Medium- and Long-term Storage Technologies for a  
100 Percent Renewable Electricity System in Austria

(2) Energieerzeugung/ -infrastruktur und Netze

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Motivation and central research questions

The medium and long-term variability of renewable energies poses an unprecedented challenge to the electricity system. According to the Renewables-Expansion-Act (EAG) [1] Austria aims to generate an additional 27 TWh of electricity from renewables to achieve a net 100 percent renewable electricity system by 2030. In light of this transition, medium and long-term storage technologies (MLSTs) are becoming ever more essential. These technologies can contribute significantly to balance seasonal fluctuations, increase security of supply, reduce energy import dependency, and achieve a cost-efficient electricity system. However, a storage strategy for Austria is missing.

The research project **MILES** [2]aims to assess the demand, systematic integration, and techno-economic evaluation of MLSTs in the context of the Austrian electricity system and the EAG targets.

The central research questions in MILES are:

* What is the demand for and what are the systemic effects of MLSTs based on objectives such as minimization of total system costs, reduction of CO2 emissions, reduction of electricity and natural gas imports etc.?
* Could MLSTs be profitable in 2030 under the current market system? Where is the profitability threshold in the context of system-wide storage investments? Which business models are available for individual installations?
* What are the most promising MLSTs for future R&D activities?

Methodology

One of the strengths of MILES is its interdisciplinary methodological approach, which includes expertise from both technology development and electricity system modeling (see Figure 1). In order to answer the research questions stated above, as a first step, a detailed literature review on the state of the art of potential MLST technologies is conducted. Alongside techno-economic process variables such as power, efficiency, cycle stability, lifetime, energy storage capacity, CAPEX, OPEX etc., the focus is also on resource availability and sustainability of candidate technologies. Based on the findings, a detailed set of modeling parameters for the MLSTs in question is determined.

In the current state-of-the-art, techno-economic analyses of storage systems are mostly carried out in the sense of "stand-alone" studies, which require various assumptions, e.g. about the annual number of cycles and electricity prices, and the integration with the electricity system is usually neglected.

In MILES, this methodological issue is overcome by integrating MLSTs into the Low-carbon Expansion Generation Optimization (LEGO) [3] open source model - a digital twin of the Austrian electricity system. LEGO is an expansion planning model (generation and transmission) that can be formulated as a quadratically-constraint mixed-integer linear program based on the objective of minimizing total system costs (e.g. investment and operation). Its highly flexible temporal structure allows to model both short-term storage units and MLSTs in a fully chronological way as well as in a representative periods’ framework. Furthermore, LEGO considers the technical implications of unit commitment decisions, load flows in the high-voltage grid (represented by a DC optimal power flow approximation), etc.

In a free market, investments in generation and storage infrastructure are generally made by private investors who expect to achieve an adequate return. LEGO allows to evaluate the profitability of MLSTs (and other generation technologies) based on endogenous electricity prices (dual variables of the power balance equation). This allows, among other things, to investigate the profitability threshold of MLSTs and to identify missing money, which forms the basis for the development of dedicated market models for MLSTs.

Figure 1: Methodology applied in MILES

Expected results and conclusions

As the research project is still in its initial phase, we would like to briefly point out its goals and expected results:

* Develop a well-founded and quantitative starting point for the discussion about MLSTs with stakeholders, decision-makers, industry partners, and policy makers
* Develop technology-specific market models for MLSTs
* Establish the foundation for a storage strategy for Austria
* Establishment of a reference for the specific development of novel storage processes
* Review of feasible business models for MLSTs for the Austrian power system

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Literature

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