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Flexibility potentials in low temperature heating grids –exploring business models under current regulations

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Introduction

Grid expansion is one major cost item in the ongoing energy transition as the electrification of the heating and mobility sector as well as the feed-in of variable renewables into the grid leads to much higher peak loads. Grid friendly electricity exchange on the district level helps to stabilize the overall energy system and reduce this necessary grid expansion. But to stimulate grid friendly behaviour there needs to be an incentiviation or at least cost neutrality for the electricity consumers and producers. Low temperature heating grids offer flexibility potential on the district level with heat pumps, thermal storages, photovoltaic systems as well as batteries in a sector coupled energy system. This study explores different business models for district energy systems including low temperature heating grids and compares the results in three different case studies to gain insights how to operate the systems grid friendly by at the same time lowering acquisition costs for electricity.

The three case studies are (1) the Glückaufpark district in Gelsenkirchen, featuring single-family homes (SFH) and multi-family homes (MFH) supplied by a cold distribution network (2 - 15°C) and decentralized heat pumps; (2) Seestadt district in Mönchengladbach, a residential neighborhood composed solely of MFH with a low-temperature distribution network (39°C) utilizing central sewage water, central ground source heat pumps, and gas boilers for peak load; (3) the Shamrockpark district in Herne, which is characterized by a mixed area with a significant proportion of commercial buildings and multi-storey apartments utilizing a low-temperature grid (22°C) that incorporates low temperature industrial and internal waste heat sources used by decentral heat pumps, a small combined heat and power (CHP) unit, and a connection to district heating.

We analyze six different business models to increase the flexibility of electricity exchange: (1) Optimization of self-consumption, (2) dynamic electricity prices, (3) heat pump electricity tariff, (4) grid-oriented control (ENWG §14a), (5) peak load reduction and (6) provision of balancing energy and compare in which of the different districts it is possible to increase economic efficiency with these measures.

Methods

This study employs the KomMod optimization tool, a bottom-up techno-economic model for local energy systems that enables sector-coupled representation. Input data encompass cost data, demands for space heating, hot water, and electricity, alongside the available potential of renewable energy sources such as solar and geothermal energy or waste heat. The model is formulated as a linear programming optimization problem with the target of minimizing total energy system costs using full-year operation profiles at an hourly resolution and performing calculations based on energy balances.

Results

In the two residential districts Hassel and Seestadt dynamic pricing schemes are not economically viable as electricity consumption is high in times of high electricity prices and the load shifting potential is low. In the mixed district of Shamrockpark overall energy system costs can be decreased by switching to a dynamic tariff scheme.

Peak loads can be reduced in Seestadt and Hassel, but without reducing overall system costs which means that there are no real incentives to do so. Grid oriented control is regulated under the Energy Industry Act (ENWG §14a). Since January 1, 2024, new controllable consumption devices (heat pumps, wall boxes, storage units) must be controllable grid oriented. In return, operators benefit from reduced grid fees, either through a flat rate (Module 1) or a percentage reduction (Module 2). In Hassel significant storage capacities are required to use a heat pump electricity tariff or grid-oriented control in accordance with EnWG14a. In some

cases, decentralized heat pumps must be larger in order to bridge the blocking period/control interventions. However, slight savings (up to 2% of the total energy system) can be achieved by taking into account the thermal inertia of the newly constructed buildings. In Seestadt it results in higher investment costs for the system. Particularly in variants with cooling provision, larger dimensions of the cooling machines are required, which entails additional investment. The highest cost reduction in all districts can be achieved with the provision of balancing energy, in Seestadt it is even the only business model that can decrease costs at all.

Conclusions

In the three case studies the decrease of costs of the different flexibility business models is rather small and a simple optimization of self consumption of PV electricity shows higher cost optimization potentials. Especially in districts with a standard residential load profile with high electricity consumption in the morning and evening hours a dynamic electricity price leads to higher costs. In addition, the use of dynamic electricity tariffs competes with self-generation, as electricity prices are typically low during periods of high self-generation. In such cases, self-generation is preferred, which means that electricity is mainly imported during periods of higher electricity prices. As long as dynamic tariffs are not cheaper on average than static tariffs, the district hardly benefits from their use. Making prices more dynamic makes investments in flexibility (e.g., battery storage) more attractive. This is the case when dynamic electricity prices are combined with variable grid fees. However, variable grid fees are currently only available for controllable consumption facilities and in combination with control measures by grid operators.

Therefore economic incentives must be higher to stimulate grid friendly behaviour on the district level.

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