

The Value of Flexible Loads With Increasing Electrification

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2023 Long-term Load Forecasting Workshop



nrel.gov/EFS

The Electrification Futures Study explored 5 questions



Load

How might electrification impact electricity **demand** and **use patterns**?



Capacity

How would the electricity system need to **transform** to meet changes in demand?



Operation

How would the system operate, with high levels of electrification, to meet **reliability** needs in 2050?



Flexibility

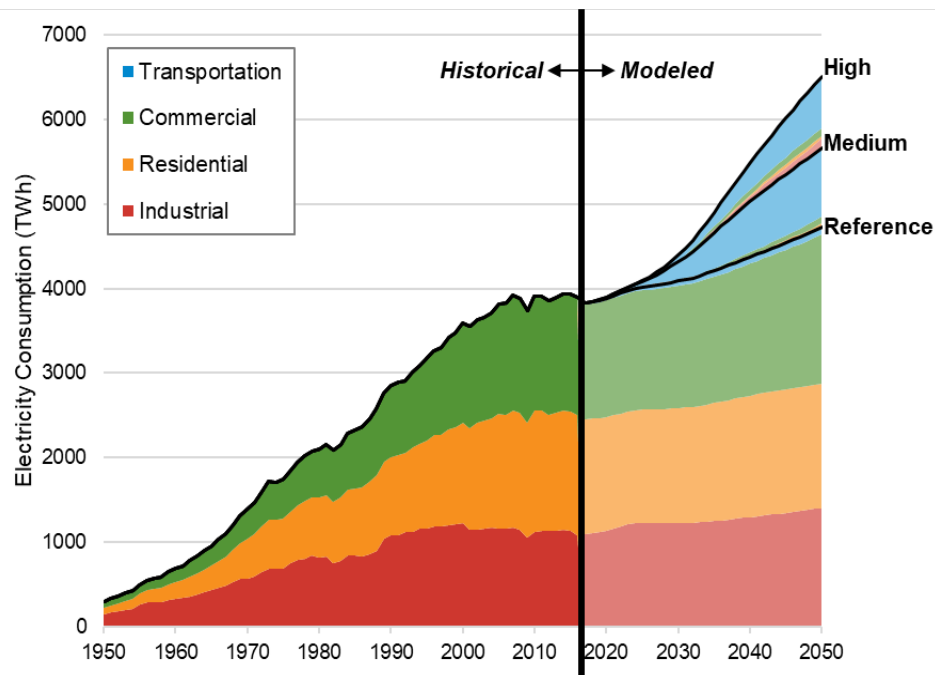
What role might **demand-side flexibility** play to support reliable operations?



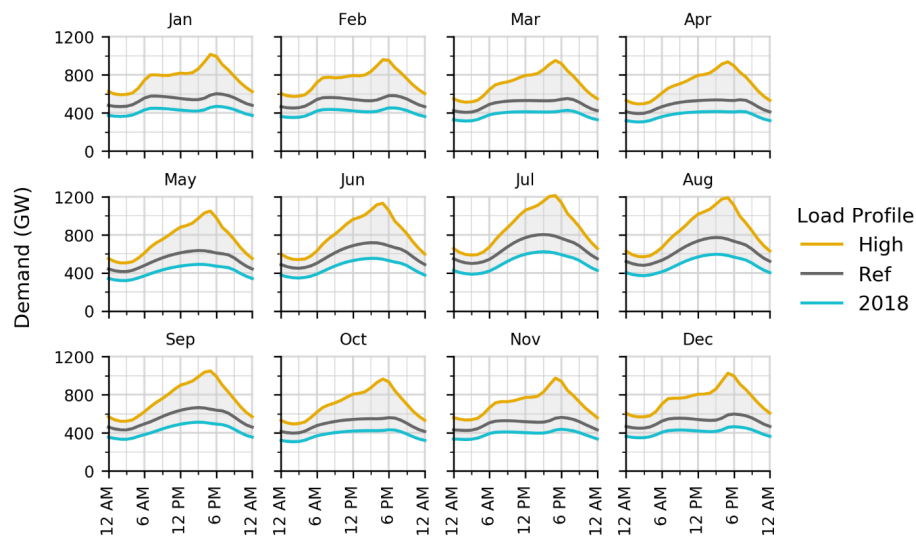
Impacts

What are the potential **costs, benefits, and impacts** of widespread electrification?

Load: Vehicle electrification dominates incremental growth in *annual* electricity demand

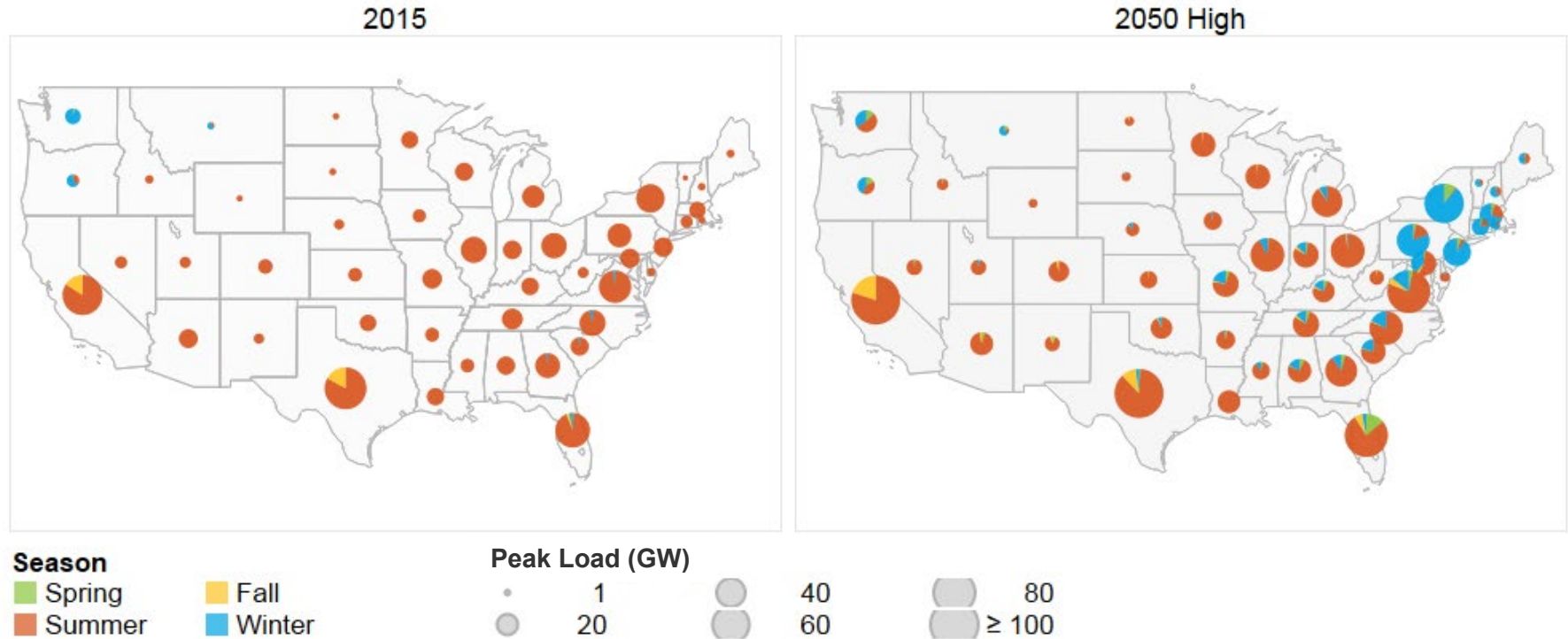


Greater electricity consumption



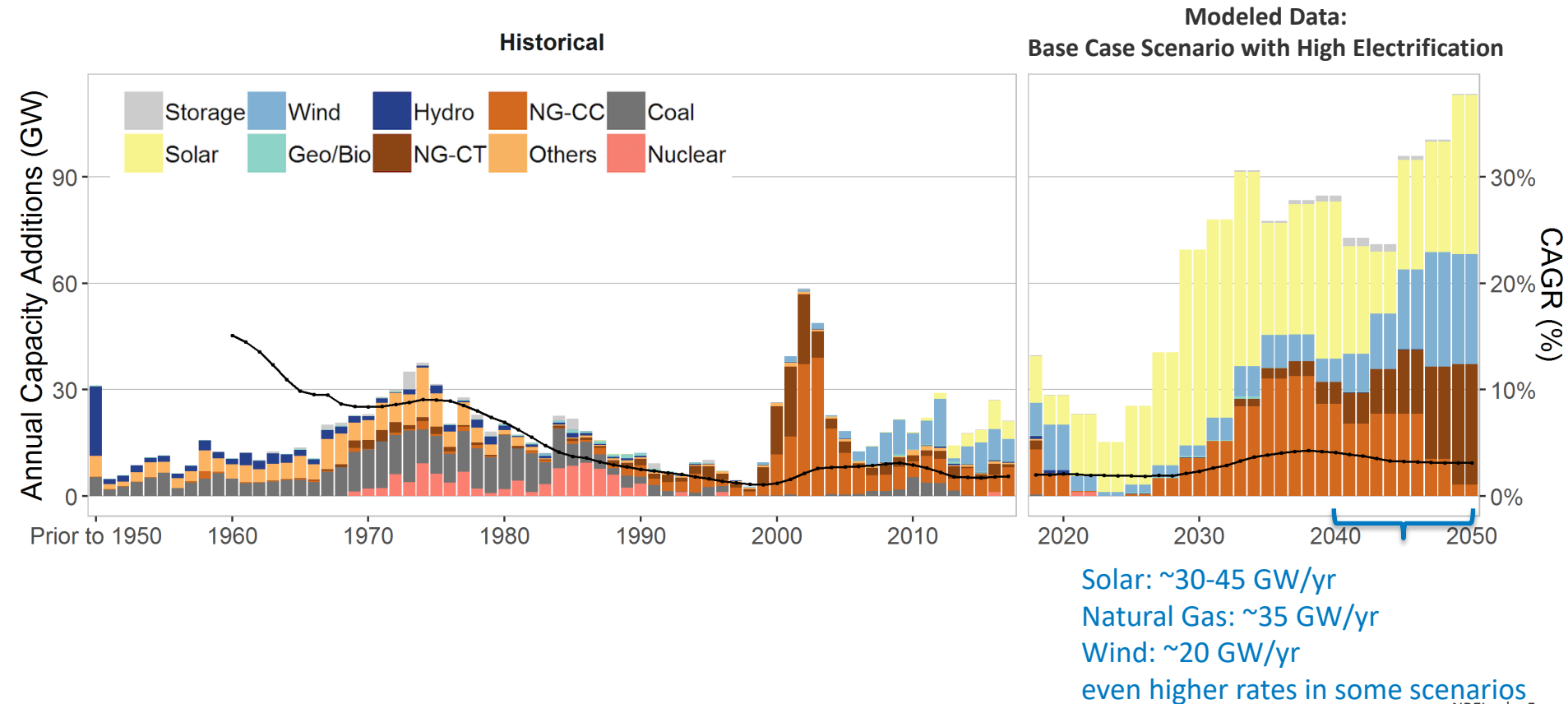
Possibly higher, sharper,
and more frequent peaks in 2050
(in the absence of demand flexibility)

Load: Electric space heating also impacts the timing and magnitude of peak demand



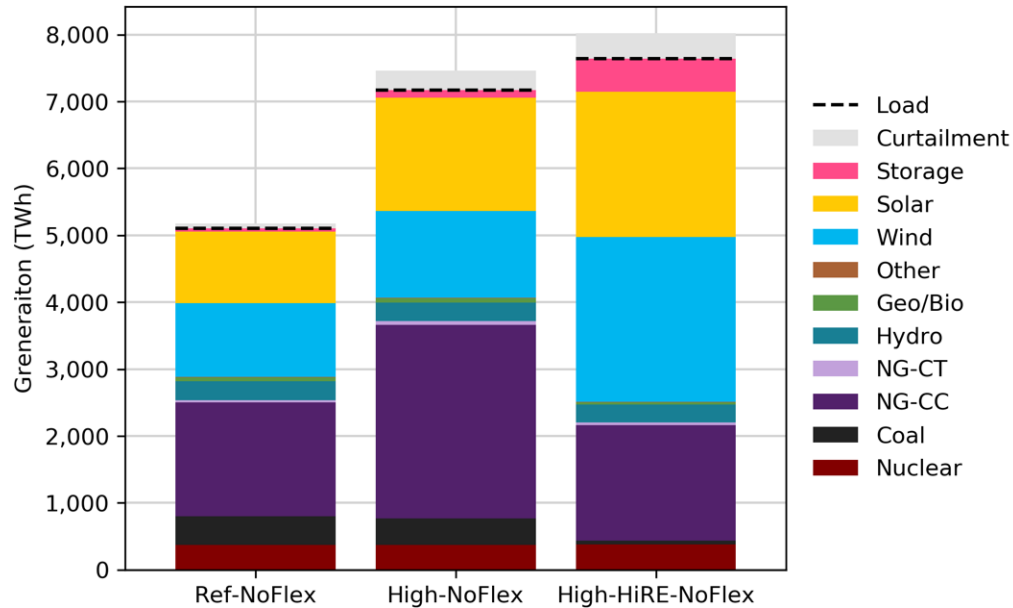
Note: Summer = June-August, Fall = September-November, Winter = December-February, Spring = March-May

Capacity: Electrification drives total installed capacity in 2050 to be 58% greater than 2018 levels



Operation: Modeled portfolios are resource adequate

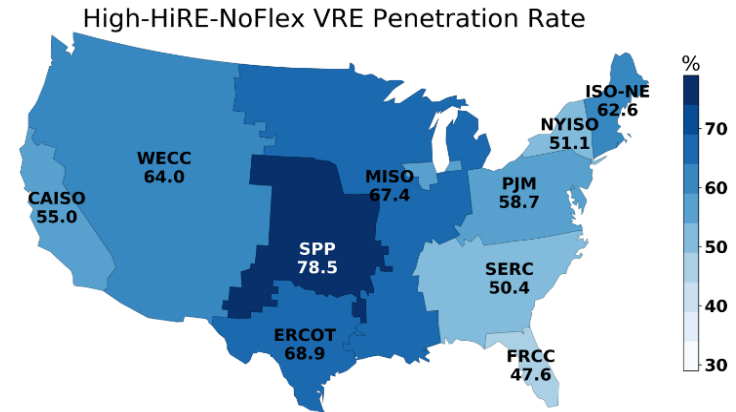
2050 Annual Generation for Scenarios without Demand-Side Flexibility



Geo/Bio = geothermal/bioenergy
NG = natural gas

CT = combustion turbine
CC = combined cycle

The system serves **more than 99.99% of the load and 99.96% of the operating reserves** in hourly simulations of all 2050 scenarios



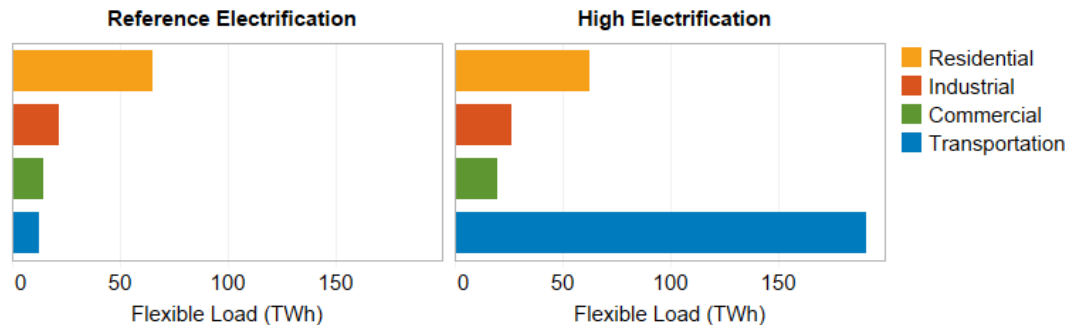
Modeling demand-side flexibility (DSF)

- 14 types of shiftable DSF across commercial, residential buildings, industrial, and transportation sectors are modeled for each modeled BA
- Parameterized by **timing, duration, participation, and capacity to increase and decrease**
- Amount and nature of flexibility depends on electrification, with greater potential for flexibility primarily from **optimized EV charging** but also managed **building and industrial** loads

% of total 2050 load that is flexible:

0% Ref-NoFlex
2% Ref-LoFlex
7% Ref-HiFlex

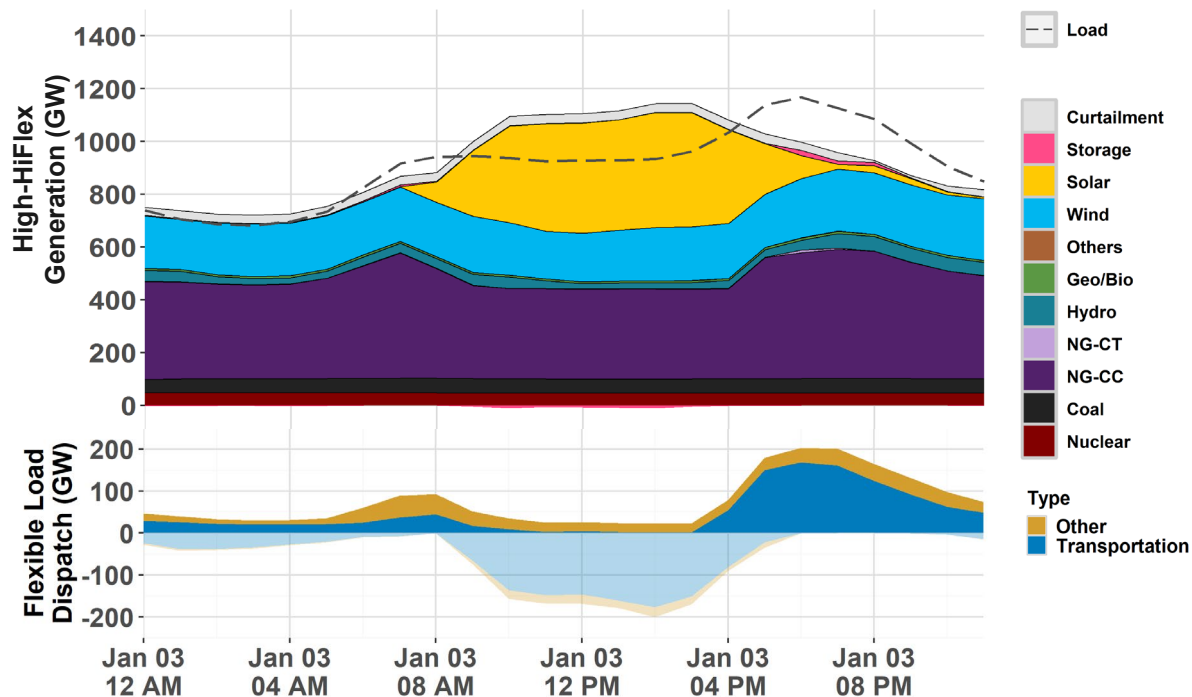
0% High-NoFlex | High-HiRE-NoFlex
4% High-LoFlex | High-HiRE-LoFlex
17% High-HiFlex | High-HiRE-HiFlex



Demand-side flexibility benefits system operation through energy shifting and reserves

Top: Simulated dispatch on Jan. 3 in High-HiFlex (highest net load ramp day in High-NoFlex)

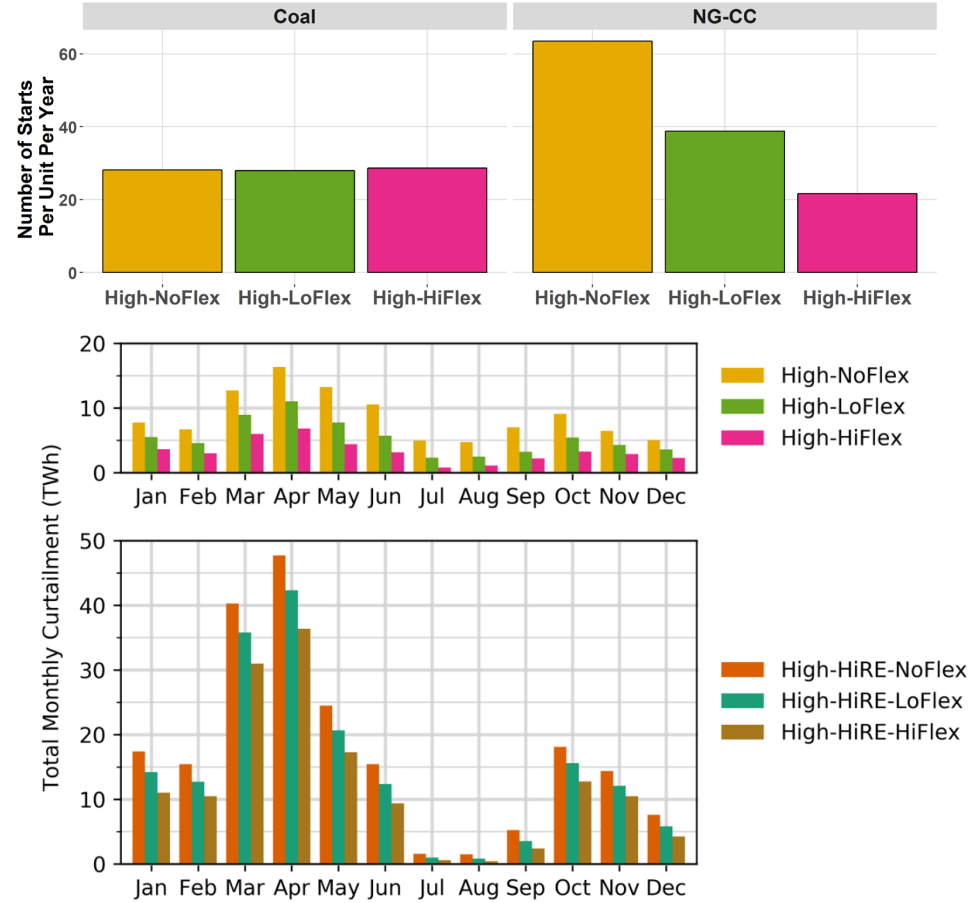
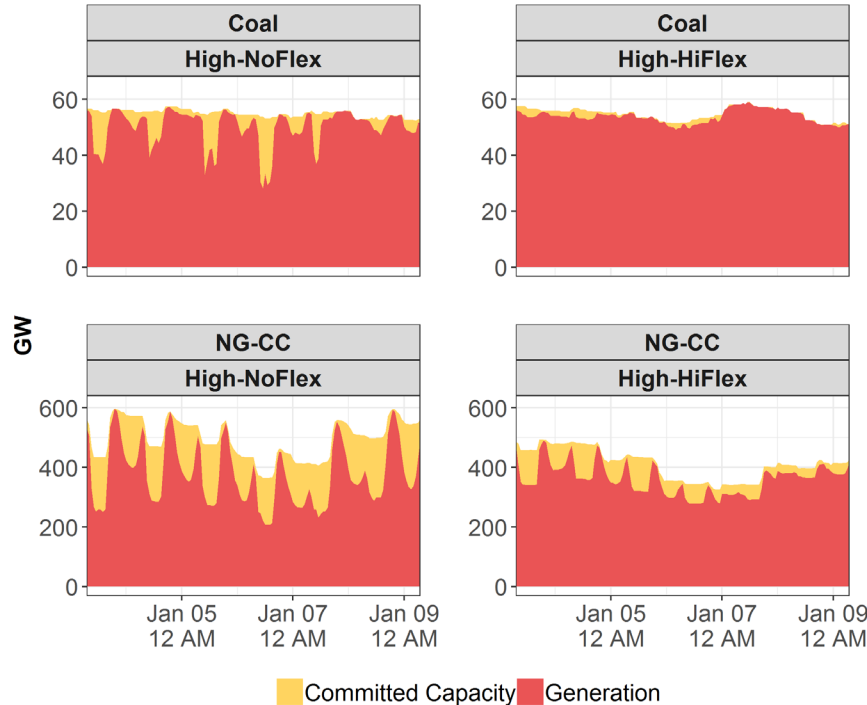
Bottom: Zoom-in of DSF dispatch for the same time period. Positive generation indicates reduced consumption.



Dotted line shows original static load from High-NoFlex

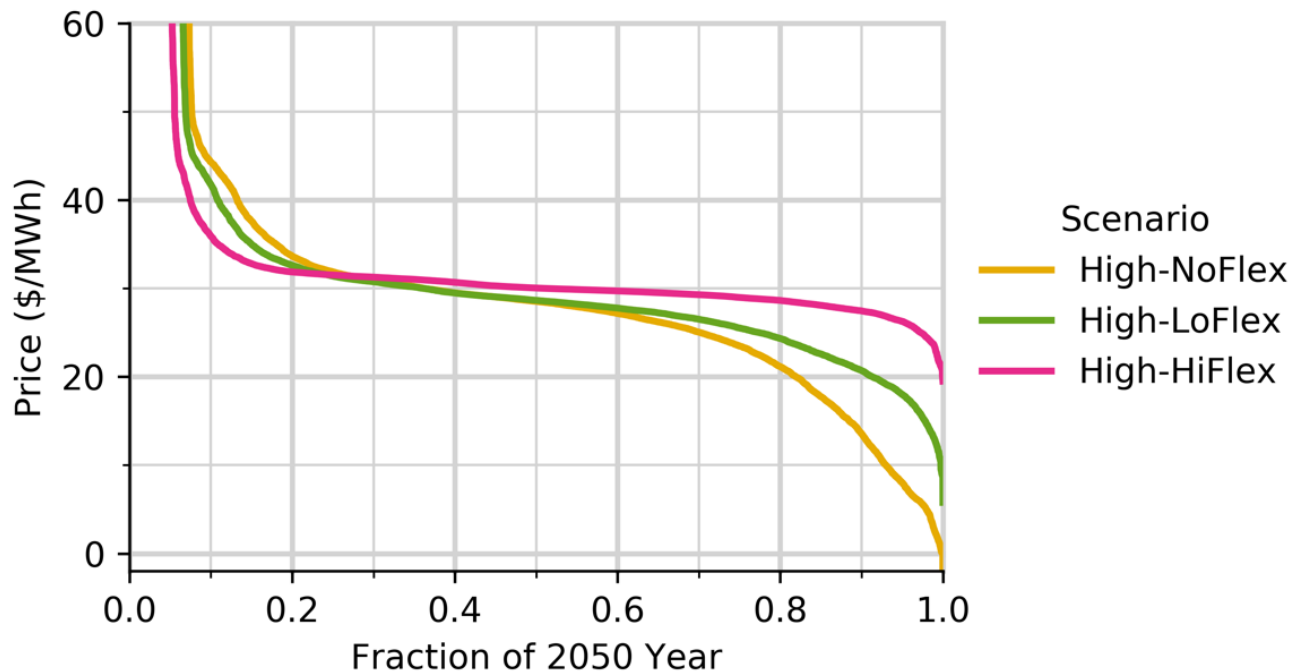
Demand-side flexibility reduces thermal plant cycling and VRE curtailment

Committed capacity and generation from coal and natural gas in a sample week in January



Demand-side flexibility reduces price volatility

Duration Curve for the National Average Marginal Hourly Price
from Each Balancing Area, Weighted by Load



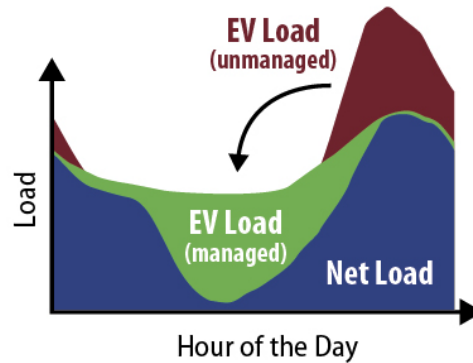
Flexible loads provide value by mitigating power sector infrastructure needs, systems costs, and price volatility

Electrification Futures Study analysis indicates that flexible loads:

- **Reduce bulk electric system costs** in all scenarios
- **Mitigate** some electrification-induced **investments**
- **Reduce operational costs by up to 10%**
- Enhance the ability of electrification to decarbonize the energy sector by **reducing VRE curtailment**
- **Reduce price volatility**

Caveat: no incremental cost to implement load shifting considered

Value of Electric Vehicle Managed Charging



Managed EV charging can support grid planning and operations



Reduce Bulk Power Systems Investment Costs
20–1350 \$/EV/year



Reduce Bulk Power Systems Operating Costs
15–360 \$/EV/year



Reduce Renewable Energy Curtailment
23–2400 kWh/EV/year



Reduce Distribution Systems Investment Costs
5–1090 \$/EV/year



Increase Distribution Systems EV Hosting Capacity
30–450%

Anwar et al., 2021. “Assessing the value of electric vehicle managed charging: a review of methodologies and results.” *Energy & Environmental Science*



Thank you!

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