Available at www.scientevents.com/proscience/

ScientEvents

ProScience 6 (2018) 12-17

ProScience

Conference Proceedings

3rd International Conference on
Applied Mineralogy & Advanced Materials - MMS2018

Life-cycle assessment of near zero energy buildings (NZEB) in comparison with regular new buildings

Ove Mørck[1], Kirsten Engelund Thomsen[2], Kim B. Wittchen[2]

[1]*Kuben management, Copenhagen, Denmark*
[2]*Danish Building Research Institute, Aalborg University, Copenhagen, Denmark*
**ovmo@kubenman.dk*

Abstract

The EU Horizon 2020 (https://ec.europa.eu/programmes/horizon2020/en) research project "Solution sets for the Cost reduction of new Nearly Zero-Energy Buildings – CoNZEBs" (www.conzebs.eu) started in June 2017. CoNZEBs will identify and assess technology solution sets that lead to significant cost reductions of new Nearly Zero-Energy Buildings in four EU member states: Denmark, Germany, Italy and Slovenia. The focus of the project is on multi-family houses. The project will start by setting baseline costs for conventional new buildings, currently available NZEB and buildings that go beyond the NZEB level. The CoNZEBs project will end ultimo 2019.

The project will use the basic characteristics of NZEB to first identify technologies that can be made more cost-efficient if applied to NZEB. Secondly, these technologies will be combined into cost-efficient solution sets or concepts for NZEB. The technology solution sets will include approaches that can reduce costs for installations or generation systems, pre-fabrication and construction acceleration, local low temperature district heating including renewable energy systems (RES), and many more.

All solution sets will be assessed regarding cost savings using life cycle costs (LCC) analysis, energy performance and applicability in multi-family houses. A life cycle environmental impact assessment (LCA) of different building levels and NZEB using the solution sets will provide a longer-term perspective. The results of the LCC and LCA analyses will be compared to those obtained for conventional buildings built according to current building regulations and conventionally built NZEB.

The paper presents the status of this work, which includes the definition of reference buildings, the identified solution sets and the first LCC and LCA calculations performed with ASCOT_LCA.

ISSN: 2283-5954
Selection and peer-review under responsibility of MMS2018 Scientific Committee
DOI:10.14644/mms.2018.003

Keywords: Technology solutions, Low-energy buildings, Life-cycle analyses, Cost-efficient solutions

1. Introduction

The paper summarizes some of the outcomes of the work within CoNZEBs project. The CoNZEBs project team consists of 9 organizations from 4 countries (Germany, Denmark, Italy and Slovenia). The focus of the project is on multi-family houses. Close cooperation with housing associations allows for an intensive interaction with stakeholders and tenants. The project starts by setting baseline costs for conventional new buildings, currently available NZEB and buildings that go beyond the NZEB level. It then analyses planning and construction processes, end user experiences and identifies cost reduction solution sets. An overview of the work packages is seen on figure 1.

Solution sets are collections of energy efficient technologies used in nearly zero energy buildings (NZEB) that in the specific case constitutes a building that meets the national NZEB requirements or beyond. A solution set may vary from one context or location to another and may include any number of technologies. Solution sets have either to result in reduced investment and operational costs.

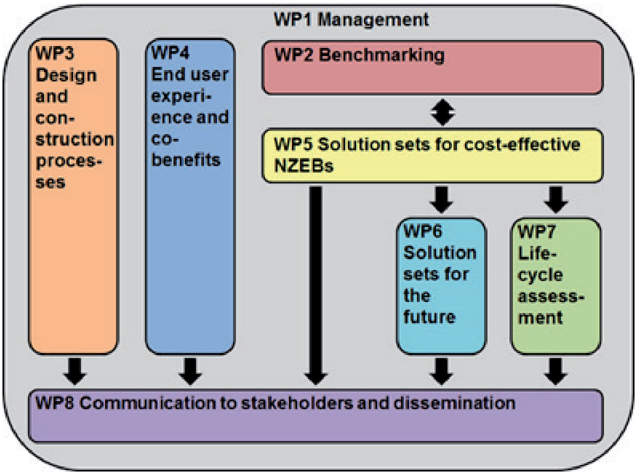

Fig. 1. Overview of CoNZEBs Work Packages

2. Work Package 2 - Benchmarking

In this work package the cost baselines for different building energy performance levels were set. It analysed and compared the investment and energy costs in the four countries for:

- New multi-family houses built according to current national minimum energy performance requirements
- Existing examples of NZEB (nearly zero-energy building) multi-family houses
- Multi-family houses that go beyond the NZEB-level

The work was based on literature on building costs, on the knowledge gained by the different research organisations and complemented by the cost experience of the national housing organisation. The work of Concerted Action EPBD on NZEB was used as well.

The CoNZEBs partners have collected and analysed available data of investment costs and energy costs. Despite extensive efforts including literature research, the use of data available at the CoNZEBs housing organisations and publicly available building cost data of research and demonstration buildings the number of analysed buildings were between 8 and 46 at the time of the completion of this report. The project partners will continue the search for relevant data in order to improve the quality of the calculated averages.

The calculated differences of the average investment costs for building components and building services systems of the NZEB and the minimum energy performance building level per country can give rough indications of the cost barriers for building NZEB in the countries:

1. Germany: 44 €/m² living area
2. Denmark: 65 €/m² gross floor area
3. Italy: 229 €/m² useful area
4. Slovenia: 104 €/m² conditioned net floor area.

3. Work package 3 - cost reduction in the design and construction process

According to the CoNZEBs projects general aim of investigating costs for building technologies and energy systems, Work Package 3 focuses on costs associated to the design and construction processes, without taking into account the other expenditure items. In this framework, the following definitions apply:

- Design process costs: fees for professional figures involved in the design and planning process and related to the structure, the architecture and the mechanical and electrical systems of the building.
- Construction process costs: costs incurred during the construction phase excluding those incurred for products purchase and installation.

Identifying possible cost reduction areas, one of the objectives of Work Package 3, is a challenging task, since in most cases even actual costs are not available in a systematic way at EU and specific country levels.

The actual average design and planning costs vary strongly from country to country. In the participants countries the percentages of total construction costs varied from: 2-20%. In other European countries, the design and planning costs vary from a low in Poland of 3-8 % to a high in Switzerland of 16-30 %. The higher percentages apply to the smaller projects.

In the partner countries measures were identified to have the potential to result in substantial savings in the construction process.

The findings and result of this Work Package are to be used in support of the selected technologies and solutions sets identified in WP5 and may open new research scenarios, where energy and cost performances of NZEB might be assessed at a broader level with respect to actual approached and methods.

4. Work package 5 -NZEB solution sets

The focus of WP5 is to identify solution sets that reduces the construction and/or operational cost for NZEB while at the same time maintaining the level of operational energy needed in the building. In this context, a solution set is a combination of different measures to the building envelope or technical building systems - e.g. reduced façade insulation in combination with rooftop PV - that in total delivers the same energy performance, but at a lower construction and life cycle cost. Each of the participating countries have analysed several candidate solution sets, in e.g. Germany at least 8 sets, before selecting the ones presented in the project deliverables.

Among the solution sets are:

Denmark: 1) High efficiency insulation in exterior walls. 2) Reduced insulation in walls, roof and floor; Roof PV panels, DHW solar heating, Decentral mechanical ventilation, efficient water fixtures. 3) Reduced insulation in walls, roof and floor; Roof PV panels; DHW solar heating. 4) Four-layer windows; Water saving fixtures; Natural ventilation. 5) Reduced insulation in walls, roof and floor; Decentral mechanical ventilation; Heat recovery on grey wastewater.

Germany: 1) Decentral electric heating, e.g. heated glass or marble plates; DHW generation by decentral electrical continuous-flow water heaters; Decentral pre-heating of water by heat recovery on grey waste water; Decentral ventilation units with heat recovery; PV-system; less insulation of the building envelope. 2) Central air-to-air-heat pump in ventilation; DHW generation in decentral electrical continuous-flow water heaters; Pre-heating of water by heat recovery on grey wastewater; less insulation of the building envelope. 3) District heating and DHW; DHW is circulated using a pressure-controlled demand-driven pump; Ventilation is covered by a demand-controlled mechanical exhaust ventilation system; less insulation of the building envelope.

In the solutions sets shown above, decrease of the insulation level in the thermal envelope is one of the common features. This is natural when considering the resulting cost reductions that includes: smaller façade area, smaller foundations, cheaper window installation, smaller roof, smaller need for build-up area or larger habitable area at the same build-up area.

Reductions in investment costs range from 1 €/m² (but with a slightly better energy performance) to 84 €/m², with the highest cost savings in the German solution sets. A report from the work package will present solution sets from all four participating countries in a comparable form. Solution sets can obviously not be compared directly across climate zones and national legislation. However, it is envisaged that some solutions in another country's solution set may inspire to new combinations and hence new solution sets.

5. Work package 7 – Life-Cycle Analyses

Work package 7 is building on the work of work package 5 - the idea being that for the decision-making process the knowledge about the investment costs may be too limited. It is important also to look at the cost over a lifetime (life cycle costs) and the environmental impact of the building project – also assessed over a lifetime. Therefore the objectives of work package 7 are:

- Providing essential life cycle performance (LCC and LCA) comparisons and results in addition to the energy and investment cost information of WP5.

- Informing the building owners and building users about the differences of the life cycle assessments between conventional new multi-family houses and corresponding cost-efficient NZEB and beyond NZEB buildings

In this work package the solution sets identified in work package 5 is further analysed with respect to life cycle costs (LCC) and life cycle environmental impact assessment (LCA or LCIA). The solution sets will be assumed implemented for NZEB buildings and buildings beyond NZEB (ZEB and plus-energy buildings) and the results of the LCC and LCA analyses compared to those obtained for conventional buildings built according to current building regulations and conventional built NZEB. A Danish tool, ASCOT_LCA, that simultaneously perform LCC and LCA calculations will be further developed to handle the identified solutions sets. Thereafter the tool will be used for the evaluation and sensitivity analyses of the developed solution sets. ASCOT_LCA was first developed in a Danish R&D project and then further developed within the EU FP7 project "School of the Future" (www.school-of-the-future.eu) and the IEA EBC Annex 56 - Cost Effective Energy and Carbon Emissions Optimization in Building Renovation (http://www.iea-annex56.org).

The work of Work package 7 has started with defining the reference buildings for each country/climate, identifying the weather data to be used in ASCOT_LCA and implementing the calculations and parameters of the technologies identified in the solutions sets of WP5. In addition, the participants of the project has agreed on the desired output.

The next step is performing all the calculations, which is planned to be completed by March 31, 2019. The final report of WP7 is due July 31, 2019.

So, at this moment only the first calculations have been performed for the Danish NZEB reference building and one of the solution sets - no.3 where the savings have been obtained by reducing the insulation levels of the building envelope and instead added a solar heating system and a PV system - both of 0,5 m² per apartment. The results are shown on figure 2.

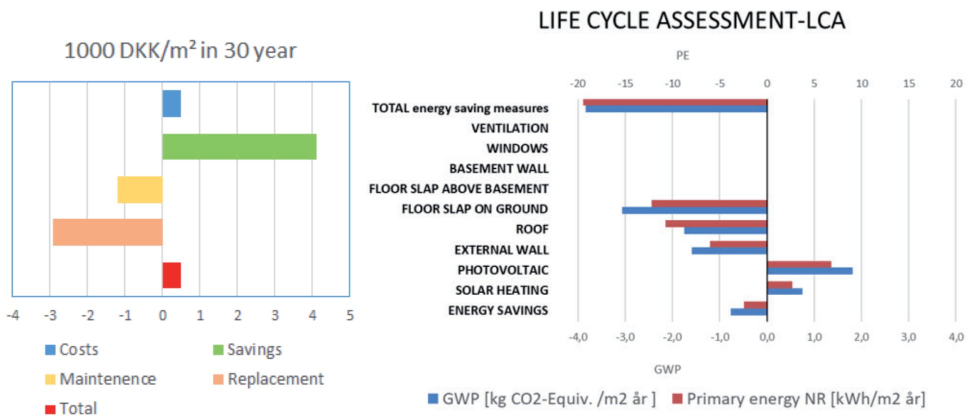

Fig. 2. Life cycle costs (left) of the Danish Solution set no. 3 in comparison to the reference NZEB building and life cycle impact assessment (right) in comparison to the reference NZEB building

In the CoNZEBs project, the primary focus of the LCA will be on the Global Warming Potential (WP)-CO2-emissions and the non-renewable primary energy (NRPE) consumption, but also the other LCA parameters, such as Ozone Depletion Potential, Photochemical Ozone Creation Potential, Acidification Potential, Eutrification Potential and Abiotic Depletion Potential will be calculated.

6. Conclusion

The CoNZEBs project has now been running for 14 months and interesting results are starting to show up. In this paper selected results from the work packages directly related to the cost of minimum EPBD, NZEB and beyond NZEB have been presented. It appears that establishing the benchmark costs is not an easy task – the statistics on NZEB and beyond NZEB buildings is scarce and the way they are calculated vary from country to country. Still, reasonable benchmarks have been established and ways to reduce the overall construction costs identified both in WP3 – covering the design and construction phases. Especially in WP5, where several solution sets were identified – bringing the investment costs down by up to 84 €/m². This is actually higher than the identified differences between minimum EPBD and NZEB buildings in Denmark and Germany. The first results of WP7 are also quite remarkable. The LCC over 30 years show a positive Net Present Value of a solution set that cuts down on the passive means (insulation thickness) and instead adds active systems in the form of a thermal solar heating system and a PV-installation for the Danish climate. Even more interesting are the results of the life cycle environment assessment, which show that the “active” choice has far lower environmental impact of the 30 years analysed period than the “passive” system. This is backed by some of the comments of the building designers and contractors, who answered the questionnaire in WP3, claiming that minimum EPBD and NZEB requirements should be more flexible and holistic and include LCA as well as energy use calculations.

The CoNZEBs project clearly follows the ‘common thread’ to identify cost efficient solutions for low energy buildings established in the many previous cooperation projects mentioned in the introduction and adds valuable new components to these – especially the analysis of design and planning costs and the life cycle environmental assessment perspective.

7. Acknowledgements

The CoNZEBs project is a co-operation between 4 different countries: Germany (Fraunhofer IBP & ABG-FH), Denmark (Kuben, BL & SBi, AAU), Italy (ENEA & ACER RE) and Slovenia (GI ZRMK & SSRS). The partners are from different research organisations and national housing organisation. Fraunhofer IBP leads the project.

The authors like to thank our colleagues for their involvement and commitment in the project.

The CoNZEBs project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement no. 754046.

References

https://ec.europa.eu/programmes/horizon2020/en
www.conzebs.eu
www.school-of-the-future.eu
http://www.iea-annex56.org