links that inform about relevant CO_2-emissions

Energy statistics Building statistics Other links	

4. Construction activity

4.1 Please look carefully in your Energy Statistics concerning annual construction activity in m^2 distributed on type of new buildings and fill in the form. The building types given in the answer table below is fixed according to the EPBD terminology stated in the Annex of the EPBD.

	2004	2005	2006	2007
Building type	**m^2**	**m^2**	**m^2**	**m^2**
Single family houses of different types				
Apartment blocks				
Offices				
Education buildings				
Hospitals				
Hotels and restaurants				
Sports facilities				
Wholesale and retail trade services buildings				
Other types of energy consuming buildings				
Total				

5. Energy consumption in standard and very low energy buildings

5.1 Please inform about the energy consumption in standard and very low energy buildings, as stated in the building regulations (formal) and in reality (estimated) as well. The real (estimated) energy consumption includes all energy consumption in the building, e.g. computers, TV's, elevators, building management systems, lighting (internal and external), micro wave ovens, pumps, fans, swimming pools, etc.

	Standard buildings		Very low energy buildings	
	formal	estimated	formal	Estimated
Building type	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2
Single family houses of different types				
Apartment blocks				
Offices				
Education buildings				
Hospitals				
Hotels and restaurants				
Sports facilities				
Wholesale and retail trade services buildings				
Other types of energy consuming buildings				

State official name of low energy building:

Comments/explanations:

6. Information about studies concerning low energy buildings

6.1 Please inform about the existence of national studies evaluating the impacts of a wider introduction of low energy buildings.

National studies evaluating the introduction of low energy buildings YES ☐ NO ☐

If YES, please give at brief summary or a link to relevant documents in English focusing of the cost-effectiveness, expected costs, potential for energy savings and CO_2 emission reduction, and job creation:

6.2 Possible links or title to national reports evaluating the introduction of low energy buildings:

7. Instruments and programmes used to promote low energy buildings

7.1 Please inform about the existence of instruments used to promote very low energy buildings

No instruments introduced ☐
Yes, Instrument was introduced ☐

If YES, Member States that have adopted some approach and promotion instruments for very low energy houses, give a list of measures with some pro and cons:

Promotions instruments	pros	Cons

7.2 How is the education and training challenge dealt with in your country? Please add information about programmes for education or training programmes for contributors to the construction process (e.g. architects, engineers, craftsmen, etc.) to meet the very low energy buildings standards:

7.2.1 Are there special initiatives for the public sector?

7.3 List known barriers in prioritised order, and if possible give a short description of how these are addressed in national activities. In this context barriers mean obstacles and hindrances that prevent investors and potential owners of new buildings to construct very low energy buildings.

Barriers (prioritised)	Description
1.	
2.	
3.	
4.	
5.	
6.	
7.	
9.	
10.	

8 Remarks

Annex 2 – Description of the SBi CO_2-calculator

The CO_2 calculator is used to determine the annual CO_2 saving corresponding to a specific energy saving. The calculator (spreadsheet) has three fields for input or prerequisites. The first field is reserved for the energy mix relevant for the actual saving, in this case energy consumption in buildings. The second field is reserved for future energy mix. The third field is reserved for CO_2 contents. See figure 6.

Type of buildings:

Annual saving (TJ): **1.000**

Building energy break downs
final, climate adjusted
TJ

Energy content	Energy consumption	Space heating	Energi mix present	Energi mix future	CO_2 contents tonnes/TJ present	CO_2 contents tonnes/TJ future	Annual savings CO_2 (metric ton) present mix	Annual savings CO_2 (metric ton) future mix
Heating oil	25 000 000	24 000 000	15%	0	78	78	11 387	-
Natural gas	29 000 000	29 000 000	18%	25%	57	57	10 037	14 225
Coal and coke	4 000	4 000	0%	0%	100	100	2	-
Renewable energy	36 000 000	36 000 000	22%	25%	-	-	-	-
Electricity	38 000 000	5 000 000	3%	25%	170	150	5 170	37 500
District heating	79 000 000	70 000 000	43%	25%	26	20	11 241	5 000
Town gas	400 000	400 000	0%	0	60		145	-
Other, specify here!								
Total	**207 404 000**	**164 404 000**	100%	100%			**37 982**	**56 725**
Annual saving per squaremeter (tonnes/m²):							0,012	0,018

Figure 6. The CO_2 calculator determines the CO_2 emission corresponding to any energy saving entered the input box right at the top.

Concerning the energy mix, the calculator will use the energy mix for space heating, subsidiary the energy mix for energy consumption as a whole. In the energy mix column both present and future mix is shown in percentages, the first based on the energy mix selected, the other estimated according to expectations to the future energy supply in the actual MS. Moreover, the calculator must know the CO_2 content of the fuels that are entered into the energy breakdown. Usually, the content of the two columns are identical except for the content of CO_2 related to electricity and district heating, as these might change over time.

The overall input for an annual energy saving has its starting point in an energy saving calculation, in this case the energy saving per m² by low energy building multiplied by the annual building construction activity.

Annex 3 – Additional information from MS

In general, the relevant websites and institutions providing further national information.

Denmark

- Danish Energy Agency: www.ens.dk
- Danish Enterprise and Construction Authority: www.ebst.dk
- Danish Building Research Institute: www.sbi.dk

France

- www.effinergie.fr
- www.ademe.fr
- www.legrenelle-environnement.fr/

Germany

- German Energy Agency: www.dena.de
- German Environment Agency: www.umweltbundesamt.de
- Ministry for Industry and Technology: www.bmwi.de
- Ministry for Transport, Construction and Urban Development: www.bmvbs.de
- Environment Ministry: www.bmu.de
- Federal Construction and Planning Agency: www.bbr.bund.de
- Construction Knowledge Network: www.baunetzwissen.de
- Future House Programme: www.zukunft-haus.info
- Skills Centre for Cost-effective High-quality Construction: www.kompetenzzentrum-iemb.de
- National Statistics: www.destatis.de
- Sustainable Construction Society: www.gesbc.org
- Passive House Institute: www.passiv.de
- BINE Sustainable Energy Information Service: www.bine.info
- Research for Energy-Optimised Construction: www.enob.info
- Energy Users Association: www.energieverbraucher.de

The Netherlands

- www.senternovem.nl
- www.vrom.nl
- www.passiefbouwen.nl
- www.passiefhuis.nl

United Kingdom

- A useful summary of the many housing energy related policies and instruments that are in place in the UK can be downloaded from: www.eeph.org.uk/uploads/documents/partnership/Final%20EEPfH%20Government%20Instruments.doc. This document contains many useful links to other documents.
- www.planningportal.gov.uk/england/government/en/
- www.carbontrust.co.uk/publications

General information

- ec.europa.eu/energy/strategies/index_en.htm
- www.buildingsplatform.org/cms
- www.eceee.org
- www.EuroACE.org

This survey investigates the impacts associated with a wider introduction of very low energy buildings in five Member States of the European Union. In Denmark, France, Germany, The Netherlands, and United Kingdom, energy and CO_2 savings were estimated going from current building regulations' minimum energy performance requirements to the future national standard of very low energy buildings. Based on the estimated savings two different scenarios were calculated, one moving stepwise to very low energy buildings and one moving directly to the very low energy standard for all new buildings.

Furthermore, an overview is given that outlines established promotion instruments and also the barriers for introducing very low energy buildings in the selected countries.

1 edition, 2009
ISBN 978-87-563-1361-2