

The impact of EU nearly-zero energy building (NZEB) regulations on heating and heat pump choices in buildings

Scott Bryant^a, Lukas Bergmann^{a*}, Steven Ashurst^a

^aDelta Energy & Environment, Argyle House, 3 Lady Lawson Street, Edinburgh, EH3 9DR, UK

Abstract

Buildings represent a key battleground in the EU sustainable energy transition, representing 40% of final energy consumption and approximately 36% of total greenhouse gas emissions. In an attempt to address this issue, Nearly Zero Energy Building (NZEB) regulations were implemented as a tool for significantly reducing energy use in new buildings, and existing buildings subject to major renovations. However, with 28 individual countries responsible for defining their own NZEB policy, many of which are not fully-defined, or are difficult to interpret. This has created great uncertainty as to what heating technologies will be eligible for installation under NZEB policy in new-build EU dwellings. This paper outlines the findings from research into the eligibility of heat pumps under NZEB regulations in 3 EU Member States: Germany, Denmark and the United Kingdom.

Results showed that despite differing approaches to NZEB between countries, under the right circumstances almost all heating technologies could be eligible. However, the current format of future NZEB regulations appear to be most beneficial for heat pumps in terms of ease of meeting regulations. With five years left until NZEB implementation, the regulatory landscape remains uncertain in many EU countries - even those with well-defined NZEB regulations. When installed in a new-build dwelling built to minimum standards, heating market players will need to look to install additional technology or fabric measures alongside their heating systems to meet regulations. This will have an impact on the required future actions of heating system suppliers and heat pump manufacturers over the coming years.

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Selection and/or peer-review under responsibility of the organizers of the 12th IEA Heat Pump Conference 2017.

Keywords: nearly-zero energy buildings; new-build; heat pumps; energy performance of buildings directive

1. Introduction

The Energy Performance of Buildings Directive (EPBD) aims to significantly improve the energy efficiency and total energy consumption of buildings throughout the EU [1], which represents 40% of total final energy consumption and 36% of European greenhouse gas emissions [2]. The EPBD attempts to do this by focusing on influencing energy efficiency in new buildings, and existing buildings that are subject to major renovations. However, like much of the research literature to-date [3][4][5][6] this policy does not look too closely at the impact these regulations will have on heating manufacturers and their product offerings in the future, and subsequently on what heating system choices will be eligible for installation in the future.

With the re-casting of the EPBD in recent years [7], there appears to be acknowledgement of the need for a shift in focus towards the solutions offered by the building and heating industry through the implementation of an

* Corresponding author. Tel.: +44 (0) 131 625 3332.

E-mail address: lukas.bergmann@delta-ee.com

additional set of regulations within the EPBD known as Nearly Zero Energy Buildings (NZEB). Defined under the EPBD as “a building that has a very high energy performance...the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources”, NZEB policy and regulations appear to focus on the material and heating system solution choices allowable in future new-build dwellings [8]. Some researchers, such as [9] and [10], promote the importance of better understanding the impact NZEB regulations will have on heating system eligibility for installation in the future, but typically focus on specific heating systems in specific countries, rather than taking a wider approach. However, with 28 individual member states responsible for defining their NZEB regulations, many of which are either not fully-defined, or difficult to interpret [11], this has left many building sector stakeholders, such as heat pump manufacturers, uncertain as to where they and their product offerings stand in the wider EU context and how they should act under an implemented NZEB policy in the various EU new build heating markets.

To this end the following paper explores the probable impact of NZEB regulations on the future new build residential dwelling market in Europe. The paper sets about interpreting what the NZEB regulations mean in practice for a given EU Member State, and how this will impact the required building designs, and thus heating systems (and in turn heat pumps) which could be eligible for installation. More specifically, this analysis will be used to better understand what impact NZEB policy and regulations will have on heating technology manufacturers, and how they are likely to need to act in the future if they are to remain viable in a more energy efficient residential dwelling sector.

2. Methodology

In looking to determine the knock-on impacts and required heating product offering changes to be provided by heating manufacturers under NZEB regulations, the researchers established that it was necessary to model the impact of regulations on residential dwelling energy consumption (and greenhouse gas emissions). This was required in order to assess the eligibility of specific heating technologies for installation and use in new build residential dwellings i.e. how these technologies would influence household energy consumption and emissions. Based on previous examples of NZEB impact modelling research [12][13] it became evident that the complexity of the issue in terms of the differing implementation between the 28 EU member states required a selection of specific Member States for further analysis in order for the research to be manageable.

As part of the research, 5 Member States were selected for detailed analysis and modelling: Germany, Denmark, the United Kingdom, France and Italy. Based on their residential energy consumption figures, and the varying level of NZEB policy development [11][14] it was felt that these markets provided a representative picture of the varying future new build EU residential markets for further exploration of the potential technology eligibility impacts of future NZEB regulation implementation. Due to the lack of availability of information on NZEB regulations in Italy, only 4 of these countries were analysed in more detail: Germany, Denmark, the United Kingdom and France.

The analysis was further broken down by climate zone as per the ErP and Energy Labelling directive [8] in order to assess whether differing climate regions [15] within a single country would impact on heating system eligibility. Information from existing policy, regulations and case-study documents was collated to develop a general picture of the status of NZEB requirements in each country. Where there were gaps in available regulatory information, primary research with industry, associations and government was conducted to further clarify NZEB definitions. This allowed for a succinct analysis of the current status and direction of travel of the NZEB regulations in each member state.

Parallel to this research, a static building physics model was developed in-house to simulate the compliance (or not) of heating technologies under respective member state NZEB regulations in new build dwellings. This model was developed due to the lack of detailed models, as mentioned by [12][13], which examined the direct influence of residential dwellings compliance with NZEB regulations as a result of the building design and heating system choice/s. A nominal building representative of an average dwelling in each country, including all relevant aspects such as U-values of the building envelope components, internal and solar gains, ventilation losses, etc. was simulated for each of the three countries analysed.

Modelling results allowed for the performance comparison of different heating systems under future mandatory NZEB requirements in new build dwellings. These systems included:

- A/W Heat Pump (A/W HP)
- Ground-Source Heat Pump (GSHP)

- Exhaust-Air Heat Pump (EAHP)
- Hybrid Heat Pump (with Gas Boiler)
- Stirling Engine micro-CHP
- Internal Combustion Engine micro-CHP
- Solid Oxide Fuel Cell (SOFC) micro-CHP
- Proton Exchange Membrane (PEM) Fuel Cell micro-CHP
- Direct Electric
- Gas Boiler

Further analysis within the model was conducted to determine under what circumstances additional measures would be required for specific heating technologies, such as heat pumps, to meet new build dwelling NZEB regulations in a given EU member state. This allowed for a better analysis and interpretation of how NZEB policy will likely come to influence the behaviour and required actions of heating system manufacturers if their technologies are to remain relevant in the new build sector in the future.

3. Results

Based on the country-specific NZEB regulations, the model produced output on:

- heating technology eligibility under EU member states' NZEB regulations, and;
- capital and operational cost comparisons of eligible heating technologies.

Table 1 below details how different residential heating systems are likely to fare under NZEB regulations. That is, which heating technologies could be installed under minimum building standard conditions (i.e. in a new build dwelling that is constructed to meet the minimum building shell/envelope regulations for 2021 in a given country). The table also shows which technologies would be eligible for installation if additional measures were adopted (e.g. mechanical ventilation heat recovery (MVHR), solar PV, solar thermal, improved insulation).

Table 1. Heating system eligibility under NZEB regulations by country

	<i>HPs</i>		<i>Other Heating Technologies²</i>	
	<i>Meets Minimum Regulation</i>	<i>Additional Measures Required¹</i>	<i>Meets Minimum Regulation</i>	<i>Additional Measures Required¹</i>
DK	Exhaust Air Heat Pump	All other HP Types	None	All other technologies
UK	None	All HP Types	None	All other technologies
DE	A/W, GSHP, EAHP	Hybrid HP	None	All other technologies
FR	None	All HP Types (Solar PV is required)	None	All other technologies

¹(e.g. addition of solar PV, solar thermal, improved insulation, Mechanical Ventilation Heat Recovery)

² includes engine micro-CHP, fuel cells, direct electric, gas boilers

In addition to the eligibility of specific heating technologies, the modelling also showed which whole building solution (i.e. not just the heating technology, but including additional required measures, such as improved insulation) provided the lowest capital expenditure (CAPEX) and operational expenditure (OPEX) costs for the builder/developer/end-buyer. Table 2 below outlines which heating technology solution provides the cheapest overall installed new build solution that meets the expected NZEB requirements i.e. which technology (including any additional measures that might need to be installed) provides the lowest upfront cost, and the lowest operating costs.

Table 2. Example of lowest comparative CAPEX & OPEX heating systems

	<i>Lowest CAPEX Solution</i>	<i>Lowest OPEX Solution</i>
DK	Exhaust Air Heat Pump	Ground Source Heat Pump
UK	Gas Boiler + Solar PV	Exhaust Air Heat Pump + Solar Thermal
DE	A/W Heat Pump	Gas Boiler

4. Discussion

In spite of the differing approaches to NZEB between EU Member States, and the apparent tougher regulations in some markets (e.g. Denmark), essentially all heating technologies that we examined could be eligible under

NZEB new build regulations (as shown in Table 1). It appears to be a matter of getting the installation package right. For heat pumps, NZEB new build regulations as they stand appear to be mostly beneficial. Heat pumps appear to “come out on top” when it comes to meeting NZEB requirements under minimum future building regulations. That is, heat pumps typically meet NZEB requirements “as is”, requiring no or minimal building improvements beyond minimum building standards to meet NZEB regulations in most member states that we examined. Furthermore, they appear to have the lowest comparative upfront total new build system cost (see Table 2) in two of the three markets we compared on a financial basis (looking beyond just the cost of the heating system itself). With this said, the UK and French markets are still up for grabs, with all technologies (including heat pumps) requiring some form of additional installed measures to be eligible.

Interestingly, the role of Solar PV, and Solar Thermal for domestic hot water production, looks to be critical for many heating systems to be eligible under NZEB regulations. This raises the question as to the future role of these systems in the heating sector, and how heating system manufacturers will need to change their current business models and interact with other product providers as part of the heating system sales and installation process. It suggests that supply-side stakeholders, such as heating system manufacturers, will have to become more engaged with one another in order to deliver eligible solutions for customers. That is, the current behaviour of heating system manufacturers remaining relatively unengaged in the building process and allowing an installer [15], end-customer or building designer to decide to install their system is unlikely to work as a viable business model in the future under NZEB regulations.

These findings suggest that heating system manufacturers will have a vital important role to play in the future success of the roll-out of NZEB regulations in the new build dwelling sector, but will not be able to continue effectively under business-as-usual practices. This appears to support the views of [16][17] that improving energy efficiency also needs to consider the behaviour and actions of supply-side market players. NZEB policy and regulations appear set to influence this over the coming years.

5. Conclusion

With five years to go, the regulatory landscape around NZEBs remains diffuse in many European countries, although a general NZEB picture is emerging. This paper has investigated the likely impact of this policy on heating system manufacturers, from the perspective of the eligibility of their products under future new build dwelling NZEB regulations. However, it should be noted that this research provides only a snapshot of the building market (having only investigated 4 EU Member States, albeit counting for a large proportion of the EU heating market). Furthermore, the modelling conducted as part of this research was based around a nominal house that reflected the “average” new build dwelling in a given country. The reality will be much more complicated, with heating system eligibility likely to vary greatly from one dwelling to another, and the actions and reactive behaviours of current heating manufacturers are not likely to be uniform or even necessarily rational.

In light of the limitations of the research, it is suggested that the next steps to develop this research further take a more in-depth, country specific approach. On the modelling side it is suggested that more detailed models are developed to more accurately reflect the actual housing stock in a given market, to determine what heating systems on offer by manufacturers will be eligible. Additionally, it is suggested that developing relationships and projects with these stakeholders will be vital to better understand how their current behaviours as businesses differ to those that will be required if they are to remain relevant market players under future NZEB regulation implementation. Whatever the case, it has become apparent that if the EU is to successfully implement its energy efficiency policies in the residential housing sector through EPBD and NZEB regulations, heating system manufacturers will need to change their current way of thinking and their business practices, both as individual companies and as a sector.

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