

Decarbonization of Residential Energy Demand - The Role of Retail Rates and Network Tariffs

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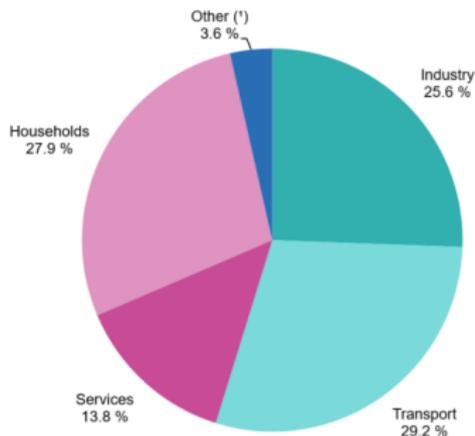
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Context - Energy use in EU

Final energy consumption by sector, EU, 2021 (% of total, based on terajoules)

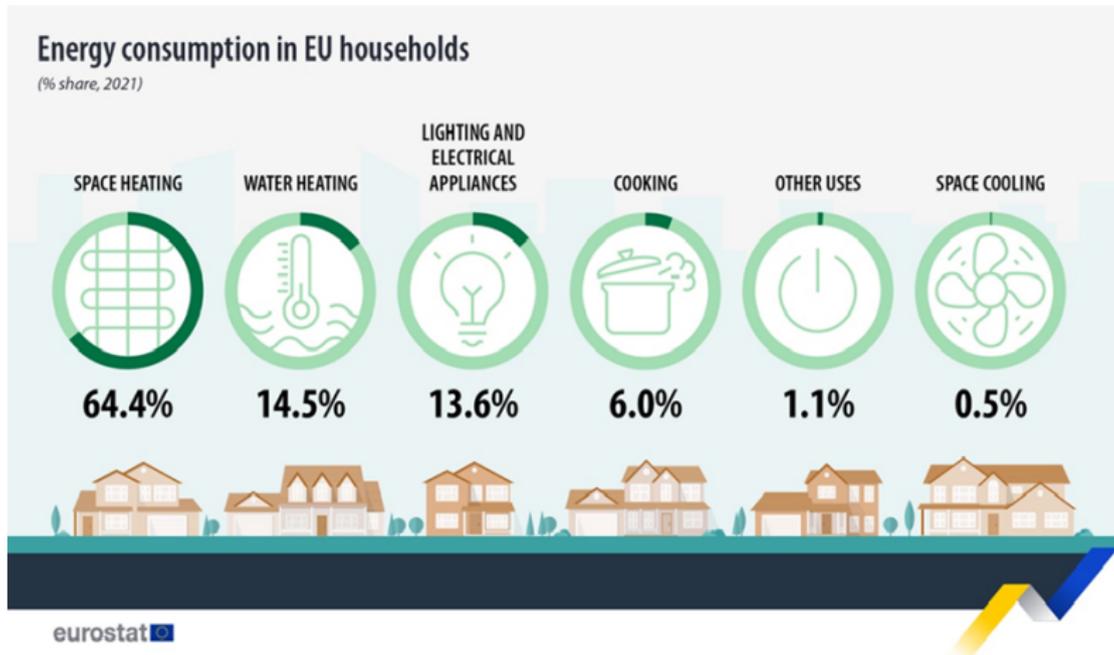


(*) International aviation and maritime bunkers are excluded from category Transport.

Source: Eurostat (online data code: nrg_bal_c)

eurostat 

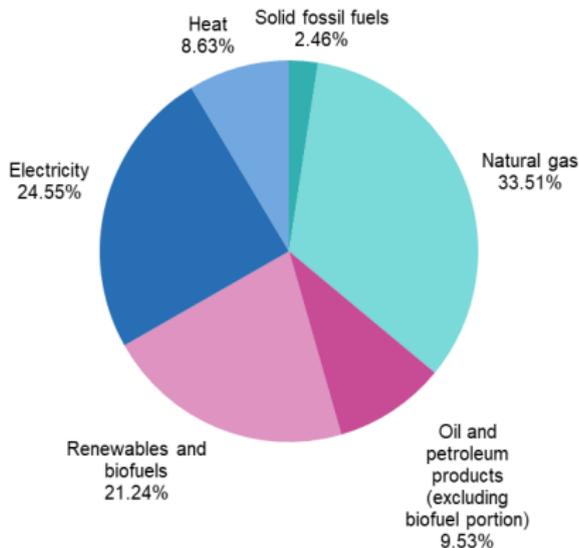
Context - Energy use of households



Not included here: private transportation

Context - Energy sources of households

Final energy consumption in the residential sector by fuel, EU, 2021



Source: Eurostat (online data code: nrg_bal_c)

eurostat 

Not included here: private transportation

Research questions

In light of the European target to be carbon neutral by 2050 and reduce emissions 55% compared to 1990 by 2030:

Techno-economic

- What are cost-efficient ways to reduce emissions from residential energy demand?

Political

- How can emission reducing options be incentivized?
- Focus here: retail rates and network tariffs
- Additionally: carbon policies, V2G options

Technical option space

Energy end-uses of households

- Transport: combustion engine vs. electric
- Heating: gas vs. heat pumps
- Electricity: grid plus self-generated (PV)
- Hot water: gas vs. electric boilers
- Cooking: gas vs. induction

Networks

- Local network upgrades in case electric peaks overload network assets

Future plans: include efficiency, in particular building upgrades, heating grids, communal storage and generation options

Retail rates and network tariffs

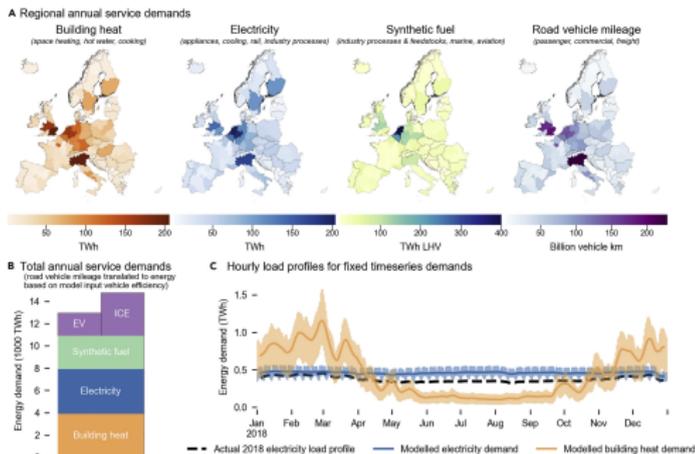
Retail rates

- Prices charged for electricity procurement
- Examples: flat, Time-of-Use, real time pricing
- Can incentivize certain options, especially with flexible resources such as batteries, EVs and thermal storage

Network tariffs

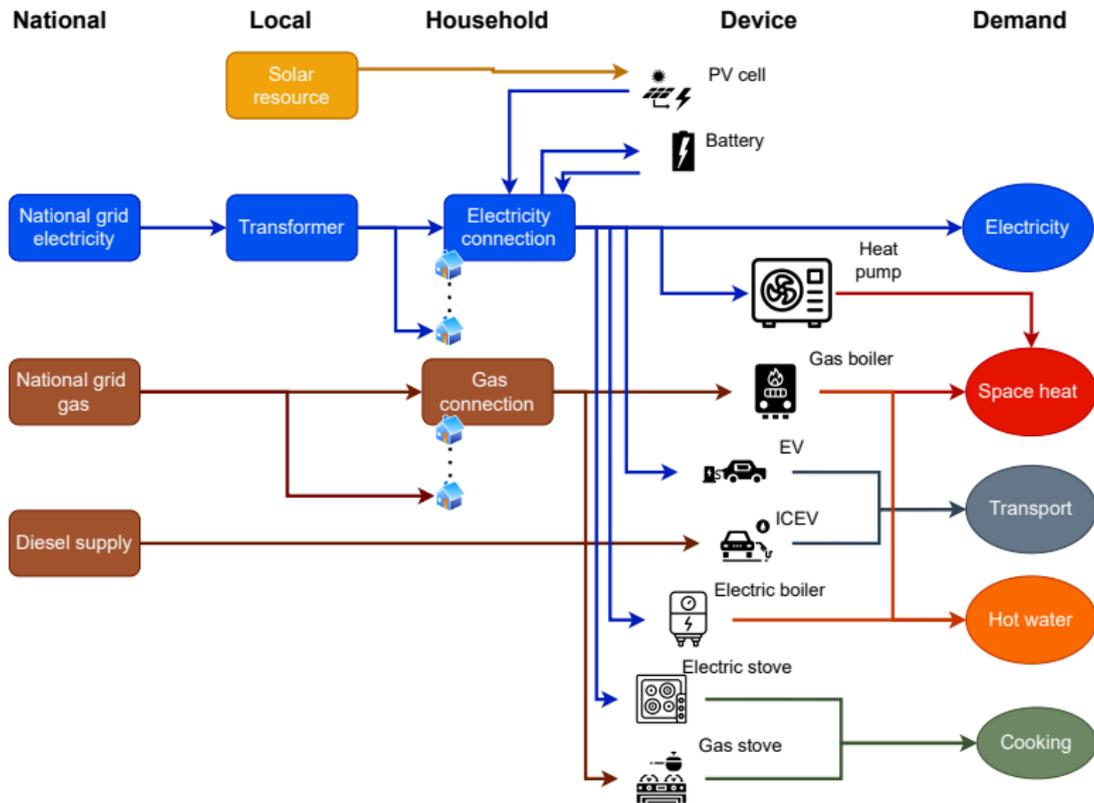
- Charged for usage of the network
- Examples: fixed, flat volumetric, ToU, capacity-based pricing
- Can help protect against network overload, reducing network costs

- Open source energy system model
- Wide range of energy carriers, generation options, transformation devices and demands
- Here: local scale



¹B. Pickering, F. Lombardi, and S. Pfenninger (2022). "Diversity of options to eliminate fossil fuels and reach carbon neutrality across the entire European energy system". In: *Joule* 6.6, pp. 1253–1276. ISSN: 2542-4351. DOI: <https://doi.org/10.1016/j.joule.2022.05.009>

Local model overview



Modeling strategy

- Model is initialized with fossil options (gas heating and cooking, combustion engine vehicle) at zero cost
- We use electricity prices from a near-zero carbon 2030 European energy system (from Calliope-Europe)
- Electrification options and PV cells are given as possible investment options
- We experiment with different combinations of possible retail rates and network tariffs

Scenarios

Retail rates

- Flat-rate, Time-of-Use, Real-time electricity pricing

Network Tariffs

- Fixed, Capacity-based

Carbon constraints

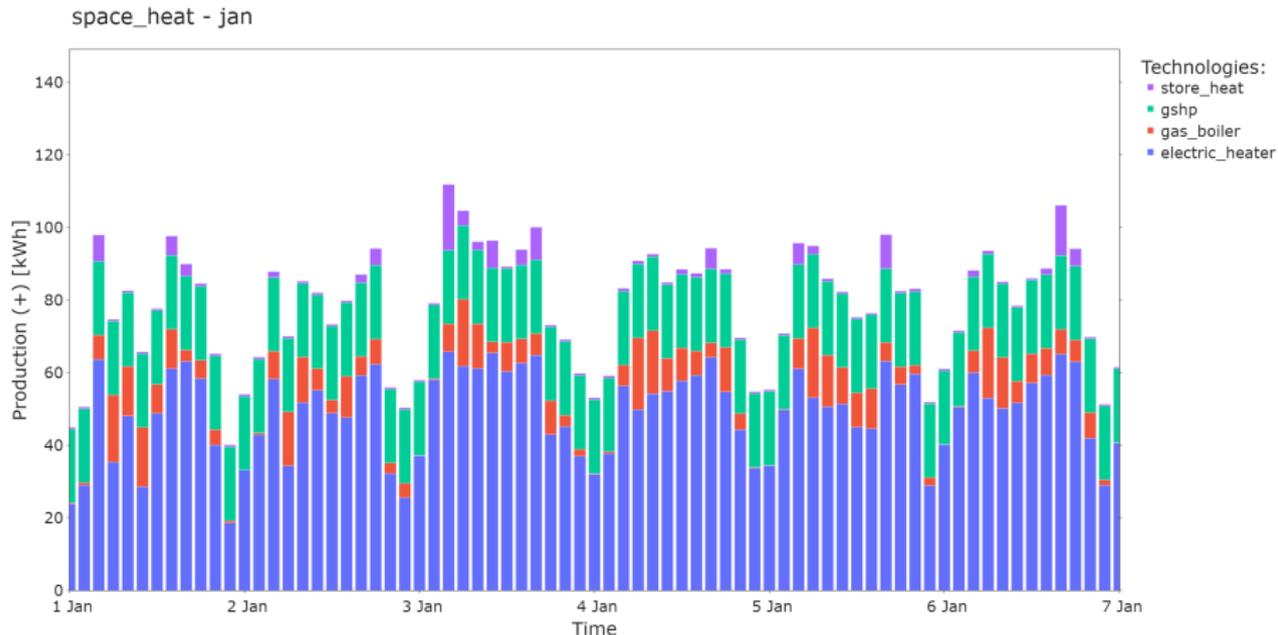
- None, Carbon-cap, Increased carbon tax

EVs

- Dumb-charging, Smart-charging (V1G), Smart vehicle to grid (V2G)

Preliminary Results

With RTP, V1G, fixed network tariff, no carbon policy



need to re-check model assumptions and equations

Summary and next steps

- Using energy system model calliope to assess investments in low carbon system configuration in residential neighborhoods
- Focus on the impact of retail rates to incentivize required investments
- Investigate interactions with network tariffs and related policies, such as carbon caps/taxes and V2G options
- Next: checking model assumptions and validity, implementing network constraints and upgrades
- Future research: go to meso-scale (city or regional), investigate more options such as heat grids, seasonal heat storage, energy efficiency (building insulation) and communal batteries/solar fields

Thanks for your attention

Bibliography I

Pickering, B., F. Lombardi, and S. Pfenninger (2022). “Diversity of options to eliminate fossil fuels and reach carbon neutrality across the entire European energy system”. In: *Joule* 6.6, pp. 1253–1276. ISSN: 2542-4351. DOI: <https://doi.org/10.1016/j.joule.2022.05.009>.