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Heat Roadmap Europe: Identifying the balance between saving heat and supplying heat

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ABSTRACT

The cost of heat savings in buildings increase as more heat savings are achieved and hence, alternatives other than savings typically become more economically feasible at a certain level of heat reductions. The challenge addressed in this paper is to identify when the cost of heat savings become more expensive than the cost of sustainable heat supply, so society does not overinvest in heat saving measures. This study first investigates the heat saving potentials for different countries in Europe, along with their associated costs, followed by a comparison with alternative ways of supplying sustainable heating. Furthermore, the levelised cost of supplying sustainable heat is estimated for both a single technology and from an energy system perspective. The results are analysed by assessing various parameters such as socio-economic costs and energy efficiency improvements in the national energy systems. The results demonstrate the economically feasible levels of heat savings and heat production for various European countries, highlighting differences in their national conditions and energy systems. The findings in this paper indicate that overinvestments in heat savings can be avoided by saving heat until a level around 30–50% of projected heat demands and supplying the remaining heat demand with sustainable heat sources.

1. Introduction

This paper presents two distinct methods and analyses for assessing the balance between heat savings and heat supply for various European countries. The purpose is to shed light on the debate about feasible levels of heat savings and the different methods that can be used to analyse this. If this balance is not identified societal overinvestments could be the outcome. Currently little knowledge is available about feasible levels of heat savings and how these are impacted by local conditions and settings. This paper therefore contributes with possible methods for analysing the relation between heat savings and heat supply and presents the findings when applying these methods.

The European Union targets of achieving 27% energy efficiency improvements by 2030 compared to projections will be a challenge to meet. Therefore, it is important to identify the balance between heat savings and heat supply as both of these might have a role in achieving these efficiency targets [1]. Similarly, the affordability to achieve this target will be vital. Energy efficiency and renovation of buildings is recognised as beneficial in the European Commission: "*Investments in this area [building renovations] can provide great returns in terms of growth and jobs*" [1], page 13.

All EU member states are obliged to "*… carry out and notify to the Commission a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling*" [2], page 20. It is therefore relevant to analyse for each member state the feasible level of heat supply in order to accommodate feasible heat production through the potentials for cogeneration and district heating and cooling [3]. This paper contributes with analyses of the roles of heat savings and heat supply and how these are both crucial for a future low-carbon society.

The hypothesis in this paper is that there is a certain level where it becomes more economical to supply heat rather than continuing to save heat, see Fig. 1.

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If this hypothesis is valid it means that it will not be possible to simply use savings as the only measure to improve the future energy systems. The three questions that will be answered are:

- What are the heat savings potential for various European countries?
- What is the unit cost of heat supply for various heat supply technologies in the future?
- At which point does it become more economical to supply heat rather than saving heat for various European countries applying two different methods?

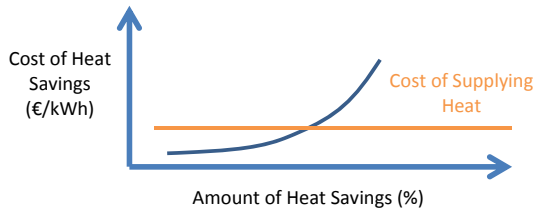

Fig. 1. Theoretical illustration of the relation between cost of heat savings, the amount of heat savings and the cost of heat supply.

Heat saving strategies have recently been described in a number of studies focusing on decarbonising the European heating and cooling sectors through a combination of heat savings and district heating [4] and by implementing energy efficiency in buildings across Europe [5] [6]. Other studies focus on similar research areas, but on a national scale for Denmark [7], including potential barriers for renovating buildings such as tariff systems and the need for a financial reform in a Danish context [8]. Studies also focus on different ways and strategies of achieving heat savings in multi-storey buildings [9] and for specific energy sectors such as the paper industry [10]. Some of these strategies relate to improving single technologies such as industrial heating technologies [10] while others focus on energy savings through improved efficiency in buildings across EU-27 [11]. These studies show that heat savings are vital if a future low-carbon energy system is to be achieved.

Several studies also conclude that heat savings cannot stand alone and that heat supply in the future will also be necessary through efficient heating technologies such as district heating [12] to avoid unfeasible investments in building refurbishments [13] [14]. This is in particular the case since there is a mismatch between the consumption in net zero-emission buildings and the production in the energy system [15]. Heat savings is therefore not the only measure required for achieving a low-carbon energy system and research therefore focus on sustainable heating technologies such as expansion of district heating in both Denmark [16,17] and in Germany [18], integration of electricity in the heating sector [19,20] and improved storage options [21]. Other studies find that net zero energy buildings must be coordinated with the heat supply networks in order to integrate excess heat from solar thermal into the remaining energy system [22].

However, only few attempts of quantifying the balance between heat savings and heat supply have been developed so far and only for national systems such as Denmark [7] [23] and the UK [24] or on urban district scale [25]. In Ref. [26] optimal private investments are considered for both heat demand and heat supply and an additional focus is on health damage costs of particle emission from heat supply technologies. The balance between heat demand and supply is considered for a community near San Francisco in Ref. [25] focusing on costs, carbon dioxide emissions and system efficiency while [24] emphasises the role of domestic energy efficiency in the United Kingdom without further assessment of feasible saving levels. Single-country assessments are also part of [7,23] while [27] analyses Europe as a single entity.

These studies therefore only present single-country assessments and do not draw comparisons between multiple countries or comparisons between different methods.

This paper therefore contributes with new types of analyses in more detail applying two different methods for quantifying the balance between heat savings and heat supply for various countries. The findings presented here provides the first attempts of quantifying this balance between heat savings and heat supply in multiple national energy systems. In addition, this is the first time a comparison is carried out for two different methods of assessing the balance between heat savings and supply.

The background for this paper is the research project called STRATEGO, financed by the Intelligent Energy Europe, with the aim of supporting the development of enhanced heating and cooling plans for national authorities in European countries. The STRATEGO project combines research from a number of universities and private partners in order to develop future energy efficient Heat Roadmap scenarios with low-carbon heating and cooling sectors for the Czech Republic, Croatia, Italy, Romania and the United Kingdom and builds on top of the previous Heat Roadmap Europe pre-studies [28–31]. Focus in the STRATEGO project is on energy efficiency on both the demand and supply side of the heating sector, while the focus in this paper solely is on energy efficiency improvements on the demand side.

This paper is structured with a description of the methods applied in Chapter 2 for heat savings potentials and associated costs followed by a description of the two methods that are compared for assessing feasible balances between heat savings and heat supply. Chapter 3 then presents the main results and findings for both of these two methods and finally, the conclusions are summarised in Chapter 4.

2. Methods

This paper compares heat savings to heat supply by comparing different heat saving levels and the impacts on the Economy (socio-economic costs), Energy (Primary Energy Supply) and Environment (Carbon Dioxide Emissions). This allows for considering a variety of metrics when identifying heat saving levels and ensuring that for example reductions in energy demand is accompanied by acceptable changes to the socio-economic costs. If only considering a single metric such as the energy demand the maximum technical saving potential should be implemented regardless of costs and would then only be limited by implementation concerns.

First, the heat saving potentials and costs are presented followed by two different methods for balancing heat savings and heat supply: a Levelised Costs approach and an Energy Systems approach.

2.1. Heat saving potentials and costs

Heat savings will play an integral part of a future decarbonized energy system as previously described, but the question is how much is feasible and how it differs between different countries according to the conditions of the local energy systems. A method is developed in Ref. [32] to assess heat saving potentials along with the associated costs of implementing these for different countries using the BEAM (Built Environment Analysis Model) tool [33]. Further documentation of the BEAM tool as well as the input data used to calculate the energy saving costs are available from Ref. [32]. The tool focuses solely on the buildings in a country and is used to project respectively a future reference and energy efficiency

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