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Design of energy-efficient buildings using interaction between Building Simulation Programme and Energy Supply Simulations for District Heating

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ABSTRACT

Building design must evolve from today's practice – where the individual building parts are optimized separately – into a future where the whole building, including all installed systems, is optimized by integrating innovative technologies that will furthermore make the building itself an active part of the total energy system. Integrated design is a design process informed by multidisciplinary knowledge, where different software plays an important role in the designing process. Numerous simulation programs from different kinds of engineering fields (indoor climate, energy balance, district heating, life cycle assessment etc.) exist today, but their capabilities are not used in an integrated way and optimization opportunities are often lost.

The purpose of this presentation is to demonstrate the importance of handling links between different simulation tools in order to manage the implementation of $C0_2$ neutral communities. A link between a dynamic energy simulation program for buildings and a simulation program for district heating networks is demonstrated. The results of the investigation give an example of how to analyze a community and make recommendations for applying the low-energy district heating concept for low-energy buildings. The annual energy performance is evaluated as well as the socio-economy of a demonstrative network based on realistic energy loads that derived from a human behaviour model. Finally the presentation comments on the reasonable lower limit for the heat demand density for which the connection to low-energy district heating networks is cost-effective and energy efficient.

By using a dynamic energy simulation program for buildings it is possible to analyze the influence of the human behaviour for the building and link the results to the simulation program for district heating networks. The results show that human behaviour can lead to 50% higher heating demand and 60% higher peak loads than expected according to reference values in standardized calculation of energy demand pattern in energy-efficient buildings. The consequence is that in order to get the full potential of the energy saving in the society it is very important to address the decisive involvement of the end-users. The human behaviour is the factor that affects the most the energy use in low-energy buildings and should be included in energy simulations. The results can then be linked to programs simulating the energy supply system in order to support the design of CO_2-free communities. The cases considered, although referring to the Danish tradition in the construction sector and to the Danish climate, have a general value and are adaptable to other situations and countries.

The results demonstrate that there is a large potential for distributing energy in areas with energy efficient buildings. As a measure for the feasibility of district heating, the linear heat density can be used as a representative value, and the results show that it is possible to supply heat with low-energy district heating networks in a cost-effective way in areas with linear heat densities down to 0.20 MWh/(m·year). Even in cases where the user behaviour is not optimal, the system is able to deliver heat to each customer.

The low-energy district heating concept could be strategic for reaching ambitious energy and climate targets and has the potential for being widely implemented in Europe, taking into account what concluded in the EcoHeatCool project, 2006 about the European heat market. Similar conclusion can be drawn for other countries where energy saving measures and efficiency in the energy supply agenda are priorities in the political agenda.

In the perspective of a 100% RE-based heating sector, the presentation explore the opportunity to apply community energy systems optimized to supply low-energy buildings, since there might be the chance that such concept can be more cost-effective than single-building-oriented concepts (in specific conditions).