

Life Cycle Cost Optimization of a Bolig+ Zero Energy Building

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Buildings consume approximately 40% of the world's primary energy use. Considering the total energy consumption throughout the whole life cycle of a building, the energy performance and supply is an important issue in the context of climate change, scarcity of energy resources and reduction of global energy consumption. An energy-consuming as well as producing building, labelled as the Zero Energy Building (ZEB) concept, is seen as one of the solutions that could change the picture of energy consumption in the building sector, and thus contribute to the reduction of the global energy use. However, before being fully implemented in the national building codes and international standards, the ZEB concept requires a clear understanding and a uniform definition.

The ZEB concept is an energy-conservation solution, whose successful adaptation in real life depends significantly on private building owners' approach to it. For this particular target group, the cost is often an obstacle when investing money in environmental or climate friendly products. Therefore, this PhD project took the perspective of a future private ZEB owner to investigate the cost-optimal Net ZEB definition applicable in the Danish context.

The review of the various ZEB approaches indicated a general concept of a Zero Energy Building as a building with significantly reduced energy demand that is balanced by an equivalent energy generation from renewable sources. And, with this as a general framework, each ZEB definition should further specify: (1) the connection or the lack of it to the energy infrastructure, (2) the unit of the balance, (3) the period of the balance, (4) the types of energy use included in the balance, (5) the minimum energy performance requirements (6) the renewable energy supply options, and if applicable (7) the requirements of the building-grid interaction. Moreover, the study revealed that the future ZEB definitions applied in the Denmark should mostly be focused on grid-connected ZEBs – Net ZEBs, and the annual primary energy balance.

The Life Cycle Cost (LCC) analysis conducted with a study case of a multi-storey residential Net ZEB aimed to determine the cost-optimal "zero" energy balance, minimum energy performance requirements and options of supplying renewable energy. The calculation encompassed three levels of energy frames, which mirrored the Danish low-energy building classes included in the current building code, and ten renewable energy supply systems including both on-site and off-site options. The results indicated that although the off-site options have lower life cycle costs than the on-site alternatives, their application would promote renewable technologies over energy efficiency measures. Thus, they oppose the Danish plans to gradually make the energy performance requirements stricter. Moreover, the results showed that district heating is a less cost-attractive solution than a ground source heat pump for a private building owner. Finally, with 2010-level of energy prices, cost-optimal "zero" energy balance accounts only for the building related energy use.

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