An aerial photograph of a city, likely Zurich, showing a river (Limmat) flowing through the center. The river is surrounded by historic buildings and modern infrastructure. A large, domed building (the ETH Zurich main building) is visible in the lower right. A yellow crane is visible in the foreground, extending over the river. The image is used as a background for the presentation slide.

# Charging toward a cleaner future: the transition to electric vehicles

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# We need electric vehicles (EVs) ... and they're finally coming!



## **Tesla Model Y (EV):**

43 - 65k CHF

~ 500 km range

~ 3 CHF / 100km



## **Skoda Octavia (Gas):**

35 - 45k CHF

~700 km range

~ 9 CHF / 100 km

- **Lifecycle** emissions in Europe vs. gasoline <sup>1</sup>:

- 3X lower today
- 4X lower in 2030

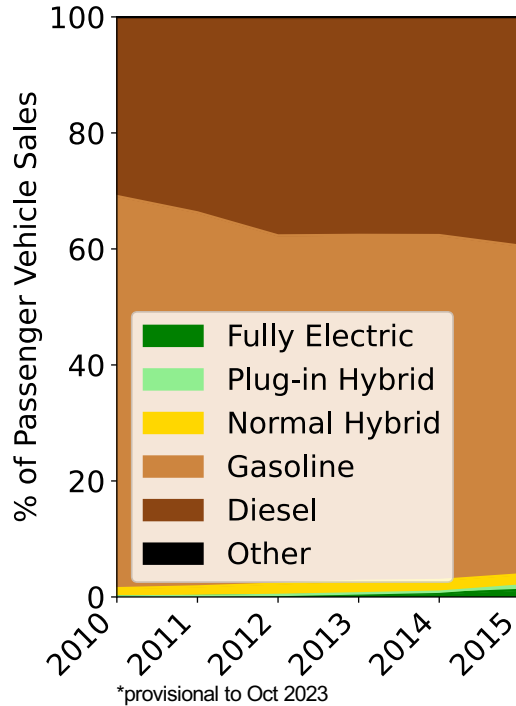
*The New York Times*

## ***European Union to Ban Gas-Powered Cars by 2035***

sale of

The law is part of the E.U.'s ambitious plans to make the 27-member bloc carbon neutral by 2050.

# We need electric vehicles (EVs) ... and they're finally coming!



9%

34%

29%

7%

20%

27% in 2023\*

**Target: 50% by 2025**

"Roadmap Elektromobilität 2025". <https://roadmap-elektromobilitaet.ch/de/idee/>

"Road vehicles - New registrations." Federal Statistical Office. (2023). <https://www.bfs.admin.ch/bfs/en/home/statistics/mobility-transport/transport-infrastructure-vehicles/vehicles/road-new-registrations.html>



But, how will we charge them? We need to prepare solutions.



? Clean ?  
? Affordable  
Reliable ?  
? Convenient  
?

Photo Credit:  
Marek Studzinski,  
unsplash.com

# We research charging patterns and charging access



Photo Credit:  
Michael Fousert,  
Sophie Jonas,  
Marjan Blan,  
unsplash.com

# Charging patterns are important for distribution grid planning

- Heterogeneous charging behaviours for location, timing, and speed



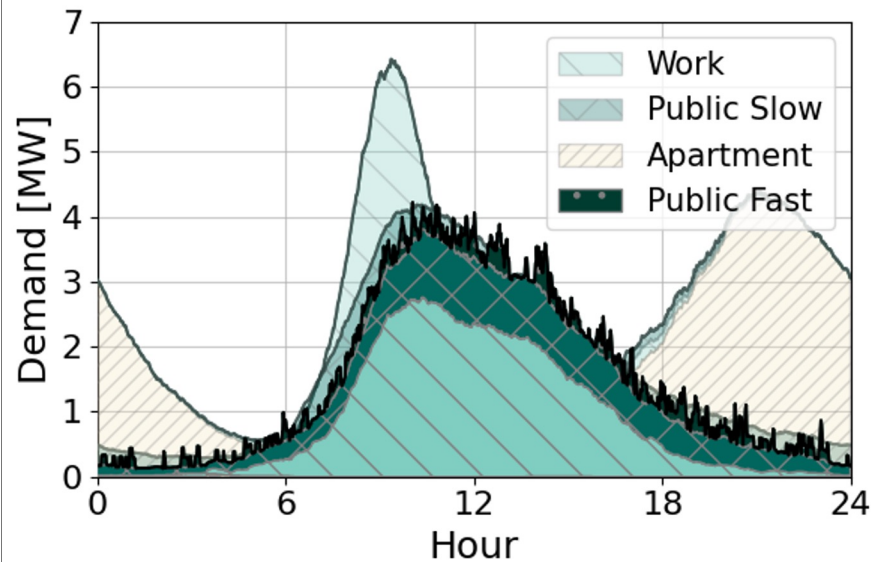
How will future drivers behave?

How should we prepare the distribution grid?

Photo Credit:  
Greg Rosenke,  
unsplash.com



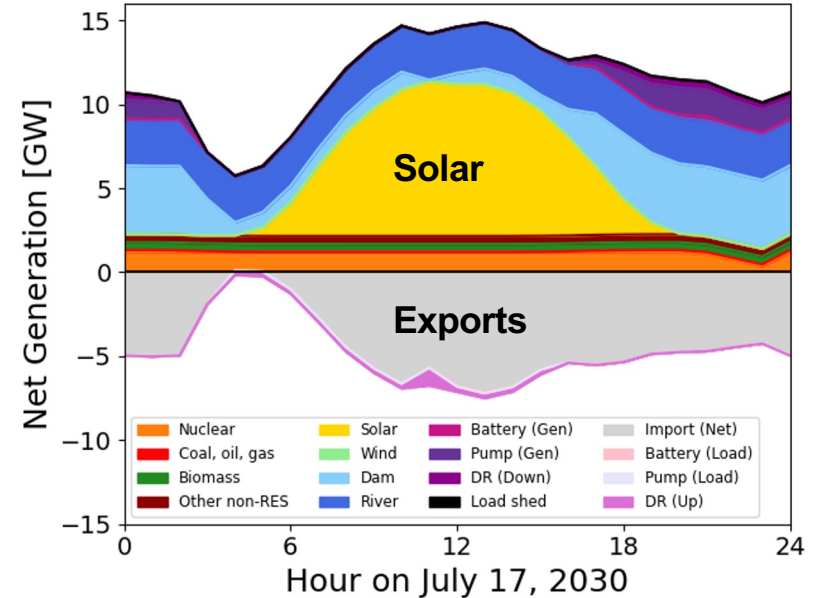
# Charging patterns affect electricity generation planning



## Different timing for each behaviour

How common will each be? Total demand?

Powell, Siobhan, Gustavo Vianna Cezar, and Ram Rajagopal. "Scalable probabilistic estimates of electric vehicle charging given observed driver behavior." *Applied Energy* 309 (2022): 118382.



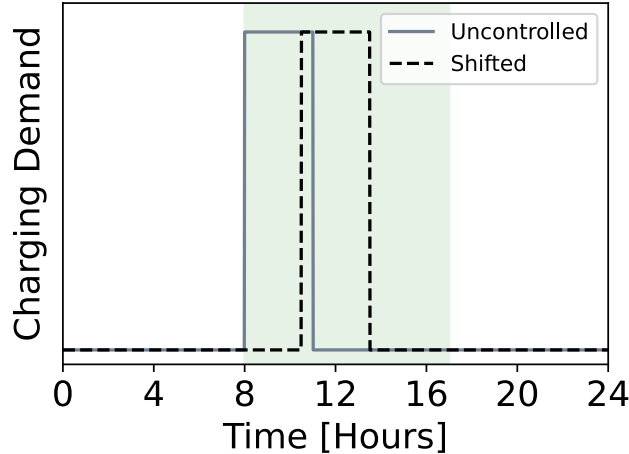
## Different timing for electricity generation

How much storage? Imports? Exports?

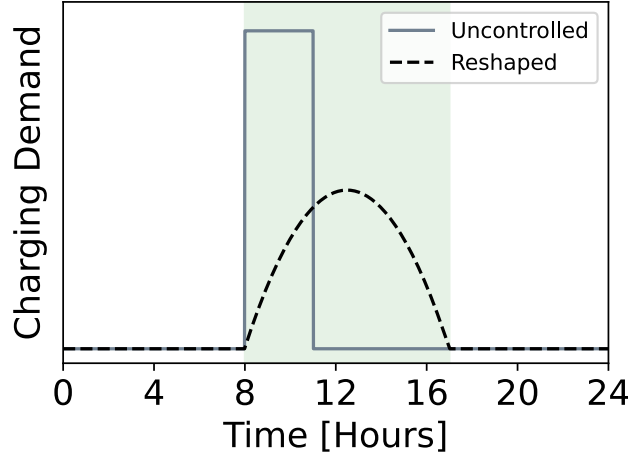
Schwarz, Marius and Samuel Renggli. "Assessing the Feasibility of Scenarios for the Swiss Electricity System: Nexus-e Interactive Results Viewer." <https://nexus-e.org/a-perspective-on-nuclear-power/>

# We can use flexibility to make grid preparations easier

Arrival → Departure



Timer to Delay Start



Reshape Charging Process



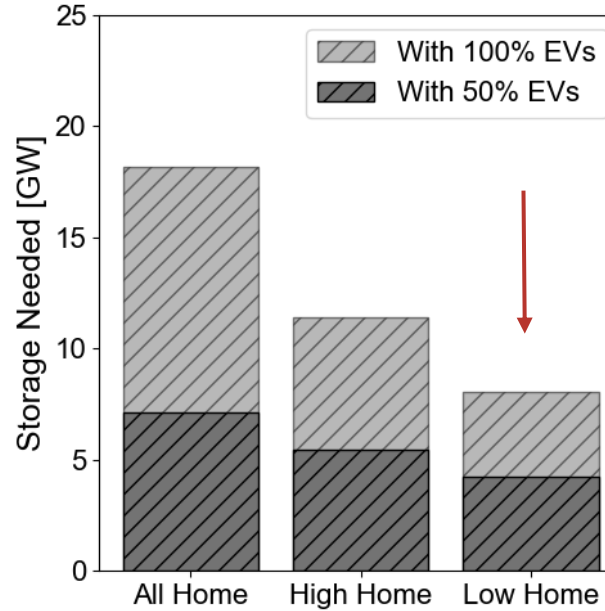
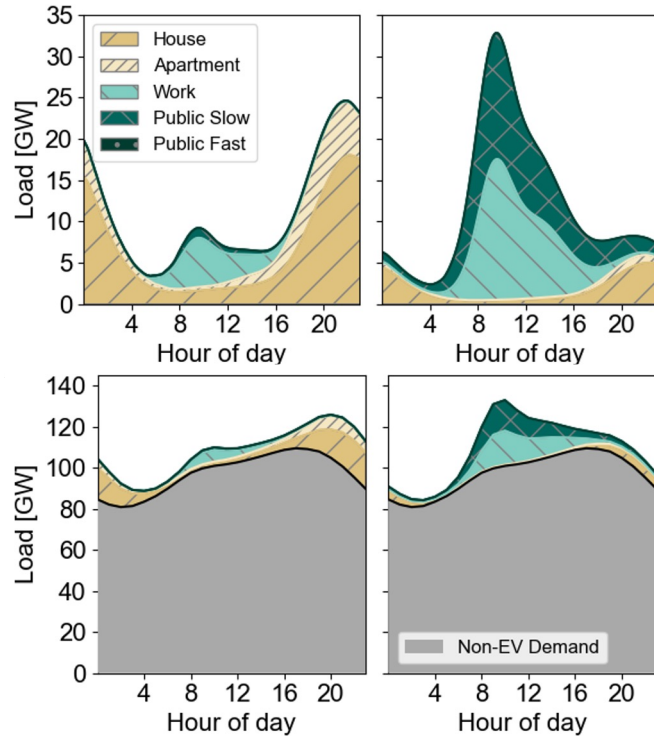
Change Plug-in Decision

How should pricing and control signals be designed for the grid?

Deep dive: Can charging infrastructure be a source of flexibility?



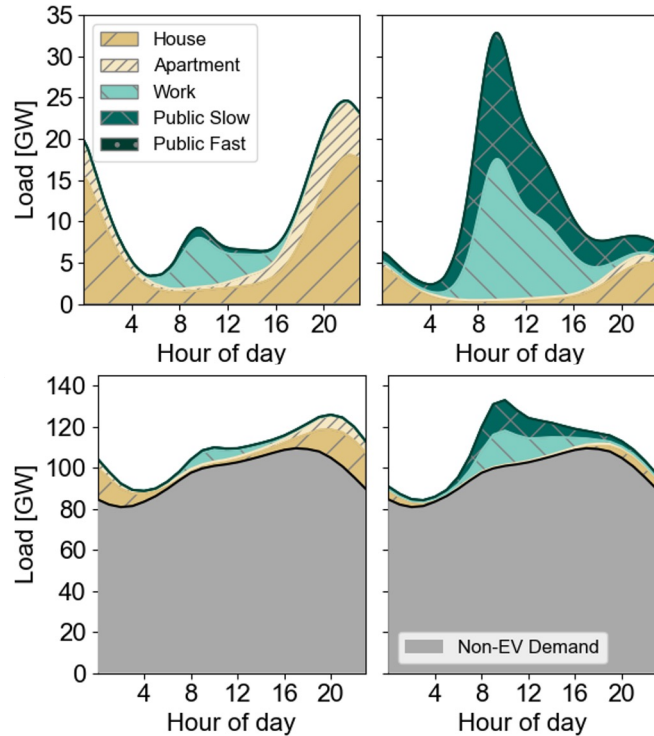
# Charging infrastructure can help in California



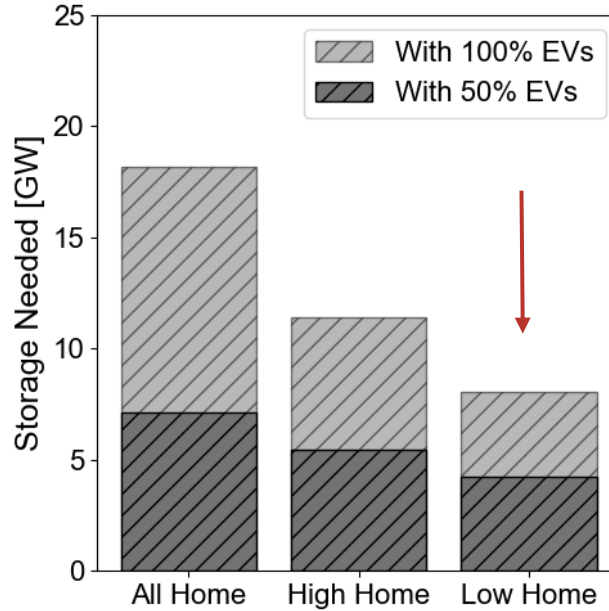
- Daytime demand aligns with solar
- More daytime charger access:
  - Reduces need for storage
  - Reduces emissions
  - Reduces ramping

Powell, Siobhan, et al. "Charging infrastructure access and operation to reduce the grid impacts of deep electric vehicle adoption." *Nature Energy* 7.10 (2022): 932-945.

# Charging infrastructure can help in Switzerland



Powell, Siobhan, et al. "Charging infrastructure access and operation to reduce the grid impacts of deep electric vehicle adoption." *Nature Energy* 7.10 (2022): 932-945.



Will we get the same result for Switzerland?

- Solar ✓✓
- Evening demand ✗✗
- Daily vs. seasonal ✓✗
- Charging patterns ✓✗
  - Flexibility ✓✓
  - Infrastructure ✓✗

- Daytime demand aligns with solar
- More daytime charger access:
  - Reduces need for storage
  - Reduces emissions
  - Reduces ramping



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Photo Credit:  
Eric Weber,  
[unsplash.com](https://unsplash.com)

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