

LINKING HEAT AND ELECTRICITY MARKET FOR COST EFFECTIVE RENEWABLE ENERGY INTEGRATION

Philipp Riegebauer, Phone +49 (0) 21143519504, E-mail: philipp.riegebauer@fh-duesseldorf.de
Dieter Oesterwind, Phone +49 (0) 21143519502, E-mail: dieter.oesterwind@fh-duesseldorf.de
Lukas Volkmann, Phone +49 (0) 21143519506, E-mail: lukas.volkmann@fh-duesseldorf.de

Overview

Reliable and sustainable power supply is becoming of crucial importance with increasing share of renewable energies. The challenging task for the power system in future is the permanent balancing between energy availability and demand over time and distance. To integrate the fluctuating energy into the power supply and ensure the stability of the electric grid different approaches exist. They can be classified as demand side management, generation management, storage and grid optimization. The rapid expansion of renewables is also presenting enormous challenges for the electricity market. It has to be ensured that the most economical option is chosen to integrate renewables into the power system. A key factor for cost efficient renewable energy integration is a flexible demand. This means the ability to adapt the demand in response to varying price signals of the market. A very promising option is Power to Heat which allows linking the electricity with the heat market. With Power to Heat energy from renewables can be used for thermal processes instead of fossil fuels in periods of renewable surplus energy. Fossil fuels will be saved and can be used on their part for energy generation to bypass periods of high demand and low renewable energy production. Main object of analyses in the context of the study are thermal processes which can be operated flexible by electric or conventional heating.

Methods

Research is focused on short-term price formation of demand side management options in liberalized electricity markets with sufficient guaranteed capacity. Spot price formation can be described by the ascending short-term marginal cost curve of all available generation capacities (merit-order) and demand. In future, negative residual load is expectable during surplus periods of renewables when demand is completely covered by wind turbines and photovoltaic. As shown in Fig. 1 (left) feed-in from renewables reduces the spot price level due to their negligible marginal costs. If the capacity of flexible demand is higher than available renewable surplus spot price formation is determined by customer's willingness to pay for additional consumption. As shown in Fig. 1 (right) this leads to higher spot prices and uprated marginal returns created only by market-based incentive mechanisms. Higher capacities of Power to Heat on the market would obviously affect the outcome of the trading.

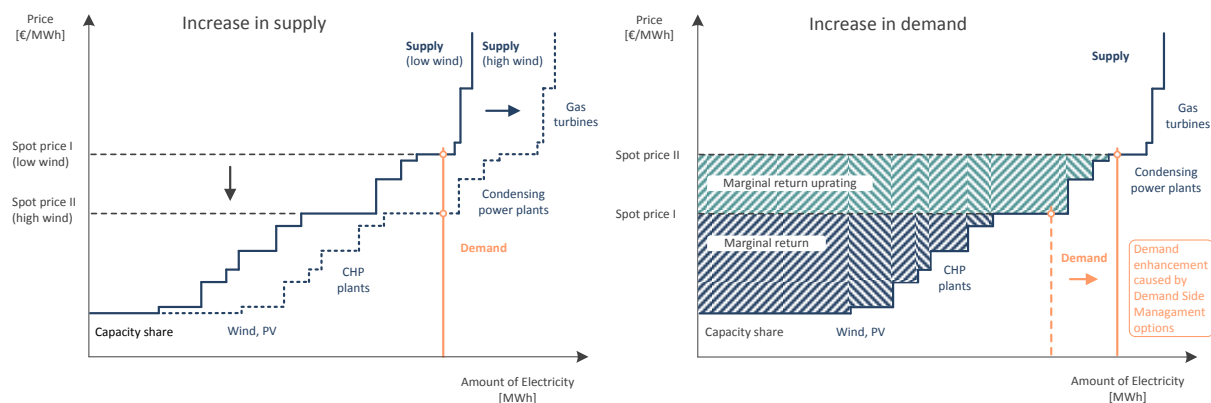


Fig. 1: Systematic of short-term pricing mechanism with high renewables feed-in and flexible demand

Modeling electricity prices is based on a time-series regression analysis of hourly price data and residual load. The simulation of future short-term electricity prices is accomplished by combine the time-series regression analysis with future renewable capacities. To calculate the future renewable electricity generation actual specific feed-in data of hourly utilization of renewable energies is scaled to the lead scenario of the 2013 German network development plan. Modeling the residual load, renewable surplus and possible times of energy shortage finally requires implementing load data into the model. To calculate the pricing effects an economic model is used which considers the potential of Power to Heat and which indicates the cost factors for implementation. The potential of Power to Heat depends on possible additional income in contrast to the conventional technologies for heat production. In this case the plant or heater is shut down and no electricity will be fed into the grid as well as the requested heat is generated by electricity. A simulation is made on a hourly basis for companies of the paper- and chemicals industry, district heating and the residential sector.

Results

The electricity price is the main factor to evaluate cost effectiveness using Power to Heat. Beside the electricity price the cost effectiveness for the usage of electricity instead of fossil fuels for heat production depends on the ratio of gas prices as well as taxes and levies for renewable energy such as costs for grid use. Fig. 2 shows the additional income with Power to Heat in combination with conventional heat generation taking the lead scenario 2013 of the German network development plan into account. The additional income is equal to the possible amount of taxes and levies. The results show clear financial incentives for implementing Power to Heat. E.g. calculations indicate an additional income for the paper industry of approx. 41 €/MWh without the need of a transformer and a fixed payback period of 15 years for the investment of an electrode boiler. In the residential sector the technical implementation is possible with a simple small scale heating element. For single-family households results show a significant smaller income of approx. 25 €/MWh.

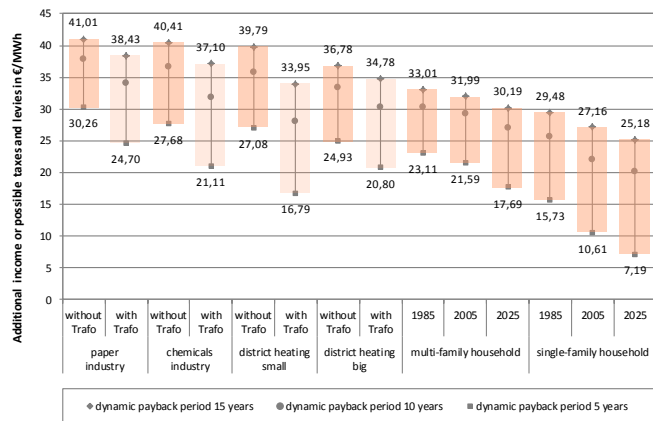


Fig. 2: Additional income or possible taxes and levies for Power to Heat in combination with conventional heat generation

Conclusions

The heat market has a high energy need and consequently opens a high potential for electric heating. Furthermore, carbon dioxides are saved to a large extent due to the heat market's strong dependence on fossil fuels. Overall, the objective must be the reduction of economic costs, resulting from the minimized expansion of the grid and generation capacities. Options which may be used to ensure an economic integration of renewables should be market-based and non-discriminatory and a competitive pricing must be guaranteed. The preexisting of the mentioned conditions is necessary to enable a significant impact of demand side management options like Power to Heat.

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