

Integrating flexible demand in the sectors industry and households into the agent-based electricity market model PowerACE

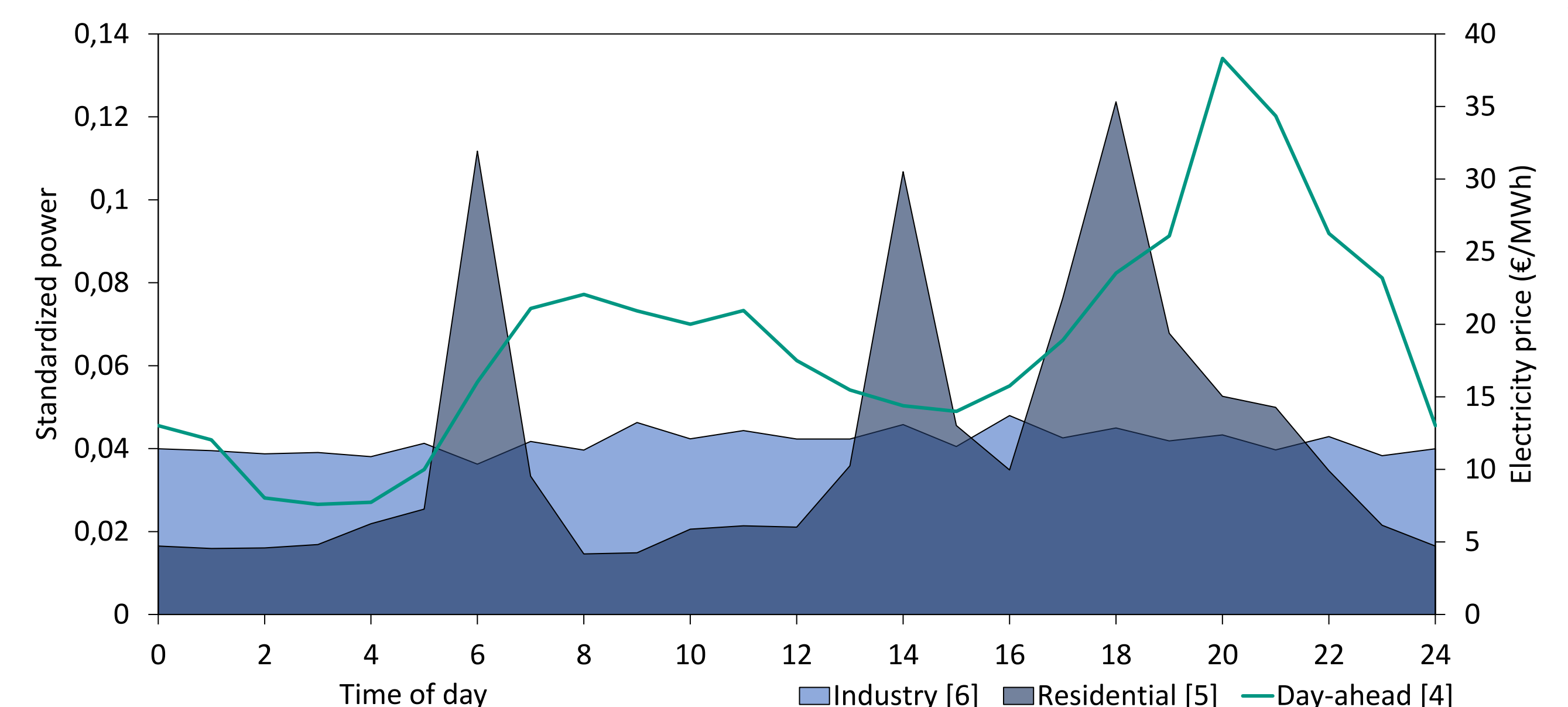
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Background and Motivation

- National low carbon economy objectives drive greater electrification across various sectors, notably in industry and residential areas, projecting a rise in electricity consumption in the coming years [1]
- This increase poses a challenge to the electricity system in maintaining equilibrium between supply and demand, which can be addressed by flexible demand sectors that offer load shifting or load shedding [2]
- While theoretical potentials exist, various technical, economic, organizational and policy barriers still hinder the realization of the full flexibility potential [3]
- The research objective:**
 - What are effective strategies to trade demand flexibility on the day-ahead market?
 - Integration of demand flexibility into the agent-based electricity market model PowerACE focusing on the industry and the residential sectors

[1] A. Boldrini, D. Koolen, W. Crijns-Graus, E. Worrell, and M. van den Broek, "Flexibility options in a decarbonising iron and steel industry," Renewable and Sustainable Energy Reviews, vol. 189, p. 113988, Jan. 2024, doi: 10.1016/j.rser.2023.113988.
[2] D. Koolen, F. M. De, and S. Busch, "Flexibility requirements and the role of storage in future European power systems," JRC Publications Repository, https://publications.jrc.ec.europa.eu/repository/handle/JRC130519 (accessed Feb. 29, 2024).
[3] L. Scharnhorst, D. Sloot, N. Lehmann, A. Ardone, and W. Fichtner, "Barriers to demand response in the commercial and industrial sectors – An empirical investigation," Renewable and Sustainable Energy Reviews, vol. 190, p. 114067, Feb. 2024, doi: 10.1016/j.rser.2023.114067.

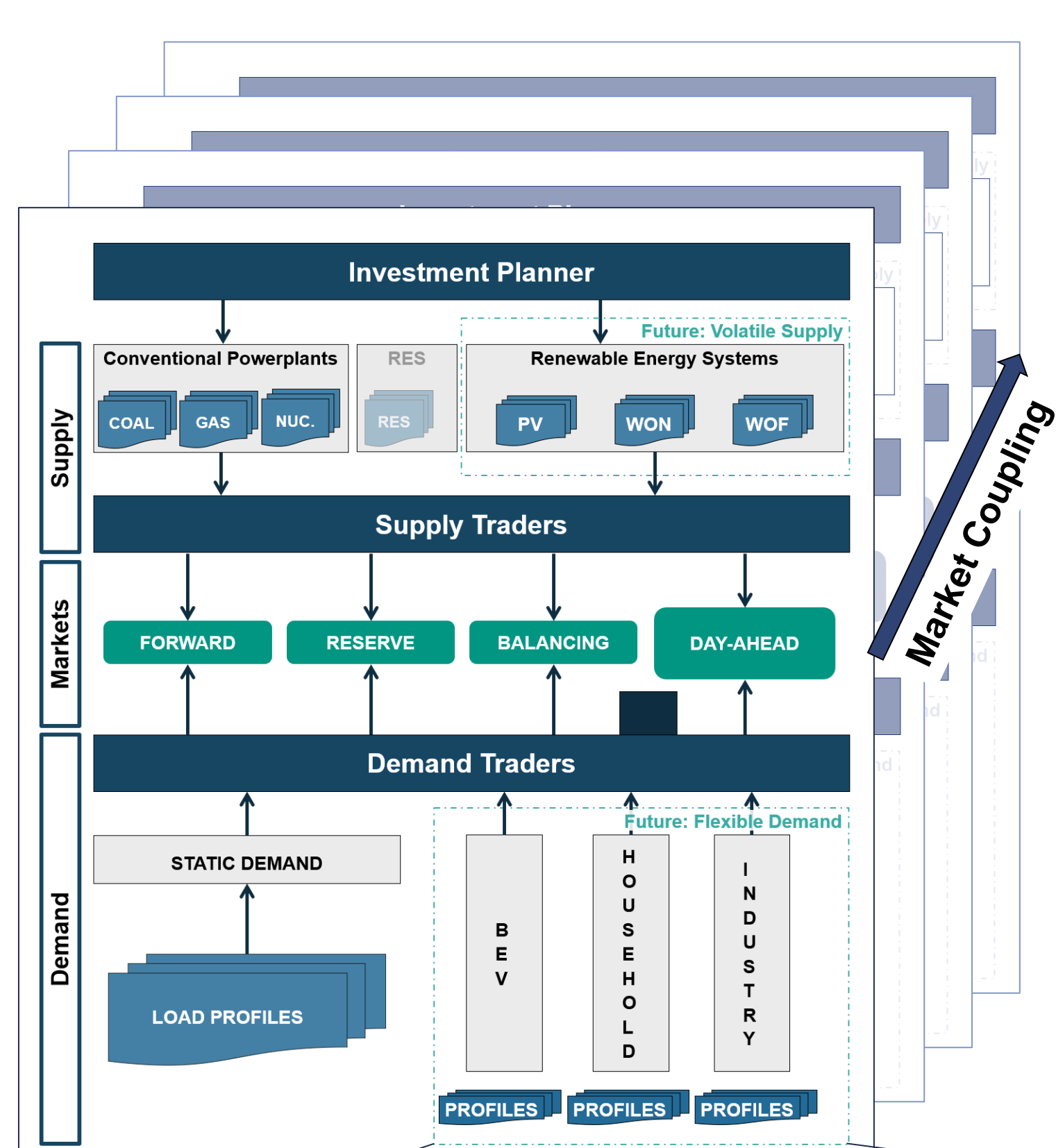
Industry & residential demand and day-ahead prices



[4] "Price Spot Market", Energy Charts, date: 25.05.2020, https://energy-charts.info/charts/price_spot_market/chart.html?l=de&c=DE&year=2020&week=22 (accessed Mar. 19, 2024).
[5] Beuth „VDI 4566:2021-07 – EFH ÜWB“ https://www.beuth.de/de/technische-regel/vdi-4655/336886496 (accessed July 13, 2023)
[6] Own computation based on a process specific industry demand simulation, with synthesized technology specific input data, e.g. [7,8]
[7] Seim, S., Ruedt, D., Wu, Q., Held, M., Verwiebe, P., Mueller-Kirchenbauer, J., Regression-based electricity load profiles of 32 industrial and commercial subsectors in Germany. 2021, Berlin. https://zenodo.org/records/4576494 (accessed 19.03.2024)
[8] Dock, J., Janz, D., Weiss, J., Marschnig, A., Kienberger, T., Time- and component-resolved energy system model of an electric steel mill. Cleaner Engineering and Technology, vol. 4, 100223, Oct 2021, https://doi.org/10.1016/j.clet.2021.100223

Methodology

PowerACE



Definition of Flexibility

In this case, flexibility is defined by the authors as measures that enable load shifting or load shedding in response to a (price) signal [10].

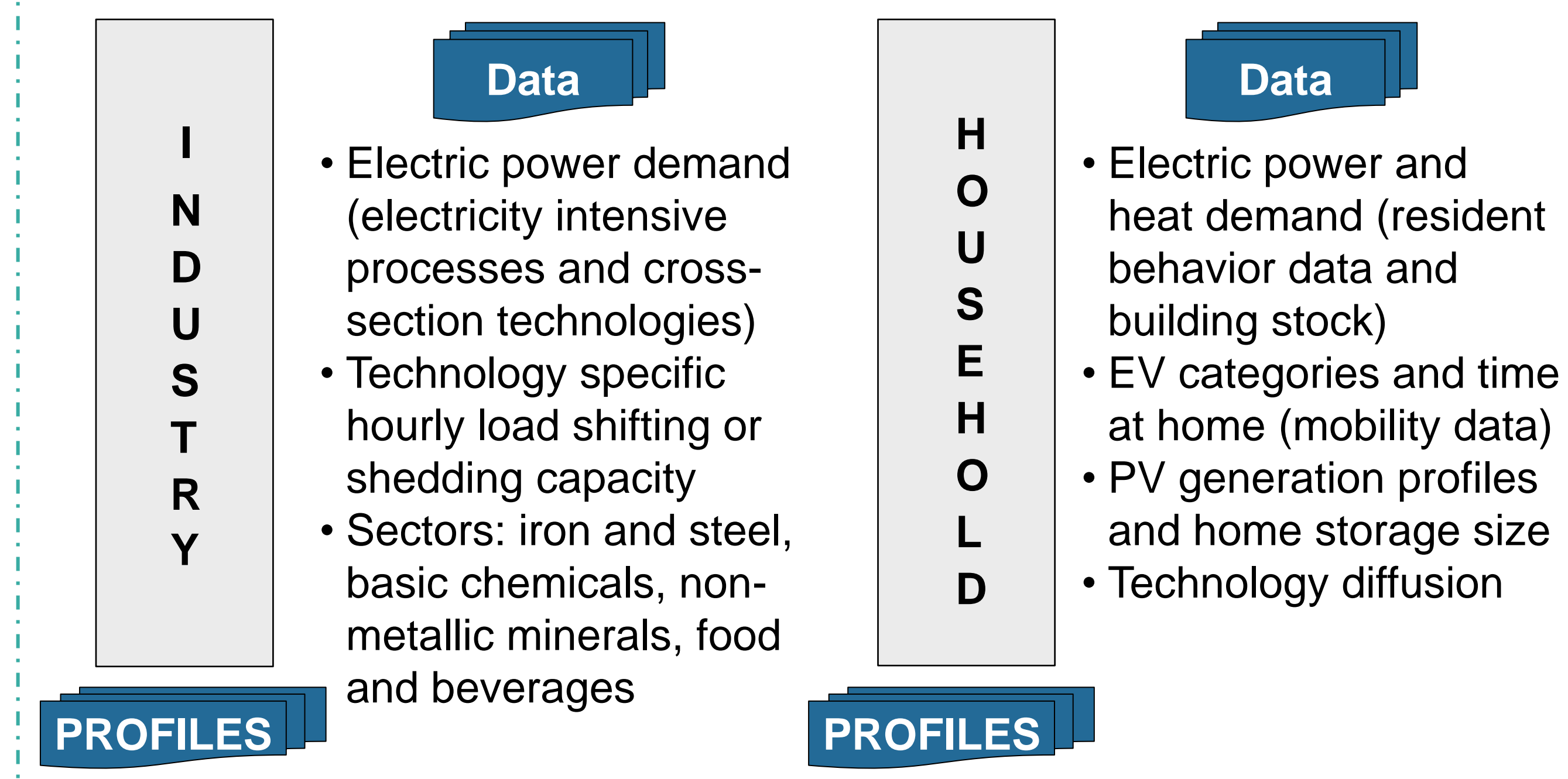
Characteristics:

- Hourly load profiles
- Technological restraints
- Shifting time
- Shifting frequency
- Shifting costs

Legend



Future: Flexible Demand



[10] "Benefits of Demand Response in Electricity Markets and Recommendations for achieving them - a Report to the United States Congress Pursuant to Section 1252 of the Energy Policy Act of 2005," U.S. Department of Energy, USA, Feb. 2006. [Online]. Available: https://www.energy.gov/oe/articles/benefits-demand-response-electricity-markets-and-recommendations-achieving-them-report

Industrial flexibility

The industry sector is the largest electricity demand sector in Europe and historically the largest provider of flexibility. Electricity intensive production processes, as well as cross section technologies can provide considerable flexibility potential. But what effects may the bidding of industrial flexibility have on electricity prices?

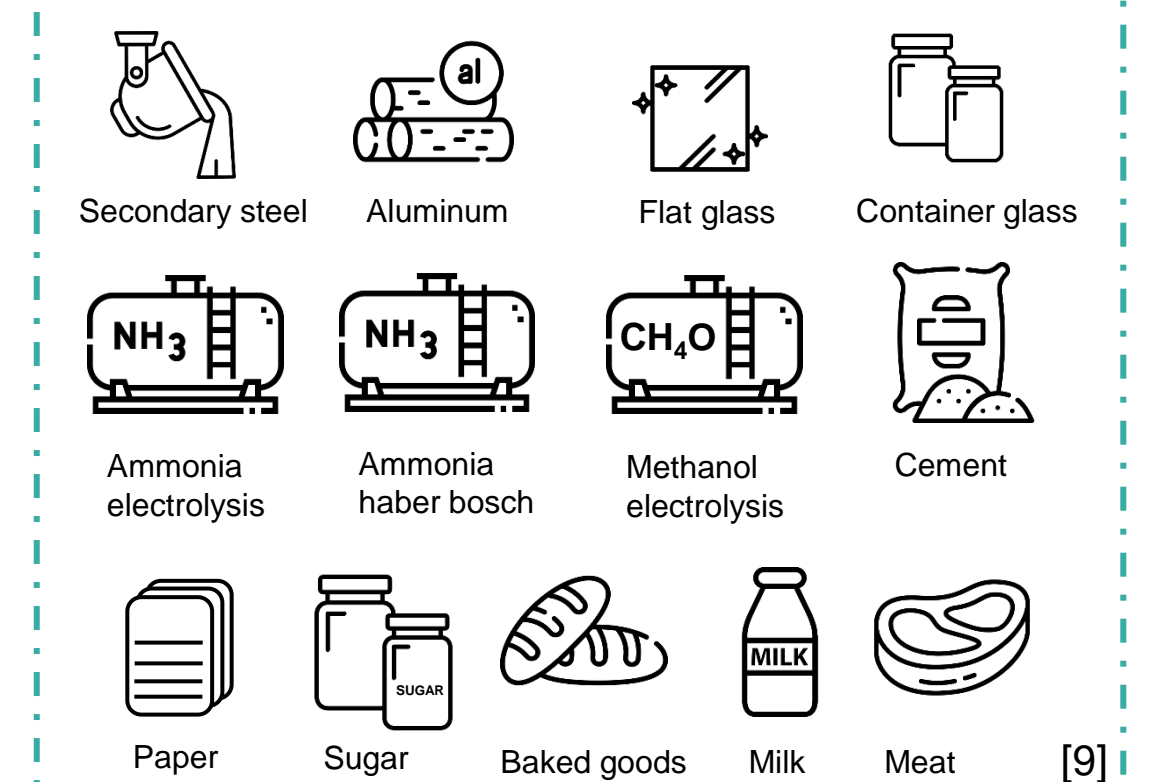
First Phase

Deriving the load shifting and shedding potentials of various industry processes based on the electricity consumption development from an industry demand simulation model which simulates the diffusion of decarbonization technologies up to the year 2050 for Europe.

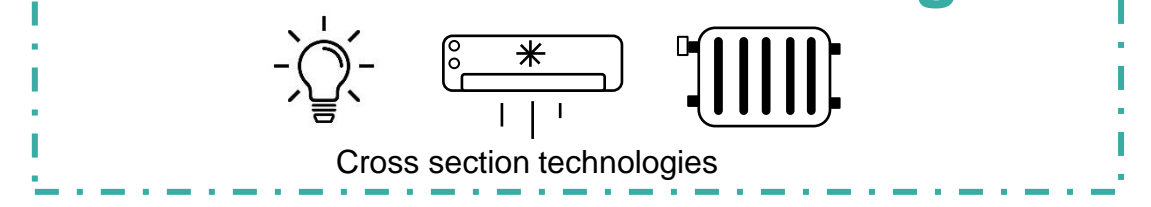
Second Phase

Development of an industry flexibility agent that trades the load shifting and shedding potentials on the day-ahead market.

Processes



Cross section technologies



[9] Icons: https://www.flaticon.com/free-icons/

Flexibilities from residential households

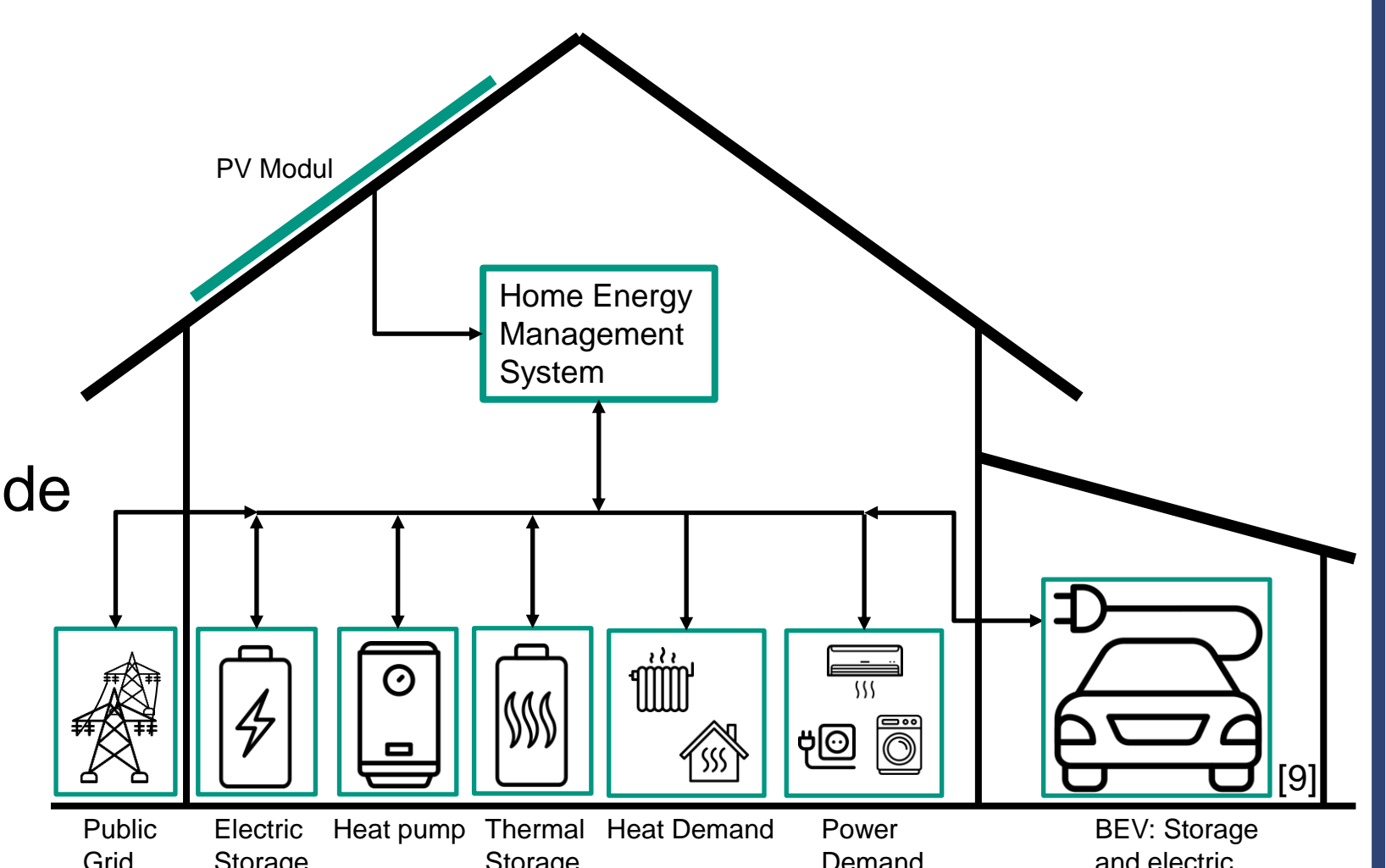
With the transformation in the heating and transportation sectors, households are becoming increasingly electrified. These technologies can be controlled in terms of time, feed-in and consumption to create flexibility in the electricity market. What effects occur on the market, when a very large capacity from households trade their flexibilities at the day-ahead market?

First Phase

Preparation of a static load shifting potential in a separate MILP optimization model and subsequent use in PowerACE.

Second Phase

Development of agents that trade their load shifting potentials on the day-ahead market and are influenced by the market and electricity price.



[9] Icons: https://www.flaticon.com/free-icons/

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