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PATHFNDR

Market + policy

The impact of electricity tariffs and investment costs on PV and battery storage implementation: a Losone case study

Work package 2

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1 OBJECTIVES

This study evaluates how the electricity tariff and investment costs affect the adoption of solar PV and battery storage in Swiss households through following research questions:

- How do electricity tariffs and investment costs affect the adoption of PV and battery storage?
- How does the adoption of PV and/or battery affect the electricity grid at the household level?

2 CONTRIBUTION TO PATHFDNR

Energy system design to grid simulation: The energy system design of individual houses are studied and the selected designs will pass to the ETH-FEN team for grid flexibility simulation.

Electricity tariff evaluation: The research framework developed in this work can be used to investigate the impact of electricity tariffs on the design and operation of the energy system for individual houses.

Flexibility technology data validation: The flexibility technology data collected in WP 3 are used in this case study; this can both validate the data and provide feedback to improve the data collection.

3 METHODOLOGY

A mathematical programming-based energy system modelling tool, ehubX[1], optimizes the design and operation of the energy system of individual buildings.

The model consists three types of mathematical formulations: balance equations (e.g. energy, costs, mass), constraints (e.g. system/resource capacity, operational and environmental limits), and objective function (e.g. minimising costs and/or emissions).

3.1 Input

Demand: 42 of buildings in a Losone district heat region are selected for the case study due to the availability of historical hourly heat demand data. The hourly electricity demand are simulated by HSLU.

PV potential: The potential area of rooftop PV for each building are obtained from EPFL[2].

Energy costs: the electricity price and feed-in tariffs are summarised in Table 1 and Figure 1.

Heating technology: except the district heating (i.e. actual heating technology), heat pumps is also simulated to represent the high electricity demand scenario.

3.2 Objective function

Current results are based on minimising the annualized overall system costs (i.e. investment and operation). However, emission minimisation and Pareto front of cost/emission minimisation can be investigated in the future.

3.3 Scenario analysis

The impact of selected design parameters (see Table 2) is investigated by scenario analysis. The results of each scenario is compared in the results section.

Table 1: Key costs parameter and assumptions

Technology	Specification	Cost	Reference
Solar PV - rooftop	<10 kW	9240 CHF + 1930 CHF/kW	Energie Schweiz 2023
	10-30 kW	12072 CHF + 1646 CHF/kW	
Battery (Li-ion, residential)	>10 kWh, 4hr	1036 CHF/kWh	Lazard LCOE+ 2024
	>10 kWh, 1hr	1243 CHF/kWh	
Electricity price	Time-of-use	Peak/off-peak:44.93/28.59 Rp./kWh	strompries
	Hourly price	Day-ahead price + 15.76 Rp./kWh	Energy charts
	Feed-in tariff	15 Rp.kWh	

Table 2: Key design parameters for scenario analysis

Variables	Values
Heating technology	District heat (DistHeat), Heat pump (HP)
Electricity price	Time-of-use (peak/off-peak), Hourly price
Battery cost	25/50/100% of baseline battery costs
Feed-in tariff	0/50/100% of baseline tariff

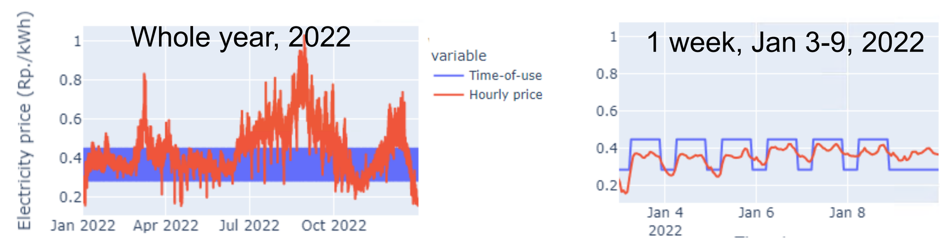

Figure 1: Time-of-use tariff and hourly price, 2022

4 RESULTS

The energy technology capacities of each building in different heating technologies with baseline time-of-use tariff and feed-in tariff are shown in Fig. 2.

- The PV installed capacity of each building in both scenarios are the same; due to the cost of PV is lower than the peak electricity price.
- The installed capacity of batteries are changing between two scenarios. For the buildings that battery capacity is higher in district heating scenario (Fig. 2a), PV generation is higher than demand and then batteries are used to store the excess electricity. For the buildings that battery capacity is higher in heat pump scenario (Fig. 2b), electricity demand is higher than PV generation at the heating season, and thus the batteries are used to store electricity at off-peak time.

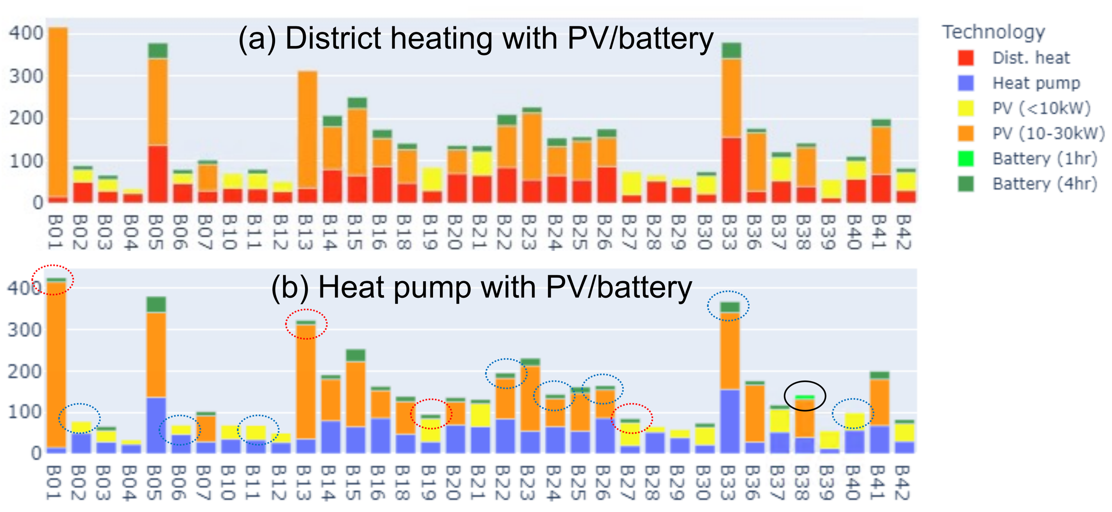

Figure 2: Energy technology capacities of each building with (a) district heating and (b) heat pumps. *Unit: kW for heating and PV; kWh for batteries*

The aggregated PV and batteries capacities (3a) and energy balance (3b) of 42 buildings under different scenarios are shown in Fig. 3.

- The cost of batteries has significant impact on the install capacity.
- No batteries installed in hourly price scenario; this indicates that the frequency and magnitude of hourly price fluctuation is not enough to make battery solution cost effective.
- The potential rooftop area is fully utilised in most of the scenarios based on today's high electricity price, except the scenario that has no feed-in tariff for PV generation.
- The change from district heating to heat pumps increase the electricity demand by the factor of 6, but it only reduce ~15% of electricity sell to grid. It is due to the seasonal mismatch between PV generation and heat demand.

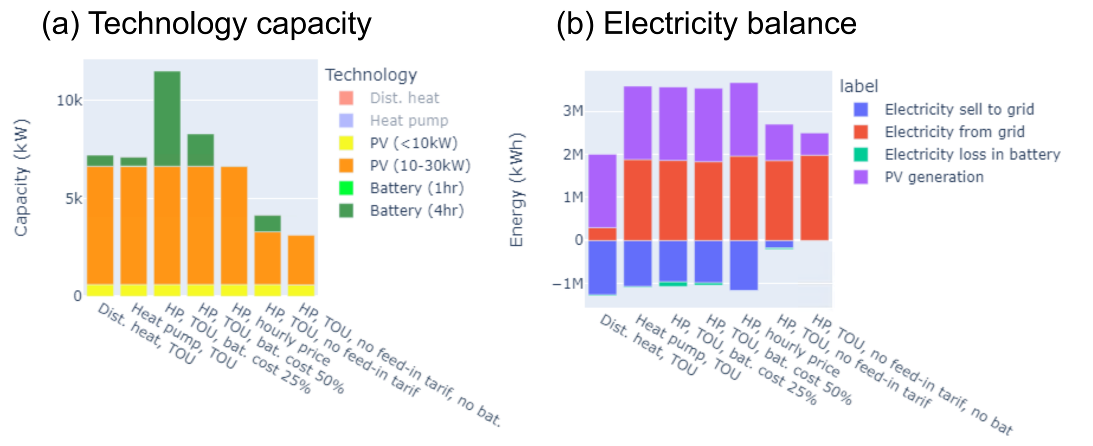

Figure 3: Aggregated technology capacity (a) and energy balance of electricity (b) of 42 buildings in seven different scenarios.

Aggregated 3-day electricity import/feed profiles of 42 buildings in five scenarios are shown in Fig. 4. Installing batteries can reduce the electricity feed back to the grid and shift import electricity to off-peak time.

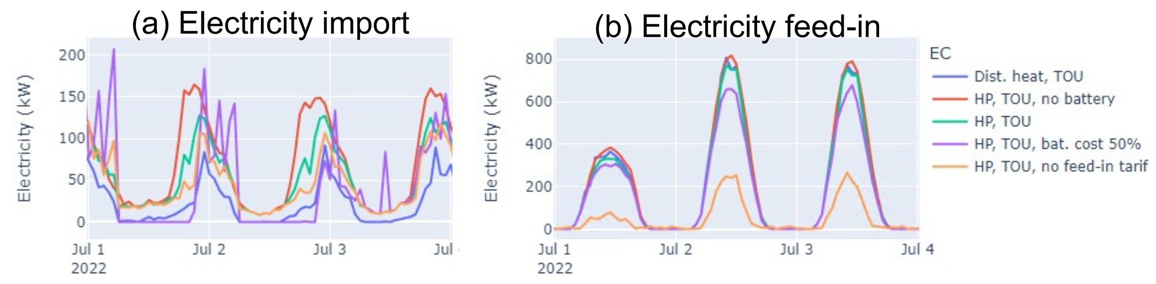

Figure 4: 3-day aggregated profiles of (a) electricity from the grid and (b) electricity sell to the grid of 42 buildings in five different scenarios.

5 SUMMARY

- The key parameters affect the implementation of PV and batteries are investigated based on the data of Losone. Time-varying tariff is one of the key factors that affect both the adoption and operation of battery
- This framework can be used to evaluate the impact of different energy tariff design on the energy system at the building level.
- This work can be further extend to study the battery storage at the district level, such as shared batteries of the neighborhood.

REFERENCES

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