Energy Performance Certificate Database in Denmark

Fact sheet

for:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

On behalf of:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

of the Federal Republic of Germany

European
Climate Initiative
EUKI

by:
Ecofys: Kristen Brand, Bernhard von Manteuffel, Andreas Hermelink

03 September 2018

The project Bridging European and Local Climate Action is financed by the European Climate Initiative (EUKI). EUKI is a project financing instrument by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). It is the overarching goal of the EUKI to foster climate cooperation within the European Union in order to mitigate greenhouse gas emissions. It does so through strengthening cross-border dialogue and cooperation as well as exchange of knowledge and experience.
The information and views set out in this study are those of the author(s) and do not necessarily reflect the official opinion of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

This study is based on a policy paper with an overview of greenhouse gas emission reductions and policy instruments in non-ETS sectors across Europe (hereafter referred to as 'Policy Paper'). The Policy Paper can be downloaded from the EUKI website.

ABBREVIATIONS

BDSG	German Federal Data Protection Act (‘Bundesdatenschutzgesetz‘)
CCC	Council on Climate Change
DEA	Danish Energy Agency
DIBt	German centre of competence for construction (‘Deutsches Institut für Bautechnik’)
DKK	Danish krone
EED	Energy Efficiency Directive
EnEV	German Energy Savings Ordinance (‘Energieeinsparverordnung’)
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
EU	European Union
EUR	Euro
GDP	Gross domestic product
GDPR	General Data Protection Regulation
GHG	Greenhouse gas
IT	Information technology
IWU	Institut Wohnen und Umwelt
m^2	Square metre
MS	Member State
$MtCO_2e$	Million tonnes of carbon dioxide equivalent
NZEB	Nearly zero energy building
SBi	Danish Building Research Institute (‘Statens Byggeforskningsinstitut’)

TABLE OF CONTENTS

1. SUMMARY

Energy Performance Certificates (EPC), and databases that contain all of the information of the EPCs, are a policy tool used throughout the European Union to address the problem of incomplete information about the energy performance of buildings in the housing and buildings market. In order to truly address the issue of non-transparent information and maximise the value and impact of EPCs, national databases have been created to centrally capture the information on energy performance and make it available to a range of stakeholders, which can in turn be used to make purchasing decisions, conduct analyses and inform policy. With high-quality, widely-available information about, e.g. the energetic performance of buildings, building age classes and types, and the share of renewables used, building owners, occupiers and other property actors can make informed purchasing/renting decisions to the benefit of energy efficiency.

Each Member State has its own approach to gathering EPC data, and while differing conventions make immediate comparison difficult, the experiences of other countries offer valuable insight into how the value of a database can be maximised and ultimately contribute to the achievement of energy efficiency targets and emission reductions in the buildings sector. Denmark serves as one such example. In Denmark, an EPC database has been in existence since 1997 and is publicly available online. On the website, the entire EPC and other public information is available. Regular quality checks of the data are carried out and data is uploaded to the system automatically. The breadth, quality and accessibility of the Danish EPC database allows stakeholders to extract and utilise a wealth of information to raise awareness for and ultimately contribute to energy savings.

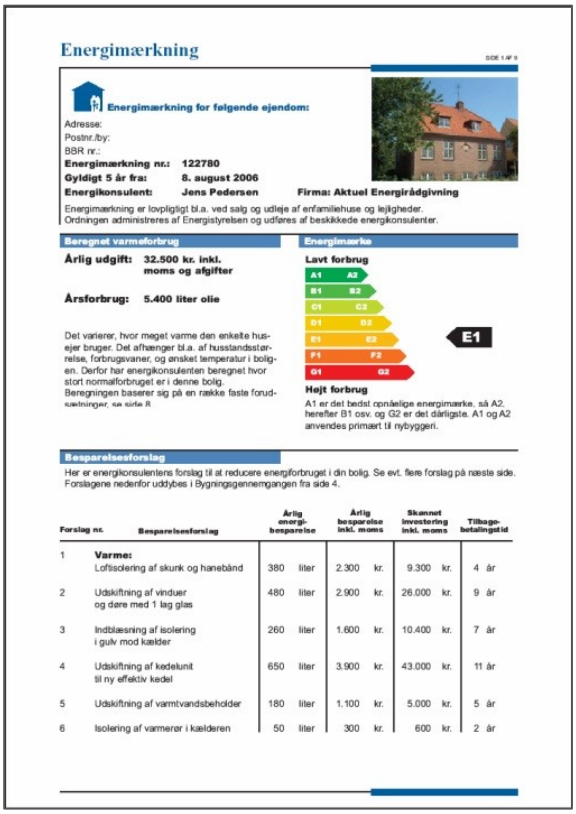
In Germany, a national database exists but is only accessible to enforcing authorities (i.e. the 16 'Länder' governments) and the certifying experts, but not the public. The quality and breadth of the data collected is limited. Due to the strict data privacy laws, the metadata currently collected in the EPC database in Germany (certificate and building type, responsible local government, certifying company) does not include any information about the energy performance of the buildings. The database has also only been in place since the Energy Savings Ordinance ('Energieeinsparverordnung', EnEV) 2014 and thus does not represent extensive coverage of the German building stock. With limited information and accessibility, the database's ability to address the problem of incomplete information about status and progress of energy performance in the housing and buildings market is hindered. The public is prevented from making informed purchasing and renting decisions based on EPC data and research institutions cannot conduct meaningful analyses about the building stock or monitor the progress of efficiency policies and programmes.

This study explores the Danish system and transferability thereof to Germany. After consultation of German and Danish country experts, it can be concluded that while adopting elements of the Danish database is technically feasible in the German context, data privacy legislation presents a fundamental challenge in that it restricts the amount and type of information that may be shared about the energetic performance of buildings. While unlikely that the German EPC database could completely replicate the Danish model, elements thereof could be adopted to improve the system and address the information gap in the German buildings sector. One option could be a confidential database with a more thorough data collection process that results in publicly available aggregate data. Another possibility (not necessarily mutually exclusive) is to have building owners 'opt-in' to make their data available to selected actors.

2. INTRODUCTION TO THE INSTRUMENT

The European Union (EU) established the EPC as a policy measure to address the problem of non-transparent information about the energy performance of buildings in the housing and buildings market and to promote the energy performance of buildings becoming a major determinant of customer decisions regarding the purchase or renting of buildings. Introduced in Art. 7 of the Energy Performance of Buildings Directive (EPBD) in 2002 (European Commission EPBD 2002/91/EC, 2002), EPCs became an important policy instrument that is to create a market pull for enhanced energy performance of buildings and thereby reduce primary energy consumption and greenhouse gas (GHG) emissions in the buildings sector.

The main aim of the EPCs is to serve as an information tool for building owners, occupiers and the property actors when a building or building unit is sold or rented. An EPC depicts the energy performance of a building with a comparison label, similar to that of the EU Energy Efficiency Label. The following Figure 1 shows an example of a Danish EPC.



Energimærkning

SIDE 1 AF 9

Energimærkning for følgende ejendom:

Adresse:
Postnr./by:
BBR nr.:
Energimærkning nr.: 122780
Gyldigt 5 år fra: 8. august 2006
Energikonsulent: Jens Pedersen **Firma: Aktuel Energirådgivning**

Energimærkning er lovpligtigt bl.a. ved salg og udleje af enfamiliehuse og lejligheder. Ordningen administreres af Energistyrelsen og udføres af beskikkede energikonsulenter.

Beregnet varmeforbrug

Årlig udgift: 32.500 kr. inkl. moms og afgifter

Årsforbrug: 5.400 liter olie

Det varierer, hvor meget varme den enkelte husejer bruger. Det afhænger bl.a. af husstandsstørrelse, forbrugsvaner, og ønsket temperatur i boligen. Derfor har energikonsulenten beregnet hvor stort normalforbruget er i denne bolig. Beregningen baserer sig på en række faste forudsætninger, se side 8.

Energimærke

Lavt forbrug

A1 A2
B1 B2
C1 C2
D1 D2
E1 E2
F1 F2
G1 G2

E1

Højt forbrug

A1 er det bedst opnåelige energimærke, så A2, herefter B1 osv. og G2 er det dårligste. A1 og A2 anvendes primært til nybyggeri.

Besparelsesforslag

Her er energikonsulentens forslag til at reducere energiforbruget i din bolig. Se evt. flere forslag på næste side. Forslagene nedenfor uddybes i Bygningsgennemgangen fra side 4.

Forslag nr.	Besparelsesforslag	Årlig energi-besparelse	Årlig besparelse inkl. moms	Skønnet investering inkl. moms	Tilbage-betalingstid
1	**Varme:** Loftisolering af skunk og hanebånd	380 liter	2.300 kr.	9.300 kr.	4 år
2	Udskiftning af vinduer og døre med 1 lag glas	480 liter	2.900 kr.	26.000 kr.	9 år
3	Indblæsning af isolering i gulv mod kælder	260 liter	1.600 kr.	10.400 kr.	7 år
4	Udskiftning af kedelunit til ny effektiv kedel	650 liter	3.900 kr.	43.000 kr.	11 år
5	Udskiftning af varmtvandsbeholder	180 liter	1.100 kr.	5.000 kr.	5 år
6	Isolering af varmerør i kælderen	50 liter	300 kr.	600 kr.	2 år

Figure 1: Example of Danish EPC (BuildingRating.org)

The EPC displays additional information, for example, “recommendations for the cost-optimal or cost-effective improvement of the energy performance of a building” (European Commission & EPBD 2010/31/EU, 2010). According to rational actor theory, building owners are incentivised to invest in energy efficiency measures as a result of EPCs because “a) their awareness of the energy efficiency of their buildings is increased, b) the performance certificate provides information on cost-efficient renovation methods, and c) investments in energy efficiency potentially translate into higher property value” (Amecke, 2011). Therefore, by revealing reliable information on a building’s energy efficiency, EPCs have the potential to be a powerful market tool for influencing purchasing and renting decisions, thereby creating demand for energy efficiency in buildings.

In order to maximise and eventually materialise the potential of the EPCs to improve the energy performance of buildings, it is crucial that the certificates be made available to the relevant stakeholders (i.e. the public). The EU recognised this and with the EPBD recast in 2010 encouraged, but did not require, Member States (MS) to create EPC databases. Currently many EU MS already have an EPC database, but the extent to which the databases are publicly available varies significantly between MS (see Figure 2). Where databases exist either open access to a selection of EPC information is provided[1], only summarised results are made publicly available[2], or access to EPC

[1] Denmark, Estonia, Hungary, Ireland, Lithuania, the Netherlands, Portugal, Sweden, parts of the United Kingdom-England and Wales and Norway.

[2] Belgium-Flanders, Greece, Croatia, Hungary, Romania.

information is provided upon request by a third-party organisation. In some MS, the public does not have access to the EPC database[3].

There are other aspects of EPC databases that can vary and impact the quality and value of the database such as how the information is uploaded to the database and the amount and kind of information included in the database. In nearly all MS, upload is the responsibility of the qualified expert who conducted the assessment and can be done automatically via standardised data protocols before or after the certificate is issued; manually via a form on the online platform; or by sending an electronic copy of the EPC to a central secretariat that is responsible for storing and/or transferring information to the EPC database (BPIE, 2015).

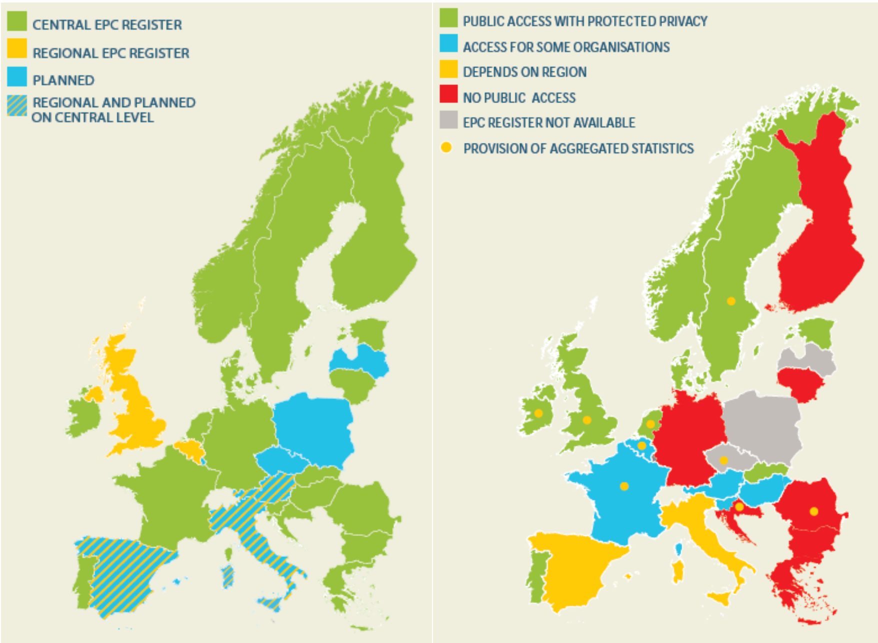


Figure 2: EPC databases across Europe (left) and public access to EPC databases across Europe (right) (BPIE, 2015)

In Denmark, all EPCs are registered in a central database administered by the Danish Energy Agency (DEA) and are displayed on a website accessible to the public. Given, for example, its open nature and extensive content, the Danish EPC database has been chosen as an example of good practice in national climate policy and is analysed in detail in this study, in particular regarding transferability to the German context.

[3] Bulgaria, Germany, Finland, Malta and Cyprus.

3. NATIONAL CONTEXT

3.1 National climate policy

Danish climate change mitigation policy is guided by both compliance with international climate obligations and achieving national targets for the energy sector. Passed in 2014, the regulatory framework for climate-related policy is outlined in the Danish Climate Law. The goal of the statute is “to transform the Danish economy into a low-emission society by 2050” (Danish Energy Agency, 2018). This is described as a future “in a resource efficient society where energy supply is based on renewable energy resources, and where the greenhouse gas emissions from other sectors is significantly lower, while at the same time leaving room for economic growth and development” (Danish Energy Agency, 2018).

In addition to establishing a Council on Climate Change (CCC) (with academic experts in the fields of energy, transportation, agriculture, environmental protection, nature and economics) and submitting annual energy policy reports to parliament, the government also establishes new national climate targets every year. There are several climate-related legal frameworks that set out specific work areas and obligations or targets. The 2015 government platform is to completely phase out the use of fossil fuels by 2050 and the Danish Climate Law, as stated above, seeks a low-emission society by 2050. Denmark also strives to meet the EU’s 2020 and 2030 targets and translate them into national law. In 2030 this means, 39% reduction in GHG compared to 2005 in non-ETS sectors and a renewable share of 50% of energy consumption in 2030. To evaluate the progress made against its climate targets, the DEA (situated under the Danish Ministry of Energy, Utilities and Climate) publishes two reports each year: the Danish Energy Statistics and the Danish Climate and Energy Outlook. According to the Climate and Energy Outlook, Denmark is expected to (over)achieve its goal of reducing GHG emissions from buildings, agriculture and transportation, resulting in an overachievement of 14 million tonnes CO_2e ($MtCO_2e$) during the obligation period. At least every five years, the minister for energy, utilities and climate is to propose national climate targets that have ten-year perspectives and a level of ambition that reflects ambitions for 2050.

3.2 Sector context

To achieve Denmark’s ambitious energy and climate targets, extensive reductions in the energy consumption of buildings are necessary. Denmark seeks a 35% reduction in net energy consumption for heating and hot water in the building stock by 2050 (compared to 2011). Energy consumption in Denmark’s buildings currently accounts for 40% of Denmark’s total energy consumption and heating buildings accounts for 35% of final energy consumption. Denmark has made substantial progress reducing the energy consumption of buildings in recent decades but now has, compared to other MS, a smaller margin for further reductions (JRC, 2016). Nonetheless, with the Building Class 2020, which is likely to be mandatory no later than 2020, Denmark reports to be on track to meet the EU requirements for new buildings to implement nearly zero energy buildings by 2020 (Danish Government, 2014).

An important policy for realising this 35% reduction target is the National Building Renovation Strategy (Art. 4 Energy Efficiency Directive, EED), set out by the government in the report ‘Vores Energi’ (‘Our Energy’) (Danish Government, 2011). The ambitious renovation strategy consists of over 20 new initiatives representing comprehensive coverage of the various building types (JRC, 2016).

According to the Strategy, the new building stock of Denmark is limited compared to the total building stock. While the new building stock during the economic boom years reached 1% of total building stock, this proportion has been substantially lower in recent years and limited demolition of existing buildings has taken place. As a result, most of the existing buildings will remain in use until 2050. Over 70% of the current building stock and 80% of detached houses were erected before 1979 prior to building regulations outlined legitimate energy requirements and thus currently require thorough renovation. Substantial opportunities therefore exist to reduce energy consumption in Denmark's building stock (Danish Government, 2014). The Danish CCC estimates that energy renovation in buildings could result in savings of 1.4 $MtCO_2e$ up to 2030 (The Danish Council on Climate Change [Klimarådet], 2017).

Denmark's building stock is valued at approximately DKK 3,700 billion (EUR 496.5 million), which is more than double Danish gross domestic product (GDP) in a year. About DKK 80–100 billion, 2.1–2.7% of the value of the buildings, is spent on renovation and other investments each year. Annual household spending on heating exceeds DKK 40 billion (Danish Government, 2014).

In terms of savings, the greatest potential can be found in single-family houses, as more than half of the heating consumption in buildings is generated in these dwellings (Danish Government, 2014). An analysis has been conducted by the Danish Building Research Institute ('Statens Byggeforskningsinstitut', SBi) indicating that a 28% reduction in net heating demand compared to 2011 can be achieved in 2050 with the energy efficiency requirements for components included in the 2010 Building Regulations (Wittchen, Kragh, & Aggerholm, 2016).

4. GENERAL DESCRIPTION OF THE POLICY INSTRUMENT

4.1 History

The initial Danish energy certification scheme, established in 1997, consisted of two parts and resulted in three different databases (Thomsen, van Eck, & Heinze, 2009):

> Part 1: Small buildings and owner-occupied flats that should be certified when they were sold; Buildings were certified once based on calculated energy performance. Two companies provided different certification tools and the data was stored in two different databases, one per tool.

> Part 2: Large buildings (> 1.500 square metre (m²)); Buildings were certified every year based on an operational (i.e. measured) rating. Data was stored in a separate database as the structure highly differed from the input to the databases with calculated energy performance.

In 2006, the Danish certification scheme was adjusted as a result of the EPBD (Thomsen et al., 2009). The current Danish energy certification scheme, in place since 2006, also consists of two parts (small buildings < 1.000 m² and large buildings > 1.000 m²), but both are certified with calculated energy performance and not a measured net energy rating. Only one central database, capturing both parts, is currently in place and the calculation of the EPC can only be performed with one calculation engine that companies with various user interfaces are required to use.
Denmark was one of the first European countries to create a central EPC database (Austria: 2005, Bulgaria: 2005, Belgium-Flanders: 2006).

4.2 Legal basis

EPCs were introduced in European legislation for the first time in 2002 in the context of the EPBD (European Commission EPBD 2002/91/EC, 2002). All MS were required to introduce an effective certification scheme by 4 January 2009 for (1) all buildings or building units that are newly constructed or undergoing major renovation, (2) all buildings or building units sold or rented out to a new tenant, and (3) all buildings in which the total useful floor area over 1,000 m² is occupied by a public authority and frequently visited by the public (BPIE, 2014a).

The EPBD recast in 2010 (European Commission & EPBD 2010/31/EU, 2010) added further elements to ensure that EPCs have a high impact in the future. These items include the availability of EPCs in sale and rent transactions (Art. 13), a public register of experts (Art. 17), an independent control system[4] (Art. 18) and penalties for non-compliance (Art. 27). According to the EPBD, it is not mandatory to set up an EPC database; however, most MS have set up a system to collect data on a voluntary basis[5].

In Denmark, 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 1759 of 15 December 2015 (Handbook for EPC experts) (Thomsen et al., 2014).

[4] Annex II of the Directive specifies the EPC verification options that need to be taken into account when designing the scheme, such as the validation of the input data, verification of results and recommendations, on-site visit of the building or other equivalent measures.

[5] In 2014, 24 countries had operational central/regional EPC databases (plus Norway; Poland, Latvia, Luxemburg and the Czech Republic lining up to launch their own registries). In some countries (e.g. the United Kingdom and Belgium – Flanders), there are separate databases for residential and non-residential buildings. For Italy and Spain, the databases are only available in selected regions (BPIE (2015)).

4.3 Functioning

In Denmark, all EPCs are registered in a central database hosted and administered by the DEA. All EPCs are publicly available on the website http://sparenergi.dk. The EPC database contains the data input file entered by the EPC consultant and the report for the building owner. This includes the complete EPC information and other public information such as property and land value. Additionally, online public access is also granted for aggregated statistics on energy performance of the Danish building stock (Find energimærket på din bygning) (Thomsen et al., 2014). More extensive data and a property data report with additional information (i.e. water supply and soil contamination) is available but access must be requested and granted by DEA. For the respective property owners, sensitive information such as overdue debt to the municipality is available (BPIE, 2014b). The supporting documentation such as photographs and other supporting material are not currently stored on the EPC database (Hansen, 2017).

Several screenshots depicting the database can be found below. Despite efforts to make the database user-friendly, it has been noted that for 'normal' building owners the interface can be difficult to use (Hansen, 2017).

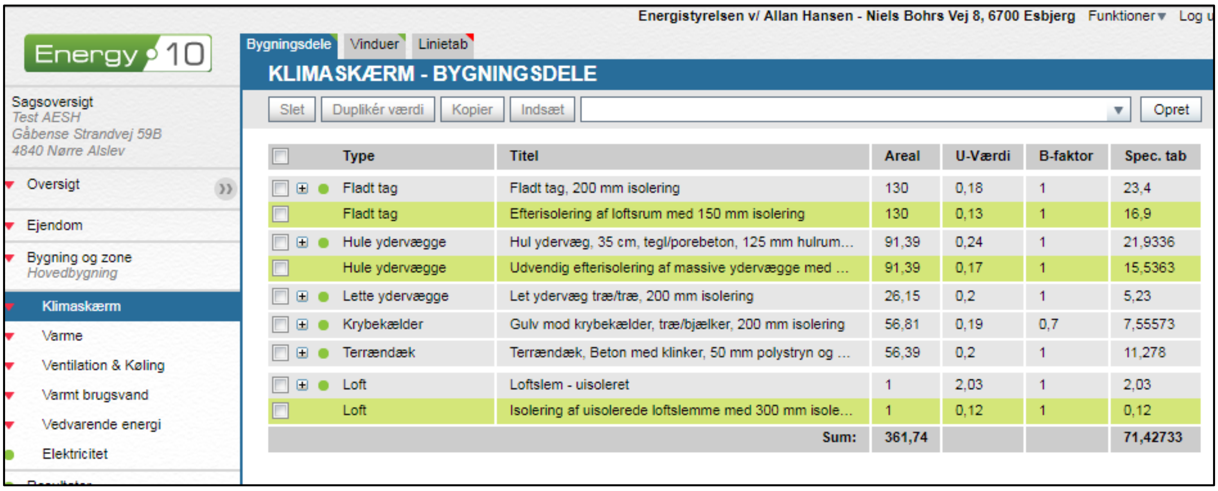


Figure 3: Example of the web-based EPC calculation software (Hansen, 2017)

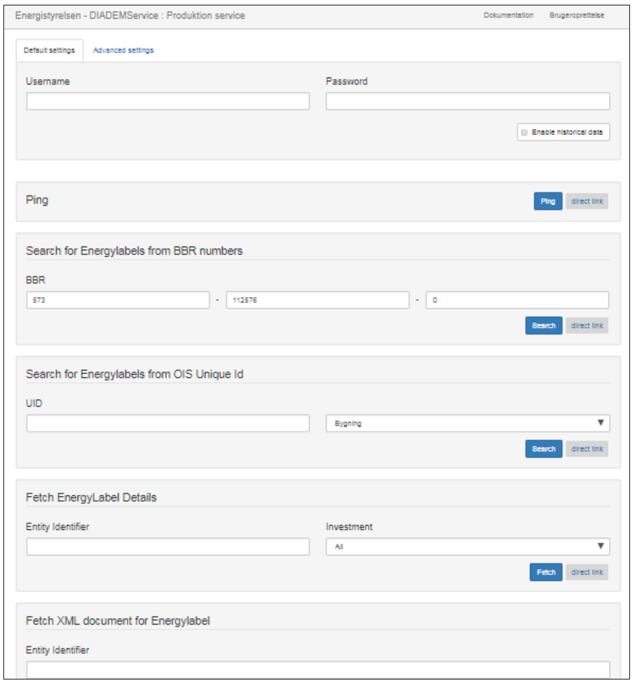


Figure 4: Web-based system to extract details from published EPCs (Hansen, 2017)

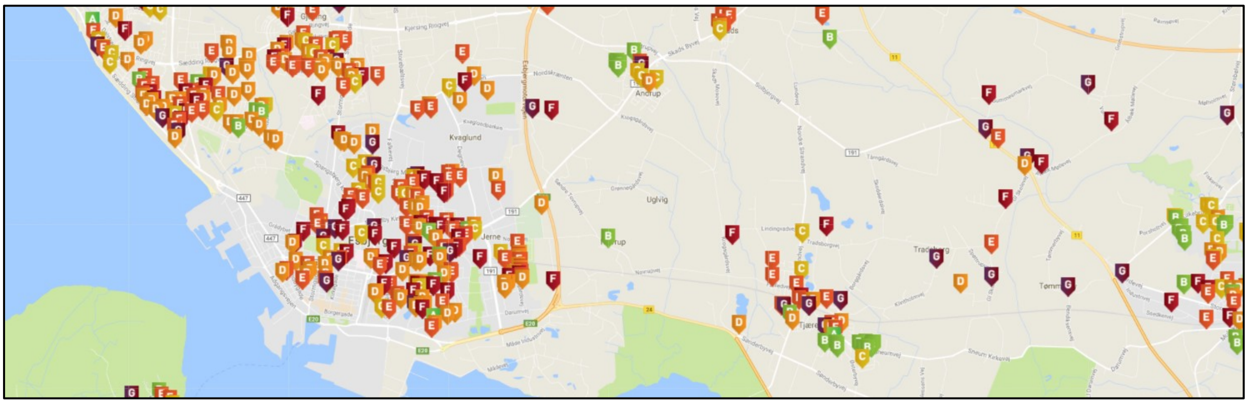


Figure 5: Distribution of EPCs on a map (Hansen, 2017)

Uploading the data to the database is the responsibility of the qualified expert. In Denmark, like in nine other MS, the upload to the EPC database is handled automatically through a standardised data protocol (e.g. xml or editable pdf) instead of manually retyping the results of the EPC in input forms as is the case in three MS (BPIE, 2015).

By the end of 2016, 527,655 EPCs had been issued for new and existing residential buildings. As approximately 61,000 EPCs have been issued in the year 2016, it is likely that this number has since increased to approximately 600,000. It is estimated that about 90% of the EPCs are still active as they are valid for 10 years[6] and many were reissued in 2016[7] (hence the active/valid EPCs in the database totals approximately 540,000). The total stock of new and existing residential buildings is approximately

[6] In Denmark, at least a mechanism exist that reduces the validity of an EPC to 7 years if the EPC identifies significant energy savings with a simple payback time of less than 10 years and with total savings greater than 5% of the energy consumption.

[7] Based on interview with Allan Hansen (DEA) on 08 May 2018.

1,600,000, meaning that currently more than one third (~34%) of the residential building stock is registered in the database (Hansen, 2017).

Figure 6: The digital EPC in Denmark (Thomsen et al., 2014)

When calculating the EPC, it is mandatory to use software systems approved by the DEA. Currently, there are two systems available, both of which are developed by private companies. For each EPC, the assessor pays a fee to the respective company, meaning no public money is used to develop or support the EPC calculation software. It is free to use the software and only when the EPC is published is the assessor required to pay the fee to the software developer and the DEA.

In Denmark, the DEA carries out quality assurances of EPCs on a regular basis and in the case of a complaint (e.g. no EPC provided by owner before rental contract is signed). For these quality checks, random samples from the central EPC database are taken. Also, a digital analysis of the quality of data is performed to detect, for example, outliers and errors. 156 controls were carried out in 2016, which is approximately 0.25% of the annually reported EPCs (Hansen, 2017). When errors are identified, the respective companies must correct the EPC. In the case of substantial errors, the company receives a notification, which may lead to a warning (displayed in the online register of experts) and as a last resort, the certified company may be sanctioned, e.g. have its license suspended. The latter has not occurred in Denmark to date, but as of 2014, 45 warnings had been issued by the DEA (Thomsen et al., 2014).

Furthermore, DEA has developed a digital EPC. Together with a new EPC benchmarking-tool and a financing calculator, the digital EPC makes the EPC easily accessible and useable.

Energy efficiency has become a selling point, and the digital energy label offers a quick overview of a building's overall economic profile (Thomsen et al., 2014). Figure 6 above shows an example of the digital energy label in sale advertisements.

The EPCs, and therefore also the EPC database, include recommendations for cost-effective energy efficiency measures. These recommendations do not replace an in-depth energy consultation but provide a first indication for next energy efficiency actions to the landlord.

Often EPC databases are accessible to or administered by research institutes or similar organisations that use the data to perform tasks such as:
Identify energy savings potential for different building types;

- Analyse potential costs of the savings; and
- Support political initiatives for promoting energy savings.

In Denmark, the SBi at Aalborg University has access to the database and is able to perform these tasks for the Danish Government (Thomsen et al., 2014).

4.4 Interlinkages with other policy instruments

The Danish EPC database is interlinked with the Danish Strategy for Energy Renovation, which provides a strategic framework for increased use of EPCs by giving them a more obvious link to energy renovation (Thomsen et al., 2014). In the Strategy for Energy Renovation, several objectives are described as part of the government's approach to maintaining an effective and targeted energy labelling scheme for buildings. These include, amongst others, setting up a website where building owners and tenants can use the energy labels to better understanding the energy saving potential in their buildings; draw up guidelines for how energy labelling can assist with building maintenance and renovation; and strive for improvements in the quality, simplicity, and costs of energy labelling (Danish Government, 2014).

As part of the Strategy for Energy Renovation, the EPCs and the database, as with all initiatives, should be coordinated to create synergies. The Strategy points out that, for example, the objective in the Climate Plan to reduce Denmark's total GHG emissions by 40% in 2020 compared to 1990 levels has the same aim of reducing energy consumption and is thereby inextricably linked. The Strategy should also be considered compatible with the government's architecture policy 'Mennesket in centrum' ('Putting people first') published in 2014 (Danish Government, 2014).

5. IMPACTS OF THE POLICY INSTRUMENT

5.1 Effectiveness

A well-designed and long-standing EPC database such as the one in Denmark, with automatic data uploading and validation, can contribute to reduce energy demand and emissions in various ways. With a wide range of information available, the Danish building stock can be characterised with high accuracy as more than 30% of the residential buildings in Denmark being part of the EPC database. Also, the Energy Efficiency Watch Project found that 21% of experts considered energy certification of buildings in Denmark to be very effective (partly effective: 56%; not effective at all: 23%). For comparison, in Germany this number is lower with 14% (partly effective: 50%; not effective at all: 35%) (Energy Efficiency Watch, 2015).

This enables policy makers to draw reasonable conclusions about where to set the right energy saving incentives in the future. For example, the penetration of the higher efficiency certification classes (A–B) in comparison to the ones with lower efficiency (C–G) can be monitored over time (see Figure 7).

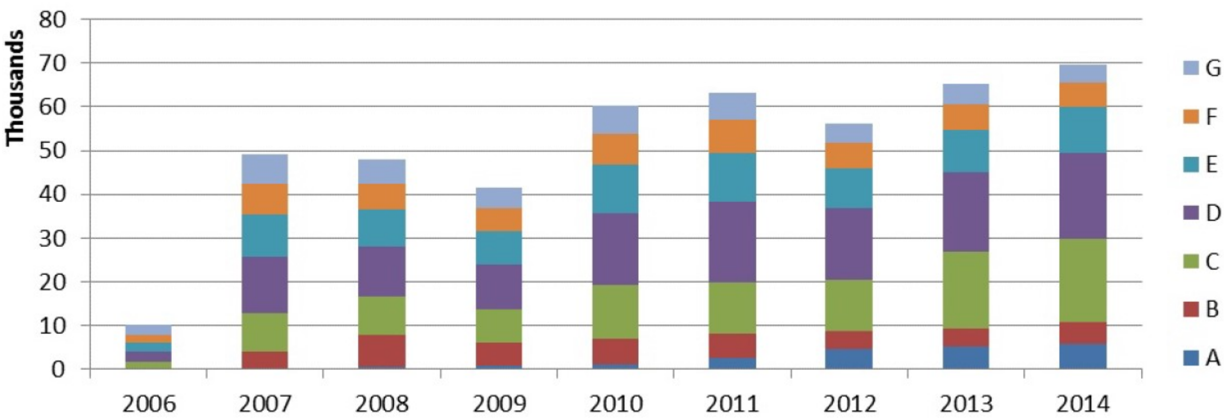


Figure 7: Evolution of the EPC classes for Danish residential buildings (Thomsen et al., 2014)

As a result, the effectiveness of policy instruments to ensure a shift to the future nearly zero energy building (NZEB) classes[8] can also be monitored.

In addition, statistics per building type can also be extracted from the EPC database, making it possible to differentiate between policy instruments per building type. The following figure shows all registered Danish residential buildings since 2006 per certification classes A to G.

[8] EPC class A including A2010, A2015 but also the NZEB class A2020.

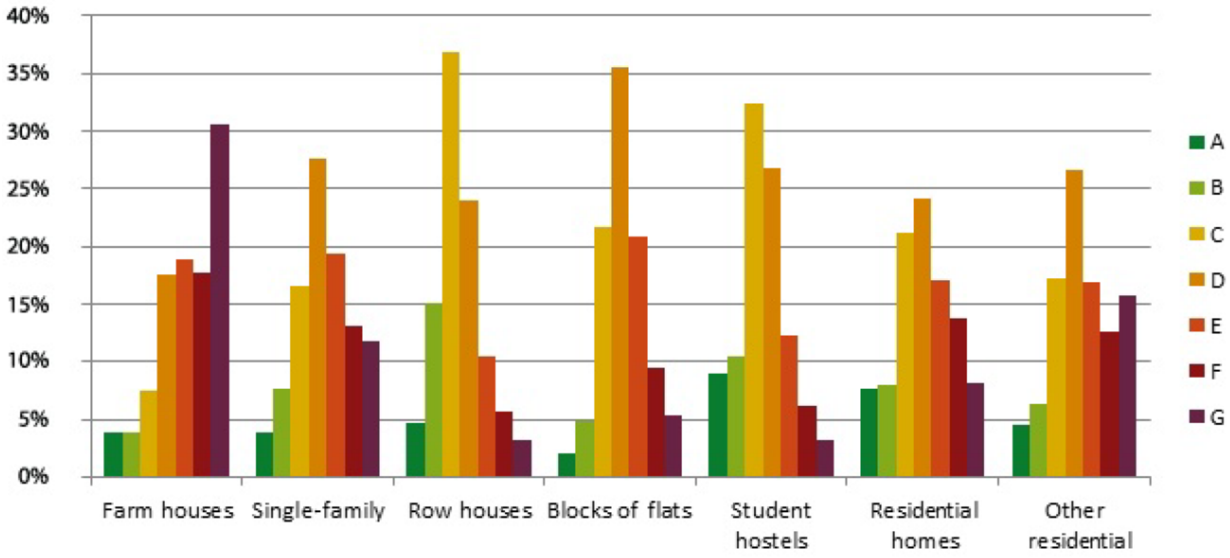


Figure 8: Distribution of the EPC classes for Danish residential buildings as registered in the current EPC scheme since 2006 (Thomsen et al., 2014)

Therefore, the Danish EPC database enables policy makers to identify savings potentials for different building types and analyse potential costs of these savings e.g. to support political activities that promote energy savings.

Furthermore, openly accessible data can raise awareness for the energy efficiency topic amongst the public, e.g. when comparing the building class of the own building with buildings in the neighbourhood. The database can also serve as a benchmarking tool allowing the user to see how common the building class of his/her building is on national level.

In Denmark, another important effect of having an EPC database is the impact on the price of buildings. A study of the SBi and the Aalborg University (Jensen, Kragh, & Hansen, 2013) showed that the sales prices of single-family houses increased in correlation with improved EPC classes of the buildings (Thomsen et al., 2014).

Generally, it can be stated that for an EPC database to be effective, the following conditions need to be met (Loga et al., 2012):

- data is collected in one central database
- data is of high quality (ensure high education and skills of the building energy performance expert)
- data is updated on a regular basis
- data is comprehensive so that it is possible to extract enough information from the database to redo the energy performance calculation
- database must be based on professional database management tools to ease analyses and reporting from the database

By implementing a system that broadly fulfils these criteria, the Danish authorities have effectively used EPC and other public information to inform stakeholders in the buildings sector and contribute to energy savings.

5.2 Cost efficiency

In Denmark, the tasks associated with registrations of certified energy labelling companies, supervision, control, quality assurance, operation of registers and other information technology (IT) systems, and other aspects of managing the energy labelling scheme is financed by the fee levied on each published EPC[9]. The cost of running the website in 2016 totalled EUR 604,838, but it should be noted that the site contains all EPBD information and not solely EPCs. This is also the case for the Helpdesk, which cost EUR 134,408 in 2016. In 2016, the cost of conducting quality controls of the database totalled EUR 127,688. The exact costs of implementing the Danish EPC database are not available but are likely low given the aforementioned website and Helpdesk costs. According to the DEA, the EPC scheme is self-financing (Hansen, 2017).

The DEA only hosts the database and performs automatic or randomised quality checks. Therefore, the efforts are manageable in comparison to the various positive effects of a central and publicly available database.

The cost efficiency of an EPC database is difficult to quantify as the information that can be extracted from it can be used for various purposes that are each able to support GHG emission reductions (e.g., monitor implementation and impact of policies and programmes with EPC information from the past and today). As the costs for the database are relatively low, it can be assumed that an EPC database is nearly cost-neutral.

5.3 Co-benefits and side-effects

As outlined in chapter 4.3 and 5.1, there are numerous energy savings benefits of a central EPC database where the data is analysed regularly.

An EPC database with sufficient information on the building stock functions as a tool to monitor the implementation and impact of policies and programmes also on EU level like the independent control system (EPBD, Art.18). On national level, such a database can help to set minimum energy performance requirements or serve as an input to the design of national renovation strategies (BPIE, 2015).

In addition to these aspects, the data can be used for market and economic studies showing e.g. potentials for future investments in retrofit activities. One example is the research project EPISCOPE (Wittchen & Kragh, 2016), which uses Danish EPC data to compare energy demands before and after renovation activities.

5.4 Success factors and challenges

The elements contributing to the success of the Danish EPC database have been described in the previous sections. In summary, publicly available EPC databases have proven to be extremely useful in the following ways:

- Ensuring higher accuracy of building stock data;
- Monitoring implementation and impact of policies and programmes (current compliance rates and future policy making);

[9] For single family homes EUR 17.50 for the DEA, plus EUR 13.50 for the company behind the calculation software.

> Promoting renovation activities, energy savings and potential;
> Raising public awareness for EPC classes/building energy efficiency;
> Serving as a source of data for research projects;
> Influencing the market in the direction of improved energy efficiency in buildings (relationship between sales prices and EPC class).

Despite the many reasons for supporting the implementation of an EPC database, there are several challenges that must be overcome if the German database shall become as successful as the Danish example.

Data entry and validation has the potential to be a challenge in database development and maintenance, but this must be done in order for the database to be useful and generate a certificate identification (ID). Data entry can be done manually (manual entry in input form) or automatically (uploading a standardised data protocol) like in Denmark. Manual entry can be cumbersome for the user and administrators of a database and automatic data entry requires that the system be both programmed properly and easy to use. Similarly, errors can, particularly in the case of manual data entry, arise and prompt the need for quality assurance. Protocols for quality assurance need to be developed and then regularly executed. Errors in data input are among the most typical factors influencing the quality of EPCs (Loga et al., 2012). In the case of Denmark, quality assurance is carried out by the DEA on a regular basis and in case of a complaint. In addition to a standardised digital quality assurance to detect outliers and errors, random samples are taken from the database and evaluated in detail (see section 4.3).

The database interface can also prove to be a sticking point in EPC databases. To be useable, the interface must be user-friendly and self-explanatory for laypeople. Unlike those issuing EPCs or analysing the data, the general public, which is often the target audience of such databases, does not possess in-depth knowledge of the buildings sector and technical elements of EPCs. They must be able to identify the basic information required to make their purchasing/renting decisions.

A general comparison issue with regard to EPCs is whether the EPC are based on calculated energy demand (based on energy demand software) or metered consumption data (based on real consumption data of several years). These two types of EPCs differ significantly as the standard input values in energy demand calculations of energy demand-based EPCs often do not mirror the reality (e.g. ventilation losses, indoor temperatures, or only partly heated buildings). Nevertheless, standard input values can help make the energy performance of building more comparable as user behaviour is standardised. Therefore, within an EPC database it must be ensured that the respective certificate type is sufficiently highlighted and that aggregations are performed separately for calculated energy demand and metered consumption EPCs.

Lastly, to maintain relevance and meet the desired policy aims, EPC databases must be updated at regular intervals. The EPCs of many buildings are only updated every ten years and not on a yearly basis (e.g. with energy consumption data) as would ideally be the case. Old and therefore, in many cases inaccurate, EPCs impact the overall accuracy of the database and reduce the relevance of the instrument for policy makers. In the worst case, policy makers with an outdated EPC database might set inappropriate targets or establish misguided renovation incentives and programmes. In Denmark, a mechanism exists that reduces the validity of an EPC to seven years if the EPC identifies significant energy savings with a simple payback time of less than ten years and with total savings greater than 5% of the energy consumption.

According to the DEA, the cost and time efficiency regarding the independent control process could be improved. Furthermore, to expand the usability of the database, tailor-made analyses of the EPC database for companies could be facilitated, for example, to conduct market-based product assessments (e.g. for companies to identify areas where their services are needed). Lastly, the EPC database requires a ‘data-wash’ to remove any EPCs that are no longer applicable. In Denmark, an estimated 10% of the EPCs within the database are outdated/inactive[10].

[10] Source: Interview with Allan Hansen (DEA) on 08.05.2017.

6. TRANSFERABILITY

6.1 General comparability of the context

In assessing the transferability of the Danish EPC database model to the German context, it is clear that economic considerations, the makeup of the buildings sector, or market actors do not present the biggest barriers to adoption. Since Germany already has a database in place but is lacking several elements that make the database more impactful (i.e. transparency and high-quality content), transferability is most relevant in the political, administrative, and even cultural context.

The primary barrier to full adoption of a Danish approach to an open EPC database is that of data protection. The German Data Privacy Law ('Bundesdatenschutzgesetz', BDSG) and the recent General Data Protection Regulation (GDPR) on EU level protects personal data including information about the energetic quality of single buildings. For this reason, no complete, publicly available database is currently in place.

Despite the limitations presented by the German Data Privacy Law, confidential database input for aggregated data outputs (e.g. analyses per building type) have been used in recent projects such as for the city of Hamburg and may also be possible in other federal states of Germany.

One could generally conclude that the concept of a more open EPC database similar to that of the Danish example, could be implemented in Germany if personal data is secured, albeit not fully available to the public. A detailed analysis of the data privacy law in Germany (BDSG) and the GDPR on EU level, however, would be necessary to test this assumption.

6.2 Properties of the instrument

As Germany already has a central EPC database, taking the next steps and improving the database with higher quality information is fairly straightforward. In Germany, the German centre of competence for construction ('Deutsches Institut für Bautechnik', DiBt) already uses an automatically generated output (xml-file) containing all EPC data when performing quality checks on the EPCs, which could be used for the future automatic upload of the EPC data (Deutsches Institut für Bautechnik, 2018).

An improvement of the German database would require Germany to extend the validity check of uploaded data to new data inputs (e.g. plausible thresholds for primary energy demands). Furthermore, the data would need to be made available (in useable formats) to the parties allowed to extract it from the database. Therefore, a user-friendly online platform would need to be developed. Also, a publicly available database would naturally invite more interest, and as a result more queries and requests for information from the database will be raised with the DiBt. Consequently, additional personnel would likely be needed to administer the setup and maintenance of the new database.

In Germany, the registration of EPCs[11] and the collection of EPC metadata in a central database has only been in place since 1 May 2014 as part of the German Energy Savings Ordinance (EnEV 2014). Accompanying the database, a control system for validating the EPCs has also been in place since

[11] Note: EPCs existed since the EnEV 2007 but without a central registration.

2014[12]. The authority responsible for addressing national building control issues, DiBt, oversees the central database and performs a validity check of the input data for the German government whereas detailed quality control is performed by the Länder (Schettler-Köhler, 2015).

When considering transferring the Danish EPC database example to Germany, the key barrier, however, is Germany's strict data privacy law (BDSG). Due to the strict data privacy laws, the metadata currently collected in the EPC database in Germany does not actually include any information on the energy performance of the buildings and is thus very limited in terms of the value it could generate (see chapter 5). The metadata collected in the German database comprises of only the following:

- Type of certificate;
- Building type;
- New or existing building;
- Responsible local government;
- The certifying company.

This data is collected upon the mandatory registration of EPCs according to EnEV (§26c) and is accessible to enforcing authorities (i.e. the 16 Länder governments) and the certifying experts, but not the public. To resemble the Danish example, the German database and EPC processing procedures would need to be reconfigured to allow maximum data input within the confines of data privacy restrictions. Apart from these increased efforts and if no legal barriers hinder implementation, the concept of the Danish EPC database can be transferred to Germany.

6.3 Potential impacts

As addressed in chapter 5, there are numerous benefits of a publicly available and high-quality EPC database. While estimating the quantitative impacts of an improved database for Germany proves to be extremely difficult, it is clear that Germany could benefit from better building stock data, a more thorough understanding of the impact of certain policies and programmes on energy consumption/GHG emissions and increased public engagement and awareness of energy savings. Furthermore, Germany could see increased transparency for parties purchasing or renting, more advanced analysis of building data for public research projects, linking of energy performance to financial incentives, and ultimately a shift in the market towards more energy efficient buildings.

One example of a Danish study from 2016 using primarily the records in the EPC database as a basis for the calculation model is 'Potential Heat Savings During Ongoing Renovations of Buildings Until 2050'. The study was conducted as part of the Danish participation in the EPISCOPE project supported by Intelligent Energy Europe (Wittchen et al., 2016).

In Germany, the building energy efficiency analyses are often based on the study on the database of the building stock 'Datenbasis Gebäudebestand' from 2010 (Diefenbach, Cischinsky, Rodenfels, & Clausnitzer, 2010) and other relevant but sometimes outdated studies. Up-to-date and historical EPC data from a database could contribute to more accurate and extensive analyses.

[12] Quality assurance is organised in accordance with the three options of the Directive 2010/31/EU. Option A: validity check of input data of the building (Info Germany: 5% random sample by DiBt); option B: check of the input data and verification of results; option C: full check of the input data and results, possibly including site visit (info Germany: the 'Länder' decide on option B and C).

6.4 Conclusion

This study explores the Danish EPC database system and the transferability thereof to Germany. The experiences of Denmark offer valuable insight into how the value of a database can be maximised and ultimately contribute to the achievement of energy efficiency targets and emission reductions in the buildings sector.

After consultation of German and Danish experts, we find that Denmark's EPC database can serve as a role model for Germany. The Danish database is publicly available on a website, where the entire EPC as well as other information is provided. The quality and accessibility of the Danish EPC database, allows stakeholders to extract and utilise a wealth of information to raise awareness about energy consumption and savings. Armed with this information, users can make informed purchasing and renting decisions, ultimately contributing to energy savings in the buildings sector.

In Germany, a central EPC database is currently in place, but the amount and type of information collected cannot support meaningful analyses and access to the database is restricted. The Danish database whereas is publicly available and provides a wealth of information upon which consumers can base purchasing decisions and researchers and policy makers can conduct analyses. While it is questionable whether the German database can be altered to reflect all of the positive aspects of the Danish experience, it is likely that smaller changes can be made to improve the value and usability of the German database on a relatively short term.

In this respect, several scenarios for Germany are foreseeable. One option could be a confidential EPC database where the upload of the standardised data protocols, which are automatically produced by the energy certification software when printing an EPC, is mandatory before receiving a certification ID. With this confidential data, publicly available aggregations (e.g. per building type and region) are performed and serve as a benchmarking tool for building owners to raise awareness. Furthermore, more concise aggregations would be possible for researchers and policy makers within the confines of data privacy restrictions.

Secondly, to further improve the data quality, building owners could be given the possibility to 'opt-in' and make their detailed data (searchable by address) available to

a. the public,
b. non-governmental organisations conducting research, or
c. only for policy making purposes.

The first option (a.) would raise awareness as building owners and residents could compare the energy performance of their buildings with others in their neighbourhood. The two following options (b. and c.) could, despite partially restricted access, facilitate research, energy concepts and policy recommendations on various levels (city, federal and national level).

While unlikely that the German EPC database could completely replicate the Danish model, elements thereof could be adopted to improve the system and address the information gap in the German buildings sector.

7. REFERENCES

Amecke, H. (2011). *The Effectiveness of Energy Performance Certificates: Evidence from Germany*. CPI Report. Retrieved from Climate Policy Initiative (CPI); Deutsches Institut für Wirtschaftsforschung (DIW) website: http://climatepolicyinitiative.org/wp-content/uploads/2011/12/Effectiveness-of-Energy-Performance-Certificates.pdf

BPIE. (2014a). *Energy Performance Certificates across the EU.: A mapping of national approaches.* Brussels.

BPIE. (2014b). *Energy Performance Certificates Databases: Current status of implementation across Europe.*

BPIE. (2015). *Central Energy Performance Certificate Register*. Brussels.

Danish Energy Agency. (2018). Danish climate policies. Retrieved from https://ens.dk/en/our-responsibilities/energy-climate-politics/danish-climate-policies

Danish Government. (2011). *Vores Energi.*

Danish Government. (2014). *Strategy for energy renovation of buildings: The route to energy-efficient buildings in tomorrow's Denmark*. Copenhagen.

Deutsches Institut für Bautechnik. (2018). EnEV-Registrierstelle: EnEV 2013: Stichprobenkontrolle. Retrieved from https://www.dibt.de/de/Geschaeftsfelder/GF-EnEV-Registrierstelle-Stichprobenkontrolle.html

Diefenbach, N., Cischinsky, H., Rodenfels, M., & Clausnitzer, K.-D. (2010). *Datenbasis Gebäudebestand – Datenerhebung zur energetischen Qualität und zu den Modernisierungstrends im deutschen Wohnugebäudebestand* (Germany No. 19.03.2012).

Energy Efficiency Watch. (2015). *SURVEY REPORT 2015: Progress in energy efficiency policies in the EU Member States - the experts perspective*. Retrieved from http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Survey_Summary_EEW3/EEW3-Survey-Report-fin.pdf

European Commission, & EPBD 2010/31/EU. (2010). RICHTLINIE 2010/31/EU DES EUROPÄISCHEN PARLAMENTS UND DES RATES vom 19. Mai 2010 über die Gesamtenergieeffizienz von Gebäuden. (153), 13–35.

European Commission EPBD 2002/91/EC. (2002). *The Energy Performance of Buildings Directive (2002/91/EC).*

Hansen, A. (2017). *S18-Knowledge market on costs for the development and operation of the EPC registers and associated software: EPBD CA IV Bucharest Meeting-26 October 2017.*

Jensen, O. M., Kragh, J., & Hansen, A. R. (2013). Energimærke og salgspris. *Energiforum Danmark*. (4), 18–20. Retrieved from https://issuu.com/dortenorregaardlarsen/docs/energiforum_danmark_4-2013

JRC. (2016). *Synthesis Report on the assessment of Member States' building renovation strategies*. Retrieved from http://publications.jrc.ec.europa.eu/repository/bitstream/JRC97754/syntesis%20report%20building%20renovation%20strategies_online%20fin.pdf

Loga, T., Diefenbach, N., Corrado, V., Corgnati, S., Ballarini, I., Talà, N., Kragh, J. (2012). *Use of Energy Certificate Databases as Data Source for National Building Typologies: TABULA Thematic Report N° 1*. Darmstadt.

Schettler-Köhler, H.-P. (2015). *Implementation of the EPBD in Germany: Status in December 2014.*

The Danish Council on Climate Change (Klimarådet). (2017). *Transition Towards 2030: Building Blocks for a Low-Carbon Society*. Retrieved from Klimarådet website: http://www.klimaradet.dk/en/analyser/denmark-and-eus-2030-climate-goals

Thomsen, K. E., van Eck, H., & Heinze, C. (2009). *Database Management*. Berlin.

Thomsen, K. E., Wittchen, K. B., Ostertag, B., Varming, N. B., Egesberg, L. T., & Hartung, T. (2014). *Implementation of the EPBD in Denmark: Status in December 2014.*

Wittchen, K. B., & Kragh, J. (2016). *Danish building typologies and building stock analyses*. Copenhagen.

Wittchen, K. B., Kragh, J., & Aggerholm, S. O. (2016). *Potential heat savings during ongoing renovations of buildings until 2050*. Copenhagen.