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MODELING OF ELECTRICITY SAVINGS IN THE DANISH HOUSEHOLD SECTOR USING BALMOREL

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Abstract

In this paper we examine the investments in energy-efficient household appliances from an energy system perspective. We consider a set of ten appliances constituting the majority of the electricity consumption in the private household sector, and investigate whether investing in improved energy efficiency can compete with the cost of electricity supply from existing or new power plants. To assess the analysis, Balmorel, a linear optimization model for heat and power sectors, has been extended in order to assess the best possible investments in more efficient household appliances. The model is non-exclusively tested on the Danish energy system under different scenarios, and computational experiments show that several energy efficiency measures in the household sector should be regarded as valuable investments, while others would require some form of support to become profitable. The analysis also reveals the impact that changes in the Danish electricity consumption would have on the surrounding countries in terms of power system configuration and emission reduction.

1. INTRODUCTION

Besides the effort in integrating renewable sources in the system, the Danish government has set a number of targets for the further development in Energy Efficiency measures. The following natural step is to understand where investments should be targeted in order to obtain the most cost-effective energy system.

2. METHODOLOGY

The Balmorel model is an optimization model for the electricity and combined heat and power systems, previously applied to several energy systems and for a wide range of purposes. In this study, the model has been extended to allow investments in more efficient households appliances (refrigerator, fridge, washing machine, lighting, dryer etc.). The trade-off between investment cost and demand reduction for each appliance category is handled by the model, which evaluates when it is optimal for the system to trigger the investment and in which extent. The Danish system have been tested under four different scenarios: with and without energy efficiency investments (which we call “save” and “base” scenario respectively), for a past and a future year (2012 and 2025). For the 2012 case, we examine a known energy system, resembling the current one, which is fully determined exogenously. In contrast, for 2025 the energy system is also allowed to evolve by investing in new power plants and decommissioning the old and unproductive ones.

3. RESULTS

Among the large output of the simulations, our analysis is focused on a few factors considered as the most relevant. They include changes in fuel consumption, electricity prices, system costs, CO₂ emissions and investment level for the different appliances. In the “save” scenarios the fuel mix has changed, resulting in a reduction of coal and natural gas utilization. In relation to this, a CO₂ emission reduction occurs for both 2012 and 2025, amounting to 1 and 3 million tonnes resp. system-wide. Fuels and emissions changes realises not only in Denmark, but also in Germany and the Nordic countries, showing the importance of interconnections. The electricity prices for the base case are on average slightly lower (of ca. EUR 0.20) for both of the Danish electricity zones. Finally, the lighting appliances result as the most cost-effective energy saving implementation, and their investment level is very high, implying a yearly demand reduction of more than 1 TWh out of 34. On the other hand, no investment occur for most of the other categories.

4. CONCLUSIONS

Some of the energy efficiency investments in the Danish household sector are relevant to obtain a more cost-effective energy system. Such investments are beneficial in terms of emissions, electricity prices and fuel consumption. Further work includes the simulation over more years, the identification of the subsidy level necessary to trigger additional investments, and the analysis of the link between energy system and behavioural dimension.