ENERGY STORAGE INVESTMENT IN SWITZERLAND: A HOUSEHOLD MODEL APPROACH LINKING HEAT AND ELECTRICITY

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Overview

Switzerland is aiming to profoundly transform its energy system by 2050 through decommissioning its nuclear power plants, enhancing the use of renewable energy sources (RES) and fostering energy efficient processes and technologies. The successful implementation of this plan, which is outlined in detail in the Energy Strategy 2050, implies structural changes in the operation and management of the electricity network as well as the introduction of new, more flexible and more efficient technologies in the heating and electricity sectors (SFOE, 2018).

It is foreseen that the deployment of new energy storage technologies will be pivotal for the introduction of a higher share of intermittent renewable energy sources and the substitution of fossil fuels for heating applications. Having a robust network of energy storage for both electricity and heating could allow to cope with the rapid variation of electricity supply of solar and wind energy sources and it could also facilitate the substitution of fossil fuel heating technologies for new and more efficient ones.

An usual way to incentivize the introduction of novel energy technologies is to put in place legislation and policies that create positive market signals favouring the technology`s roll out process, overcoming high initial capital costs and the inherent competitive disadvantage that this creates. While there are multiple technology and energy system assessments on the potential and role of storage, studies combining technology aspects with regulatory and market drivers (i.e., different tariff structures, RE incentive policies, etc.) are still scarce.

This paper addresses this gap by investigating the level of penetration of energy storage technologies in Swiss households. The novelty of this research is that it considers multiple technology options and applies different tariff schemes and support policies for both electric and heat storage systems in a dynamic cost-based decision model.

Methods

The model presented in this paper is being developed in the context of the project SwissStore, a joint research with the participation of the Chair of Energy Economics of the University of Basel (UNIBAS), the Chair for Energy Efficiency of the University of Geneva (UNIGE) and the Competence Center for Thermal Energy Storage of the Lucerne University of Applied Sciences and Arts (HSLU) and it is financed by the Swiss National Science Foundation (SNSF).

The project's framework consists of the interaction of two different models in an iterative setting. The first one, named GRIMSEL, is a national dispatch model that minimizes the total costs of the Swiss electricity system from a social planner perspective. The second model and the main focus of this paper, is a bottom-up actor based investment model of the Swiss residential sector.

The actor model minimizes the respective household's energy costs by simulating the yearly electricity and heating demand and the potential technology options on the supply and storage side on hourly basis under different market and policy scenarios. The model incorporates more than 300'000 buildings, depicting them by household type (single or multi-family), urban setting (urban, suburban and rural), geographical location, age and electricity and heating demands. The technologies included are solar PV, electric batteries, heating systems (heat pumps, oil, wood, gas) and seasonal thermal storage.

In order to reduce the computational effort, the number of technology combinations that are considered is reduced by a preselection process. This process is based on the actor's compatibility with certain technologies (e.g. the use of a gas heating system is only used if there is a direct connection to a gas grid) and the synergy between the system components (e.g. solar PV, heat pumps and seasonal storage). Additionally, the scenario definition is comprised of two main dimensions, "Policy" and "Drivers". In the "Policy" dimension we take into account different paths of development for taxes (e.g. carbon tax), subsidies and fuel prices, while in "Drivers" we consider the main factors that are expected to affect the policy pathways in the foreseeable future, more specifically climate scenarios, building stock evolution and technology development.

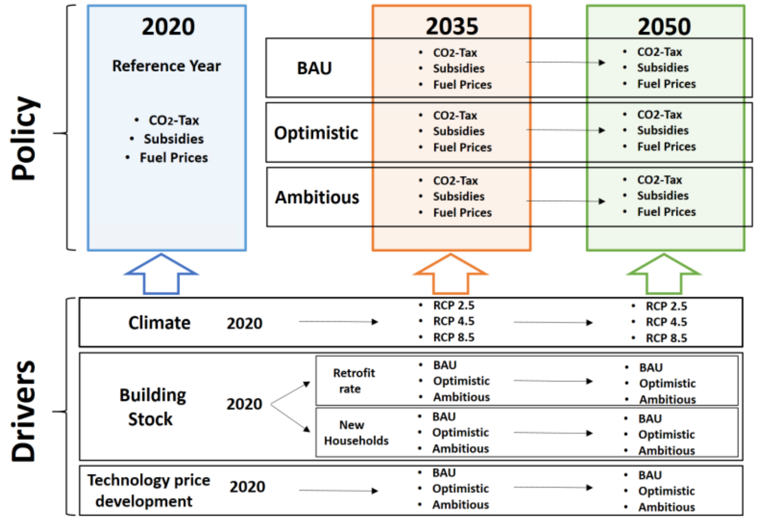

Figure 1. SwissStore scenario structure

The cost minimization is conducted for a full year with an hourly resolution for the defined scenarios based on average demand and renewable profiles. In a second step, the model selects the least costly option for a given actor by comparing the Equivalent Annual Cost of all technology configurations, i.e. annualized capital and operational costs.

To analyse the impact of those individual household decisions on the overall Swiss electricity system the results are coupled with the national system model GRIMSEL. The aggregated electricity demand curves and PV capacity for all actors from the household model is plugged in the dispatch model, providing the feedback effect on wholesale electricity prices. As those price changes can alter the optimal investment decisions, the new prices are again provided as input within the household model. This iterative process continues until we reach a stable electricity price output.

Expected Results

We expect to identify which supply and storage configurations will be chosen under different scenarios, with a main focus on electricity tariffs (e.g. fixed vs. variable structures for grid and energy components) as well as different potential support systems and energy policies (e.g. renewable support, carbon pricing, investment subsidies, etc).

Given the high level of uncertainty of the underlying future costs and price assumptions, we pursue to determine if there are robust technology choices (i.e. being optimal or close to optimal in multiple scenarios) and consequently, which technology pathways will result from the different tariff and support strategies.

Conclusions

The results will allow us to identify and highlight potential incentive problems on the household level under different future system conditions. In particular, we aim to quantify the resulting inefficiencies from fixed household tariffs in providing a reasonable mix of PV and storage investments and operation. Additionally, the model outcome can shed light on which RE and storage technologies have more potential in the future, based not only on their technical performance and costs, but also under different incentive regulations.

The described methodology aims to capture the interaction between the supply and demand side of the electricity market, allowing us to investigate the impact that consumer's investment decisions could have in it. More importantly, it also enables us to analyze the effect of different tariffs and incentive schemes, providing us with a basis to assess a variety of policy measures aiming to decarbonize the residential sector in alignment with the national energy and environmental policies.

References

SFOE Swiss Federal Office of Energy (2018), Energy Strategy 2050 once the energy act is in force Version from 18.01.2018. https://www.bfe.admin.ch/bfe/en/home/policy/energy-strategy-2050/_jcr_content/par/tabs/items/tab/tabpar/externalcontent.external.exturl.pdf/aHR0cHM6Ly9wdWJkYi5iZmUuYWRtaW4uY2gvZW4vcHVibGljYX/Rpb24vZG93bmxvYWQvODk5My5wZGY=.pdf