FLEXIBLE AND SYNCHRONIZED LOCAL ENERGY SYSTEMS-CONCEPT DEVELOPMENT AND DEMONSTRATION – A CASE STUDY OF A RURAL DISTRICT HEATING NETWORK IN AUSTRIA

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Motivation and Core Objectives

Ambitious decarbonization targets on an international level, and specifically Austria, the 2030 targets of 100% renewable electricity supply require a massive increase of PV and wind generation, leading to significant fluctuation on the electricity grid. However, significant challenges are the limited supply potential and the required system flexibility. On the other hand, there are more than 2400 rural biomass-based district heating networks (DHN) in Austria, many of these plants are old with a low efficiency and need retrofitting. The integration of power-to-heat (p-t-h) units can unlock the flexibility of DHN and thus increase the local hosting capacity for PV and Wind; further on, biomass combined heat and power (CHP) units can support the renewable electricity generation that cannot be provided by PV and wind. However, there are currently no clear business models for this integration, i.e. only 3% of the rural DHN have CHP plants, and there are very few heat pumps integrated. Aim of the project Flexi-Sync [1] is to strengthen local and regional energy systems by optimizing the flexibility of the heating/cooling sector in order to enable district energy systems to act as a component in balancing the electrical grid. This work describes results of the Austrian part of the project, i.e. the application of the Flexi-Sync methodology to the district heating network (DHN) of Maria Laach.

Description of the Austrian Demo Site Maria Laach: The district heating plant Maria Laach in Lower Austria is a typical biomass heating plant for the rural region in Austria. The plant supplies more than 30 heat consumers, among them restaurants, hotels, schools, public buildings and multifamily buildings, and covers a heat demand of up to 1,650 MWh annually. Heat is generated by two biomass boilers, one 440 kW constructed in 2006 and the other 280 kW constructed in 2009. The biomass used in the boilers is sourced from 16 farmers and members of the cooperative Bioenergie NÖ [2]. The biomass boilers are connected to an 8 m³ large buffer storage tank that functions as load compensation. A large share of the substations in the district heating grid are also equipped with buffer storage tanks. The large storage tank and the substation storage tanks have potential to be utilized for dynamic load management. To enable a high utilization of biomass in the Maria Laach plant, there are also plans to invest in a small biomass CHP of 50 kWel. The CHP, relying on wood pyrolysis, would cover the base load in the district heating network and prevent inefficient part load operation of the biomass boilers. A CHP could theoretically also act on the electricity balancing markets in Austria.

Methodology and Expected Results

The project has following stages:

First, the flexibility potential of the current district heating network is quantified (accounting for system design and operational aspects). Based on these parameters, a Mixed Integer Linear Programming model is used to represent the status-quo at the pilot-site Maria Laach, as well a variety of possible scenarios, including singular or mixed electricity market participation, possible flexibility installations and using a demand shift algorithm to use buildings as flexible heat-storages. The main aim of the model is to estimate the operational costs and revenues for different scenarios. The results represent the economic potential for each scenario without considering real-world implementation problems, e.g., the need for reliable forecasts or predictive control. This investigated flexibility options of the heating network

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are evaluated economically. For this, a cost-benefit-analysis (CBA) will be conducted using dynamic investment calculation

Second, this result is scaled up to heating sector (residential and service sectors) in the whole region of lower Austria. For this purpose, the HLA-Times (Heat Lower Austria Times Energy Model) was developed under TIMES-MARKAL energy modelling framework. In addition, electric energy prices for Austria are calculated in accurate way through a specific model with Balmorel [3] energy system model and interlinked to HLA-Times. These prices are also used in the simulation to assess the impact of flexibility measures in Maria Laach.

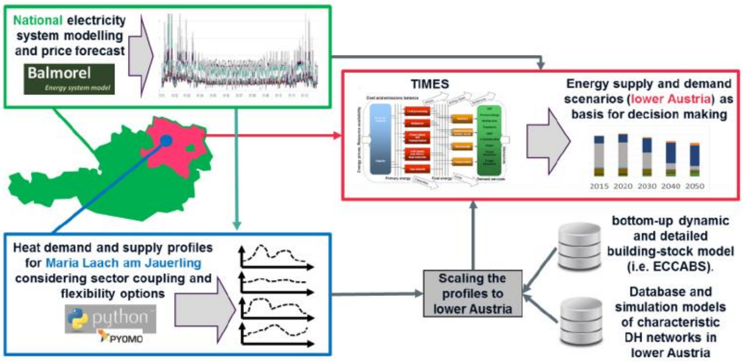

Figure 1: Approach

Third, at the demo site Maria Laach, supply and demand optimization will be tested and evaluated through an active demand side management in operational or near operational environments. For that an IoT (Internet of things) platform will be applied on the existing SCADA (Superadvisory and Control and Data Aquisition) system. The biomass heating plant with its boilers, buffer storage tank, grid pumps and the substations are visualised by the system. The operation data are stored. With the integration of the IoT platform the plant including the substations can be remote controlled. For the research on building flexibility 6 substations were chosen. Due to the use of the different buildings also the characteristics of heat demand differ. Demand forecasting will be done with machine learning which takes different parameters such as outdoor climate, time of day or holidays and historical data of the SCADA system into consideration. Demand forecasts will be delivered for energy, flow and temperatures, from the district energy grid level to individual substations [4].

Aim is that the district heating optimisation will receive information on the available building flexibility to use in optimisation and the demand control of the buildings will receive a control signal to control the demand for optimal efficiency from a system perspective. It is expected that this will lead to savings for both the district heating utility and the property owners. The demand side flexibility consists mainly of thermal storage and buildings as storage, CHP for heat and power generation and heat pumps as power to heat units. The thermal storage enables heat demand to be shifted in time, and heat pumps in combination with district heating make it possible to alternate between heat sources. This use and combination of resources for flexibility are among the elements that will be tested within the project, with a focus on smoothing volatile electricity supply through the increased expansion of renewable electricity.

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