IMPACTS OF RESIDENTIAL ENERGY EFFICIENCY AND ELECTRIFICATION OF HEATING ON ENERGY MARKET PRICES

Christian F. Calvillo, Centre for Energy Policy, University of Strathclyde, christian.calvillo@strath.ac.uk
Karen Turner, Centre for Energy Policy, University of Strathclyde, karen.turner@strath.ac.uk
Keith Bell, Electronic and Electrical Engineering, University of Strathclyde, keith.bell@strath.ac.uk
Peter McGregor, Fraser of Allander Institute, University of Strathclyde, p.mcgregor@strath.ac.uk

Overview

Energy efficiency is attracting the attention of policy makers worldwide, with many measures targeting the residential sector. It is expected that energy efficiency measures will bring changes on the energy system. However, the changes on electricity prices due to energy efficiency and the electrification of heating have been scarcely addressed in the literature.

This paper presents an assessment of the impact on electricity prices produced by energy efficiency and the decarbonisation of heating in the residential sector. A linear programming problem is used to find the optimal planning and operation of electric heating and residential loads, following a price-maker approach. Then, the potential cost changes for the residential consumers, and the impacts on electricity prices in the wholesale day-ahead market are estimated, considering different residential energy efficiency and electric heating scenarios.

Following the explanation of method, a discussion of results is presented, considering how the energy efficiency measures and the electrification of heating change the energy price curves and the policy implications of this finding. In addition, it is discussed how these price changes might affect the consumption behaviour of other energy users, again commenting on possible energy policy challenges.

Methods

A linear programming problem is used, following a price-maker approach. The objective of the optimization problem is to minimize the energy costs for the residential clients by optimally managing the heating resources.

Air-source heat pumps (HP) have been selected as the representative technologies for thermal energy production. In addition, Different numbers of residential consumers are considered for this analysis. The average change on electricity prices and the impact on the electric energy costs due to the electrification of heating and energy efficiency measures are computed as well.

The impact of on the market has been simulated by clearing the aggregated residential client’s energy (to sell or to buy) against a set of residual demand curves (RDC). The year is represented with 288 residual demand curves, corresponding to one representative curve per hour, 24 hours per day and 12 representative days for the year.

To avoid non-linearities, energy cost curves are computed from the residual demand curves, and a piecewise linear function approximation is applied. In this study, 23 points have been used to model the 22 considered segments for the energy cost curve approximation.

Results

Preliminary results show that the electrification of residential heat (for instance, with air source heat pumps) do increase the electricity demand and, consequently, the prices. However, if managedly optimally and with the assistance of energy efficiency measures (building envelope that convserves the heat inside buildings for longer), the heat demand can go to off peak hours, reducing the overall energy costs for households. Figure 1 shows an example of price changes due to shifting electric load from peak to off-peak hours, decreasing the prices of the former but increasing the price for the latter. It can also be seen that this behaviour tends to flatten the load and energy price curves.

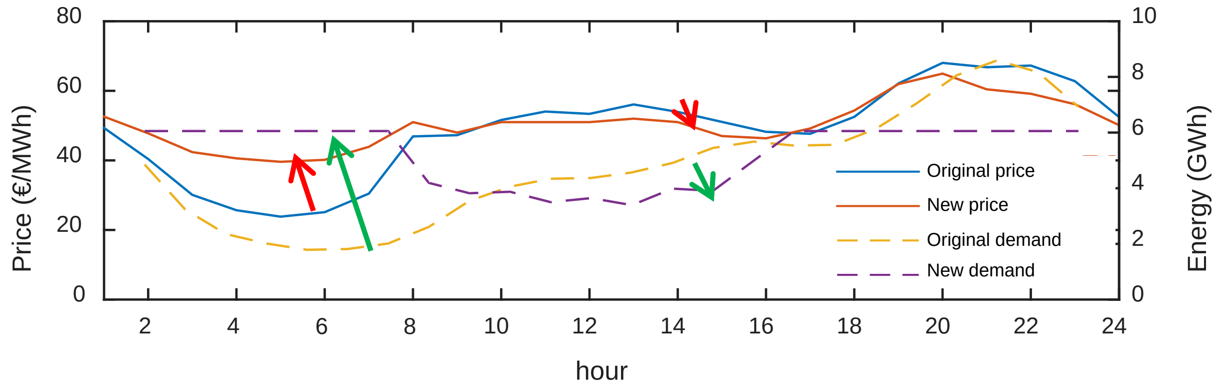

Figure 1. Example of residential load changes and their impact on electricity price.

These preliminary results suggest that energy efficiency measures not only produce savings due to reducing heating demand, but also by facilitating a better management of heating technologies.

Conclusions

Even though the price-maker model used is a simplified approach of the market (other agents reactions to new prices are not considered), it provides some insight on potential savings due to residential energy efficiency measures and impacts of the electrification of heating. It is important to remark that these economic benefits are for the aggregator or retailer participating in the market. However, it is sensible to consider that these benefits could be translated to a large extent to the final consumer as well.

The electrification of certain services such as heating or transport could increase electricity prices, directly affecting the affordability of such services for consumers. However, with the assistance of energy efficiency measures and by optimally managing heating resources, the energy costs increases could be mitigated or cancelled out.

In addition, flattening the load profiles and the price curves also impact the supply side, potentially changing the merit order of generators. With a flatter demand, there is less need to shutdown and start up generators, and generators can work at their optimal performance, improving efficiency.

The outcomes obtained are relevant for policy makers and stakeholders, to understand better the potential impacts of decarbonisation of services and energy efficiency measures in the residential sector, also providing awareness on potential conflicting targets, such as electrification of heat vs energy affordability.

References

Scottish Government, St Andrew's House. "National Infrastructure Priority for Energy Efficiency - Scotland's Energy Efficiency Programme." Consultation, January 24, 2017. http://www.gov.scot/Publications/2017/01/2195/downloads.

Blesl, Markus, Anjana Das, Ulrich Fahl, and Uwe Remme. "Role of Energy Efficiency Standards in Reducing CO2 Emissions in Germany: An Assessment with TIMES." Energy Policy 35, no. 2 (February 2007): 772–85. doi:10.1016/j.enpol.2006.05.013.

Calvillo, C. F., A. Sánchez-Miralles, J. Villar, and F. Martín. "Optimal Planning and Operation of Aggregated Distributed Energy Resources with Market Participation." Applied Energy 182 (November 15, 2016): 340–57. doi:10.1016/j.apenergy.2016.08.117.

[192] L. A. Wolsey and G. L. Nemhauser, *Integer and Combinatorial Optimization*, 1 edition. New York; Chichester: Wiley-Interscience, 1999.