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) while phasing out fossil fuels 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 model presented here is the first stage of the market module within the *SwissStore* model, which will include a full simulation of the Swiss electricity market developed by UNIGE and a spatial heating model of Switzerland developed by HSLU. The market module will integrate the electricity and heating modules by executing a technology decision making process that captures the changes in the country`s technology deployment, and hence the energy consumption mix, based on *SwissStore`s* market conditions and scenarios. The technology decisions are made by consumer archetypes (Figure 1), which are defined according to the Swiss context, and they will be included in the full model in an iterative process, reflecting the new market and price conditions.

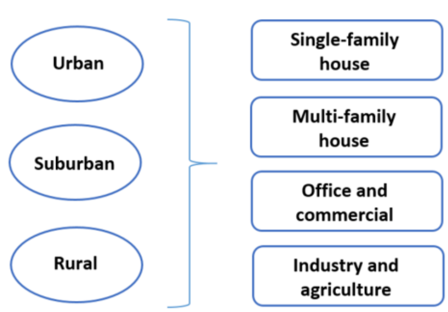

Figure 1. SwissStore consumer archetypes

The current stage of the model only focus on households, which will have as an objective the minimization of their total cost of energy. The household will take a decision of either maintaining the status-quo, i.e. buying electricity from the grid and keeping their current heating system, or to install a residential photovoltaic system (PV), a different electric or heat storage system or substituting the heating technology.

The simplified cost minimization equation (1) includes the capital and operational costs of a change in technology s ($CAPEX$ and $OPEX$), and the cost of energy (grid demand d^{grid} multiplied by the price of energy p) over the analysis period t, for a given archetype a.

$$min\ C_{elec} = \sum_{a,s} CAPEX + \sum_{a,s} OPEX + \sum_{a,s,t} (d_{a,s,t}^{grid} \cdot p_t) \quad (1)$$

It is important to highlight that the net value of grid electricity demand can take either positive or negative values, meaning that the consumer can either consume electricity from the grid or inject it in case it has its own PV or electric storage system. The simplified demand equation (2) shows the interaction between the energy demand of the archetype (d^{act}), the supply of the PV system (s^{pv}) and the demand or supply of the storage system (d^{st} and s^{st}, respectively) on a given period t.

$$d_{a,s,t}^{grid} = d_{a,t}^{act} + d_{a,s,t}^{st} + - s_{a,r,t}^{pv} - s_{a,s,t}^{st} \quad (2)$$

Regarding the specifications of the model, the time resolution is one hour with a total analysis period of a year for the early stages of implementation. Aditionally, among the set of technologies that will be incorporated into the model we can mention PV solar panels for electricity generation, heat pumps and seasonal storage for heating and lithium-ion, lithium-titanate, lead-acid and sodium-sulfure batteries for electric storage.

Expected Results

Based on detailed household data we aim to identify which supply and storage combinations will be chosen under the different incentives schemes included in the model. The main focus will be on different 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 uncertaintiy 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.

Moreover, 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. This result can be highly relevant in the design of future energy related policies in Switzerland.

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