THINKING HEAT AND ELECTRICITY MARKETS TOGETHER – A SOLUTION TO INTEGRATE HIGH RENEWABLE INFEED?

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Overview

Renewable capacity growth is substantial around the world. Particularly the fluctuating renewable energy sources of wind and photovoltaics form the main pillars of future electricity generation. This unpredictable renewable infeed comes along with distinctive challenges for technical and market integration. This is especially valid for countries with strong wind and photovoltaic capacity development e.g. China. A key issue is to find reasonable use for excess fluctua-ting renewable electricity generation and avoid curtailment of renewables with close to zero short-term marginal costs.

The approach is to extend conventional options for heat production with an option to produce heat with electricity. This holds great promise for addressing the vexing challenge of matching an increasing infeed of fluctuating renewable energy with an inelastic energy demand. The objective is to find out whether there is an intrinsic micro-economic benefit for consumers and producers to shift electricity consumption for heating purposes in dependency of the momentary requirements and market signals. The chosen approach combines focus areas of current scientific research for system integration of renewables: market coupling, flexibility on the demand side and market-based operation.

Methods

1st, the study draws on empiric data of the electricity market for Germany. Following current scientific knowledge a reproducible model based on the residual load is applied. This multivariate short-term price model, which includes a deterministic and a stochastic part, is developed to reflect the functional correlation of electricity prices and fluctuating renewable electricity generation. 2nd, heat demand is modelled using empiric data for residential and district heating as well for a paper and a chemical company. At the end, two models are combined: The model of price formation in the electricity market and the decision model for the heat producer. The combination of two models and the essential use of empiric data are unique for this paper.

The market-driven operation of power to heat is in the focus of this paper. From a micro-economic perspective, the electricity demand for heating purposes must compete with conventional heat production cost in the sectors. Short-run marginal cost curves for heat production are calculated for conventional and power to heat systems. A short-run mar-ginal cost curve represents the relation between incremental cost in the short-run of a good and the quantity of output produced. Hourly specific spread patterns for 22 years for diverse applications in the different sectors are processed.

Results

First, the paper discusses technical feasibility and identifies the sectors, which should be yield first for heat production with electricity. Technical complexity is highest for the industry sector. Electrode boilers are suitable for providing process steam, but the high process steam requirements make downstream superheaters necessary. Nonetheless, the corresponding economy of scale effect decreases average specific investment cost in the paper and chemical industry. Specific investment cost are higher for district heating despite modest technical requirements. A higher the norm standard of a residential

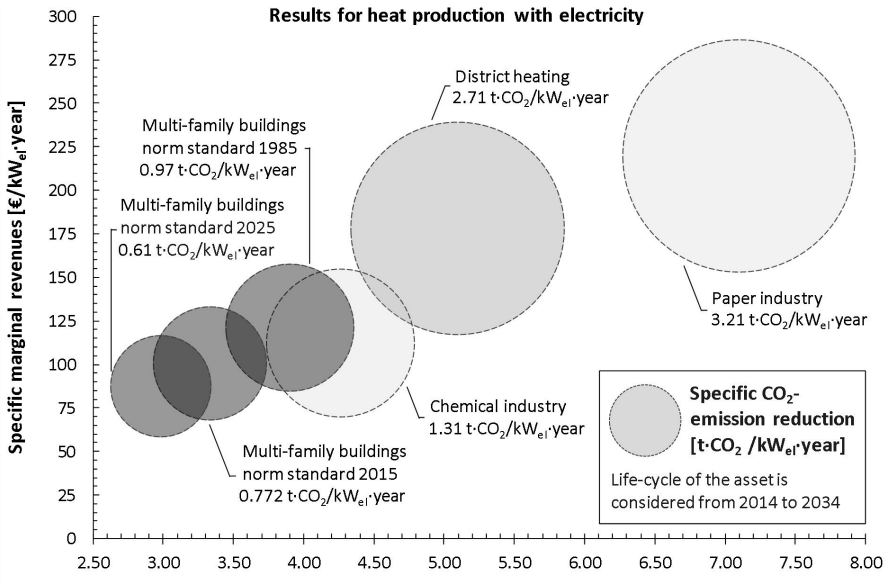

Fig.1: *Results of heat production with electricity for marginal revenues, final energy consumption and CO_2-emission reduction; without state induced price components, moderate price scenario, gas as source for conventional heat production, sector specific*

building improves thermal effi-ciency, which lowers the thermal demand for heating purposes.

A trans-sectoral economic comparison is the focus of the second section. Analysis show that in all application fields the levelized cost of heat produced with electricity are competitive with the conventional heat production cost. As shown in Fig. 1, heat production in times of low electricity prices results in significant revenues. However, these results are restricted to the exclusion of state-induced price components. In Germany, the benefits in electricity use for heating purposes will be small, if the full extent of taxes and levies on electricity consumption is considered. Economic operation is limited to the paper and chemical company due to prevalent tax exceptions for energy intensive industries.

Third section of the paper describes market interaction effects. Flexible demand interacts with the electricity market and has an electricity price stabilizing effect. Higher electricity prices inhibit the economic efficiency of heat production with electricity that accompany a self-stabilizing effect. Final investigation with focus on macro-economic criteria shows that distinctive advantages come with the connection of the heat and electricity market. 1st, heat production with electricity increases the use of renewable electricity generation. 2nd, it leads to higher short-term electricity prices. 3rd, heat production with electricity promotes a solution for the strong fossil fuel dependency of the heat market. CO2-emissions are reduced by using renewable electricity for heat production rather than gas as fossil energy source. This is also illustrated in Fig. 1. Substitution of fossil combustion with renewable sources is indispensable in order to fulfill national, European or global CO2-emissions obligations. It is especially efficient in the heating sector, where decarbonization has been sluggish.

Conclusions

Among the key findings is that economic performance for heat production with electricity depends strongly on the regulatory framework. Matching a flexible infeed with a fixed structure of state-induced components is not adequate. Policy-relevant conclusion is that government intervention will be required to reach a socially optimal level. To reach cost efficient system stability regulatory intervention is advised to establish a time-variable tax structure and a transparent electricity market price. This will help to overcome barriers for renewable market integration in Countries with high capacity development e.g. China and Germany.

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