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sweet swiss energy research for the energy transition
EDGE

Distributive effects of electricity tariff design on Swiss households

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Introduction

Dynamic electricity tariffs are a common suggestion for activating the flexibility of consumers for shifting electricity demand across the day:

- Dynamic energy prices give incentive to consume when energy is cheap to generate.
- Time-dependent grid charges give incentive to consume when grid is not congested.

See, e.g., (Schlecht, Ramírez-Molina and Darudi 2025)[1]
We ask the questions:

- How do dynamic tariffs affect households' bottom-lines?
- How are effects distributed across households and across different parts of the population?

[1] Ingmar Schlecht, Héctor Ramírez-Molina and Ali Darudi (2025). *AGGREGATE – The value of aggregators in a flexible and decentralized Swiss energy system*. Final project report. URL: https://www.aramis.admin.ch/Texte/?ProjectID=51523.

Preview of results

- Heterogeneity across households of impacts from introducing dynamic tariffs is vast.
- Low income households experience, on average, more negative impacts than do high-income households.

$\rightarrow$ We detect a trade-off between equity and efficiency.

Model

We couple a model of **energy cost minimization** on **buildings level** with a general equilibirum model for analyzing **distribution of impacts** across **households**.

SwissStore

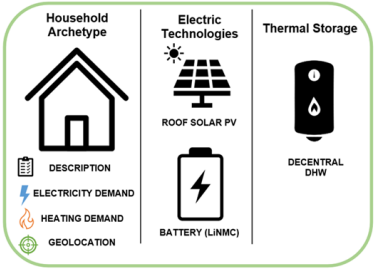
- rational agents optimize **buildings**
- observe building properties, heating system, solar irradiation
- invest in PV and batteries to minimize cost of a fix level of energy services

Swisstribution

- market equilibrium in the Swiss economy
- **households** experience changes in costs (according to SwissStore) and income (general equilibrium).

Model: SwissStore

- Minimizes total energy system costs for buildings
- Coverage of the whole Swiss residential sector (320k building archetypes, 1.4 million buildings)
- High geographical resolution (solar irradiation for PV, heating demand and heat pump efficiency for heating)
- Archetype specific heating demand profiles with daily resolution (from SwissRes model, UNIGE)
- Investors consider existing infrastructure (e.g., EVs, different heating technologies) and can invest in PV and batteries.



Model description: (Schlecht, Ramírez-Molina and Darudi 2025).[a]

[a] Ingmar Schlecht, Héctor Ramírez-Molina and Ali Darudi (2025). *AGGREGATE – The value of aggregators in a flexible and decentralized Swiss energy system*. Final project report. URL: https://www.aramis.admin.ch/Texte/?ProjectID=51523.

Model: CGE

Swisstribution is a computable general equilibrium (CGE) model of the Swiss economy (Landis 2019).[2]

- market equilibrium between all sectors, government, and households in the Swiss economy
- household represenatation by microsimulation of 6000+ households
- **households** change expenditures according to SwissStore results
- endogenous changes in wages and capital rents
- $\rightarrow$ households experience impacts on consumption utility from both expenditure and income side.

[2] Florian Landis (2019). "Cost distribution and equity of climate policy in Switzerland". In: *Swiss Journal of Economics and Statistics* 155.11. DOI: 10.1186/s41937-019-0038-2.

Model: coupling

Data challenge 1:
Linking buildings in SwissStore (federal buildings registry) to households in distributional analysis (SHEDS survey).[3]

Common variables used for matching:

- Canton
- Degree of urbanization
- Building type (single family home / multi family home)
- Heating system
- Age of building
- Size of dwelling unit (given in SHEDS, estimated for SwissStore)

[3] Mehdi Farsi and Sylvain Weber (2024). *Swiss Household Energy Demand Survey: Past experiences and new perspectives*. Working Paper 24-06. IRENE Working Paper. URL: https://www.econstor.eu/handle/10419/306529.

Model: coupling

Data challenge 2:
Complement SHEDS data with statistical weights and data on household expenditure and income from HABE.[4]

This was achieved by following the statistical matching procedure by Torné and Trutnevyte 2024.[5]

[4] Bundesamt für Statistik (2014). *Steckbrief Haushaltserhebung: Neues Gewichtungsmodell, Resultate 2000-2003 und Studie zur Altersvorsorge*. URL: http://www.bfs.admin.ch/bfs/portal/de/index/infothek/erhebungen__quellen/blank/blank/habe/01.html.

[5] Alexandre Torné and Evelina Trutnevyte (1st Feb. 2024). "Banning fossil fuel cars and boilers in Switzerland: Mitigation potential, justice, and the social structure of the vulnerable". In: *Energy Research & Social Science* 108, p. 103377. DOI: 10.1016/j.erss.2023.103377.

Model: coupling

Including SwissStore results in Swisstribution CGE model:

- Scenario differences (dynamic tariffs − flat tariffs) in expenditures for *electricity*, *heating fuels*, *operation costs*, *annualized investment costs*
- SwissStore assumes same level of energy services in both scenarios
  $\rightarrow$ recalibrate utility functions of microsimulation such that
  - same level utility is generated
  - with changed expenditures according to SwissStore

Scenarios

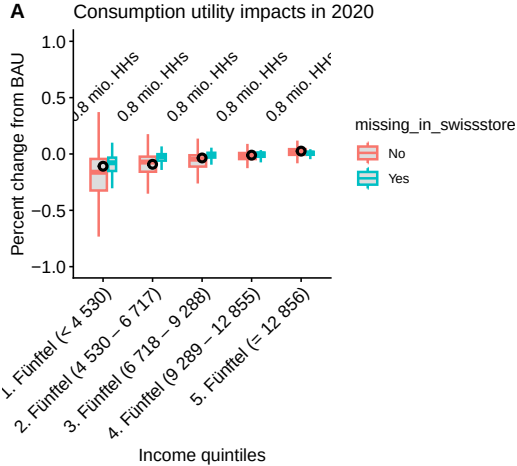
2020

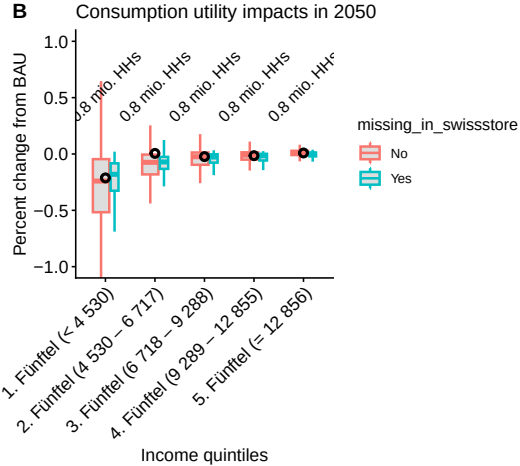
- SHEDS survey gives EV ownership of EVs
- Heating systems according to SHEDS/SwissStore
- Tariffs:
  - historic flat tariffs (2023)
  - dynamic tariffs in proportion to historic hourly spot market prices (2023)

2050

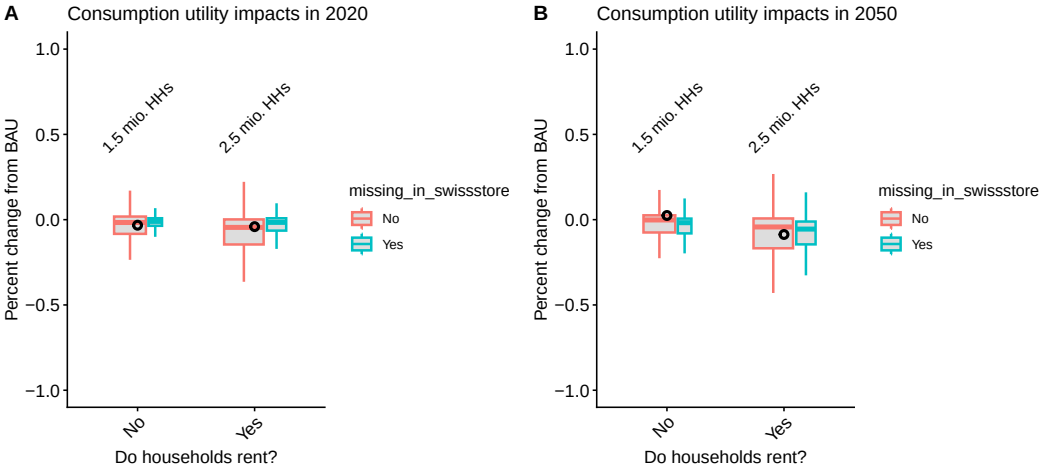
- Households who own **cars in 2020**, own **EVs in 2050**
- Heating systems are least cost options according to SwissStore (flat tariff scenario)
- High fossil fuel price scenarios (Sweet-Edge's REO)
- Tariffs according to price projections of FEM (Sweet-Edge's REO):
  - flat energy tariff covering average annual electricity prices
  - dynamic tariffs in proportion to hourly spot market prices

Results: Per income class

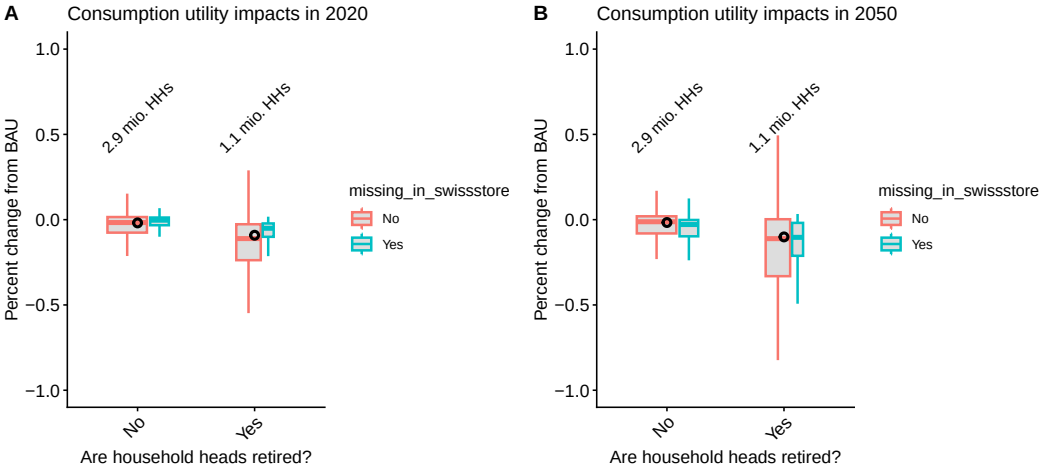




Results: Do households rent?



Results: Are household heads retired?



Conclusion

Findings:

- Impacts are very heterogeneous.
- *On average* population groups do not gain or lose much.
- Impacts are regressive (hurt low-income households relatively more than high-income ones)

Policy options to consider and analyze:

- Making dynamic tariffs optional would allow negatively impacted households to opt out. But how to handle self-selection?
- "Profile contracts" may help, but design choices remain to be explored. ("In such contracts customers pre-agree an amount of energy and a consumption profile, while hourly deviations are charged at spot prices.", see Winzer et al. 2024)[6]

[6] Christian Winzer et al. (2024). "Profile contracts for electricity retail customers". In: *Energy Policy* 195, p. 114358. DOI: 10.1016/j.enpol.2024.114358.

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Thank you for your attention

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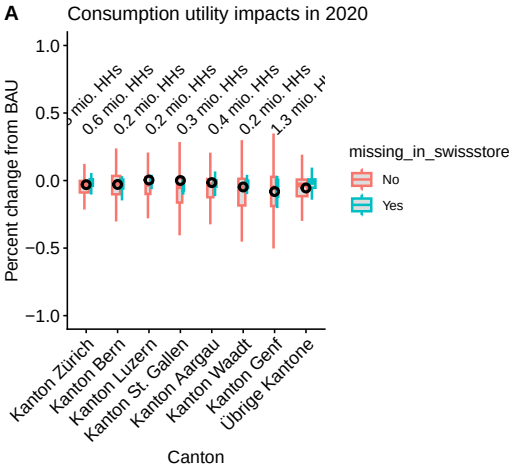
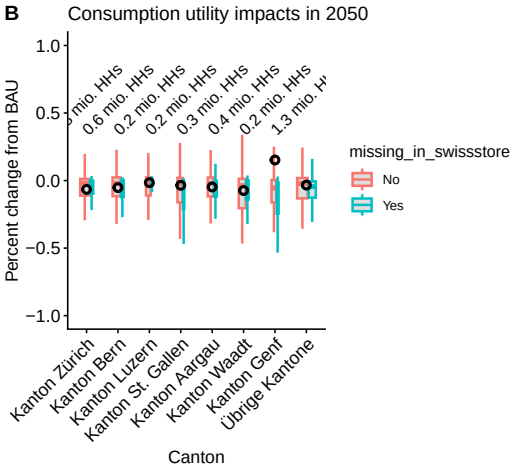
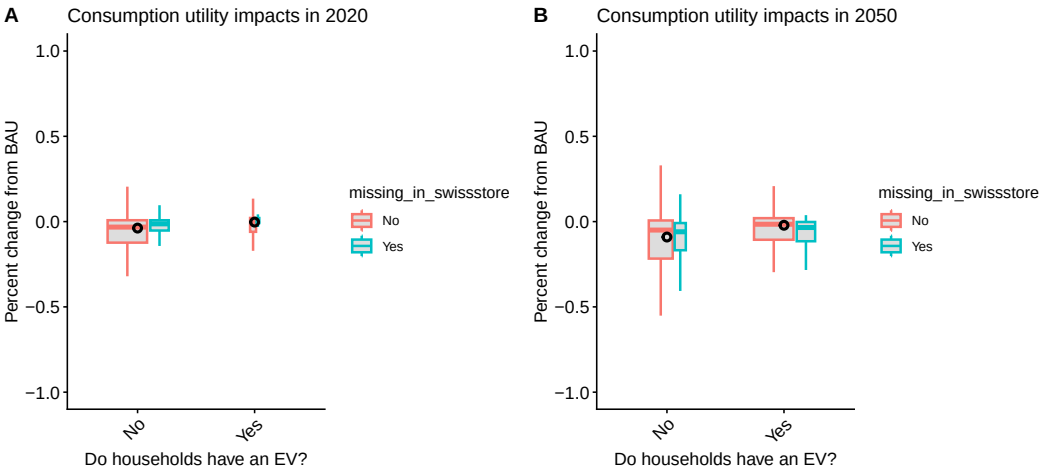
Appendix material: Results by canton

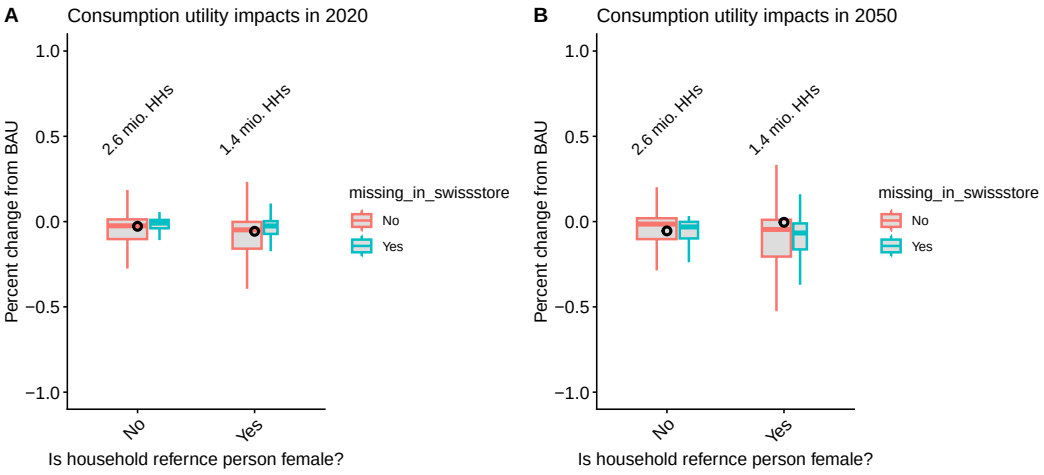




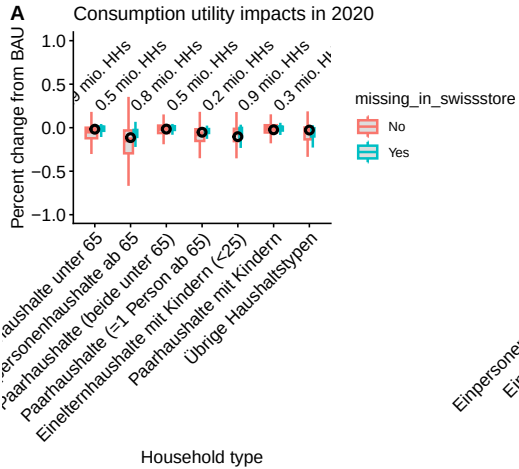
Appendix material: Results by EV ownership

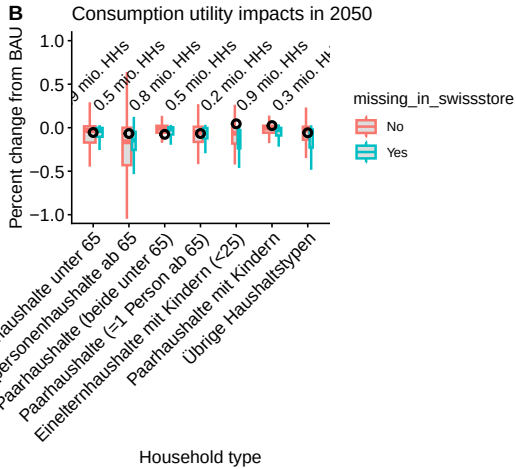


Appendix material: Results by female reference person

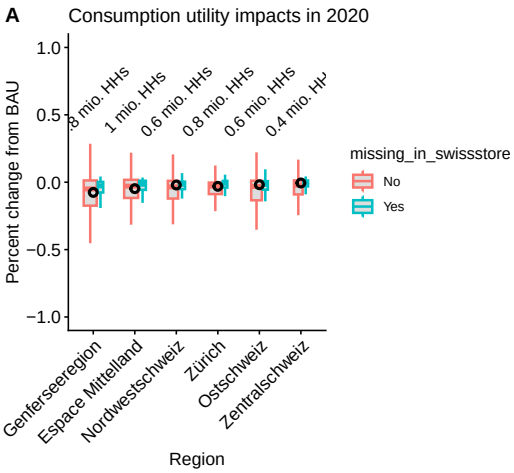


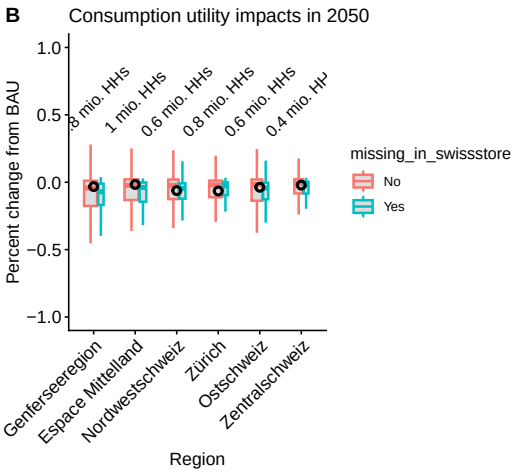
Appendix material: Results by household type





Appendix material: Results by region





Appendix material: Macroeconomic indicators

Table: Change in macroeconomic indicators for switching from flat electricity tariffs to dynamic ones (assuming demand flexibility from heating).

Indicator	Change in 2020	Change in 2050
Consumer welfare (%)	−0.0078	0.0009
Wages (%)	0.0403	0.0509
Capital rents (%)	0.0029	0.0474
Household electricity consumption in Swisstribution (PJ)	−2.22	−3.77