POTENTIALS AND BARRIERS OF MULTI-ENERGY-SYSTEMS FOR PROVISION OF FLEXIBILITY TO POWER MARKETS

Christoph GUTSCHI[1], Xiandong XU[2], Karl RITTMANNSBERGER[3], Muditha ABEYSEKERA[2]

Motivation

The European Union's 2030 targets for renewable energy, greenhouse gas emission and energy efficiency require significant changes in the energy system. Due to the increasing share of fluctuating renewable power generation and the difficulties in generation forecasting, there is a growing need for additional flexibility to ensure the reliable and efficient operation of the electricity system. The project MAGNITUDE [1] investigates the possibilities of multi-energy-systems (MES) to provide flexibility to the power system based on the experiences of higher time constants, higher inertia and inherent resilience of gas and heat/cold networks compared to electricity networks. Enhanced synergies between different energy carriers appear as possible means to provide flexibility to the electricity system but also to drive efficiency and business innovation in the energy sector as a whole. [1]

The investigations in the project focus on seven case studies in different European countries:
Paper industry (Austria), steel industry (UK), large- and small-scale district heating systems and heat supply (Italy, Denmark), wastewater treatment and sewage gas exploitation (Spain), and district heating and cooling supply (France, Sweden).

The present paper explains the ongoing investigations and first results for the Austrian case study of a steam system in an integrated pulp and paper mill.

Approach

The steam system applied in the investigated paper mill can be considered as a typical industrial steam system with different primary fuels, back-pressure steam turbines, and heat (steam) demand on different pressure levels (high-, mid-, and low-pressure). The investigations started with modelling the existing steam system and in-depth calculation of the technical feasibility to provide flexibility to the power grid during different states of operation. Even though the steam turbines produce a considerable amount of the electricity demand; the paper mill is still a net consumer of electricity from the public grid. Flexibility to the power system can be provided by shifting consumption between the power and the gas grid:

In case of provision of positive balancing energy, the boilers increase gas consumption and high-pressure (HP) steam generation. The additional HP steam is increasing the power generation in the turbine, which results in reduced net consumption from the power network. The additional amount of low-pressure steam cannot be used on-site and must be blown over roof, which is a major drawback.

If negative balancing energy is requested, the gas flow to the boilers and the steam generation can be reduced, and the steam flow to the turbine can be controlled by means of bypass valves. As a result, the electricity consumption from the public network is increased while the gas consumption from the public grid is reduced in parallel.

An analysis of the characteristics of the existing flexibility markets in Austria [2] showed that the steam system could indirectly support renewable integration by offering flexibility to the following markets: aFRR, mFRR, intra-day or day ahead.

A discussion of five technical improvement options showed that the installation of a steam accumulator will be the best option to increase energy efficiency and flexibility provision from the paper mill. Currently, simulations are ongoing to identify the optimal dimension of the steam accumulator from a technical and

[1] cyberGRID GmbH & Co KG, Weimarer Strasse 119/1, 1190 Wien, Austria, cg@cyber-grid.com
[2] School of Engineering, Cardiff University, Queen's Buildings, The Parade CF24 3AA Cardiff, Wales, UK, XuX27@cardiff.ac.uk, AbeysekeraM@cardiff.ac.uk
[3] Mondi Neusiedler GmbH, Theresienthalstraße 50, 3363 Ulmerfeld-Hausmening, Austria, karl.rittmannsberger@mondigroup.com

economic perspective. The comparison of the simulation of the operation of the paper mill with and without steam accumulator will show the impact of the steam accumulator in terms of energy efficiency, fuel and electricity costs and the revenues from participation in the abovementioned flexibility markets.

In parallel, the potential barriers for the flexibility provision from MES in Austria are investigated. The results are explained in the following chapter.

Findings

Industrial MES like paper mills can provide flexibility services to existing ancillary service markets or to the intra-day market. While the technology of steam systems and steam accumulators seems to be well proven, some tariffs for system utilisation and renewables contribution might yet be improved to better support the participation of industrial (net) consumers of electricity.

The participation in Austrian ancillary service markets requires a prequalification by the Transmission System Operator *Austrian Power Grid* (APG). In the last years, APG proved to be supportive to industrial flexibilities. Compared to the requirements for pure generators, here are no major barriers for participation of flexible consumers arising from the prequalification process [3,4].

Provision of negative balancing energy will result in an increase of consumption and may cause additional peak consumption values. The operator of the industrial facility will be charged for additional peak consumption on monthly basis according to the Electricity System Charges Ordinance [5] Section 5. Section 5 (9) regulates the *system utilisation charge* for balancing service providers at a fairly reduced rate. Unfortunately, this reduced rate is only available for balancing service provision but not for negative flexibility provided to intraday markets, which are crucial for operators of fluctuating renewables.

An additional barrier for provision of negative balancing services arises from the Green Electricity Act [6] Section 48 (2), which regulates the rate of *renewables contribution* (Ökostromförderbeitrag) for consumers and also sets peak rates for consumers. These peak rates are only depending on the network level of the connected consumer but do not consider the provision of any kind of ancillary services. As a consequence, the currently implemented rules for renewable contribution penalize the provision of negative balancing services. This may hinder the integration of renewable energies.

Literature

[1] Website of the Magnitude project, https://www.magnitude-project.eu/
[2] L. Cauret, R. Belhomme, P. Raux-Defossez, J. Eberbach, Eising, Manuel, J. Steinbeisser, J. M. Pagan Carpe and S. Nösperger: Deliverable D3.1 Benchmark of markets and regulations for electricity, gas and heat and overview of flexibility services to the electricity grid, MAGNITUDE European project, April 2019, https://www.magnitude-project.eu/results-and-publications/main-results-including-public-deliverables.
[3] Austrian Power Grid: Teilnahmebedingungen für Regelenergie Ausschreibungen, https://www.apg.at/de/markt/netzregelung/teilnahmebedingungen (Version of Jan. 2nd, 2020)
[4] The FutureFlow Consortium (Horizon 2020, grant agreement n° 691777): Deliverable 1.1 – Requirements for DR & DG participation in aFRR Markets, 2016.
[5] Austrian Electricity System Charges Ordinance: Verordnung der Regulierungskommission der E-Control, mit der die Entgelte für die Systemnutzung bestimmt werden (Systemnutzungsentgelte-Verordnung 2018 –SNE-V2018), Fassung vom 07.01.2019
[6] Austrian Green Electricity Act: Bundesgesetz über die Förderung der Elektrizitätserzeugung aus erneuerbaren Energieträgern (Ökostromgesetz 2012 – ÖSG 2012), Fassung vom 27.12.2019

Acknowledgements

The work presented in this paper was carried out in the MAGNITUDE project which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774309.

This paper and the results described reflect only the authors' view. The European Commission and the Innovation and Networks Executive Agency (INEA) are not responsible for any use that may be made of the information they contain.