Status on national legislation for implementing Nearly Zero Energy Buildings

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Abstract
The status on implementation of Nearly zero energy buildings (NZEB) on national level varies with different national primary energy requirement on 20 kWh/m² in Denmark to 160 kWh/m² in Austria.
Such a difference shows that the interpretation of NZEB is widely different in the member state and has not been the original intention from the European Commission in the development of NZEB requirement in the Energy Performance of Buildings Directive (EPBD).
Detailed studies has been made and shows that there is a difference in the structure of the national legislation, where additional requirement, like demanded ventilation flow, ventilative cooling, daylight – that are not included in the requirement to NZEB buildings – can grow the energy efficient performance of buildings.
Other studies shows that only a few member states has included supplementary requirement to indoor climate in existing and NZEB buildings. This is also a challenge as the EPBD, clearly require that member states shall take account of general indoor climate conditions.
This paper will give an overview of implementation of NZEB on national level and will take its starting point in the BPIE studies on “Implementation of Nearly Zero Energy Buildings” and “Indoor air quality, Thermal comfort and daylight”. It will elaborate on the specific requirement in a few countries and will based on cases and demonstration projects bring forward proposals for a common interpretation for NZEB houses.

Keywords - NZEB legislation; Energy Performance of Buildings Directive; Indoor comfort in NZEB buildings; Active House

1. Introduction
A common methodology has not been developed by the European commission; leaving the individual countries and municipalities, with their own interpretation of nearly Zero-Energy Buildings (NZEB).
A survey by Building Performance Institute Europe [2] by April 2015 shows that 17 countries has implemented a methodology for NZEB definitions in the individual countries. The survey also shows a large difference in the interpretation as well as in the levels of ambitions.

Supplementary to the energy requirement in the EPBD [1] the article 3 of the directive also require that member states shall take account of general indoor climate in order to avoid negative effects. Such a requirement calls for specific requirement to indoor climate, in parallel to the energy efficiency requirement. However, it is very seldom the case.

2. National levels for NZEB

In a majority of the member states, the definition of NZEB refer to maximum primary energy as indicators, with very different levels of ambitions with Denmark having 20 kWh/m² as the most ambitious country to Austria with a level of 160 kWh/m², looking to be less ambitious. However the figures cannot be compared as they are based on different methodologies, which is explained later.

Other countries use a methodology where the NZEB requirement are based on a performance of a NZEB reference building and where the primary energy use of the specific building must be better than the one for the a reference building with same design and geometry.

<table>
<thead>
<tr>
<th>Country</th>
<th>Austria</th>
<th>Belgium</th>
<th>Denmark</th>
<th>France</th>
<th>Germany</th>
<th>Netherland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. PE kWh/m²</td>
<td>160</td>
<td>45</td>
<td>20</td>
<td>40-65</td>
<td>KfW 55</td>
<td>EPC=0</td>
</tr>
<tr>
<td>Reference method</td>
<td>30% of reference</td>
<td>KfW 40</td>
<td>EPC=0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The definition of NZEB allow for use of renewable energy, with the intention to integrate more renewable energy in the energy systems. Many countries has chosen to allow for use of integrated renewable energy on the building or the plot as an instrument to reduce the primary energy requirement for the specific building.

Thereby there is a mix between production and use, and it must be questioned if this is a good long term solutions. In countries with high ambitions for primary energy demand, like Denmark with 20 kWh/m², a level of integration of renewable energy on the building or the plot of app 50% is needed to reach the ambitious level. This shall be compared with the Danish energy system, that already has an integration of 50% renewables [3].

All countries follow the methodology of appendix one of the EPBD, however a few also include energy for lighting in the requirement, as well as some countries also sets requirement to the appliances.
3. The ambitious level for NZEB

Methodology in Denmark

The Danish level for NZEB buildings is set to a PE level of 20 kWh/m² for dwellings and is recognized as the most ambitious requirement in Europe. However the level of the requirement shall be seen within two perspectives. Firstly the NZEB level allows for use of lower PE factors, which is 1.80 for electricity and 0.6 for district heating both app 25% lower that the factors used in 2015. Secondly it allows for use of renewable energy and will normally require use of a certain amount of installed renewable energy and often up to 50%, bringing the building to a real energy demand in the building to around 40 kWh/m².

The NZEB requirement includes requirements for the building envelope, insulation and components. These requirements are included to ensure the quality of the basic building, which is designed to last for many years and expensive to change once it is built. The dimensioning heat loss must not exceed 1.7 W/m² in one story and 4.7 W/m² in two story buildings.

Requirements for the building envelope does not include windows and doors, thus avoiding unnecessarily small windows giving bad indoor climate design and the so called “peephole architecture”, which by mistake was used in the 80ties due to strong heat requirement.

Requirement to windows are instead based on the energy balance methodology, with a requirement of an energy balance level for facade windows on 0 kWh/m², meaning that there are no heat loss from windows during the heating season. The requirement for roof windows is +10 kWh/m² window, meaning that the roof window must deliver energy to the building during the heating season and thereby reduce the energy demand for heating.

The overall structure in Denmark is good and allows for a relative free design of the building, giving architects, house builders and investors a freedom to choose design solutions and create innovation. However studies by the Danish engineering association [4] shows that the level can be to ambitious, as the marginal costs to integrate renewable energy is higher than the marginal costs to do the same in the energy system.

Methodology in Austria

The Austrian level [5] for NZEB is set to a PE level of 160 kWh/m² for dwellings and is often called the most un-ambitious requirement in Europe.

However it is not necessarily the case. First of all the PE level include the energy for appliances, which – if not calculated – is set to 16.4 kWh/m² bringing it to a primary energy level of 43 kWh/m² with a primary energy factor of 2.68 for electricity. Secondly, Austria has initiated a PE factor for integrated renewable energy on the building with the consequence that
electricity produced from PV on the building cannot be deducted 1:1 from the energy frame as the case in Denmark and other countries.

As an alternative to the PE method, mentioned above, the Austrian methodology also allows for use of two alternative methods, either a Heat Demand methodology or an Energy Demand methodology.

The heat demand method base the requirement on the shape of the building with 10 x (1+3.0/lc) kWh/m² where lc is the volume/area factor of the building, often around 1.3 brings the maximum requirement for heat to around 30-35 kWh/m² depending on the shape of the building.

The above is only a requirement to the energy used for heating and with the modern technologies and solutions available it looks to be less ambitious as the Danish requirement, however the Austrian requirement are not as un-ambitious as first indicated, looking on the PE values only.

NZEB levels
The conclusion on the above is that the national requirement cannot be compared between member states, and that is also not the purpose of the EPBD. It can be valuable to discuss if the existing structure creates trade barriers and limit the transnational innovation within buildings, and if a common methodology for NZEB could grow development and innovation.

4. Requirement to indoor climate in NZEB legislation

Buildings are built for people to live, work and be inside in, and the energy delivered to the building is used to create good indoor conditions.

Taking that in mind it is interesting that only one country has focused on this in the definition of NZEB and increased the requirement to indoor comfort levels in NZEB legislation.

It is a challenge as more energy efficient and airtight buildings has a higher risk for overheating during summer and warm periods. There is also a risk of less good daylight conditions if the outer surface of a building is designed with focus on the heat loss only and thereby create a risk for minimizing the window area and indoor daylight conditions.

Such a challenge is best exemplified with energy efficient buildings being designed with large window areas towards the south, in order to gain passive solar energy and designed with small windows to the north, in order to reduce heat loss. Studies shows that such buildings has a risk of unpleasant indoor comfort, both for summer and winter conditions [6].

Therefor NZEB requirement should be followed by complementary requirement to the indoor comfort levels for individual rooms.

The Danish implementation of NZEB buildings [7] has taken this challenges and increased the requirement to thermal comfort for the summer conditions as well as it is required use solutions that can set different temperatures for individual rooms during the heating season.
The rules in the Building Regulations sets a requirement to a ventilation level of 0.3 l/s/m² in homes and allow now for use of demand-controlled ventilation, depending on the use of the rooms, number of people etc.

Finally the requirement to daylight conditions has been strengthened with 50% and all rooms must have sufficient daylight conditions with window to floor area of min. 15% or a daylight factor of 3%.

<table>
<thead>
<tr>
<th>Thermal comfort winter</th>
<th>Thermal comfort summer</th>
<th>Ventilation and air quality</th>
<th>Daylight conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum 20 °C with possibility for individual temperature control in each room</td>
<td>Max 100 hours above 26 °C and max 25 hours above 27 °C</td>
<td>Airflow of 0.3 l/s/m². In schools CO₂ level may not exceed 900 ppm for longer periods or use of demand controlled ventilation.</td>
<td>Min. 15% window to floor area or 3% daylight factor</td>
</tr>
</tbody>
</table>

Focus on indoor climate conditions can reduce the use of energy in buildings, where for instance use of demand controlled ventilation can lead to significant energy saving and use of daylight reduce electrical lighting.

A study on barriers for development of NZEB projects [8] shows that buildings with good daylight conditions can have reduced energy needs when electricity for light is included, like in French legislation.

It is the same for the use of natural ventilation and ventilative cooling, which in the same study are proven to keep the indoor temperature below the required thermal comfort levels and thereby avoid use of energy for air-condition systems.

5. **Sustainable design methodologies**

Several sustainable building systems like DGNB, LEED, MinergiC, etc. sets requirement to indoor climate conditions, parallel to the requirement to energy efficiency and are thereby in front of EPBD.

Active House also takes indoor climate into consideration and by its focus on a balance between energy (energy demand, energy supply, primary energy) and comfort (daylight, thermal comfort, air quality) it has already proven that it is possible to balance NZEB requirement with good comfort.

Several projects has been designed and with full scale demonstration project like Model Home2020 [9] the philosophy has been proven to work in the design process, as built solutions, and for evaluation of the projects.

Through sustainable building systems like the one above it has been proven that investors, architects and industry has solutions available for NZEB projects, however as long as indoor climate it is not implemented
into a part of the NZEB legislation there is a high risk that new buildings will have less good indoor climate.

6. Conclusion

Findings
As there are no common methodology for NZEB buildings, it is not possible to compare the energy efficiency and the CO2 emissions from buildings.

NZEB buildings can be build with the existing technologies. But if indoor comfort requirement are not include in the early design process there is a risk for a higher use of energy and risk of bad indoor climate.

Low energy consumption and good indoor climate conditions can be meet in NZEB projects, if both parameters are included in the early design process. The challenges is that national legislation and the EPBD do not have a sufficient requirement to indoor climate conditions.

Recommendations:
A revision of the EPBD should focus on development of a common NZEB methodology, which also take indoor climate conditions into consideration with a requirement that member states sets specific requirement to Thermal Comfort, Air Quality and Daylight conditions.

Parallel to the above the revision should strengthen the focus on use of renewable energy. Some countries require up to 50% renewable energy installed on the building to reach the national NZEB level. The use of renewable energy should grow, but it must be discussed if it shall be integrated in the NZEB definition or it should be allowed to use renewable energy from the grid, which can be more cost efficient.

References
[2] Approaches and indicators used by EU28 and Norway for the nZEB definition, Building Performance Institute Europe, April 2015