Energy labels and energy efficient properties

Methods for identification and definition of energy efficient properties in Denmark

Prepared by:	Torben Østergård
Checked by:	Steffen E. Maagaard
Approved by:	Steffen E. Maagaard
Date:	25.01.2019
Version:	
Project no:	1010817

MOE A/S
Mariane Thomsens Gade 1C, 1.
DK-8000 Aarhus C
T: +45 8750 8700
CVR no: 64 04 56 28
www.moe.dk

Contents

1 Introduction

At the request of Nykredit, MOE has prepared this memorandum about the Danish energy labelling scheme and energy efficient buildings in an international context. The memorandum is to contribute to creating a knowledge base about the energy efficiency of Danish properties and to describe how energy efficient properties in Denmark can be quantified.

The following focus areas will be discussed below:

- The Danish energy labelling scheme – background, assignment of labels, availability of data and distribution on the building stock
- The energy labelling scheme and Danish energy production/consumption in an international context
- Identification of energy efficient properties in Denmark and at Nykredit
- Definition of energy efficiency and comments on data quality

2 The energy labelling scheme in Denmark

The Danish energy labelling scheme is part of the remit of the Danish Energy Agency, but it is subject to common EU guidelines defined in the *Energy Performance of Buildings Directive* (EPBD)[1], the objective of which is to improve the energy performance of buildings. Below is a description of the Danish scheme and how the labels are distributed on the Danish building stock (Sources from the Danish Energy Agency [2][3][4]). In section 3, the scheme is described in a European context.

2.1 What is the energy label?

The aim of the statutory energy label is to disclose the energy consumption of the building and point to potential energy-saving measures. Since its introduction in 1998, the scheme has been used to classify buildings on a scale from A to G. Due to stricter requirements and ambitions in the building regulations, the ‘A’ category now comprises the classes A2010, A2015 and A2020 (Figure 1). The energy label is assigned in an energy labelling report that also includes a building description and calculation assumptions, as well as an estimate of the most cost-effective measures that can reduce the energy requirement of the building.

Figure 1 The Danish energy labelling scale. Source [2].

The energy label is based on a theoretical calculation of energy consumption under standard assumptions regarding user behaviour and weather conditions. Hence, the label indicates the energy standard of the building, but not its actual consumption. This method provides a better basis for comparing the state and quality of different buildings. The calculation takes into account the current source of heating and contributions from renewable energy sources. Statement of the source of heating makes it possible to determine the building’s primary energy requirement using national energy factors for electricity and heating, respectively. So the energy label reflects the aggregate primary energy consumption to be produced in order to operate the building.

2.2 Who assigns the energy label and how long is it valid for?

Energy labelling is performed by an energy consultant who has been through a government training programme and passed an exam. When assigning an energy label, the consultant must comply with the instructions of the "Håndbog for energikonsulenter" (energy consultants' manual). The consultant must be employed by a firm that is certified and registered with the Danish Energy Agency. It should be noted that the price of an energy label is subject to a maximum of approx DKK 4,500-7,300 incl VAT, depending on the building's construction year and size. This is to ensure that the building owner does not incur unnecessarily high costs for the mandatory labelling.

An energy label must be assigned when new buildings are constructed and when existing buildings are sold or let. After this, the label is valid for 10 years so that the same label may be used in connection with repeated sales within its validity period. For public sector buildings, the label *must* be renewed before it expires[1].

2.3 Which data is the energy label based on, and which data is publicly available?

The theoretical calculation on which the energy label is based is made using the Be18 calculation program, which is developed by the Danish Building Research Institute on the basis of European standards (ISO 13790 and ISO 52016). The program calculates the building's annual heating requirement, cooling requirement and electricity requirement (for operation) based on detailed measurements and assumptions regarding heated areas, building envelope, windows, ratio of sunlight to shadow, heat generators, ventilation, lighting[2] and installations. As previously stated, standard values are applied for weather conditions, family size, operating times and consumption habits. For this combination of building-specific and general values, the theoretical energy requirement is calculated, which is then converted into primary energy consumption via the energy factors.

For newly constructed buildings, the energy calculation is typically performed by a consultant engineer. The calculation, drawings and documentation are sent to the energy consultant, who then checks them and assigns the energy label and suggests energy improvements. When labelling an existing building, the consultant physically inspects and measures the building. If the consultant does not have access to eg buried installations or insulation in outer walls, their values are determined on the basis of tables for typical buildings of the same type and age.

Once the energy label has been assigned, the calculation and report are sent to a central database at the Danish Energy Agency. Via address searches, the general public can find the individual energy labelling reports at SparEnergi.dk [3]. At the same website, users can find statistics of building energy labels broken down by use, source of heating and construction year.

2.4 Breakdown of energy labels by use, source of heating and construction year

This section provides an overview of the breakdown of energy labels by use, source of heating and construction year. The figures below (2, 3 and 4) are based on data from the above website, SparEnergi, and from the Danish Energy Agency.

First, all buildings are compared, stating their use, in Figure 2. Overall, buildings labelled A or B account for approx 15.4% of energy labelled properties, while most fall into the categories C, D and E (~68%). If we look at the individual uses, terraced houses and similar are most energy efficient, with 24.4% in categories A and B, while just under 10% of multi-storey properties and farmhouses

[1] Buildings of less than 250 m² are exempted, however.
[2] Lighting for non-residential buildings only.

fall into these categories. So the breakdown varies considerably, depending on the use of the building.

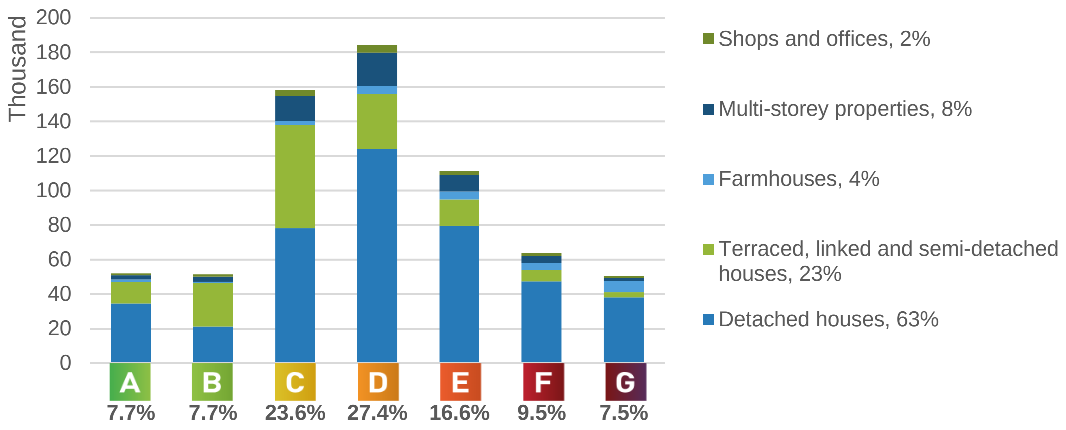


Figure 2 Breakdown of energy labels in Denmark by use. Data from [3].

Figure 3 shows some clear tendencies as regards energy labelling and the source of heating used in buildings. The share of buildings with oil-fired boilers falls from 33% for buildings with the poorest label to approx 0% for A-labelled buildings. Conversely, the relative share of buildings with district heating rises as the label improves. The overall district heating share is 46%. But for district heating a fall is seen from B- to A-labelled buildings, mainly because of a rising tendency to use heat pumps (HP) in new buildings. It may seem strange that the shares of electric heating and heat pumps are greatest for the most energy efficient buildings (A) and for the poorest (F and G). This is because heat pumps are used in A- and B-labelled houses since they convert each kWh of electricity into approx 3-5 kWh of heat (COP factor for the system). On the other hand, an electrically heated building without a heat pump, but with electric radiators, obtains only 1 kWh of heat for each kWh of electricity, which is reflected in the lower energy label (F or G).
In the above comparison of energy labels and sources of heating, it should also be remembered that the label is determined on the basis of the previously mentioned energy factors. So the source of heating plays a significant role when converting the energy requirement into primary energy – before the label is assigned. It should also be noted that the Danish electricity production on which the heat pumps are based is relatively sustainable, see section 3.1.1.

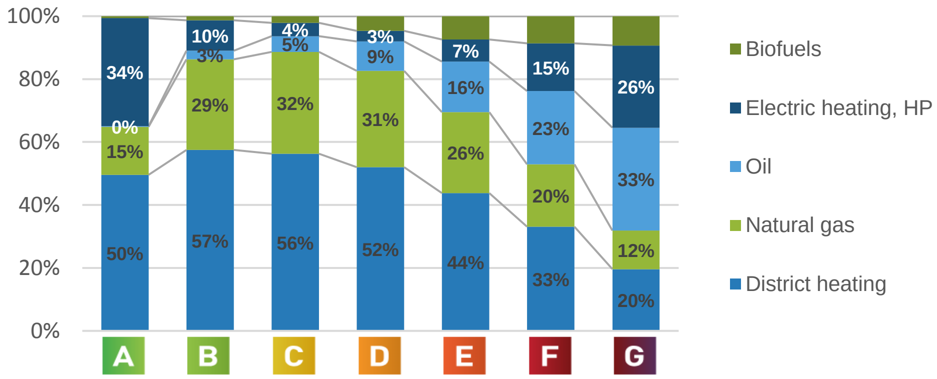


Figure 3 Breakdown by source of heating relative to energy labels for detached houses. Data from [3].

Figure 4 shows a breakdown of energy labels *for detached houses* by construction year, grouped by architectural traditions (until 1960) and changes in building regulations (after 1961). The periods are not of equal length, but the most productive decades are the 1960s and 1970s and to some extent also the 1950s and the period since 2010. Due to renovation, all periods include buildings with energy labels A and B. In the periods until 1978, these A- and B-labelled buildings account for max 1.9%, however (and 4% for the period 1979-98). An original detached house from the 1960s or 1970s typically has energy label D or E [7], so the share of C-labelled buildings in these periods is primarily attributable to renovation. The same principle applies to buildings from before 1960. Extensive and costly renovation is required in order to obtain an A or B label, and it is assessed that only a small number of buildings will move into these categories if renovated. For the newest buildings from 2011 or later, 131 detached houses have energy labels C to E (approx 0.4%). This may reflect errors, exemptions or considerable time lags between building permission and occupation.

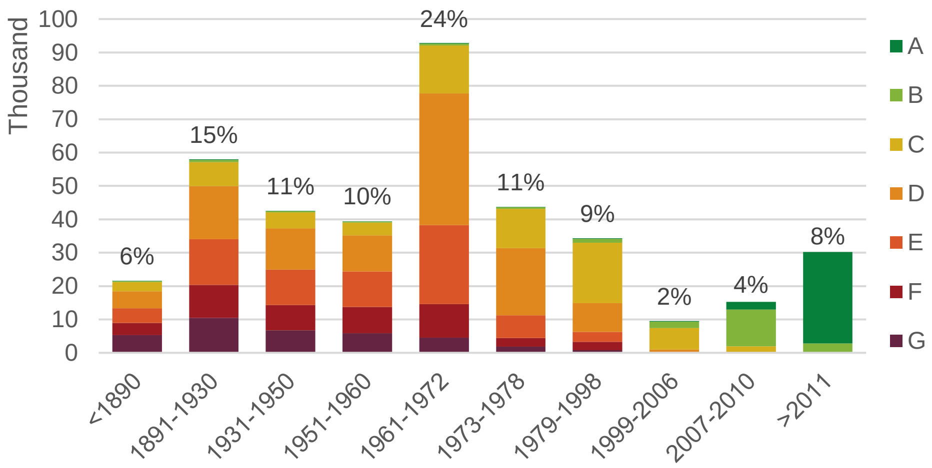


Figure 4 Energy labels for detached houses by construction year. Percentages indicate the relative share of the period in question. Data from [3].

3 Danish building regulations and energy labelling in an international context

As previously mentioned, the Danish energy labelling scheme is comprised by common guidelines in the EU's Energy Performance in Buildings Directive (EPBD) from 2010 [1]. Likewise, there are common standards (ISO 13790 and ISO 52016) for the calculation programs typically used for the national energy labelling schemes. All the same, it is up to the individual EU member states to interpret the guidelines and standards. Hence, there is considerable variation in the individual member states' energy labelling schemes and their definitions of "nearly zero-energy buildings" (nZEB), which is required for all new buildings from end-2020. However, the energy consumption requirements constitute only a limited part of the national building regulations. A brief description of the energy-related provisions of the Danish building regulations is provided below, after which they are assessed in a European context.

The Danish building regulations, BR18, contain 563 sections grouped into 35 chapters, of which only two (11 and 25) relate to energy consumption. Besides that, the regulations relate to a number of different areas such as fire, the building site, pollution, structures, playgrounds, noise, light and view of the surroundings, thermal indoor climate, etc. In this context the focus is on Chapter 11 "Energy consumption".

The most extensive element of Chapter 11 "Energy consumption" is the building's energy framework, which is the upper limit for the building's primary energy consumption (calculated using the above-mentioned Be18 program). Observation of the energy framework is a prerequisite for regulatory approval and for obtaining energy label A2015. A more stringent energy framework applies to the voluntary low-energy class 2020, which is linked to energy label A2020. This is also Denmark's definition of "nearly zero-energy buildings", based on the EPBD guidelines for new buildings in 2020. The energy framework calculation provides an overall picture of the energy performance of the building, but also contains requirements for many of the building's subcomponents. For example, there are minimum insulation requirements for the various building elements, and the energy balance for windows must be positive[3]. Below these requirements are compared with those applying in other Nordic countries and EU member states.

3.1 Danish rules in an international context

First, the energy framework requirements are compared across the Nordic countries, with which Denmark often compares itself. Table 1 shows the existing requirements, although the list varies a little due to differences in definitions and calculation practices. For example, Denmark has separate requirements and limit values for energy labels for residential buildings and other building types (offices, industry, healthcare, education, etc.). In Norway, the building types are specified in more detail (the list is not exhaustive). In Sweden, the source of heating is also taken into account, as well as the geographical location of the building, the country being divided into four different climate zones with different weather conditions. The weather conditions are of significance in this context. For each country, standardised weather data is applied. Norway and Sweden have colder climates, which is reflected in the higher energy framework values. It should also be noted that the energy requirements in Denmark and Norway are based on theoretical calculations, while Sweden applies the measured energy requirement in the first year of operation. Finally, energy production varies considerably across the Nordic region – district heating, wind turbines, water power and nuclear power. So it is difficult to make a fair comparison on the basis of the energy framework requirements.

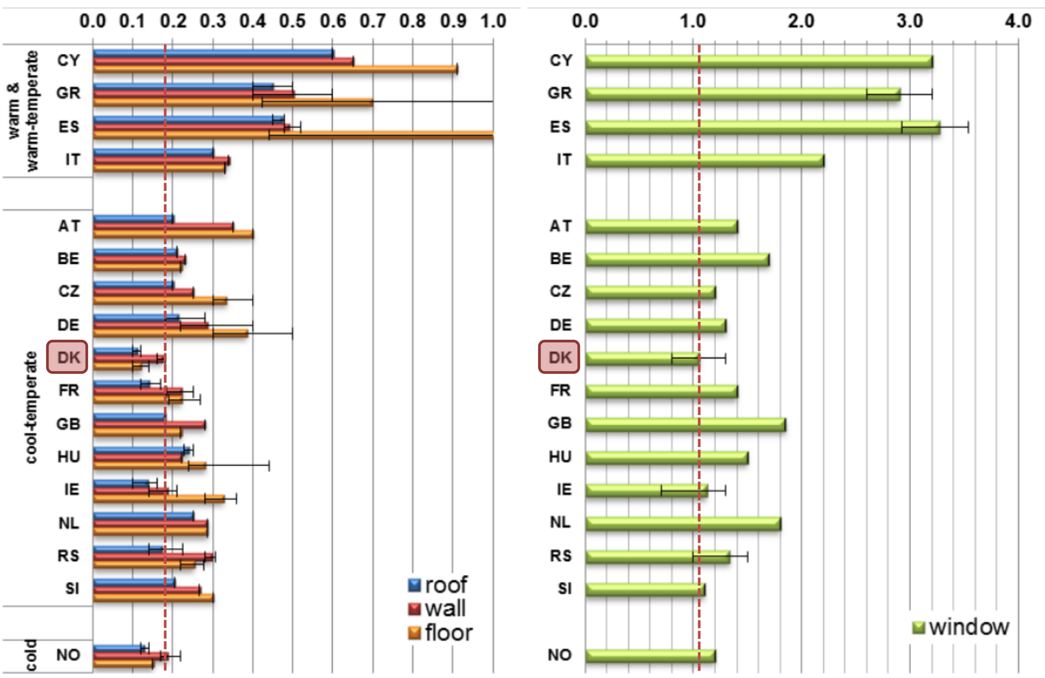
[3] Other energy requirements relate to the heat loss of the building, ventilation efficiency, etc.

Table 1 Nordic energy requirements, kWh/m²/year. A is the heated floorage area. Based on [4][8][9].

Denmark		BR18	Low-energy 2020
	Residential buildings	30 + 1000/A	27
	Other (commercial, hospitals, ...)	41 + 1000/A	33
Norway		TEK 17	
	Small houses	100 + 1600/A	
	Residential blocks	95	
	Offices	115	
	Schools	110	
	Hospitals	225	
	Hotels	170	
	…		
Sweden		Other heating	Electric heating
North	Residential, single family	130	95
	Residential, multiple families	115	85
	Non-residential	105	85
South	Residential, single family	80	50
	Residential, multiple families	75	45
	Non-residential	65	45

A comparison across all EU member states involves the same problems as those outlined above. In 2015, the non-profit think tank "Buildings Performance Institute Europe" compiled an overview of the individual member states' definitions and implementation of "nearly zero-energy buildings" [10] (see comparison in Figure 7 in the Appendix). This shows the same diversity in energy framework requirements and calculation assumptions. However, it is worth noting that according to this comparison Denmark is among the member states with the largest number of requirements beyond the energy framework requirement. These include requirements for envelope performance, overheating indicator (residential buildings) and performance of technical systems. The envelope performance (EP) is determined using a simple calculation that is the same for all member states and does not include energy factors. So the EP requirements give a better indication of the level of ambition of the individual member states if they are grouped by climate zone. The EU-funded EPISCOPE project compared energy performance and EP for representative sample buildings from 20 member states. The authors looked at newly constructed buildings from 2015, among which the Danish buildings stand out as having the best quality (cf Figure 5)[4]. It should be noted that the insulation properties of the building envelope, especially for temperate and cold climate zones, is by far the most important single parameter in terms of reducing a building's energy requirement. The results from these projects (TABULA and EPISCOPE) support the general view of Denmark as a leader within energy-efficient construction in recent decades[5].

[4] Danish buildings constructed in 2015 must be regulated according to the 2010 building regulations, corresponding to energy label A2010 or above.
[5] Historical values for U values on the façade of residential buildings can be found in the TABULA project [14].



Error bar: range of values for the different example buildings and variants

Figure 5 U values (insulation properties in W/m²K) for representative buildings constructed in 2015. Figure from [11].

3.1.1 Danish energy production in an international context

When assessing the energy efficiency of Danish buildings, it is also relevant to say a little about energy production. For many years, Denmark has been a leader in terms of developing and implementing renewable energy sources. As illustrated in Figure 6, Denmark is among the EU member states with the highest share of renewable energy. The top performers – Sweden, Latvia, Finland and Austria – all benefit from access to water power, which accounts for the lion's share of their production of renewable energy. Denmark's high share has been achieved mainly via development and installation of wind power.

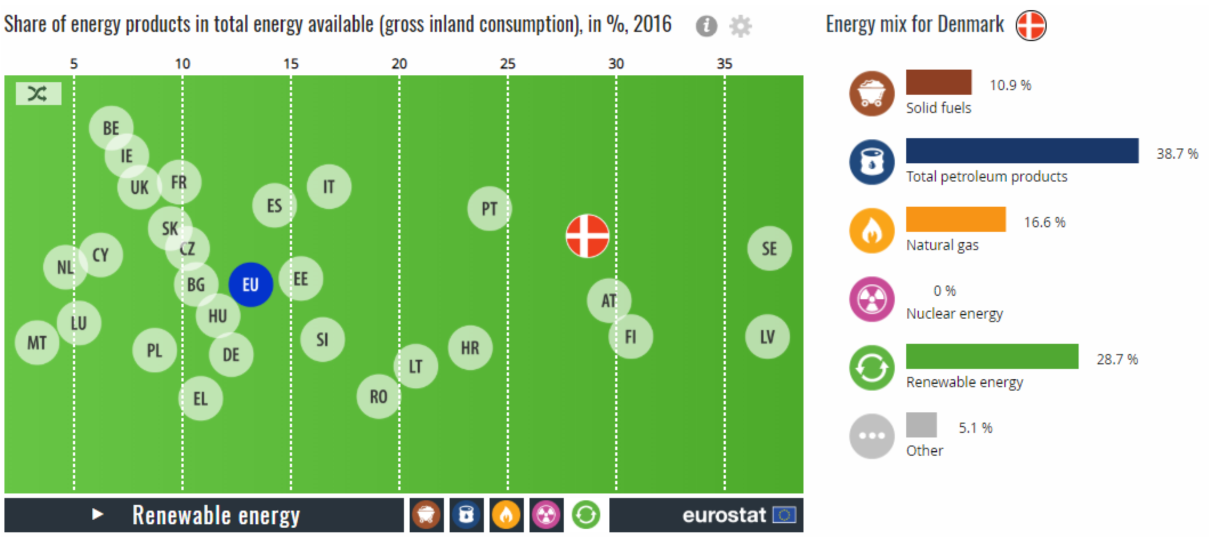


Figure 6 Share of renewable energy in national energy production in 2016. Source: [12]

However, the largest share of the energy requirement of buildings is linked to heating, with district heating as the most prevalent source of heating. District heating is also regarded as an efficient and environmentally friendly resource and Denmark is among the countries worldwide with the highest prevalence of district heating[6]. Production of district heating in Denmark is based on a combination of solar panels and surplus heat from electricity production and industry.

The individual country's mix of energy production is typically included in the energy framework calculations via energy factors. Hence, this is taken into account, and in Denmark the energy factors are adjusted when the building regulations are updated. But, as already mentioned, it is not easy to compare energy framework requirements and the included energy mixes across countries. An attempt to compare legislation on the energy efficiency of new buildings was made by the "Global Buildings Performance Network", which gives Denmark a top ranking among 25 countries and federal states (see Figure 8). Although there are many details and different definitions, it is the assessment of MOE that Denmark is (still) among the leaders within energy legislation and implementation for buildings.

[6] In 2013, 63% of the Danish population received district heating – a figure surpassed only by Iceland and Latvia [15].

4 Identification of energy efficient properties

4.1 In Denmark

In this section it is assessed whether energy labels can be used as an indicator of the most energy efficient properties in Denmark.

The energy labelling scheme is the only mandatory national certification scheme for the energy performance of buildings. By far the largest share of the Danish building stock is energy labelled, and all buildings constructed after the introduction of the scheme in 1998 should have a label. The classification is closely linked to the building regulations. Since 2008, newly constructed buildings have been energy labelled in accordance with the regulations in force – or voluntary, enhanced versions of these regulations. For example, buildings approved in the period 2008-10 will have energy label B or above. Similarly, buildings approved in the period 2010-15 will have energy label A2010 or above. For older buildings, there is not a one-to-one correlation between minimum label and regulations for the construction year; instead the label is based on the energy consultant's physical inspection of the building. The general requirement to use certified, impartial energy consultants helps to ensure objective and factual energy performance assessments. Validity requirements help to ensure updated and reliable energy labelling.

Besides the energy labelling scheme, various voluntary schemes exist, such as LEED, BREEAM and DGNB. These voluntary schemes are more comprehensive and include almost 100 criteria for assessing the sustainability of a building. In Denmark, only a modest number of buildings have such certifications[7].

In conclusion, the energy label is assessed to be a useful indicator of the energy performance of Danish buildings. As the breakdown in Figure 2 shows, A and B labels each account for approx 7.7% of the energy labelled properties. However, the statistics do not include buildings that are not energy labelled. Since these buildings were constructed before 1998, most of them are expected to have an energy label of C or below. Depending on the number of unlabelled buildings, the share of buildings labelled either A or B is likely to be well below 15% of the building stock in Denmark. If focus is purely on A-labelled buildings, these are certain to be among the most energy efficient in Denmark. By international standards, they will presumably rank even higher due to the more stringent requirements in Denmark since the introduction of BR10 in 2010.

4.2 At Nykredit

Since Nykredit accounts for a considerable share of all mortgage lending in Denmark, it is assumed that the breakdown by energy label for the mortgaged buildings will resemble the breakdown for the aggregate Danish population. There may be a bias on account of buildings with no outstanding debt, presumably older properties, for which the average energy performance is lower. So in general buildings mortgaged by Nykredit may be more energy efficient and newer than the average of the Danish building stock. Based on the information provided, MOE estimates that A- and B-labelled buildings in the Nykredit portfolio will be among the 15% most energy efficient buildings in Denmark.

[7] As at 13 December 2018, there were 50 DGNB certified buildings in Denmark [16].

References

[1] European Parliament, "Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings," *Off. J. Eur. Union*, no. L 153, pp. 13–35, 2010.

[2] Danish Energy Agency, "Energimærkning af bygninger," 2019. [Online]. Available: https://ens.dk/ansvarsomraader/energimaerkning-af-bygninger. [Accessed: 17-Jan-2019].

[3] Danish Energy Agency, "Find dit energimærke | Energistyrelsen," 2019. [Online]. Available: https://sparenergi.dk/forbruger/vaerktoejer/find-dit-energimaerke. [Accessed: 16-Jan-2019].

[4] Danish Energy Agency, "BR18," 2019. [Online]. Available: http://bygningsreglementet.dk/. [Accessed: 18-Jan-2019].

[5] IT and Development Agency of the Danish Ministry of Taxation, "BBR - Bygnings- og Boligregistret," 2019. .

[6] IT and Development Agency of the Danish Ministry of Taxation, "OIS - Din genvej til ejendomsdata," 2019. [Online]. Available: https://www.ois.dk/. [Accessed: 18-Jan-2019].

[7] Danish Energy Agency, "Bygningsguiden," 2018. [Online]. Available: https://sparenergi.dk/forbruger/vaerktoejer/bygningsguiden. [Accessed: 21-Jan-2019].

[8] Direktoratet for byggkvalitet, "Byggteknisk forskrift (TEK17)," 2017. [Online]. Available: https://dibk.no/byggereglene/byggteknisk-forskrift-tek17/. [Accessed: 24-Jan-2019].

[9] Boverket, "Boverket's building regulations – mandatory provisions and general recommendations, BBR," 2016.

[10] Buildings Performance Institute Europe, "Nearly zero energy buildings definitions across Europe," 2015.

[11] EPISCOPE, "Monitor Progress Towards Climate Targets in European Housing Stocks - Main Results of the EPISCOPE Project," 2016.

[12] Eurostat, "Shedding light on energy in the EU," 2016. [Online]. Available: https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2a.html . [Accessed: 25-Jan-2019].

[13] Global Buildings Performance Network, "Compare dynamic energy efficiency policies for new buildings," 2013. [Online]. Available: http://www.gbpn.org/databases-tools/purpose-policy-comparative-tool. [Accessed: 25-Jan-2019].

[14] T. Loga, B. Stein, and N. Diefenbach, "TABULA building typologies in 20 European countries—Making energy-related features of residential building stocks comparable," *Energy Build.*, vol. 132, pp. 4–12, 2016.

[15] Global Solar Thermal Energy Council, "Top District Heating Countries – Euroheat & Power 2015 Survey Analysis," *2016*. [Online]. Available: https://www.solarthermalworld.org/content/top-district-heating-countries-euroheat-power-2015-survey-analysis. [Accessed: 25-Jan-2019].

[16] Green Building Council Denmark, "DK-GBC - DGNB." [Online]. Available: http://www.dk-gbc.dk/dgnb. [Accessed: 24-Jan-2019].

Appendix

Country	Status of the definition	Main reference(s)	Year of enforcement		nZEB definition for new buildings: EPBD scope of nZEB definition [1]	Numerical indicator	Maximum primary energy [kWh/m²y]		Share of renewable energy	Other indicators	nZEB definition for existing buildings: Status of the definition	Maximum primary energy [kWh/m²y]	
			Public	Non-public			Residential buildings	Non-residential buildings				Residential buildings	Non-residential buildings
Austria	✓	OIB Guidelines 6	1/01/2019	1/01/2021	✓ [7]	✓	160	170 (from 2021)	Minimum share proposed in the draft of OIB guidelines for all buildings	EP, CO_2	✓	200	250 (from 2021)
Belgium - Brussels	✓	Amended Decree of 21/12/2007	1/01/2015	1/01/2015	✓	✓	45	~90 [2]	✓ Qualitative	EP, OH	✓	54	~ 108 [2]
Belgium - Flanders	✓	Regulation of 29/11/2013	1/01/2019	1/01/2021	✓	✓	30% PE [5]	40% PE [5]	✓ Quantitative [4]	EP, OH	Under development		
Belgium - Wallonia	Under development	Consolidated report to EC	1/01/2019	1/01/2019	✓	Under develop-ment			Quantitative	EP	Under development		
Bulgaria	Still to be approved	National nZEB Plan, BPIE study	1/01/2019	1/01/2021	✓	Still to be approved	~30-50 Included in the calculation; building needs to comply with class A	~40-60	Quantitative	EP	As for new buildings	~30-50 Included in the calculation; building needs to comply with class A	~40-60
Croatia	✓	Regulation OG 97/14, National nZEB Plan	1/01/2019	1/01/2021	✓	✓	33-41[3]	Under de-velopment	Minimum share in current requirements for all buildings	EP	ND		
Cyprus	✓	Decree 366/2014, Law 210(I)/2012	1/01/2019	1/01/2021	✓	✓	100	125	✓ Quantitative	EP	✓ As for new buildings	100	125
Czech Republic	✓	Regulation 78/2013 Coll.	2016-2018 depending on size	2018-2020 depending on size	✓	✓	75-80% [2,5]	90% [5]	✓ Quantitative	EP, TS	✓ As for new buildings	75-80% [2,5]	90% [5]
Denmark	✓	Building Regulations 2010	1/01/2019	1/01/2021	✓	✓	20	25	✓ Qualitative	EP, OH, TS	✓ As for new buildings	20	25
Estonia	✓	Regulation 68:2012	1/01/2019	1/01/2021	✓ [7]	✓	50-100 [2]	90-270 [2]	✓ Qualitative		✗		
Finland	Under development	Consolidated report to EC	1/01/2018	1/01/2021	✓ [7]	ND			ND		ND		
France	Definition of Positive Energy Buildings under development [8]	Thermal Regulation 2012, National nZEB Plan	28/10/2011	1/01/2013	✓	✓	40-65 [2,3]	70-110 [2,3]	✓ Quantitative [4]	EP, OH, TS	✓	80 [3]	60% PE [2]
Germany	Under development	KfW Efficiency House, National nZEB plan	1/01/2019	1/01/2021	✓	Under develop-ment	40% PE [5]		Minimum share in current requirements for all buildings	EP	Under development	55% PE [5]	
Greece	Under development	Law 4122/2013	1/01/2019	1/01/2021	ND	ND			Minimum share in current requirements for all buildings		Under development		
Hungary	Under development	Amended decree 7/2006, study by University of Debrecen	1/01/2019	1/01/2021	✓	Under develop-ment	50-72 [2]	60-115 [2]	✓ Quantitative	EP	Under development		
Ireland	✓	Draft definition in National nZEB Plan	1/01/2019	1/01/2021	✓	✓	45	~60% PE [5]	✓ Quantitative [4]	CO_2	Under development	75-150	

Figure 7 Excerpt of definitions for "Nearly Zero-Energy Building" for EU member states. Abbreviations for other indicators are: EP – envelope performance, CO2 – carbon emissions, OH – overheating indicator, TS – performance of technical systems. Source: [10]

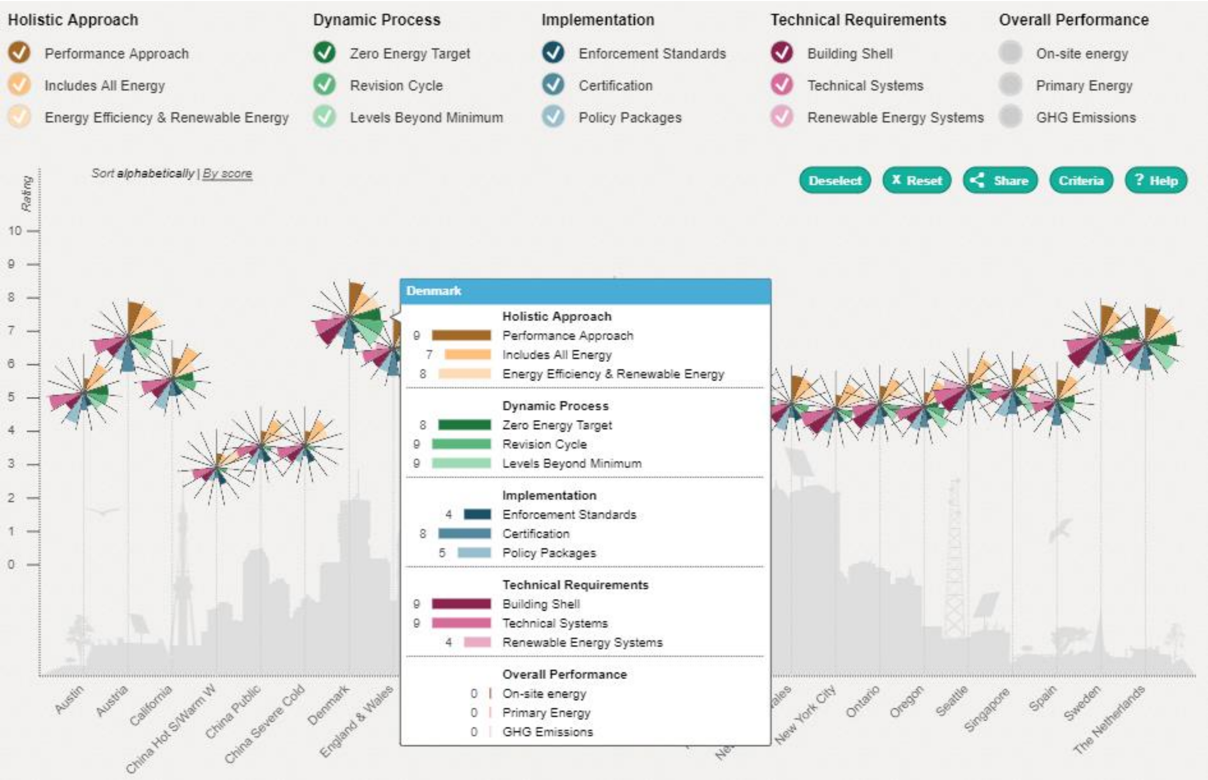


Figure 8 Holistic comparison of building regulations by Global Buildings Performance Network from 2013 [13]