Energy Week 2024
PATHFNDR CONFERENCE

Input presentation

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Large-scale flexibility from small-scale actors: a deep-dive on electric vehicle charging

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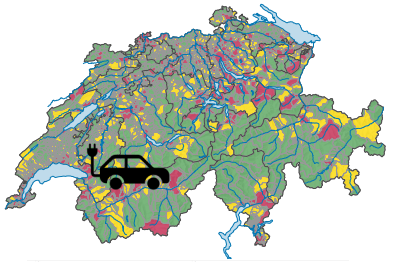
Modelling EV flexibility

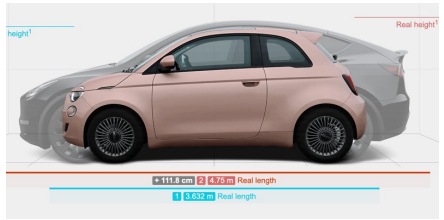
Large-scale flexibility is the sum of millions of small decisions and behaviours.



urban vs. rural

job and

family commitments



vehicle choice

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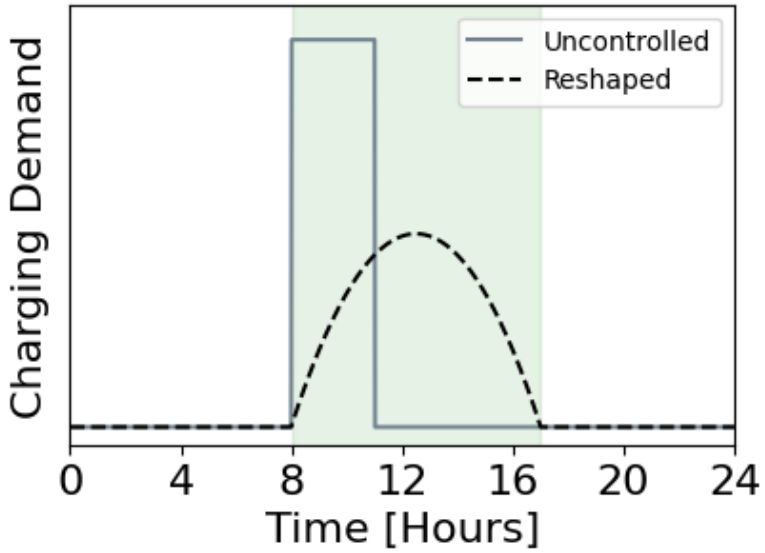
Powell et al., 2022. Applied Energy. https://doi.org/10.1016/j.apenergy.2021.118382
Powell et al., 2022. Nature Energy. https://doi.org/10.1038/s41560-022-01105-7
Herrera et al, 2024. *2024 International Conference on SEST*. https://doi.org/10.1109/SEST61601.2024.10694497
Fischer, et al., 2019. *Applied Energy*. https://doi.org/10.1016/j.apenergy.2018.10.010
Carsized.com.; BfS. *Typologie urbain-rural 2020*.

Modelling EV flexibility

Large-scale flexibility is the sum of millions of small decisions and behaviours.

Changing Mobility Options

Pricing and Infrastructure



Markets and Price Signals

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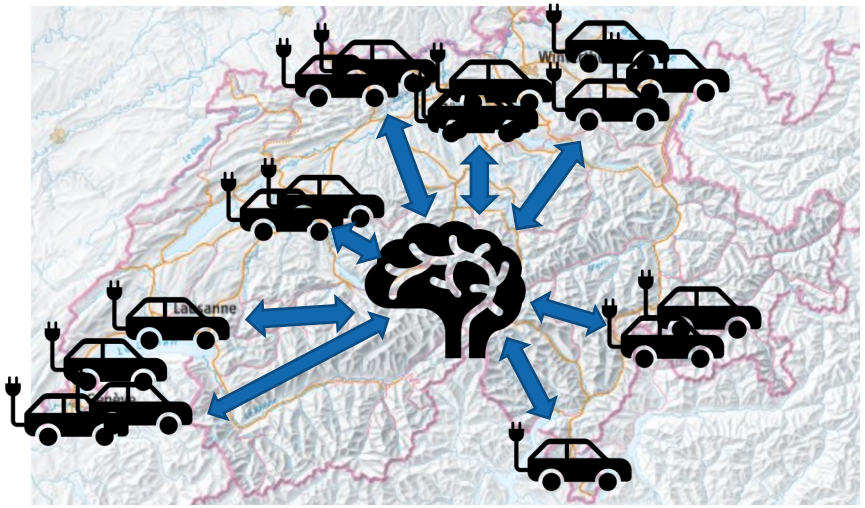
Powell et al., 2022. Applied Energy. https://doi.org/10.1016/j.apenergy.2021.118382
Powell et al., 2022. Nature Energy. https://doi.org/10.1038/s41560-022-01105-7

Accessing EV flexibility

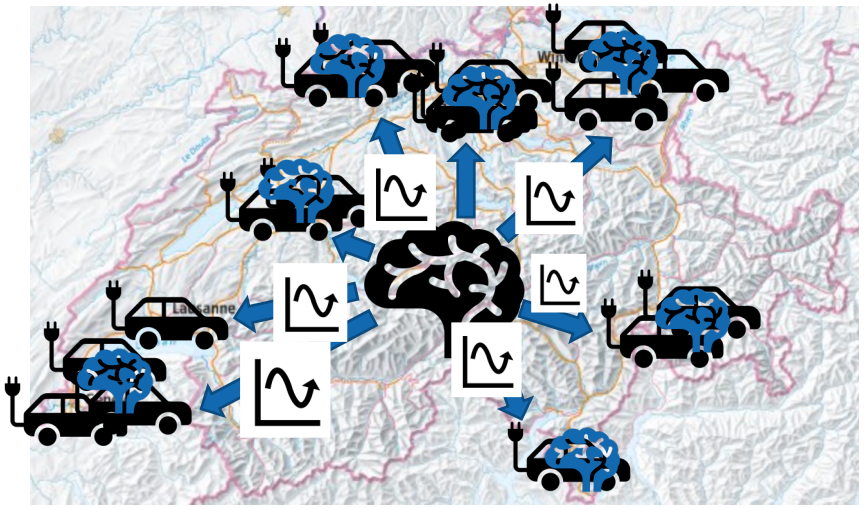
Centralized control

- Optimal solution with direct involvement of a *central decision maker*



Decentralized control

- Through *signals* communicated to distributed decision makers



Distributed decision makers compare flexibility incentives with costs

Incentives

- Profit from buying low, selling high
- Possible tax breaks
- Possible hardware subsidies

Costs

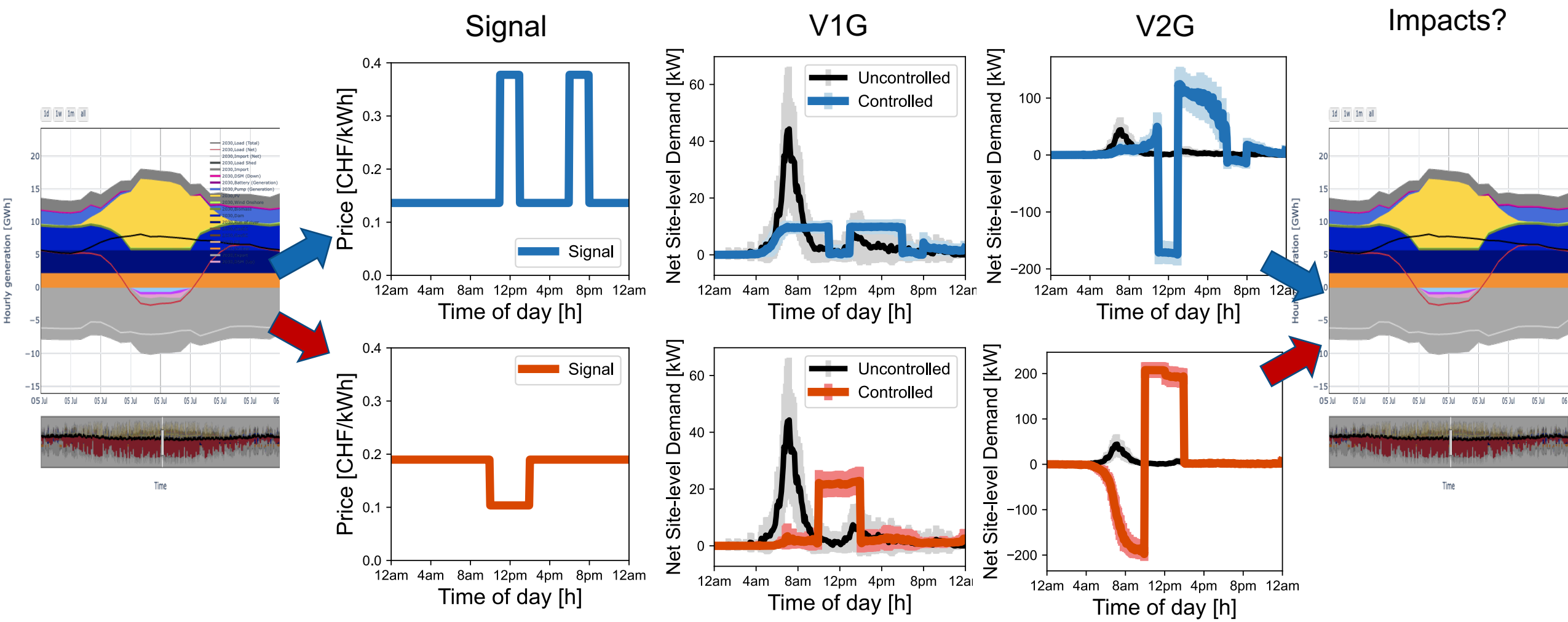
- Hardware costs + installation
- Operations and maintenance
- Discharging regulations
- Battery degradation
- Inconvenience

Our key findings on the business case for V2G in Switzerland:

- Difference between lowest charging price and highest discharging price must cover round-trip losses
- V2G-capable stations are very expensive; subsidies may be needed until prices fall

Andersen and Powell, 2024. Available at SSRN: https://ssrn.com/abstract=4918051

What signals and incentives lead to the best system impacts?



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Andersen and Powell, 2024. Available at SSRN: https://ssrn.com/abstract=4918051
Mellot et al., 2024. *In prep.*
Van Liedekerke et al., 2023. https://nexus-e.org/result-vehicle-to-grid-in-switzerland/

Summary

Conclusions:

- Large-scale flexibility from EVs and other DERs comes from **millions of small actors**:
  - Different flexibility potential
  - Different behaviours and preferences
- Flexible EV charging is a **valuable resource** for electricity system planning and operation.
- To get the most benefit, we need **better signals** for decentralized flexibility.

Open Challenges:

- **Business case** for small-scale flexibility
- **Implementation** of more complex signals or direct control
- Choosing the **best signal** for different objectives
- Weighing **generation-level vs. distribution grid** impacts

To get the most **benefit from EV flexibility** for the system, we need better **coordinated signals** telling decentralized actors and aggregators **where and when to charge**.