1. Introduction

This report presents an overview of the current Danish implementation status of the Energy Performance in Buildings Directive (EPBD), as well as an overview of planned initiatives. The report addresses the energy performance requirements for buildings, including the outline of the national plan for Nearly Zero-Energy Buildings (NZEBS) and the conclusions of the Danish study on cost-optimality of the Danish energy requirements. An overview is also given on the Danish requirements on Technical Building Systems (TBS) and the report provides an update on the implementation of the Energy Performance Certificate (EPC) and the inspection requirements for heating and Air-Conditioning (AC) systems.

In Denmark, the main focus in 2013 and the first part of 2014 was on the development of a national strategy for the renovation of existing buildings, as required in the Energy Efficiency Directive (EED), Article 4, as well as in the National Energy Agreement approved by a broad coalition in the Danish Parliament in 2012. The strategy was developed on the basis of a collaborative network process involving key stakeholders within building renovation, collectively called the ‘Danish Network for Energy Retrofit’. This comprehensive strategy was launched in May 2014 and consists of 21 initiatives to promote and improve the energy performance at renovation of buildings.

Initiatives in the strategy include an update of the energy requirements in the Danish Building Regulation, as well as ensuring a stronger compliance and a reinforcing of the EPC together with information initiatives.

The implementation process has already begun for a number of the 21 initiatives, including a revision process of the energy requirements for buildings, a new one-stop-shop for private house-owners called ‘Bedre Bolig’ (Better Home) and the introduction of a digital EPC.

In Denmark, the implementation of the EPBD is the responsibility of the Danish Energy Agency (DEA).

2. Current status of Implementation of the EPBD

I. ENERGY PERFORMANCE REQUIREMENTS

I.i. Progress and current status

In their current form, energy performance requirements for new residential and non-residential buildings were implemented in the Danish Building Regulation in 2006, after the implementation of Directive 2002/91/EC. These requirements included indicative forecasts for the tightening of the energy performance requirements in 2010 and 2015 - each time by approximately 25% compared with the...
2006 requirements. In 2009 the requirements were revised, and in the Danish Building Regulation 2010 (BR2010 - Figure 1) the energy performance requirements for new buildings were tightened by 25%, as planned. In the 2010 revision no forecast for the 2020 energy performance requirements was included. However, the building industry requested this forecast, which led to a process of cost-analysis for establishing the different levels of energy performance requirements. The outcome formed the forecast for the energy performance requirements for new buildings in 2020, i.e., the Danish NZEB definition (Figure 1).

For existing buildings, the government has developed a comprehensive strategy for the energy upgrading of the building stock. The implementation of the initiatives started in 2014 including the analyses of the energy requirements for BR2015.

**I.ii. Format of national transposition and implementation of existing regulations**

**New buildings**

BR2010 sets minimum energy performance requirements for all types of new buildings. In addition to the minimum requirements, BR2010 also sets requirements for two voluntary low-energy classes: ‘Low-energy Class 2015’ and ‘Building Class 2020’ (NZEB) - see Box 1. These two classes are expected to be introduced as minimum requirements by 2015 and 2020, respectively (Table 1).

The minimum energy performance sets the limit for maximum allowed primary energy demand for a building, including, e.g., thermal bridges, solar gains, shading, infiltration, ventilation, heat recovery, cooling, lighting (for non-residential buildings only), boiler and heat pump efficiency, electricity for operating the building, and sanctions for overheating. The overheating penalty is calculated as a fictive energy demand, equal to the energy demanded by an imaginary mechanical cooling system in order to keep the indoor temperature at 26°C. This additional energy demand is included in the calculated overall energy consumption of the building by the monthly based compliance checking tool Be10.

Buildings that comply with the two voluntary low-energy classes must prove that they have a good thermal indoor climate during hot periods. The indoor temperature in residential buildings (houses and apartments) must not exceed 26°C for more than 100 hours per year, and 27°C for more than 25 hours per year. This can be done either through Be10 or via a dynamic simulation tool. In other building types, the building owner decides the temperature limits, and summer comfort must be proven using a dynamic simulation tool. Additionally, these two classes of low-energy buildings must prove, through a pressurisation test, their compliance with the maximum infiltration rates (1.0 and 0.5 l/s.m², respectively, at a pressure difference of 50 Pa).

**Box 1: BR2010 minimum energy performance requirements.**

<table>
<thead>
<tr>
<th>Requirement Type</th>
<th>Residential Buildings</th>
<th>Non-Residential Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>$52.5 + \frac{1,650}{A}$ [kWh/m²·year]</td>
<td>$71.3 + \frac{1,650}{A}$ [kWh/m²·year]</td>
</tr>
</tbody>
</table>

where $A$ is the conditioned gross floor area.

The minimum energy performance for the voluntary Low-energy Class 2015 (A2015) is:

<table>
<thead>
<tr>
<th>Requirement Type</th>
<th>Residential Buildings</th>
<th>Non-Residential Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>$30 + \frac{1,000}{A}$ [kWh/m²·year]</td>
<td>$41 + \frac{1,000}{A}$ [kWh/m²·year]</td>
</tr>
</tbody>
</table>

Finally, the minimum energy performance for the voluntary Building Class 2020 (NZEB - A2020) is:

<table>
<thead>
<tr>
<th>Requirement Type</th>
<th>Residential Buildings</th>
<th>Non-Residential Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>$20$ [kWh/m²·year]</td>
<td>$25$ [kWh/m²·year]</td>
</tr>
</tbody>
</table>
Integration of renewable energy in NZEB 2020 is taken into consideration in the calculation of the primary energy factors (Table 2). Primary energy factors will be lowered over time as Renewable Energy Sources (RES) will make up a larger proportion of the overall energy mix.

Energy from RES installations on the building or the building site can be subtracted when calculating the overall energy consumption, but only within limits - e.g., renewable electricity is subtracted only up to the electricity demand for operating the building. There are local subsidies for private photovoltaic (PV) installations. Produced energy that is not used in the building is sold to the grid (by a low feed-in tariff). There is a maximum system size of 6 kWp for single-family houses.

Local, collective RES installations, e.g., wind turbines, shared solar heating, PV or geothermal systems, are included in the calculation as long as the building owner contributes financially to the installation. There is a requirement for thermal solar systems in buildings outside district heating areas with high Domestic Hot Water (DHW) consumption (above 2,000 l/day). The requirement should be fulfilled for both new buildings and existing buildings that undergo a major renovation. The installation should cover a demand corresponding to at least 95% of the DHW consumption from May to September.

This requirement will be replaced by a general requirement to install RES in new buildings, or buildings that undergo major renovation. The new requirement will implement the RES Directive (Directive 2009/28/EC), Article 13.4 and is scheduled to enter into force by 31 December 2014. Hence, the choice regarding specific RES technologies will be left with the building owner to ensure maximum flexibility.

The calculation procedure in BR2010 has been updated according to the new requirements and is described in the SBI Directions 213: Energy demand in buildings (Figure 3), published by the Danish Buildings Research Institute (SBI)\(^1\). The monthly quasi-stationary calculation procedure follows relevant CEN standards with national adaptations. This publication also includes the updated energy performance calculation tool Be10. The calculation core of this program is to be used by all other programs for compliance checks and for energy certification in order to ensure identical calculation of the energy performance of buildings.

### Existing buildings

BR2010 tightened the energy performance requirements for individual building components for all building types. This rule applies to the replacement of a component and to major renovation. However, the measures must be financially (plus technically and architecturally) feasible, i.e., they must have a simple payback time of less than 75% of its expected lifetime as defined in the Danish Building Regulations. In case of full replacement of a component (e.g., a new roof, new window, new outer wall), the new component must meet the requirements set in BR2010 (Table 3), regardless of profitability.

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\(^1\) *In Danish at: www.anvisninger.dk – access requires a license*
I.iii. Cost-optimal procedure for setting energy performance requirements

The cost-optimality of the current energy requirements in the BR10 was calculated in 2013 according to the procedure and the rules laid down in the Delegated Regulation 2010/244/EU. In relation to the new housing examples, the current minimum energy requirements in BR10 are all up to 16% stricter than the cost-optimal point. With the planned tightening of the requirements for new houses in 2015 and in 2020, the energy requirements can be expected to be tighter than the cost-optimal point, if the costs for the needed improvements do not decrease correspondingly.

For new office buildings the BR10 requirement is too lax by 31% when compared with the cost-optimal point. In relation to the 2015 and 2020 rules, all requirements are stricter than the cost-optimal point based on today’s prices. If the differences between the cost-optimal levels and the BR10 requirements for all the new buildings are weighted to an average, based on a mix of building types and heat supply for new buildings in Denmark, there is a difference of 3% for new buildings. The stipulated requirements for 2015 and 2020 are 34% and 49% more strict than the cost-optimal level based on today’s prices.

PV is not cost-effective today but is very close to it, especially in buildings with high electricity consumption included in the building operation, e.g., office buildings and houses heated by heat pumps. If the energy prices increase - or the cost of installing PV is reduced - it will soon be profitable to install PV in new buildings. When this occurs, the cost-optimal point will move significantly towards lower primary energy consumption in the buildings.

Component requirements for the building envelope and installations in existing buildings add up to significant energy efficiency improvement, both in the case of major and smaller renovations. The component requirements are in nearly all cases tighter than the cost-optimal point. In the case of a major renovation, the gap between requirements and cost-optimal level is very small. The tightening of the requirements to windows in 2015 and 2020 seems to move the requirements for existing buildings beyond the cost-optimal point. This will probably be solved by a future change in price for more efficient windows.

During 2014, the calculations for cost-optimal levels were revised, since the Low-energy Class 2015 is planned to become the mandatory minimum requirement in 2015. The conclusions from the updated calculations have shown that the additional costs in order to comply with the tightened requirements have decreased over the years. In 2014, the cost of complying with the 2015 requirements is close to cost-optimal point for all building types.

### Table 3: U-values and cold bridges requirements for existing buildings – examples.

<table>
<thead>
<tr>
<th>Component</th>
<th>Changed use and extensions</th>
<th>Pavilions</th>
<th>Single component requirements</th>
<th>Secondary homes</th>
<th>Maximum requirements, new buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-value requirements [W/(m².K)]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External walls and basement walls towards ground</td>
<td>0.15</td>
<td>0.20</td>
<td>0.20</td>
<td>0.25</td>
<td>0.30</td>
</tr>
<tr>
<td>Slab on ground etc.</td>
<td>0.10</td>
<td>0.12</td>
<td>0.12</td>
<td>0.15</td>
<td>0.20</td>
</tr>
<tr>
<td>Loft and roof constructions</td>
<td>0.10</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.20</td>
</tr>
<tr>
<td>Windows</td>
<td>1.40</td>
<td>1.50</td>
<td>1.65 (doors)</td>
<td>1.80</td>
<td>-</td>
</tr>
<tr>
<td>Roof windows</td>
<td>1.70</td>
<td>1.80</td>
<td>1.65</td>
<td>1.80</td>
<td>1.80</td>
</tr>
<tr>
<td>Cold bridges [W/(m.K)]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foundations</td>
<td>0.12</td>
<td>0.20</td>
<td>0.12</td>
<td>0.15</td>
<td>0.20</td>
</tr>
<tr>
<td>Joints between windows and walls</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>Minimum energy gain [kWh/m².year]</td>
<td>-</td>
<td>-</td>
<td>-33</td>
<td>-</td>
<td>-33</td>
</tr>
</tbody>
</table>
I.iv. Action plan for progression towards Nearly Zero-Energy Buildings (NZEBs)

National application of the NZEB definition

The Danish national plan for NZEB (2011)[2] lists the initiatives and policies that will increase the number of NZEBs. Examples of strategies and policies are:

> Energy-saving initiative for energy supplying companies: The government has developed a comprehensive strategy for upgrading the energy performance of the existing building stock. Danish supply companies are obliged to provide energy saving corresponding to 2.6% of the national energy consumption (exclusive transport) in 2013-2014, and 3.0% in 2015-2020. Compared with 2010-2012, in 2013 and 2014 the obligation to provide energy saving increases by 75%.

> Changeover to renewable energy: As a general rule, oil and natural gas boilers will not be allowed in new buildings as of 2013.

> Information campaigns: In relation to new buildings, building process guidelines have been drawn up for contractors, architects and engineers who wish to build in an energy efficient manner.

> Public action: Reducing the energy consumption in public buildings by 14% in 2020 compared to 2006 levels.

Figures and statistics on existing NZEBs

The minimum energy performance requirement for the voluntary Building Class 2020 is 20 and 25 kWh/m²·year for residential and non-residential buildings, respectively. Buildings complying with this voluntary building class have been in the Danish market since 2012.


In May 2014, the Danish government launched a comprehensive strategy for energy renovation of the existing building stock by compiling initiatives to promote and improve energy renovation of buildings.

The strategy is based on comprehensive analysis and includes 21 initiatives targeting specific building types from single-family houses to multi-apartment blocks, office and public buildings. It is estimated that by 2050 the initiatives in the strategy will reduce the net energy consumption for heating and DHW in the existing building stock by 35% when compared with today. Initiatives include an upgrade of the energy requirements for buildings and building parts, reinforcing of information activities, enhancement of data availability concerning tools and technical solutions for improving energy efficiency in buildings, financing, compliance, and steps to making the EPCs more robust and ensure further support of the energy renovation of buildings. Furthermore, the strategy includes a number of initiatives targeting training, education and innovation.

Analyses of the Danish building stock and energy-saving potential are made in the report “Potential heat savings during ongoing renovations of buildings until 2050”, SBI 2016:04[3], as the foundation for the Danish Strategy for energy performance upgrading of the existing building stock. This strategy was finalised in 2014 and it contains a number of initiatives for increasing the number of energy performance upgrading projects in the most cost-efficient way. A large network consisting of representatives from the construction and other sectors has contributed to these initiatives.

Denmark has committed to reduce the energy consumption in buildings owned and used by the government by 14% by 2020, with 2006 as base year. This initiative targets energy efficiency in public buildings and it will also ensure implementation of the EED Article 5. The initiative is a continuation of a long term Danish effort since 2006 to reduce the energy consumption in buildings used by the government. In parallel, existing voluntary agreements between the government and local/regional authorities to enhance energy efficiency in buildings used by these authorities will be revised to reflect the EED.

The voluntary agreements concern energy-efficient behaviour, equipment purchasing and buildings, including introduction of energy management, implementation of profitable energy-saving projects and energy efficient-operation, maintenance and reconstruction. For the period 2015-2016 approximately 100 M DKK (13.5 M€) are allocated to advance maintenance of public buildings, where at the same time energy optimisations can be implemented. The voluntary agreements mean that the owners of the public buildings have full flexibility with regard to the method for achieving energy savings. Within this context, the EPCs constitute one tool among others which are used to achieve this goal.

### I.vi. Other relevant plans

On 22 March 2012, the Danish Parliament decided on an Energy Agreement which lays down a number of initiatives to be implemented in the period 2012-2020. By 2020 the Energy Agreement will give the following main results:

- more than 35% renewable energy in final energy consumption;
- approximately 50% of electricity consumption to be supplied by wind power;
- 7.6% reduction in gross energy consumption in relation to 2010;
- 34% reduction in greenhouse gas emissions in relation to 1990.

Furthermore the Energy Agreement outlines the contents of a strategy for upgrading the energy performance of the existing building stock. This strategy was finalised in 2014 and it contains a number of initiatives for increasing the number of energy performance upgrading projects in the most cost-efficient way. A large network consisting of representatives from the construction and other sectors has contributed to these initiatives.

For the future there are several political ambitions relating to energy:

- 2030 - no more use of coal in power plants;
- 2035 - all electricity and heating covered by renewable energy;
- 2050 - all energy covered by renewable energy (electricity, heating, transports, industry).

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II. REQUIREMENTS FOR TECHNICAL BUILDING SYSTEMS (TBS)

II.i. Coverage of heating, domestic hot water, air-conditioning and large ventilation systems

The energy supply system in Denmark is undergoing great changes. In the future, the system will be based primarily on renewable energy, and the ambition of the government is to phase out oil boilers by 2030. Since 2013 it has not been permitted to install oil or natural gas boilers in most new buildings, and by 2016 it will be illegal to replace an existing oil boiler with a new one if there is access to district heating or natural gas.

The Danish Building Regulations include requirements for a wide range of TBS. There are specific energy-related requirements for boilers based on gas, oil, coal, biomass and similar fuels. The requirements for boilers operating on gas or oil, means that only condensing boilers can be used in Denmark, both for new buildings and new installations in existing buildings. Boilers operating on coal, biofuels and biomass should, as a minimum, meet the energy requirements of boiler class 5 in EN 303-5.

Ventilation is included in the regulations, and requirements for mechanical ventilation units include heat recovery rate and energy used for transport of air (limits on the Specific Fan Power (SFP) value - Table 4).

In addition to this, there are requirements for heat pumps, elevators and cooling systems.

II.ii. Regulation of system performance, distinct from product or whole building performance

There is a general requirement in the Danish Building Regulations that services have to be built in a manner that prevents unnecessary energy consumption. This means, e.g., that heating systems must be designed and built for energy-efficient operation, including the components, which must be compatible with each other and suited to the intended use of the building and building systems. Heating systems must be designed according to Danish Standard DS 469, which has different functional requirements for the commissioning of heating systems as well as additional requirements for use, operation and maintenance.

All technical systems in the building must be insulated as required in Danish Standard DS 452.

II.iii. Applicability to new, replacement and upgraded systems in existing buildings

The above mentioned requirements are applicable to all new and existing buildings, when a system or component is replaced, or a new system is installed. This means that the heat recovery rate and the specific electricity use for air transport have to meet the requirements in the Danish Building Regulations.

If only parts of a system are replaced or a new part of a system is added to an existing system, the requirement only applies to the new part of the system.

II.iv. Provisions for installation, dimensioning, adjustment and control

When technical systems like ventilation, heating and cooling systems are designed, adjusted and installed, it is mandatory to meet the requirements described in the following standards:

> DS 452 Code of practise for thermal insulation and technical service and supply systems in buildings
> DS 469 Heating systems with water as the heating medium
> DS 447 Code of practise for mechanical ventilation installations

These standards ensure the quality level of TBSs in Denmark.

II.v. Encouragement of intelligent metering

Technical systems with significant energy consumption must have meters installed if energy consumption exceeds a certain level (Table 5).

<table>
<thead>
<tr>
<th>Heat recovery rate [%]</th>
<th>SFP system [J/m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust ventilation</td>
<td>-</td>
</tr>
<tr>
<td>Ventilation units for single-family homes</td>
<td>80</td>
</tr>
<tr>
<td>Ventilation units for multi-family homes and other types of buildings</td>
<td>70</td>
</tr>
</tbody>
</table>

* For constant air volume (CAV) and variable air volume (VAV), respectively
II.vi. Encouragement of active energy-saving control (automation, control and monitoring)

A new standard for commissioning of buildings in Denmark (DS 3090:14) was published during 2014. The aim of the standard is to encourage the Danish building industry to include a systematic commissioning process between construction and operation of the building. An analysis is under way to investigate how large a potential for energy-saving there is in the commissioning process.

III. ENERGY PERFORMANCE CERTIFICATES (EPCs) REQUIREMENTS

III.i. Progress and current status on sale or rental of buildings

Overview and administration system

In Denmark, the responsibility of implementing the EPC lies with the Danish Energy Agency. The agency is also handling the daily operations, including supervision and future development of the scheme. Quality Assurance (QA) is partly performed by a private body.

It is mandatory that a valid EPC is supplied to a new owner or tenant of a building before a sale or rental contract is signed. Large buildings (1,000 m² or larger, not being public buildings) must always have a valid EPC, even if the owner/tenant has not changed. Furthermore, it is mandatory to display the label of the EPC if a building (of any type) is advertised for rent or sale in commercial media.

All EPCs are registered in a central database administered by the Danish Energy Agency and are displayed on the public website SparEnergi.dk.

The operation of the scheme is financed by fees paid by the certified companies as annual fees, as well as a fee per issued EPC.

How flats are certified in apartment buildings

When certifying apartments in apartment buildings, the whole building has to be included in the EPC so that all apartments in the building are covered by the certification. This is to ensure that all relevant energy-saving suggestions for the building, including the roof and the entire envelope, are considered by the energy expert.

The owner of an apartment building has the obligation to provide an EPC to a new tenant. If the apartment building consists of owner-occupied flats, the obligation lies collectively with the owners through a mandatory association among them. The association has the obligation to order and pay for an EPC at the request of an owner who wants to put an apartment up for sale.

Format and content of the EPC

The EPC assigns an energy rating to nearly all types of buildings and lists cost-effective measures for improving the building’s energy performance. The requirements of the EPC are stated in Act 636 of 19 June 2012, in the Ministerial Order 673 of 25 June 2012, and the Ministerial Order 203 of 6 March 2014 (Handbook for EPC experts).

The EPC rates buildings on an energy efficiency scale (Figure 8 and Table 6) ranging from A (high energy efficiency) to G (poor energy efficiency). Class A is divided into three sub-categories, A2020, A2015 and A2010.

The EPC for existing buildings contains, among others, the following information:

- the basic data of the building;
- the energy efficiency rating;
- the calculated energy consumption;
- the calculated CO₂ emissions;
- the measured total energy consumption, if available;
- a precise description of the building;
- recommendations for energy improvements.

The suggested improvements include a brief description, an assessment of the estimated cost, savings and paybacks, as
well as the impact on the energy efficiency rating if all the measures are implemented. The recommendations made must refer to the specific building.

There are several elements which can lead to energy-saving suggestions in the EPC, including upgrading and replacement of:
1. old roofs and attics;
2. old windows, doors, and overhead lighting;
3. heating systems;
4. insulation of various building components and building envelope;
5. all installations that have an impact when calculating the energy consumption, including automation.

In addition, the expert always has to consider RES.

The calculation methodology is the same as the one used for proof of compliance for new buildings according to BR10. The methodology is defined in the calculation engine of SBi Direction 213.

Energy certification of single-family houses constructed less than 25 years prior to the certification can take place without an on-site visit to the building. Energy certification of selected rental buildings can be based on the calculated or measured energy consumption. Buildings that can be certified by measured energy consumption include non-residential buildings, as well as multi-family buildings with a detailed and updated operational log. However, for office buildings and buildings used for administration, the EPC has to be based on the calculated energy consumption if the rental represents more than 25% of the total heated area of the building. An EPC based on measured energy consumption is not valid for sales.

The validity of the EPC is 10 years. However, the validity will be reduced to 7 years if the EPC identifies major energy savings with a simple payback time of less than 10 years and with total savings above 5% of the energy consumption.

**EPC activity levels**

The distribution of the certification classes for Danish residential buildings as registered in the current EPC scheme since 2006 is shown in Figure 9.

In the current EPC scheme, from September 2006 until August 2014, the number of EPCs issued is about 445,000. The Danish Energy Agency registers about 55,000 new EPCs every year, with a total of more than 1.2 million EPCs issued in Denmark since the initiation of the certification in 1997.

The evolution of the classes for residential buildings is shown in Figure 10. Note that one EPC can contain several apartments, which is why the number of apartments is higher than the total number of issued EPCs.

![Figure 9: The distribution of certification classes for Danish residential buildings as registered in the current EPC scheme since 2006.](image1)

![Figure 10: The evolution of the classes for residential buildings.](image2)
Comparing the number of EPCs issued for single-family houses with the existing building stock shows that approximately 29% of all single-family houses already have a certificate.

Table 7 shows the number of issued EPCs in private buildings each year from 2010 to 2014.

Typical EPC costs
The cost of an EPC is regulated by Order 60 of 27 January 2011. In 2014 the maximum price of an EPC for small buildings varies from 5,824 DKK to 6,988 DKK, incl. VAT (approximately 781 – 937 €), depending on the size of the building (up to 299 m²). The price of an EPC for buildings larger than 299 m² is not regulated. However, prices usually range between 0.5 €/m² and 2 €/m² per EPC.

Assessor corps
Only certified companies can issue EPCs. A certified company must implement an ISO 9001 QA scheme for its building energy certification system. There are currently approximately 255 certified companies to be found at www.sparenergi.dk. There are two kinds of energy certification experts:
1. energy experts covering single- and two-family houses of less than 500 m²;
2. energy experts covering multi-family houses, public buildings, as well as the trade and service sectors.

The education for energy experts has undergone a revision. As of 1 October 2014, energy experts must attend training that consists of obligatory courses, online tests and practical tests. No prior education is required. The education corresponds to level 6 of the European Qualifications Framework.

Compliance levels by sector
In Denmark it is not possible to collect data in order to check if an owner provides the buyer/tenant with an EPC when selling or renting. The Danish Energy Agency has only received one complaint from a tenant, so it estimates that the compliance level is high due to the owner’s/real estate agent’s obligation to display the EPC along with the advertisement for the building. Self-regulation within the real estate industry also has a positive effect on the compliance level.

Enforcement with building owners and real estate actors
If the rules regarding the EPC are not adhered to, the building owner, real estate agent, etc., may face fines and further liability. The amount of a fine for not having an EPC or for violating the EPC rules, depends on the size of the building and ranges from 2,000 DKK (268 €) to 45,000 DKK (6,036 €). For example, the owner of a building of 200 m² may face a fine of 5,000 DKK (670 €) for not having an EPC. If the EPC of a public building is not on display, the owner may face a fine of 2,000 DKK (268 €).

Along with the fine, the owner may also face an injunction from the Danish Energy Agency to display the EPC or to have an EPC issued.

At the end of 2014 four fines are being processed for not displaying the EPC in advertisements.

Quality Assurance (QA) of EPCs
The Danish Energy Agency carries out quality checks of EPCs on a regular basis, but they may also be carried out on the basis of a complaint. The Agency has set up a mandatory QA scheme in which EPCs are randomly selected from a central database for a quality check. A technical revision, which includes a re-certification by a specially appointed expert, must be carried out for 0.25% of all issued EPCs. Furthermore, an electronic analysis of all EPCs in the database is carried out to identify outliers, etc. Around 300 EPCs of all kinds of buildings have been checked between 2013 and 2014.

There are three levels of sanctions if errors are detected. Certified companies must correct the EPC and, if the errors are substantial, the company may also receive a first or second degree notification by the Danish Energy Agency. For grave or repeated errors and/or numerous notifications, the company will face a warning. The warning will be sent to the accreditation agency that certified the company. In addition, a warning will be displayed in connection with the online register of experts. In the worst case, the certified company may have its certification suspended. So far, the Danish Energy Agency has issued 45 warnings.

<table>
<thead>
<tr>
<th>Owner: Private</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-family</td>
<td>50,215</td>
<td>54,786</td>
<td>44,953</td>
<td>47,990</td>
<td>48,357</td>
</tr>
<tr>
<td>Multi-family</td>
<td>8,008</td>
<td>6,297</td>
<td>4,957</td>
<td>4,616</td>
<td>4,715</td>
</tr>
<tr>
<td>Non-residential</td>
<td>2,133</td>
<td>2,090</td>
<td>1,738</td>
<td>3,108</td>
<td>2,631</td>
</tr>
<tr>
<td>Holiday houses</td>
<td>4,468</td>
<td>607</td>
<td>388</td>
<td>-</td>
<td>645</td>
</tr>
</tbody>
</table>
Certified companies must carry out their own quality checks according to DS/EN ISO 9001.

III.ii. Progress and current status on public and large buildings visited by the public

Overview

All public buildings with more than 250 m² of useful floor area are required to have and display a valid EPC even if the owner/tenant has not changed. Since July 2012 this affects all buildings owned or used by the public. In Denmark, the definition of public buildings includes:
1. buildings used for public administration;
2. institutions, companies, associations, etc., if more than 50% of their expenses are covered by public funds; and
3. publicly-owned companies, or companies where a public body has the final say on decisions.

As of 1 January 2013, all other buildings in which an area of over 600 m² is frequently visited by the public are required to display their EPC in a place visible to the public. Only the actual rating of the EPC is required on physical display. All other key information of the certificate is publicly available on the central web-based information server www.boligejer.dk. Through this server it is possible to view the calculated consumption, as well as the name of the energy expert and the certified company who issued the certificate.

In 2013, the Danish Energy Agency has carried out 102 random checks on buildings larger than 1,000 m², which is 0.5% of all buildings in this category. It was found that about 24% of the checked buildings did not have the mandatory EPC. The owners of these buildings were given a warning and a deadline for complying with the rules, which they all did and thus no fines have been given yet. The random check did not distinguish between public and privately owned buildings, or whether the buildings were visited by the public.

It is not possible to extract the specific number of issued EPCs for buildings that are visited by the public from the database.

Format and content of the EPC

An EPC for a public building or a large building often visited by the public has the same format, content and validity as EPCs for other buildings.

III.iii. Implementation of mandatory advertising requirement

In July 2012 a new act and a new order came into force implementing Directive 2010/31/EU. The main rules of this act were applied on 1 January 2013 and concern mandatory advertising requirements and sanctions.

When a building is sold, rented or otherwise handed over to a new party and it is advertised in the commercial media, the advertisement must display the label of the EPC. If a real estate agent is involved in the sale, the seller must provide the agent with the EPC before advertising the building for sale. If the advertising requirement is not adhered to, the seller may face a fine of 2,000 DKK (268 €).

Regarding the advertising requirement for private sales on the internet, the Danish Energy Agency has, so far in 2014, performed a small random check which showed a compliance rate of 60%.

Furthermore, an initiative has been launched concerning sales where the owner does not involve a real estate agent. These advertisements are often published on the web. In collaboration with the owners of these websites, the Danish Energy Agency is looking into technical solutions to block advertisements without an EPC.

At the end of 2015, four fines for not displaying the EPC in advertisements are being processed.

III.iv. Information campaigns

Information initiatives to reduce the energy consumption in the existing building stock are one of the key elements in the Danish Energy Agreement of 22 March 2012. Previous and current activities (Figure 11) aim at producing cost-efficient information material in cooperation with relevant actors that deal with energy saving. The importance of the local perspective and private ownership is a significant part of the activities.

The Danish Energy Agency hosts websites containing both general and specific information on energy saving as well as on the EPC.

The main website of the information campaign, www.SparEnergi.dk, contains a variety of tools, information and knowledge that supports energy saving. A selection of the content is briefly described below.

Furthermore, a number of initiatives have been launched to promote the EPC and reduce energy consumption in buildings:
Better homes

A government-funded campaign has been launched to help building owners to choose the best solutions for their renovation projects (Figure 12). The campaign is called ‘BedreBolig’[4] (Better Home) and aims at accelerating energy renovation of private homes. The scheme is also part of the Danish government’s growth plan and introduces a one-stop-shop for private home owners who target an energy renovation of their homes. No direct funding to the building owners has been granted.

Digital EPC

The Danish Energy Agency has developed a digital EPC[5] that was launched in June 2014, which displays the EPC in a user-friendly manner and highlights the suggested energy-related improvements (Figure 13). Together with a new EPC benchmarking-tool and a financing calculator, the digital EPC makes the EPC easily accessible and usable. Now there is only one click between the sales advertisement and the digital EPC. Further improvements are in the pipeline. Related to this, the Danish Energy Agency has produced three leaflets with information about the EPC; one addressed to sellers of buildings, one addressed to buyers, and finally one explaining in more detail how to use the EPC.

Casebank

The Danish Energy Agency has developed a casebank[6] which contains a large number of examples of how other homeowners have renovated their home (Figure 14).

List of craftsmen

A list of relevant craftsmen[6] is published in order to make it easy for homeowners to contact craftsmen specialised in energy solutions. In essence, all craftsmen can get on the list. The better trained the craftsmen, the higher their ranking on the list.

Films and guides

A number of short films[7] have been produced, showing relevant energy solutions in households. The films present energy solutions and make them attractive to ordinary homeowners and some target at helping with the training of craftsmen. These films can also be used as marketing material by craftsmen with expertise in energy solutions. A number of guides (see footnote 8) have been published describing the process that homeowners must go through in connection with the renovation of their homes and they include an overview of the market players, a mapping of the savings potential, and a description of case studies where energy upgrading will pay off.

IV. INSPECTION REQUIREMENTS – HEATING AND AIR-CONDITIONING (AC) SYSTEMS

Regarding Article 14 of the EPBD on inspection of heating systems, Denmark has adopted the alternative approach (advice). Regarding Article 15 on AC inspections, Denmark has adopted mandatory inspections until January 2016. From 2016 onwards, the alternative approach will be implemented.

IV.i. Report on equivalence

Until 2011 Denmark was implementing Article 14 through mandatory regular inspections of heating systems. However, it was considered that the use of regular inspections was not cost-effective within the Danish legislative framework. Therefore the Danish implementation of Article 14 is done through a number of activities that each contributes to increasing the efficiency or phasing out of oil and natural gas boilers, such as advisory service, tax benefits and requirements to use RES for building heating. The Danish implementation of Article 14 should be seen as part of a long term political goal to phase out fossil fuels. Thus, the initiatives for oil fired boilers are mainly focused on replacement of the oil boilers with other heating sources, e.g., heat pumps, district heating, or solar energy. The development of the share of different types of heating systems in the residential sector in the period 1981-2014 is presented in Figure 15.

To ensure maintenance of heating systems which are not phased out, a number of initiatives has been launched in order to support a general increase of the energy efficiency of buildings. Specifically, there are a number of measures, with the same goal as the boiler inspection scheme, which will contribute either to the efficiency or the phasing out of oil and natural gas boilers. These measures include campaigns to increase building owners’ awareness of the potential value of service checks, as well as the promotion of qualified service providers.

Though there are some uncertainties in accurately determining their impacts, it is expected that the alternative initiatives will have a substantially higher impact than boiler inspections alone.

There has been no integration between the implementation of Articles 14 and 15 of the EPBD and the EED.

IV.ii. Progress and current status on heating systems

As alternatives to inspections, the following initiatives have been implemented to help ensure a higher energy efficiency of heating systems in Denmark:

> Advisory services for craftsmen and building owners (i.e., “Videncenter for Energibesarelser i Bygninger”). This service targets craftsmen and provides information and guidelines about how, e.g., to improve heating systems.

> Tax deduction for craftsmen’s fees related to renovation of buildings (“Bolig-job-ordning”). The tax deduction allowed building owners to include the cost of labour for renovations in their tax return forms, thereby giving them incentives to undertake renovation works such as replacement of the heating system.

> Obligations for energy service companies to implement energy savings for their customers.

> Reduced energy taxes for heat pump owners compared with owners of other kinds of heating systems. The tax reduction makes electricity-based heating such as heat pumps more economical compared to, e.g., oil.

Figure 15:
Residential units by type of heating, 1981-2014.
Requirements for the use of renewable energy in some buildings and efficiency requirements for boilers. In new buildings, heating with oil or gas is no longer allowed, which means that district heating, heat pumps and other heating systems with high efficiency are promoted. In existing buildings, old heating systems must be replaced with district heating, natural gas boilers or renewable energy if the building is placed within a district heating or natural gas grid. Finally, in Denmark, the efficiency requirements for newly installed boilers are higher than those required by the ECO-design Directive (2009/125/EC).

IV.iii. Progress and current status on AC systems

Overview, technical method and administration system

Denmark has adopted regular inspections for the implementation of Article 15 of the EPBD. The scope of the inspection scheme has been expanded to include all AC and ventilation systems with an effective rated output of more than 5 kW. Certain AC systems for industrial, not personal use, as well as systems operating less than 500 hours/year are excluded. The AC and ventilation systems must undergo an inspection every 5 years. Promotion of these inspections is made via the website of the Danish Energy Agency.

The inspection consists of a basic recording of data, e.g., type of system, effective rate and composition, as well as indication of the condition of the system. Moreover, the functioning and efficiency of the system are examined during the inspection. Finally, the Danish Energy Agency recommendations on energy efficiency with respect to retrofitting, maintenance and adjustment of the system are given to the owner in a report.

Data from the inspections is submitted to a database in the Danish Energy Agency. However it has proven difficult to ensure a high degree of compliance with the mandatory inspections since there is no common Danish register of ventilation systems, and no obvious way to establish such a register in a cost-effective way. In addition, the companies that perform the required inspections have indicated that it is their impression that the mandatory inspection to only a limited extent has triggered actual energy savings in the covered ventilation systems. Therefore it has been decided that the mandatory inspection scheme will be terminated as of January 2016 and replaced by alternative measures. These are envisaged to include integration with the EPC of large buildings, information campaigns and enhanced opportunities for energy companies to realise energy savings in ventilation systems as a part of their obligation to realise overall energy savings.

Arrangements for assurance, registration and promotion of competent persons

Inspections of AC and ventilation systems must be conducted by certified companies approved by the Danish Accreditation and Metrology Fund, or a similar accreditation organisation. To obtain a certification, companies must employ specially qualified personnel with experience within the field, as well as a QA system for the work carried out. Companies that are certified to carry out inspections are promoted via the website of the Danish Energy Agency.

Enforcement and penalties

It is the responsibility of the owner of an AC to get the required inspections to confirm whether conditions are met. If the mandatory energy measurement or inspections are not carried out, the owner of the AC may face fines. There have been no systematic compliance checks by energy authorities due to the lack of a common register of ventilation systems in Danish buildings and no fines have been imposed.

Quality control of inspection reports

In 2013, 131 inspections of AC and ventilation systems were carried out and reported. Of those, 27 inspection reports were controlled by the Danish Accreditation and Metrology Fund.

Impact assessment

Currently, no impact assessment has been made.

Costs and benefits

It is estimated that an inspection of an AC and ventilation system costs 2,300 DKK (310 €) paid to the inspection company, and that the inspection requires on average one hour of participation of the building owner per visit, at a cost of 500 DKK (70 €). In total, the cost for an inspection of an AC and ventilation system is estimated at 2,800 DKK (375 €). Currently there has been no estimate of the benefits from the mandatory inspections of AC and ventilation systems. Based on feedback received from the inspection companies, it is estimated that only a fraction of the inspections results in measures to lower the energy consumption.
3. A success story in EPBD implementation

The Danish Building Regulations incorporate definitions of future low-energy classes for many years to come and this has been a great success. BR10 contains definitions of ‘Low-energy Class 2015’ and ‘Building Class 2020’ preparing the Danish industry for future requirements almost 10 years in advance of the coming requirements, making them able to adapt their products to the new demands. This is one of the reasons why new very energy-efficient components are main stream today on the market, e.g., windows, fans and heat pumps. In general, it is voluntary to build in accordance with the future low-energy classes, but several local authorities have rules stipulating that a certain low-energy class should be applied in their municipality.

A study from 2014[9] demonstrates that building owners have a positive experience of moving into and living in their new low-energy houses, as 93% of building owners recommended to others to live in a low-energy house. Good indoor climate, and low energy and operational costs are emphasised as reasons. The study included a questionnaire distributed to 885 low-energy households, 370 of which answered. The building owners had moved into their houses between 2010 and 2013. The most important factors for the building owners with respect to their choosing to live in a low-energy house are shown in Figure 16. More than half (59%) of the inhabitants found that their heating consumption was as low as they expected before they moved into the house, while 7% found that their heating consumption was not as low as they had expected. One third (34%) did not know as they had not lived for very long in their houses. More than 90% of building owners found their indoor climate to be satisfactory during summer (93%) and winter (94%), while only 4% and 2% expressed their dissatisfaction with the indoor climate in summer and winter, respectively.

Another success is that only one calculation method was developed and used both for the management of construction projects and the energy certification scheme. The user interface of the tools was developed individually for each purpose as the use of the method is both for existing and new buildings, but the calculation engine is the same for all the tools. Hence, results from the tools will be the same for identical building models, and switching between tools is easy.

In Denmark, an energy certification scheme has been mandatory since 1997. All data from the certification scheme is gathered in a common database so a very wide range of information is available with respect to the building stock. The certification scheme has an impact on the price of buildings. A study made in 2013[10] showed that sales prices of single-family houses increase in line with improved EPC ratings. The result is reached by statistically comparing the energy certificate and the price of all single-family houses sold in 2011 and 2012. By doing the same with the sales of houses between 2006 and 2012, it became clear that, over time, the energy certificate has had a growing and strong effect on sales prices. Countrywide, the energy certificate has the greatest effect outside the capital area. The market turn can also be related to the EU statement that, from 2011, EPC labels should be published as part of house transactions.

![Figure 16: Most important factors for choosing a low-energy house.](image-url)

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4. Conclusions, future plans

The transposition of the Energy Performance of Buildings Directive (Directive 2010/31/EU - EPBD) was completed in Denmark in June 2012. The energy requirements in the Danish Building Regulation for new buildings have been tightened by using a step-by-step approach and introducing the new requirements as voluntary energy classes before they become mandatory, as it is the tradition in the Danish Building Regulation. The Building Class 2020, which was introduced in 2011, meets the obligations laid down in the EPBD regarding Nearly Zero-Energy Buildings (NZEBs). The Danish National Plan for NZEBs includes a number of initiatives and policies which will increase the number of NZEBs, including energy saving initiatives for the energy supply companies, strategy for the energy renovation of the existing building stock, changeover to renewable energy, information campaigns and public action.

In May 2014 the Danish government launched a comprehensive strategy for energy renovation of the existing building stock, compiling initiatives to promote and improve energy renovation of buildings. The strategy is based on extensive analysis and includes 21 initiatives targeting specific building types, from single-family houses to multi-apartment buildings, office buildings and public buildings. Initiatives include, among others, an upgrade of the energy requirements for buildings and building parts, reinforcing of information activities, enhancement of data availability, financing, compliance, and steps to making the energy performance certificates more robust and ensure the further support of the energy renovation of buildings. Furthermore, the strategy includes a number of initiatives targeting training, education and innovation.

Since the transposition of the Directive 2010/31/EU in 2012, a large effort has been made by the Danish Energy Agency and others to raise public awareness on energy use. Information campaigns, web-based interactive tools regarding energy saving measures, etc., have been widely initiated and public awareness has risen considerably. Denmark has succeeded in making the EPC visible, rendering it a clear sales parameter in the market. It still remains to ensure that certificates are homogenous and of high quality, which is why this also is an important initiative in the Danish strategy for renovation of buildings.

An interesting initiative targeting single-family houses is the “Bedre Bolig” initiative which aims at accelerating energy renovation of private homes. The scheme is also part of the Danish government’s growth plan and introduces a one-stop-shop for private home owners who aim for an energy renovation of their homes.

As for initiatives targeting energy efficiency in public buildings, Denmark has committed to reduce the energy consumption in buildings owned and used by the government by 14% by 2020, with 2006 as base year. The initiative is a continuation of a long term Danish effort since 2006. In parallel, existing voluntary agreements between the government and local/regional authorities to enhance energy efficiency in buildings used by these authorities, will be revised to reflect the Energy Efficiency Directive (EED). The commitment of 14% energy reduction by 2020 will at the same time complete the Danish implementation of Article 5 in the EED.

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