Joint utilization of demand side flexibility of heating devices and heating grids with benefits for energy suppliers and customers

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Overview

Due to the rising share of fluctuating renewable energy sources, future electricity production will not be able to adjust to the demand at all times any longer in the future. Therefore, demand side flexibility has to be boosted. Demand side flexibility can be assessed according to different parameters. For example, such assessment could look at the amount of power and energy that can be stored for use at different times, energy availability, operation constraints (i.e. minimum run time of heat pumps) and many other aspects. In particular, heating applications, which can be situated either in decentralized objects such as single-family-homes, multi-storey homes, industry and commerce facilities, as well as centralized in district heating systems, are seen as suitable for effectively realising demand side management in terms of power and energy. Due to the fact that thermal energy storage costs are much lower compared to electro-chemical storage, especially since storage structures (hot water storage, thermal storage masses of buildings) are already in place and only have to be activated accordingly, simultaneous usage of thermal storage options is investigated. .

On the other hand, the electricity market system has to be taken into account when considering flexibilisation. In the existing energy market mechanisms, optimization of electrically driven heat generation in decentralized objects has to be realized in accordance with two often contrary perspectives. When using distributed energy production in the objects (mainly photovoltaics, PV), the goal for the Prosumer should be to increase the objects' immediate consumption so as to save network charges and taxes. For the energy supplier, the immediate consumption of Prosumers leads to less sales and therefore less contribution margin. Nevertheless the remaining flexibility after optimisation of own consumption could be used for the supplier to make use of low energy price periods/daytimes in electricity wholesale.

The paper shows how both perspectives can be dealt with in a way that allows both parties (energy supplier and customer) to best profit from demand side flexibility and how power-to-heat in district heating systems can add flexibility value to the system.

Methods

Different types of residential buildings, industry and commerce facilities and district heating systems were simulated to determine their behaviour concerning different flexibilisation strategies in order to optimize their own consumption of on-site PV-production and load management as defined by the energy supplier. The simulation was done by means of a Matlab-tool for each case and was based on real prices (spot market and consumer prices). For objects without own production, the whole flexibility was used for optimising the energy suppliers contribution margin. Therefore, thermal storage has been loaded at times with the lowest spot prices (usually during the night). Objects with own production were optimised in three steps. First, on site production, consumption of household loads and heating demand has been predicted/estimated based on weather forecasts and historical data. As a second step, a time frame was defined, in which the storage must not be loaded using electricity from the network due to having a low state of energy when surplus from own production was predicted. As a last step, without the disabled time frame, the storage was loaded at low spot market prices. District heating was analysed in another way. Different production profiles including wind and PV (after optimisation at object level) and a measured load profile of a district heating network were used to investigate its economical and technical effects when using it in power-to-heat facilities with different sizes. At the end, investment considerations were done including the results of the simulation and giving cost limits for ICT connections and investment in power-to-heat facilities.

Results

First, the optimization tool with the different optimization strategies and the relevant input and output parameters will be presented.

Secondly, the results for the selected objects and their effects on both the energy supply company and the customer regarding their respective adjusted load profiles and any corresponding financial effects are shown.

Finally, the data collected is projected and combined with the district heating network and shows the effects on the figures of an entire supply area.

The results show, that different objects and scenarios can deliver different flexibility contribution. Using heat storages can deliver a huge flexibility effect for a network area including fluctuating renewables. Otherwise, economic efficiency of the measures depends very much on ICT-costs (using heating storages in households) and heating prices (in heating networks).

Conclusions

Heating devices hold a noteworthy potential for the flexibilisation of energy systems, which entails positive effects for both the customers and the utilities providers. Generally, for power-to-heat using wind (and PV-surplus) the following aspects are pointed out:

- High amount of connected wind power to higher savings per year
- High common heat generation costs are positive for power-to-heat solutions
- For power-to-heat solutions which has to pay network charges, the efficiency of the power-to-heat device should be high (usage of heat pumps)

The optimization of households has to be done by a low cost approach according to quite low target costs per household, the target costs for power-to-heat are strongly connected with the scenario.

References

Brauner, G.; Poeppl, G.; Einfalt, A.; Tiefgraber, D. (2007): Balancing of Fluctuating Regenerative Generation by DSM, TU Vienna, Wien

Bukvic-Schäfer, A. (2007): Load Management – Usage of the thermal storage capacity of buildings as non-electric energy storage in electric grids, Dissertation, University of Kassel, Germany (German language)

EEX (2016) Market Data; Electricity Exchange EEX, https://www.eex.com/de/marktdaten/strom/spotmarkt/auktion#!/2016/09/28, downloaded on 27.09.2016

Rössel, T.; Hausladen, G.; Wagner, U.; Hamacher, T.; Jungwirth J. (2011): Load Management in non-residential buildings, Presentation Energy Days Berlin May 18th – 20th 2011, Berlin, Germany (German language)