COST AND AUTARKY OPTIMIZATION WITH A MULTIMODAL BATTERY AND HYDROGEN STORAGE

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Motivation

For integration of high shares of renewable energy sources (RES) with variable production into energy systems, additional flexibility options are required. There are multiple options to provide short-term flexibility, like batteries and demand response. However, demand during winter months is higher and solar PV in particular has significantly higher production during summer months. Hence, an energy system that relies primarily on RES requires seasonal storage, too.

The energy cell JOHANN is a novel technology providing both, short-term and seasonal storage functionality. It combines an electric battery, an electrolyzer, a compressor, a hydrogen storage and a fuel cell. The battery has a higher round-trip efficiency. However, due to its stand-by losses it is not suitable as seasonal storage. The power-to-hydrogen-to-power cycle has a significantly lower round-trip efficiency, but it can be used as seasonal storage. Furthermore, overall efficiency can be increased by using thermal losses or local use of hydrogen and reach up to 90%.

In the project “Energiezelle JOHANN” [1] different use cases for the JOHANN energy cell are investigated aiming to improve autarky, self-consumption of local RES and total annual cost for energy services.

Method

The potential benefits of the JOHANN energy cell are investigated in three different use cases: A farm yard in Lower Austria, a riding stable in Burgenland and a school building in Styria. To investigate the effects on autarky, self-consumption and cost, a tailor-made linear programming optimization model is developed for each use case, simulating the optimal operation of the energy cell. In this context, different objectives, like minimizing annual cost or maximizing energy autarky are investigated and compared. Furthermore, the impact of different end user tariffs and grid tariff designs is analysed.

Figure 1 provides an overview of the general use case setup and the potential interactions between various components in the model. Local RES production and electricity purchase from the grid can be used to satisfy electricity demand or to operate the heat pump. Excess production can be stored with JOHANN using either the battery or the electrolyser. This energy can be used at a later point in time for satisfying electricity demand. Heat demand can be met in the illustrated setup by the heat pump and by the heat losses that occur during conversion between electricity and hydrogen.

The operation of this and similar setups is simulated at a quarter-hourly time resolution over the course of one year with different objective functions and related key performance indicators are evaluated and compared.

Results

The implementation of the model and the evaluation of the use cases is still in development. Preliminary results indicate that the JOHANN energy cell can increase autarky. However, it is expected that maximizing autarky and minimizing cost can be opposing objectives especially for seasonal storage. However, this depends on the end user electricity tariff and higher prices increase the economic

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efficiency of local storage technologies use for autarky maximization. Finally, the operation of the JOHANN energy cell is expected to result in a reduction of CO_2 emissions.

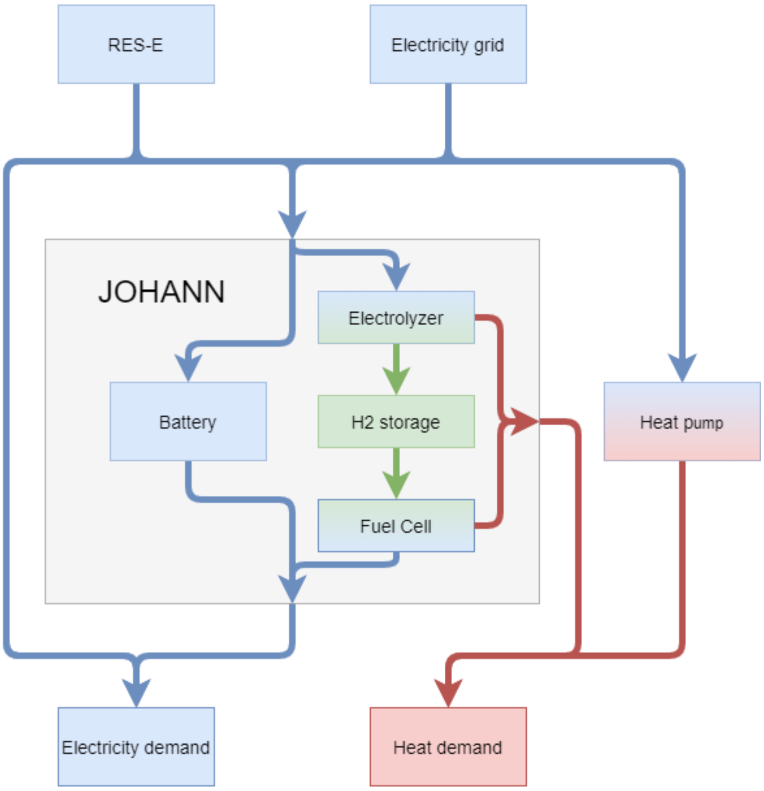

Figure 1: Flowchart of a typical use case with the JOHANN energy cell.

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[1] Green Energy Lab, "Energiezelle „JOHANN“," GEL, [Online]. Available: https://greenenergylab.at/projects/energiezelle-johann/. [Accessed 11 2021].