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TRENDS IN NATIONAL NEARLY ZERO-ENERGY BUILDING APPROACHES

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ABSTRACT

This paper presents some first approaches for the national application of the nearly zero-energy building definition according to the Energy Performance of Buildings Directive by summarising the current plans of Germany, Denmark, Ireland and the Netherlands. As a contribution from a 5th country, the planned national energy performance requirements of Switzerland for the phase from 2018 onwards were included. It was also analysed whether any of the countries will set specific requirements to the air-tightness of NZEBs and if there are specific requirements for ventilation techniques.

KEYWORDS

Nearly zero-energy building, Germany, Denmark, the Netherlands, Ireland, Switzerland, energy surplus houses

INTRODUCTION

The Energy Performance of Buildings Directive (EPBD, [1]) in the version of 2010, the so-called recast, demands in article 9 'Nearly zero-energy buildings' that *'Member States shall ensure that (a) by 31 December 2020, all new buildings are nearly zero-energy buildings; and (b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings. Member States shall draw up national plans for increasing the number of nearly zero-energy buildings. […] The national plans shall include […] the following elements: the Member States detailed application in practice of the definition of nearly zero-energy buildings, reflecting their national, regional or local conditions, and including a numerical indicators of primary energy use expressed in kWh/m² per year. …'*

In Article 2, the Directive also includes an overall definition of the nearly zero-energy building (NZEB): '*nearly zero-energy building means a building, that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby;*'.

Annex I of the Directive presents a general framework for the calculation of the energy performance of buildings. It lists the energy aspects that need to be included in the calculation, which also cover ventilation and air-conditioning. The air-tightness is mentioned here by *' The methodology shall be laid down taking into consideration at least the following aspects [...] (d) natural and mechanical ventilation which may include air-tightness…'*.

Currently, the Member States are working on the detailed application in praxis of the definition of nearly zero-energy buildings. The laws, regulations and administrative provisions necessary to comply with articles 2 to 18 (including the NZEB article 9) shall be adopted and published by 9 July 2012 and be applied from 9 January 2013, at the latest.

This paper presents some first approaches for the national application of the NZEB definition by summarising the current plans of Germany, Denmark, Ireland and the Netherlands. As a contribution from a 5th country, the planned national energy performance requirements of Switzerland for the phase from 2018 onwards were included. Switzerland is not an EU Member State. Its development in energy performance requirements is however in line with the leading countries of the EU in the same climate region. It was also analysed whether any of the countries will set specific requirements to the air-tightness of NZEBs and if there are specific requirements for ventilation techniques.

GERMANY

National approach for the NZEB definition

For along time, Germany's development of energy performance requirements for buildings has been accompanied by research and demonstration projects that showed further strengthenings to be technically feasible, which became due to market adaptions some year later also economically feasible. Figure 1 shows the minimum energy performance requirements (in 6 steps) as the upper line, the pilot projects (solar houses, low-energy buildings, three-liter houses, zero-heating energy houses and plus energy houses) as the lower line and the actual building practice in between. The requirements followed the pilot projects with 10 to 20 years time difference.

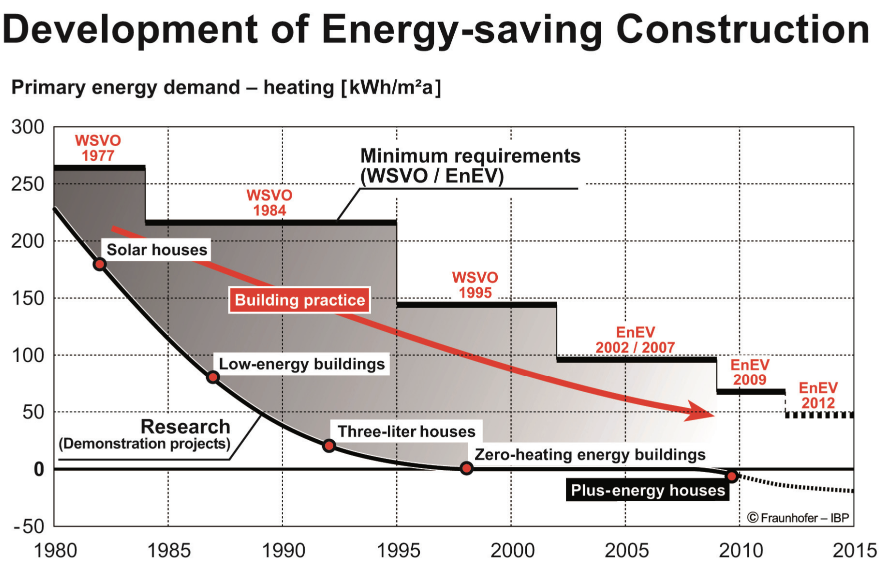

Figure 1. The historic development of pilot projects, minimum requirements and the building practice in the field of energy saving buildings in Germany.

With the last tightening of the minimum energy performance requirements by the energy decree (EnEV 2009, [2]), Germany has again become one of the countries in Europe with the strictest requirements for new buildings, see also the results of the *ASIEPI* project [3]. The national application of the definition of NZEB will be based on the results of a project called ‚*Untersuchung zur Novellierung der Gebäude-Richtlinie – Identifikation und Analyse von Hemmnissen beim Neubau von hocheffizienten Gebäuden und Entwicklung eines Konzepts zur Marktdurchdringung bis 2020*' [4] within the "Zukunft Bau" initiative of BBSR, in which the researchers analysed different possibilities for the German NZEB definition taking into account the current boundary conditions and requirements as well as the perspective of the market players such as industry, building owners, etc.

The assessment method which was proposed by the study partners Fraunhofer IBP, IB Hauser, Schiller Engineering and iTG is as follows:

- Assessment parameters (energy performance indicators): Both delivered energy and primary energy (non-renewable part).
- Balancing period: One year of operation
- Energy aspects to be included: Heating energy, ventilation and cooling energy all incl. auxiliary, lighting for non-residential buildings, energy generated from renewables (self-used and fed into the grid) if produced on-site.

There is a difference compared to the current requirements for new buildings, namely the inclusion of a maximum amount of delivered energy and the possibility to credit energy generated from renewables that is fed into the grid. The detailed quantitative requirement will be derived from an additional economical study and announced by the building ministry.

There will be no specific requirement regarding the airtightness of a NZEB in Germany. It is however clear that such a building should be designed and constructed in an airtight way in order to secure the low energy demand. The German calculation method does for a long time and will continue to credit improved airtightness. Neither will there be a specific requirement regarding the type of ventilation system. Natural or mechanical ventilation systems will be possible, all definitions will have the aim to be 'technology-open'. However it can be expected that many of the NZEBs will include a mechanical ventilation system including a heat recovery system with a high heat recovery rate. The ventilation industry (just like other manufacturers of energy efficient building components or material) will surely use the push in general awareness and will further develop their products.

Trends in high performance buildings in Germany

In September 2011 the Federal Ministry of Transport, Building and Urban Development (BMVBS) has started a subsidy programme for energy surplus houses (Effizienzhaus Plus). Energy surplus houses are defined to be buildings that produce more energy than they use. More specifically, both the annual balance of the delivered energy and the primary energy during one year shall be negative. The definition, the calculation method (which includes a default value for lighting and household electricity), and further information is available in a brochure published by the ministry [5].

A pilot project for the energy surplus houses is currently being built in Berlin, designed by the University of Stuttgart. The construction can be followed on the website of the BMVBS. The aim of this specific house is that enough of excess energy is being generated to cover the electricity necessary for driving with an electric car. In September 2011 an exhibition of several prefabricated energy surplus houses that are ready to be bought was opened in

Cologne. The buildings realise different energy concepts for achieving the energy surplus house standard.

Figure 2. Design of the energy surplus house currently under construction in Berlin.

DENMARK

In Denmark the minimum energy performance requirements for buildings are set by so-called energy frames. The energy frames for new buildings are fixed for 2010, 2015 and 2020. They divide into residential buildings (including those with similar types of use like hotels) and non-residential buildings. For buildings with a special use resulting in for example high ventilation rates there are additions to the allowed energy frames. The energy frame limits the delivered energy and includes the energy use for heating, ventilation, cooling, domestic hot water and the necessary electricity for operating the building. In the case of non-residential buildings it also includes the lighting energy. Electricity use has to be multiplied by a conversion factor and excess temperatures are punished by an addition to the calculation.

Characteristic values		**Energy frame 2010**	**Energy frame 2015**	**Energy frame 2020**
Maximum of total delivered energy to	Residential buildings (houses, hotels, etc.)	52.5 + 1650/A in kWh/m^2yr	30 + 1000/A in kWh/m^2yr	20 kWh/m^2yr
	Non-residential buildings (offices, schools, institutions and other buildings)	71.3 + 1650/A in kWh/m^2yr	41 + 1000/A in kWh/m^2yr	25 kWh/m^2yr
Conversion factors	Electricity	2.5	2.5	1.8
	District heating	1.0	0.8	0.6
Airtightness	Tested at a pressure difference of 50 Pa	1,5 l/s per m^2	1.0 l/s per m^2	0.5 l/s per m^2
Heat recovery rate		0.70/0.80*	0.70/0.80*	0.75/0.85*
Fan power		1800 J/m^3**	1800 J/m^3**	1500 J/m^3 / 800 J/m^3*

where A is the heated gross floor area

* for ventilation systems for a single dwelling

** for installations with constant air volume, the power consumption for air transport must not exceed 1800 J/m^3 fresh air

Table 1. Comparison of an extract of the energy performance requirements set in the Danish energy frames for 2010, 2015 and 2020.

Supplementary requirements exist for:
- Thermal losses in W/m² dependent on the number of building storeys
- U-values incl. a E_{ref} -value for windows dependent on the total solar energy transmittance and the transmission coefficient
- Minimum boiler efficiency
- Pipe insulation
- Automatic control
- Low temperature heating

As the 2020 levels will be difficult to achieve solely through improvements at the building envelope, heating, ventilation and lighting systems it is expected that the use of renewables will be increased.

IRELAND

Ireland plans to define the nearly zero energy building differently for dwellings and for other types of buildings. They want to implement a carbon neutral framework for dwellings in 2013 and to introduce a low energy standard for other buildings in 2016.

In order to reduce the net total carbon dioxide emissions to zero they propose first to optimise fabric, space heating and domestic hot water measures. As there will always be a base electrical load that will need to be compensated for they think of 3 possible solutions for this:
- Offsetting CO_2 emissions at the unit or dwelling level: use of onsite microgenerators to produce electricity from renewable sources and fed-in to the grid in order to balance the electricity that is provided by the grid.
- Offsetting CO_2 emissions at the development level: local wind turbines, biomass or gas CHPs as district/local/community schemes to reduce CO_2 emissions from the dwelling to zero.
- Offsetting CO_2 emissions at national level: paying a level to relevant local authorities based on the volume of CO_2 likely to be emitted. This revenue would be ring fenced for works on CO_2 reducing projects such as retrofitting existing building stock, renewable power generation, forestry, etc.

A voluntary standard for carbon neutral dwellings shall be introduced in 2013 and the adoption shall be encouraged through incentive schemes. A carbon neutral standard for dwellings requires a cross-departmental multi agency approach with buy-in and collaboration from industry. Critical success factors will be training and up-skilling on new technology, a standard for new products and technologies, research and development, appropriate commissioning and maintenance schemes and the learning from international experiences.

There are current requirements on the airtightness of buildings and on heat recovery for mechanical ventilation systems defined in Part F of the Irish Building Regulations. If and in which way they will be further tightened for carbon neutral dwellings is unclear.

THE NETHERLANDS

The Netherlands have strengthened their energy performance requirements for buildings by 40 % between 1995 and 2011. This corresponds to a development of the EPC (energy performance indicator for buildings) in the residential sector from 1.4 in 1995 to 0.6 in 2011.

Further tightenings are planned for 2015 (EPC 0.4), 2018 (EPC 0.2) and 2020 (EPC 0). Also the non-residential sector shall reach EPC 0 in 2020. For the governmental buildings EPC 0 is planned for 2018.

The energy performance calculation procedure was changed in order to have a higher degree of accuracy, to include new techniques such as biomass, micro power and solar and to allow for power generation by area or zone. An additional standard was integrated for determining the air flow and the ventilation. The new procedure takes the European standards into account.

There are some pilot zero-energy buildings in the Netherlands. They also have several existing financial instruments supporting energy efficient buildings. A special subsidy scheme for energy neutral pilot projects is planned.

SWITZERLAND

Though Switzerland is not part of the European Union, their energy performance requirements for buildings show a development similar to the neighboring countries such as Austria and Germany. Based on studies and experiences they found out that the cost-optimum for energy efficient buildings is dependent on many different influence parameters including:

- The development of the energy prices
- Investment costs which are based on the offers
- Capital costs which are based on the specific and the national financial situation
- The further development of the building technologies that can be triggered by requirements and subsidies
- Tax reductions based on the specific income
- The personal evaluation.

The cost-optimum for each building is different, depending on the size, the location and the building owner. Therefore the Swiss authorities have decided to offer a free choice of how to realise two goals:

1. Requirement for the efficiency of the building envelope
2. Requirement for the overall energy efficiency.

The free choice of either improved insulation or the integration of more renewables without any restrictions concerning the used technologies increases the public acceptance, and by stimulating competition among manufacturers it boosts innovations. To simplify the procedure, standard solutions with 11 different technology sets are offered.

Instead of primary energy factors they use so-called national (political) weighting factors. The maximum energy use of new buildings has been reduced from 120 kWh/m^{2}a in 1992 to 48 kWh/m^{2}a in 2008. The next tightening is planned for 2014. Additionally, Switzerland has a voluntary standard called ‘Minergie’ for different building types with significantly stronger minimum energy performance requirements and subsidies for the building owner. The national requirements serve as push while the Minergie label serves as pull to the development in energy saving buildings. As next steps nearly zero energy buildings and energy surplus buildings are being considered. Similar to Germany some energy surplus buildings have been built which were financially supported by the state.

For buildings with the Minergie label A and P a blower door test is obligatory and maximum air change rates of 0.6 1/h at 50 Pa overpressure shouldn’t be topped. For the lowest Minergie label the airtightness measurement is voluntary and a target value of 1.0 1/h is given. Minergie also includes requirements regarding the household equipment (best practice) and in case of the Minergie-A label a default value for the embodied energy of 50 kWh/m².

CONCLUSION

The 5 summarised developments in energy performance requirements reflect a strong tightening over the last two decades. The national applications of the nearly zero-energy building definition are ambitious in all 5 countries, including steps towards the buildings being carbon neutral. Pilot buildings of net zero energy buildings or energy surplus buildings exist in at least 3 of the countries, with Germany just having started a support programme for the 'Effizienzhaus Plus' that includes a specific calculation method for energy surplus houses.

The important impact of airtightness on the energy balance of such high performance buildings has been recognized, and specific requirements exist in several countries. There is a strong tendency towards allowing for technology-open solutions which also applies to ventilation strategies.

ACKNOWLEDGEMENTS

The summary of the national approaches for the NZEB definition in all 5 countries is based on presentations given at the international workshop 'Cost-optimal ways to Nearly Zero-Energy Buildings' on September 27, 2011 (organised by the Federal Office for Building and Regional Planning, BBR) [6].

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