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heat saving strategies in sustainable smart energy systems

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Introduction

Future sustainable energy system solutions are typically based on a combination of renewable energy sources such as wind, geothermal and solar, together with residual resources such as waste and biomass. A wide use of combined heat and power together with the utilisation of heat from waste-to-energy and various industrial surplus heat sources as well as the use of geothermal and solar thermal heat should be considered for district heating in future sustainable cities.

The application of this concept leads to a **smart energy system**, in which smart electricity, thermal and gas grids are combined and coordinated to obtain synergies between them and to achieve an optimal solution for each individual sector as well as for the overall energy system. This paper presents a methodology to identify least-cost strategies for reducing the heat demand in buildings as a part of implementing sustainable **smart energy systems**. The methodology has been applied to the Danish energy system, where the Government has formulated a strategy for transforming the whole energy system into a system based on 100% renewable energy by the year 2050.

Method

The study is based on a scenario analysis carried out in the CEESA project. The study has proposed developing an implementation plan with the use of the EnergyPLAN software to identify the marginal cost of heat production. In this study, 2010 is the reference year and, by the year 2050, a 40% increase of heated area is expected. Moreover, looking at the historical development of 17% decrease over a 40-year period (table below), an active policy will be required in order to achieve the challenging goal of reducing heat demand by 50% during the next 40 years.

Year (primo)	1970	1980	1990	2000	2010
Total heated area (Million m^2)	185.1	246.7	278.0	298.3	331.7
Total heat demand (TWh/year)	27163	34155	36793	38466	40327
Specific demand (kWh/m^2)	147	138	132	129	122
10-year growth factor		1.33	1.13	1.07	1.11

Results

The overall goal is to have a 100% renewable energy system. If heating demand is reduced, there will be less need of biomass and other renewable sources. A reduction in heat demand leads to a decrease in the overall cost of the total energy supply. The analysis considered *new buildings* consisting of single-family houses of 150 m², and 27 types of *existing buildings* that are going to be refurbished anyway for identifying the costs of different levels of energy savings. The potential energy savings in new buildings are not as high as in the older building stock and the costs of implementing the savings also differ. This means that for some building categories, higher heat savings can be achieved by implementing less expensive measures than in other building types.

The low-cost heating strategy seems to be found with **savings of 35% to 53%.** However, since the analysis only takes the single-family houses, farmhouses and terrace houses into account, **more cost efficient savings are expected in apartment blocks and offices**. Therefore, the least-cost strategy is expected to be closer to 50% than 35%.

Savings should be implemented primarily in *new buildings* and only in *existing buildings* when renovation is being carried out anyway. Otherwise, the marginal costs are substantially higher than the heat production costs.

For each building category, five heat saving measures are implemented in the calculation; these are roof, floor, outer wall, window, and ventilation.

Discussion

The results of the analysis highlight the importance of identifying long-term heating strategies since the identified least-cost solution should be implemented with a long planning horizon in mind. Firstly, savings should mostly be implemented when buildings are being constructed or when renovations are being carried out anyway, which requires several decades to include the total building stock. Secondly, it is necessary to develop a suitable district heating infrastructure, adjusted to low-energy buildings, which also calls for a long planning horizon.

Implementation of a 50% energy savings during the next 40 years is very ambitious and will require a vigorous policy. It should be emphasized that for Denmark such a future heat saving strategy is very ambitious compared to what has been achieved in previous years, since the historical development shows only a 17% decrease during the last 40 years.

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