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DANISH BUILDING TYPOLOGIES AND BUILDING STOCK ANALYSES

PARTICIPATION IN THE EPISCOPE PROJECT

SBI 2016:18

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Foreword

This report is made as part of the Danish participation in the EPISCOPE (Energy Performance Indicator Tracking Schemes for the Continuous Optimisation of Refurbishment Processes in European Housing Stocks) project supported by Intelligent Energy Europe (IEE/12/695/SI2.644739).

EPISCOPE have the following European partners:

- Institute for Housing and Environment (co-ordinator), Germany,
- Buildings Performance Institute Europe (BPIE), Belgium
- Building and Civil Engineering Institute ZRMK, Slovenia
- Danish Building Research Institute, Aalborg University; Denmark
- Austrian Energy Agency, Austria
- Building Research Establishment Ltd, United Kingdom
- National Observatory of Athens, Greece
- Flemish Institute for Technological Research (VITO), Belgium
- Politecnico di Torino - Department of Energy, Italy
- STU-K, Czech Republic
- Energy Action Limited, Ireland, Ireland
- Budapest University of Technology and Economics, Hungary
- Valencian Institute of Building, Spain
- Cyprus University of Technology, Cyprus
- Delft University of Technology, Netherlands
- Pouget Consultants, France
- Norwegian University of Science and Technology, Norway

The strategic objective of the EPISCOPE project was to make the energy refurbishment processes in the European housing sector more transparent and effective with the aim to ensure that the climate protection targets will actually be attained and that corrective or enhancement actions can be taken in due time. Due to the fact that such actions are required on national, regional and local level the project approach is to implement pilot actions on these different scales and to align and combine them by means of a common methodology.

The conceptual framework is based on national residential building typologies developed during the IEE project TABULA. These classification schemes for national building stocks have been extended to further countries. An upgrade of the WebTool also reflects the national interpretations of "Nearly-Zero Energy Buildings" (NZEB).

A major project activity was tracking the energy refurbishment progress of selected housing stock entireties. Some of these typology based "pilot actions" focus on distinct housing portfolios on local level, others on entire regional or national housing stocks. The Danish case study comprises homes in the ProjectZero in Sønderborg.

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Content

Typologies for ZBEB buildings

The Danish EPISCOPE building typology comprises residential buildings (detached single family houses; terraced houses; and blocks of flats) divided into typical age categories that each reflecting a change in building tradition or a change in building energy requirements stated in the changing different Danish building codes. The first nation-wide building energy requirements were introduced in the Danish building regulations 1961, and they have been tightened several times since then.

Table 1. Identified typical building periods in the Danish EPISCOPE building typology.

Period of construction	Comment
Before 1850	Solid walls
1851–1930	Shift in building tradition
1931–1950	Cavity walls introduced
1951–1960	Insulated cavity walls introduced
1961–1972	First energy requirements in BR61 [a)]
1973–1978	Tightened energy requirements in BR72 [a)]
1979–1998	Tightened energy requirements in BR78 [a)]
1999–2006	Tightened energy requirements in BR98 [a)]
2007–2010	Tightened energy requirements in BR06/08 [a)]
2010-2015	Tightened energy requirements in BR2010 [a)]
2015-2020	Tightened energy requirements in BR2015 [b)]
After 2020	Tightened energy requirements in BR2020 (NZEB) [b)]

a) BR is a reference to the Danish Building Regulations and the following digits refer to the year when the BR came into force.
b) Indicates the expected years for future Danish Building Regulations that will come into force.

In the Danish 2010 Building Regulations, there are projections for planned tightening of the building energy requirements that are expected to come in-to force in 2015 and 2020. The planned 2020 building energy requirements reflect the Danish nearly zero energy building (NZEB) building energy performance requirement. Currently the maximum consumption of primary energy for a residential building that complies with the 2020 requirements is 20 kWh/m² per year, covering heating, domestic hot water, ventilation, electricity for operating the building (fans, pumps, etc.) and potential penalty for overheating (calculated as the amount of electricity converted to primary energy, used in an imaginary mechanical cooling system with an average COP of 3, to bring down the indoor temperature to 26 °C). For non-residential buildings the limit for primary energy consumptions is 25 kWh/m² per year, which in addition to the above also includes electricity for artificial lighting.

Current Legal Requirements and Status of National NZEB Definition for Residential Buildings in Denmark

This chapter section presents an outline for the transposition and implementation of the EPBD (Energy Performance of Buildings Directive) Energy Performance (EP) requirements in Denmark. It also describes the future transition to the cost-optimal EP requirements, as well as the action plan for progression to NZEB by 2020.

Table 2. Development of energy performance requirements (kWh primary energy per m² of heated gross floor area per year) for typically sized residential and non-residential buildings in Denmark.

kWh/m² per year	2006	2010	2015	2020
Residential, 150 m² heated gross floor area	84.7	63.0	36.7	20
Non-residential, 1000 m² heated gross floor area	97.2	73.0	42.0	25

Minimum requirements for new residential buildings in Denmark

The EP requirements for new buildings were implemented in their current form, i.e., the EP calculation method, in 2006, after the implementation of the first EPBD. These requirements included forecasts for the tightening of the EP requirements in 2010 and 2015 — by approximately 25% compared with the 2006 requirements in each step. In 2009, the requirements were revised, and the EP requirements for new buildings were tightened by 25% in the Danish Building Regulations 2010 (BR2010). In the 2010 revision, no forecast for the 2020 EP requirements was included, but the building industry requested this forecast. This led to a process of cost analysis for establishing the different levels of EP requirements. The outcome was the forecast for the EP requirements for new buildings in 2020 — i.e., the Danish NZEB definition.

For existing buildings, the requirements were initially implemented according to the definition of the 25% rule stated in the EPBD (though no area threshold was implemented), in combination with component requirements. According to the previous Danish Building Regulation, all cost-effective measures had to be implemented if more than 25% of the building envelope or the value of the building were affected in a renovation project. However, studies regarding the impact of this rule on the implementation of energy saving measures showed that the rule was a hindrance to energy savings. It was thus decided to increase the uptake of energy saving measures in the existing building stock, by implementing more strict requirements for the replacement or renovation of the individual building components. The BR2015 includes a list of minimum requirements; most of these are considered economically profitable under normal conditions. However, the requirements for the replacement of windows must be fulfilled without consideration of the economic aspects.

New buildings

The existing BR2015 sets the minimum energy requirements for all types of new buildings. These requirements relate to the energy frame and the envelope of the building. In addition to the minimum requirements, BR2015 also sets the requirements for the voluntary Building Class 2020. This class is expected to be introduced as the minimum requirements by 2020.

The energy frame is the maximum allowed primary energy demand for a building, including e.g., thermal bridges, solar gains, ventilation, heat recovery, cooling, lighting (non-residential buildings only), boiler and heat pump efficiency, electricity for operating the building, and potential sanctions for overheating. The overheating sanction is calculated on a fictive energy use, equal to the energy needed in an imaginary mechanical cooling system in order to keep the indoor temperature at 26 °C. This additional energy use is included in the calculated overall energy demand of the building.

The energy frame for the primary energy demand in new buildings has been tightened by approx. 50% compared with the 2006 baseline. Building Class 2020 further tightens the energy frame by additional 25%, thereby reducing the allowed energy frame by 75% compared with the 2006 baseline.

The building code also sets requirements for calculating the design transmission heat loss for the opaque part of the building envelope for new buildings (it fixes the temperature differential indoors-outdoors at 32 ºC), as well as the minimum requirements for components and installations. Requirements to installations are laid out in accordance with relevant EU ordinances and directives. The minimum building envelope component requirements are primarily intended to eliminate the risk of mould growth due to cold surfaces. It is not possible to construct a building, meeting the energy frame solely by fulfilling the minimum component requirements. Both sets of requirements work in parallel with the requirements for the energy frame, and are set in order to avoid having new buildings with a high level of renewable energy production but a poor insulation level. A Building Class 2020 building must be constructed so that the designed transmission loss does not exceed 3.7 W/m² of the building envelope in the case of single-storey buildings, 4.7 W/m² for two-storey buildings and 5.7 W/m² for buildings with three storeys or more.

The BR2010 minimum energy frame requirement was:

– 52.5 + 1,650 / A [kWh/m^2.year] for residential buildings, and
– 71.3 + 1,650 / A [kWh/m^2.year] for non-residential buildings,

where A is the heated gross floor area.

The BR2015 minimum energy frame requirement is:

– 30 + 1,000 / A [kWh/m^2.year] for residential buildings, and
– 41 + 1,000 / A [kWh/m^2.year] for non-residential buildings.

The energy frame for the voluntary Building Class 2020 (NZEB) is:

– 20 / A [kWh/m^2.year] for residential buildings, and
– 25 / A [kWh/m^2.year] for non-residential buildings.

In addition to the energy performance requirements, there are requirements for the thermal indoor climate. The room in a residential building that has the highest internal loads must not show indoor room temperatures above 27 °C for more than 100 hours per year and not above 28 °C for more than 25 hours per year. The number of hours with high room temperatures in residential buildings can be calculated in the national energy performance compliance checking tool, Be15. For other building types, dynamic simulation tools are required for proof of compliance with the thermal indoor climate requirements.

Additionally, there are requirements for a good daylight level in all rooms for continuous occupancy (work and living rooms).

Status of NZEB definition for residential buildings in Denmark

The Danish NZEB definition is implemented in the current Danish Building Regulations BR2015 as predictions for tightening of the energy performance requirements in 2020, and has been described in the section above.

Methodological points for discussion in Denmark

Electricity from combined heat and power in individual buildings is not considered a contribution which is acknowledged in the energy performance of the building.

Production of electricity from PV systems and local wind turbines must be at the building, the building site or located nearby on a site that is connected to the building in legally binding agreement (it is e.g. not legal to sell the wind turbine located nearby after having constructed the building). There is a flat limit for deduction of locally produced electricity in the energy frame of 25 kWh/m² per year (calculated as primary energy). Surplus electricity from homes can be sold to the grid at a feed-in tariff of approx. 1/3 of the total price for buying electricity form the grid. It not allowed being a net producer of electricity (over the year). The primary energy factor for electricity is 2.5

for buildings that comply with the BR2015 requirements and 1.8 for buildings that comply with the Building Class 2020.

Biomass is considered a scarce energy source in Denmark and has no special benefit in the Danish energy performance calculations and has been assigned a primary energy factor of 1.0. In reality, this means that building energy saving measures in buildings heated by biomass is equally feasible as in buildings heated by fossil fuels.

District heating and ground or air source heat pumps are considered the main heating energy sources in the future Danish energy landscape. It is thus expected that replacement of existing oil- or gas-burners will be limited to one of the above sources in the near future.

Building Type Matrix

				Denmark			
	Region	Construction Year Class	Additional Classification	SFH Single-Family House	TH Terraced House	MFH Multi-Family House	AB Apartment Block
1	national (Denmark)	... 1850	Generic (Standard)	 DK.N.SFH.01.Gen	 DK.N.TH.01.Gen		 DK.N.AB.01.Gen
2	national (Denmark)	1851 ... 1930	Generic (Standard)	 DK.N.SFH.02.Gen	 DK.N.TH.02.Gen		 DK.N.AB.02.Gen
3	national (Denmark)	1931 ... 1950	Generic (Standard)	 DK.N.SFH.03.Gen	 DK.N.TH.03.Gen		 DK.N.AB.03.Gen
4	national (Denmark)	1951 ... 1960	Generic (Standard)	 DK.N.SFH.04.Gen	 DK.N.TH.04.Gen		 DK.N.AB.04.Gen
5	national (Denmark)	1961 ... 1972	Generic (Standard)	 DK.N.SFH.05.Gen	 DK.N.TH.05.Gen		 DK.N.AB.05.Gen
6	national (Denmark)	1973 ... 1978	Generic (Standard)	 DK.N.SFH.06.Gen	 DK.N.TH.06.Gen		 DK.N.AB.06.Gen
7	national (Denmark)	1979 ... 1998	Generic (Standard)	 DK.N.SFH.07.Gen	 DK.N.TH.07.Gen		 DK.N.AB.07.Gen
8	national (Denmark)	1999 ... 2006	Generic (Standard)	 DK.N.SFH.08.Gen	 DK.N.TH.08.Gen		 DK.N.AB.08.Gen
9	national (Denmark)	2007 ... 2010	Generic (Standard)	 DK.N.SFH.09.Gen	 DK.N.TH.09.Gen		 DK.N.AB.09.Gen
10	national (Denmark)	2011 ...	Generic (Standard)	 DK.N.SFH.10.Gen	 DK.N.TH.10.Gen		 DK.N.AB.10.Gen

Figure 1. Classification scheme ("Building Type Matrix") of the Danish residential building typology, now extended towards new buildings.

Table 3. Exemplary new buildings representing the latest construction year classes (Danish Building Regulations 2010).

		Single-family house	Terraced house	Apartment block
				
Number of dwellings		16,900	5,600	838
National reference area*	m²	3,048,993	953,183	1,209,504

Case study

In the municipality of Sønderborg, in the southern part of Jutland, there is a shining example, ProjectZero, of a local initiative that have resulted in extensive energy savings in residential buildings and at the same time created local workplaces. The intension with this analysis is to investigate the possible energy reduction in Denmark if the same approach had been taken for the entire Danish building stock.

The overall goal of ProjectZero is to get the entire Sønderborg-area involved in the vision of creating a CO_2-neutral growth area before 2029, creating and demonstrating new solutions, robust measurable CO_2 reductions, new green jobs and a talented generation of young people. The public-private partnership – ProjectZero – was created to inspire and drive Sønderborg´ s transition to a ZERO carbon community by 2029, based on improved energy efficien-cy, conversion of energy sources into renewables and by creating participation of all stake-holders to reach the ambitious goal: CO_2-neutral growth and sustainable urban development.

ZeroHome is a subset of ProjectZero that deals with energy upgrading of existing dwellings in Sønderborg. In this project, home owners are offered a free energy advice (not an official energy performance certificate) by an independent assessor and easy access to local resources, i.e. architects, craftsmen, financial institutions. Since 2009, about 1,200 home-owners have received free energy advice and more than 900 homeowners have already made contracts with local resources for implementation of building energy upgrading. In total there are about 18,600 home owners in the Sønderborg municipality.

The observed energy savings in Sønderborg due to the impact from ZeroHome will be extrapolated to the entire Danish building stock to evaluate how far this approach would bring Denmark on the path to achieve a CO_2 neutral building stock by 2035. To reach this goal, it is anticipated that existing buildings should cut their energy demand for space heating and domestic hot water by approx. 50 %.

Table 4. Information originates from information available at the Statistics Denmark's web service (www.statistikbanken.dk) while information about Sønderborg is delivered by ProjectZero.

Scale	# dwellings	# buildings	# inhabitants	m² national	Scale
Sønderborg	500 (estimate)	494	N/A	83 522	70 994 m²
Denmark	2 636 586	1 547 037	5 678 348	304 749 000	259 036 650

Extrapolating to the Danish building stock

Extrapolating energy savings obtained due to the ZeroHome initiative in Sønderborg to the residential building stock will open for a comparison of estimated energy savings in Danish buildings by 2050 as a result of energy upgrading works carried out in combination with building refurbishment. A study of energy savings in combination with building refurbishment [Wittchen et al, 2014a] [Wittchen et al, 2014b] suggests that by 2050, the energy demand for space heating and domestic hot water in the existing Danish building stock will decrease by 29 % until 2050, and this decrease is a consequence of the requirements for energy upgrading of building elements when they are replaced or undergoes major renovation as stated in the Danish Building Regulations 2010 [Danish Enterprise and Construction Authority, 2010]. Only those building elements that are subject to renovation/replacement due to age are considered as being upgraded in this study. Additionally, the study analyses the effect of different more tight or additional requirements have been investigated, and it seems possible to reach 35 % energy savings by improvements to the thermal envelope by 2050 if upgrading is made in combination with planned works as building elements needs replacement or refurbishment due to their age. These continuous upgrading scenarios are being compared with the relative energy savings achieved in Sønderborg due to the ZeroHome initiative to investigate the possibility to speed up and increase the implementation of energy savings by activation of local competences and nudging.

Data source

There are 3 main sources for information on the building stock and the energy savings, which are:

- The Dwelling and Building Stock register (BBR), which is the authorities mean to collect information about all buildings and estates in Denmark and to collect taxes. This register contains, among others; information about the heated gross floor area; number of floors in the building; the material used in the main constructions (external walls and roof); heating system; and, as something new, the amount of energy delivered to the building. The responsibility of providing information about delivered energy is to the supplier.
- Information provided by ProjectZero on households who have joined the ZeroHome project. This information do unfortunately not contain exact information about the obtained energy savings, but only qualitative information about the households and the energy saving measures taken due to the contact with ZeroHome.
- The Energy Performance Certification database (EPC) that contains all information collected by energy experts in their work on issuing an energy certificate for the building prior to selling or renting it out. Information in this database is only used as supplements and for information on the label (A-G) in buildings energy certificate.

Base case

The starting point of the basic case is the current situation of the Danish building stock (see Table 2) as already established based on extracts from the EPC database. This database is the source for establishing the EPISCOPE reference buildings as average buildings in each of the categories. Based on the “as-is” reference buildings and extrapolation to the entire building stock, it is possible to calculate the energy demand in the building stock and compare it to information found in the Danish Energy Agency’s annual energy statistics where residential buildings comprise one block of information.

Table 5. Calculated current (2013) energy demand for space heating and domestic hot water per m² heated gross floor area in Danish residential buildings. Source: [Wittchen et al, 2014a].

kWh/m² per. year	Before 1890	1890-1930	1931-1950	1951-1960	1961-1972	1973-1978	1979-1998	1999-2006	After 2006
Farm houses	184.3	171.4	161.8	151.2	136.2	116.9	100.3	81.0	66.6
Detached houses	170.3	164.7	164.1	154.9	134.3	119.8	105.4	83.9	67.3
Terraced houses	158.2	157.7	149.3	142.8	119.9	112.6	96.8	81.5	66.4
Blocks of flats	151.1	153.9	157.0	148.0	132.3	121.0	108.5	84.0	60.7

From information in the BBR-database for the municipality of Sønderborg, we extracted and compared registered energy consumption for those homes that are part of ZeroHome and the rest of Sønderborg. The reason for comparing ZeroHome homes with non-ZeroHome in Sønderborg is that all the homes are located in the same area, constructed by the same traditions and at similar periods. Additionally, all the homes subject to the same economical and regional conditions.

Using this methodology poses some challenges regarding uncertainties that need to be dealt with. Some of these are: no information about supplemental heating from e.g. wood burning stove and heat pumps; missing reporting of delivery from energy supply companies; faulty registration of delivery/meter reading dates; varying periods for the readings and hence irregular degree-day corrections.

Results

The prime goal for the Danish society as a whole is to become free of fossil fuels by 2050 and that all buildings are to become free of fossil fuels by 2035. For the buildings, this is to be achieved as a combination of improved energy efficiency in the buildings and an increased share of renewable energy in the energy supply. It is estimated that improvement of energy efficiency in the existing building stock (2013) should be around 50% to be able to reach the goal of fossil fuel free buildings by 2035.

On the fuel supply side of the Danish buildings, only 2 fuel types are foreseen for the fossil free fuel future. These are district heating and electric heat pumps. Naturally, the heat pumps are being supplied with electricity primarily generated by wind (dominant) and solar. It assumed that it soon will become illegal to replace old oil burners by the end of their lifetime and heat pumps or bio burners will hence become the only realistic substitutes. The same future is foreseen for natural gas burners, but on a longer term. An ever increasing share of renewable energy (bio-mass and solar thermal) are being used in the Danish district heating systems which contributes to the fossil fuel free supply of Danish buildings in the future.

The table below show the calculated energy demand in existing buildings (2013) for selected Danish building types depending on their year of construction. Calculations are carried out under the precondition that building components are being upgraded when they are being renovated according to the requirements given in the Danish Building Regulations 2010 (more strict rules) and implementation of mechanical ventilation with heat recovery when replacing the roof covering.

Table 6. Calculated energy demand in selected Danish buildings in 2050 if requirements for balance ventilation with heat recovery are being introduced when replacing the roof. Additionally, the current requirements for insulation levels when renovating a building component are estimated to become more strict (Wittchen et. al, 2014)

kWh/m² per. year	Before 1890	1890-1930	1931-1950	1951-1960	1961-1972	1973-1978	1979-1998	1999-2006	After 2006
Farmhouses	106,7	94,2	85,7	80,5	79,5	69,3	63,1	50,7	46,3
Detached houses	101,5	85,2	82,6	78,9	75,4	70,1	65,9	55,8	47,6
Terraced houses	88,1	80,5	74,5	72,7	69,9	65,5	60,0	53,4	46,8
Blocks of flats	56,1	55,4	57,0	57,9	59,8	59,4	53,0	47,6	38,5

Extracts from recorded energy consumption in BBR (district heating and natural gas) in single family homes in Sønderborg show that homes being part of Home have a normalised (degree day corrected) energy consumption of 133 kWh/m² per year. Similar homes in the same area, but not part of ZeroHome show an average energy consumption of 174 kWh/m² per year. The table below show the registered energy consumption in ZeroHome homes and the reference group in the municipality of Sønderborg for 2 building periods, i.e. before 1980 and between 1980 and 2000.

In many of the homes connected to the ZeroHome project have PV systems as their prime energy saving measure. To the largest possible extend, these homes have been filtered from the analyses. Especially for homes constructed in the period between 1980 and 2000, this is assumed to be the case. These homes all have a relatively high energy performance standard, and only very few energy saving measures are estimated to be economical beneficial. In reality, only replacement of windows in case the windows are to be replaced anyhow is economic feasible in these homes. In Denmark, it is more expensive and illegal to replace a window with one from the building year than to put in a new window of today's standard. It is thus not surprising that the registered energy consumption in the ZeroHomes is equal to that found in the reference group of homes for the most recent building period.

Registered energy consumption in the ZeroHomes in Sønderborg from the construction period before 1980 show an average energy consumption of 136 kWh/m² per year. The national average for single family homes constructed in the same period is 151 kWh/m² per year. Energy consumption on the ZeroHome group is thus significantly lower than the national average. Compared to the national average, ZeroHomes, have obtained a reduction in energy consumption of 10%, and compared to the reference group of homes in Sønderborg a reduction of 28%. This is not in line with the needs for energy savings in the Danish tertiary sector until 2050, but in line with what can be expected for energy upgrading of building components when making a renovation according to the requirements laid out in the Danish Building Regulations 2010.

Table 7. Registered heating energy consumption in ZeroHome single family homes and in the rest of Sønderborg (reference group) for 2 construction periods.

Period	Until 1980		1980-2000	
	Units -	Comsumption kWh/m² per yr.	Units -	Comsumption kWh/m² per yr.
ZeroHomes	287	136	29	102
Reference group of homes in Sønderborg	13 188	174	2 960	101
National building stock, homes	approx. 1 206 934	151	approx. 339 753	102

The reasoning for this division is that most homes constructed after 1980, even though Danish building energy performance requirements have been tightened several times since then, only opens for a limited number of economic profitable energy saving measures (except replacement of windows) and hence only limited interest in participation in the ZeroHome initiative. From the extracted energy use shown in figure 1, it is obvious that ZeroHomes constructed after before 1980 have lower energy consumption than homes in the rest of Sønderborg and in the rest of Denmark. For homes constructed after 1980, energy consumption is the same in all three areas. From this extract, there is no information on the thermo-physical state of the selected buildings and building periods.

The measured (BBR) energy consumption in the ZeroHomes have been compared (Figure 1) with a group of ordinary reference buildings in Sønderborg, the Danish building stock of single family houses and the estimated energy consumption in the same homes in 2050 if energy upgrading is done in combination with planned renovation due to end of service life of building components.

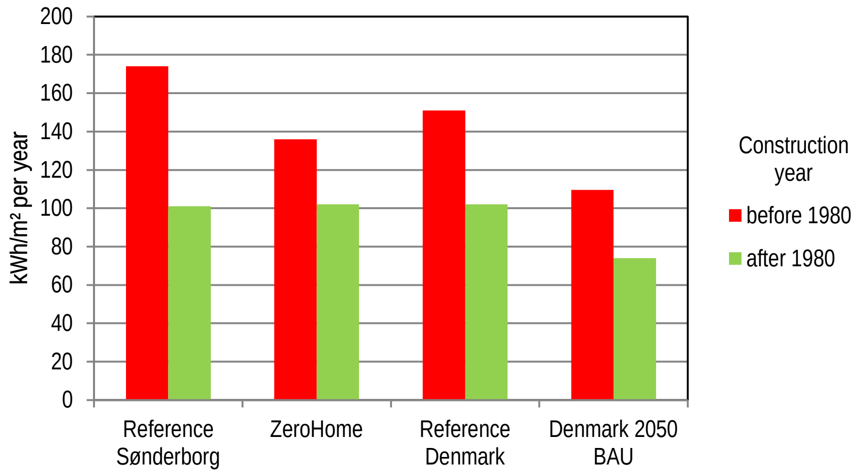

Figure 2. Measured (BBR register) annual energy consumption per m² in ZeroHomes. As a reference, homes in Sønderborg and in homes in Denmark as a whole and an estimate for the energy consumption in Danish homes by 2050 are shown for the same building periods.

Compared to the group of reference homes in Sønderborg, ZeroHomes constructed before 1980 have achieved a heating energy saving of 22%. Compared with energy use in Danish homes as a whole, ZeroHomes show a heating energy saving of 10%. No energy savings in ZeroHomes are proven for homes constructed after 1980. The energy consumption in the reference homes at Sønderborg is significantly higher than what is found for the rest of Denmark. The reason for this phenomenon may be that since energy savings came on the agenda for Danish homeowners around 2000, the building crisis have decreased the value of property, especially in areas like Sønderborg where property prices were low before the crisis. Financing institutions have over the same period changed the rules for offering mortgage loans and this has left little room for energy upgrading of low value properties.

The ZeroHome initiative in Sønderborg clearly result in energy savings, but far from enough to meet the governments ambitions plan to make Danish buildings free from use of fossil fuels by 2035. This will probably require energy savings around 50% in the Danish building stock as a whole. The project however, have proven that dedicated engagement of locals can speed up market penetration for energy savings in the existing building stock, increase investments in building industry and create additional workplaces. It is important to look upon initiatives like ZeroHome to avoid losing momentum in the implementation of energy saving measures in the existing building stock and to keep the focus on energy performance improvements in the future.

Case study conclusions

The initiative in Sønderborg related to ZeroHome has comprised a lot of effort in terms of manpower and communication with the press. On the other hand, the goal has been ambitious – a CO_2 neutral municipality by 2029 (intermediate goal of 25% reduction in 2015 compared to the 2006 level) and creation of numerous local jobs. One of the key drivers was the introduction of an independent energy advisor offering his services to home owners without any linkage to the local resources that had been officially acknowledged as energy ambassadors. Additionally, local press have been used to promote the message and highlight the positive stories about the project and the achievements.

Dissemination of this methodology on national scale will not be straight forward as it requires strong local support. In Sønderborg the local business and clean-tech companies have strongly supported the project. Additionally, one of the driving forces has been the creation of something unique among the local residents and feeling to be able to create local unity. This cannot easily be made nationally.

Never the less, playing with the idea about a nationwide dissemination of the method from ZeroHome and ProjectZero will demonstrate the possibilities for energy savings and creation of local jobs if a community strives for a common goal.

It is the aim of the Danish government that Denmark should be free of fossil fuels by 2050 and for heating buildings this should happen in 2035. To be able to reach that goal, it is estimated that the energy consumption in the existing building stock should be reduced by a minimum of 50 %. Following the current path, with energy upgrading of building components in compliance with the requirements in the Danish Building Regulations 2010 (BR2010) [Danish Enterprise and Construction Authority, 2010] when retrofitting the buildings due to termination of service life for the building components, will not result in enough energy savings (about 30 % of the 2011 national energy use in buildings) to reach that goal.

To be able to come closer to that goal there is a need for more strict requirements in combi-nation with refurbishment works and also improvements of the energy performance of windows. It is possible to get more energy efficient windows with an annual energy balance value of +15 kWh/m² per year for facade windows (current (BR2010) requirements for a facade window is an annual energy balance of -33 kWh/m² per year). Introduction of mechanical ventilation with heat recovery can also contribute to fulfilment of the goal. Analyses of different scenarios for energy upgrading in combination with planned refurbishment works have shown that it should be possible to reach the goal by implementation of stricter building element requirements. Stricter requirements will be implemented in the coming Danish Building Regulations, which will come into force by the end of 2015 [Danish Transport and Construction Agency, 2015].

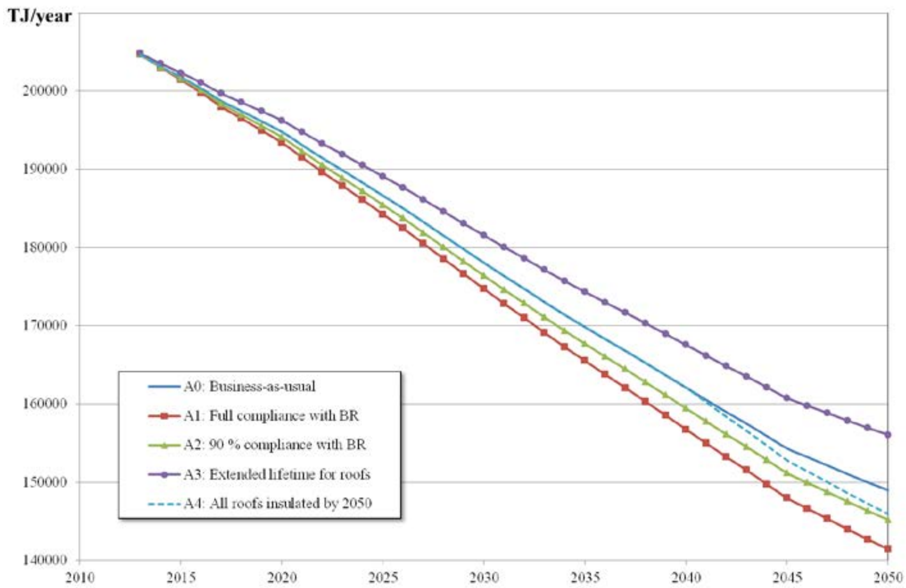

Figure 3. Development in net energy consumption for space heating, ventilation and domestic hot water in the existing Danish building stock as analysed in the A Scenarios. Energy saving measures are assumed to be implemented at the same rate as the building components are being retro-fitted due to the end of their service life. Source: [Wittchen et al, 2014b].

The analyses have not taken into account demolishing of existing buildings and replacement with new buildings by 2050. Historically, about 1 % of the Danish building stock is replaced every year. If this trend continues over the next 30 years, about one third of the buildings will be newly built by 2050 and have a significant lower energy need.

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This report provides a summary of the national input from Denmark to the EPISCOPE project supported by Intelligent Energy Europe Programme of the EU. The strategic objective of EPISCOPE was to make the energy refurbishment processes in the European housing sector more transparent and effective. Pilot actions have been conducted in 16 countries to track the implementation of energy saving measures and their effect.
The Danish case study comprises homes in the ZeroHome project, which is part of ProjectZero in the municipality of Sønderborg, a local initiative that has resulted in extensive energy savings in residential buildings. The intension with this analysis was to investigate the possible energy reduction in Denmark if the same approach had been taken for the entire Danish building stock.
The report concludes that the ZeroHome initiative clearly results in energy savings, but far from enough to meet the government's plan to make Danish buildings free from use of fossil fuels by 2035. This will probably require around 50 % energy savings in the Danish building stock as a whole. However, the project has proven that dedicated engagement of locals can speed up market penetration for energy savings in the existing building stock.

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