HSLU Lucerne University of Applied Sciences and Arts

Engineering and Architecture
BSc. Energy and Environmental Systems Engineering
Bachelor-Thesis

Impact of renewable energies on the winter energy supply and possibilities for energy storage

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Industry / Practice Partner: Institut für Innovation und Technologiemanagement IIT

1. Background, Challenge & Objectives

Background / Context
The Swiss energy market is facing an enormous challenge: According to the current energy strategy and climate targets, 70% of today's primary energy sources will no longer be viable by 2050. Already today, the Swiss energy system is under stress, as Switzerland is depended on electricity imports during the winter months.

This study compares the electricity production and consumption data of Switzerland to quantify a possible winter electricity gap. It investigates whether energy storage technologies have the potential to significantly smooth the load curve to optimize the annual balance. The purpose is to find out, how the Swiss energy system is affected by the expansion of different technologies and which synergies exist between them.

Objectives

1. Creating a situation analysis of Switzerland’s energy supply and demand.
2. Defining possible scenarios in the development of energy supply and demand until 2050.
3. Determining the potential for energy storage within the evaluated system of supply & demand.
4. Evaluating the system for synergies between different technologies.

2. Methodology / Materials

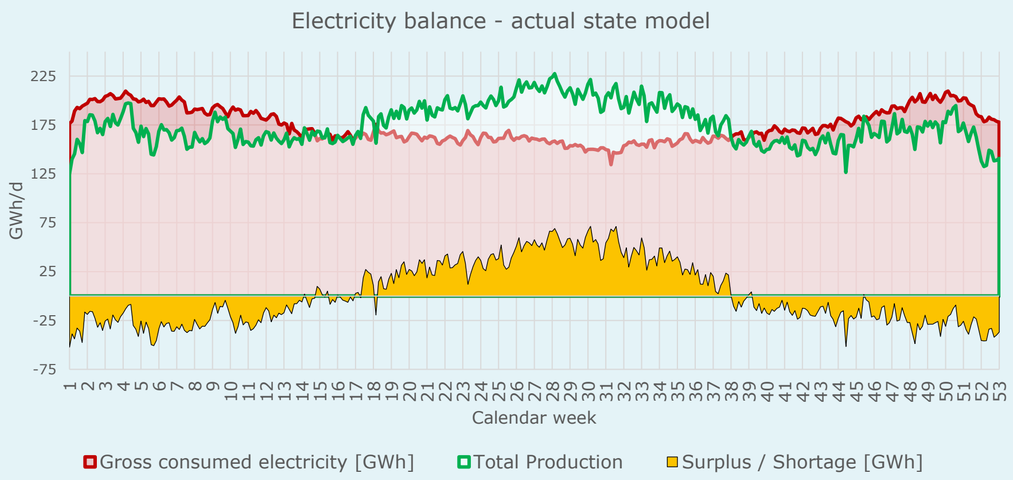
Methodology

- Literature research
- Data acquisition and comparison
- Electricity system modelling
- Scenario developement
- Quantitative analysis of the annual electricity balance

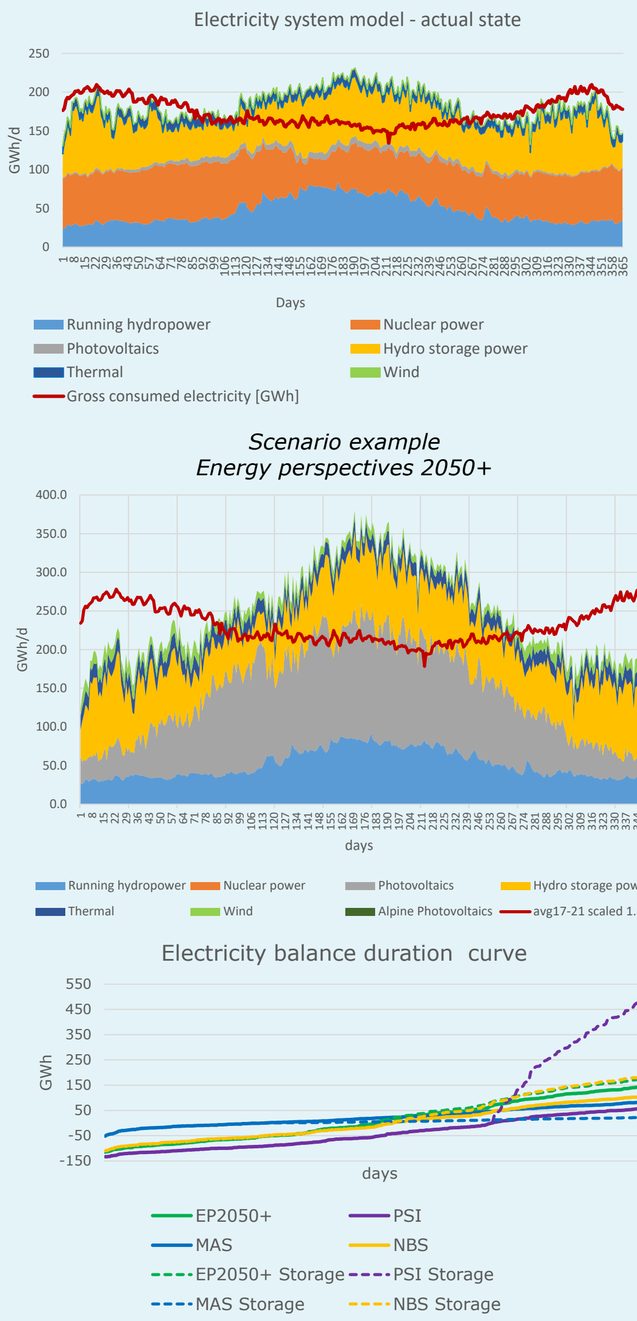
Materials / Data / Tools

- Swissgrid production and consumption data
- Generation per type data: energy dashboard
- Future energy studies

Modelling and quantitative analysis of scenarios with MS Excel



3. Results / Solution / Recommendations



1. Actual state analysis

- Production profiles
- Winter electricity gap: -4.6 TWh over 210 days

2. Scenario developement

Modelling of future electricity demand and 4 production expansion scenarios

Production expansion costs: 4-10 billion CHF

Costs for storage expansion to cover the winter electricity gap: 1-14 billion CHF

3. Storage possibilities and influence on the system

Potential long-term storage: Pumped hydro, gravitational, compressed air, Power-to-X, batteries

The lower the round-trip-efficiency, the higher the required summer surplus (dotted lines)

-> Not all scenarios provide enough summer surplus to charge such a storage.

4. Discussion, Conclusions & Outlook

Discussion
Results are highly dependend from data quality and assumptions.

Conclusions
The thesis provides an interactive model to visualize the effects of renewable energy expansion scenarios on the winter electricity supply and provides a solid basis for optimization for economic and ecological criteria.
The energy sector is strongly influenced by politics and different stakeholders, which slows developement and makes a factual-based research difficult.

With high investions in production and storage, it is possible for Switzerland to reach 100% self-sufficiency in the electrical sector.
Switzerland has the opportunity to decrease it’s dependency on energy imports, but research for big-scale electricity storage systems is nessessary in the near future.

Literature

Swissgrid AG. (2022). *Energieübersicht Schweiz (2017-2021).* Aarau

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