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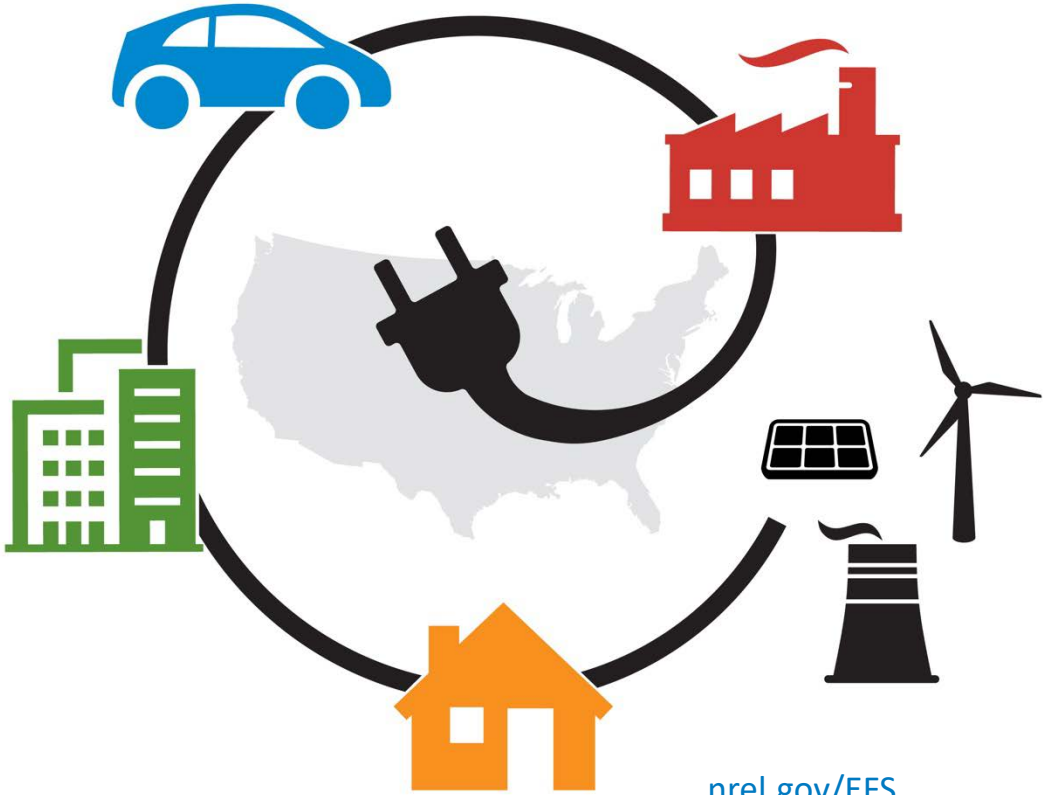
The Value of Flexible Loads With Increasing Electrification



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June 13, 2023

2023 Long-term Load Forecasting Workshop

nrel.gov/EFS

Study sponsored by U.S. DOE-EERE Office of Strategic Programs

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?

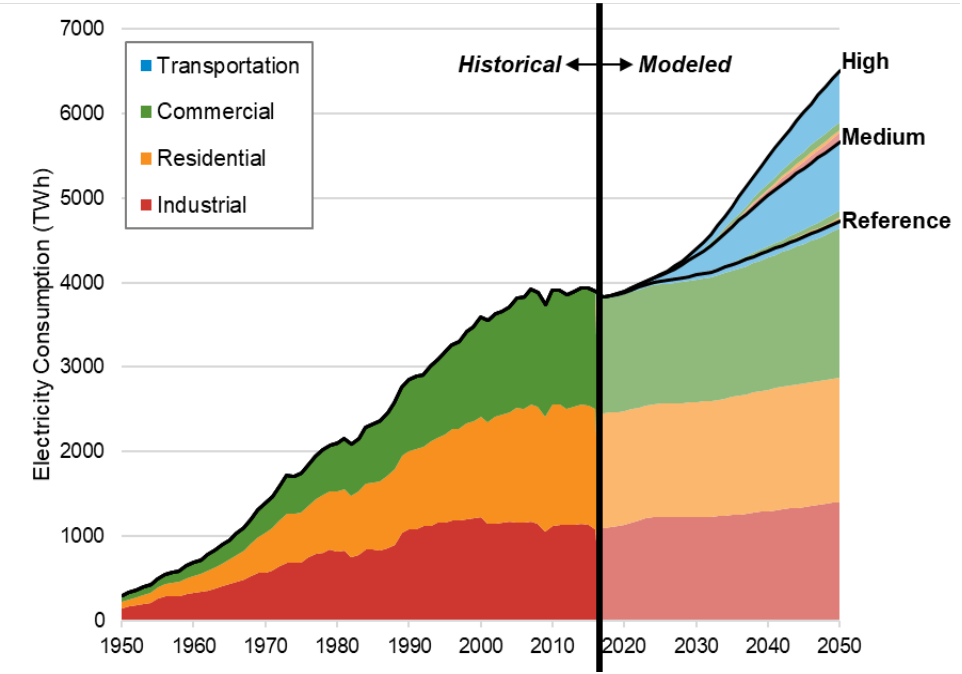
Flexibility

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

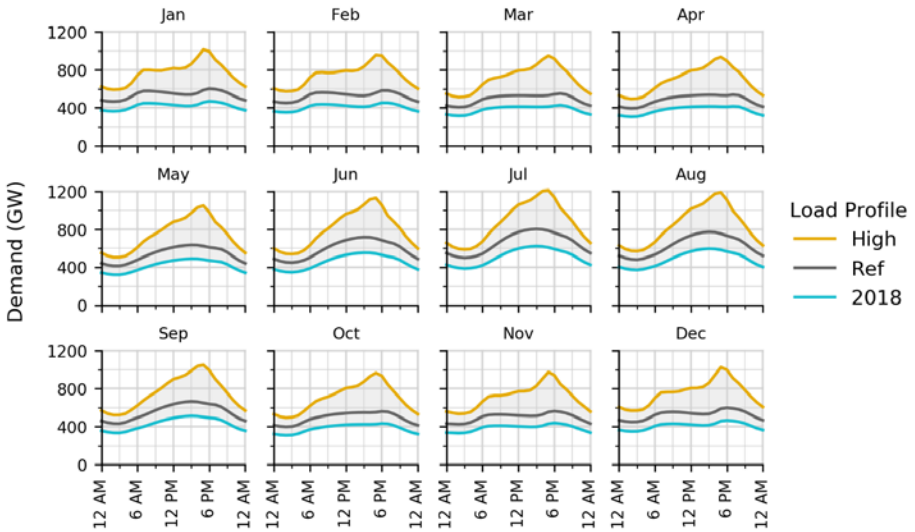
Impacts

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

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



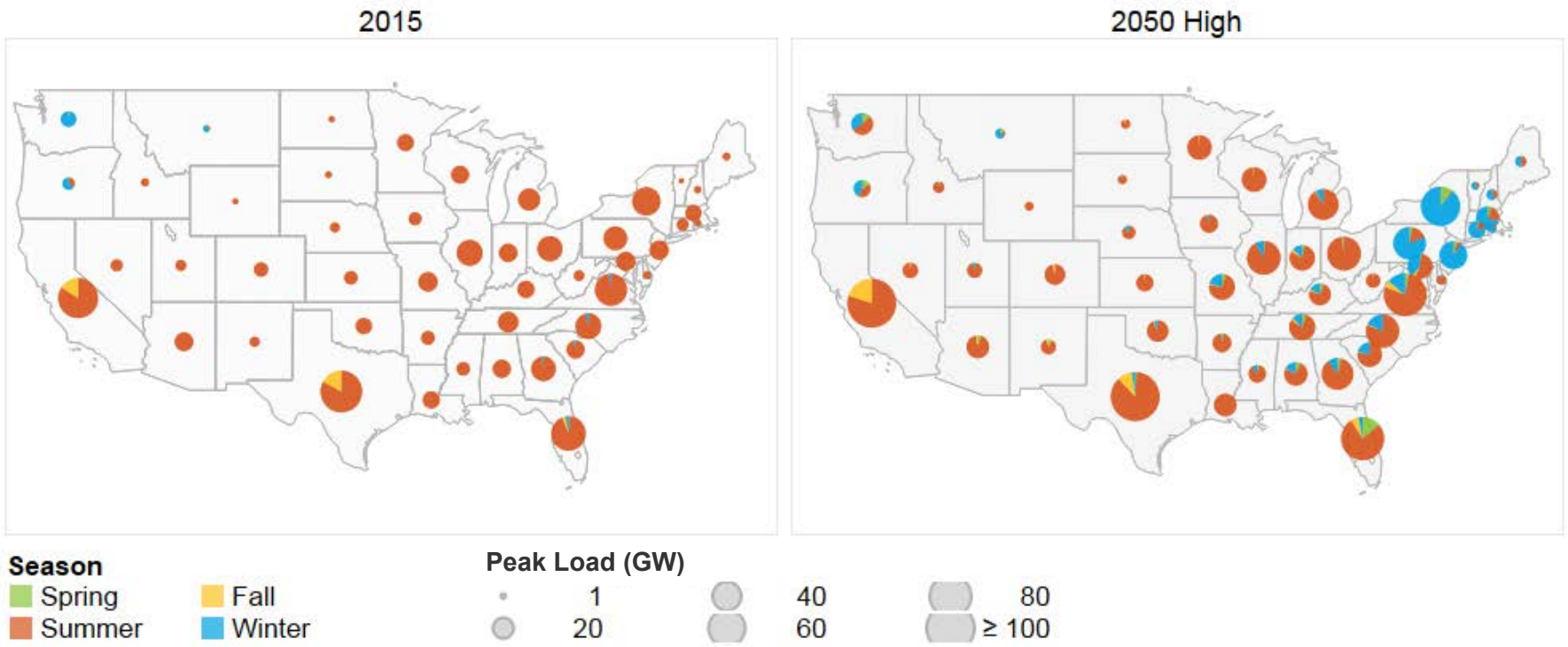
Greater electricity consumption



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

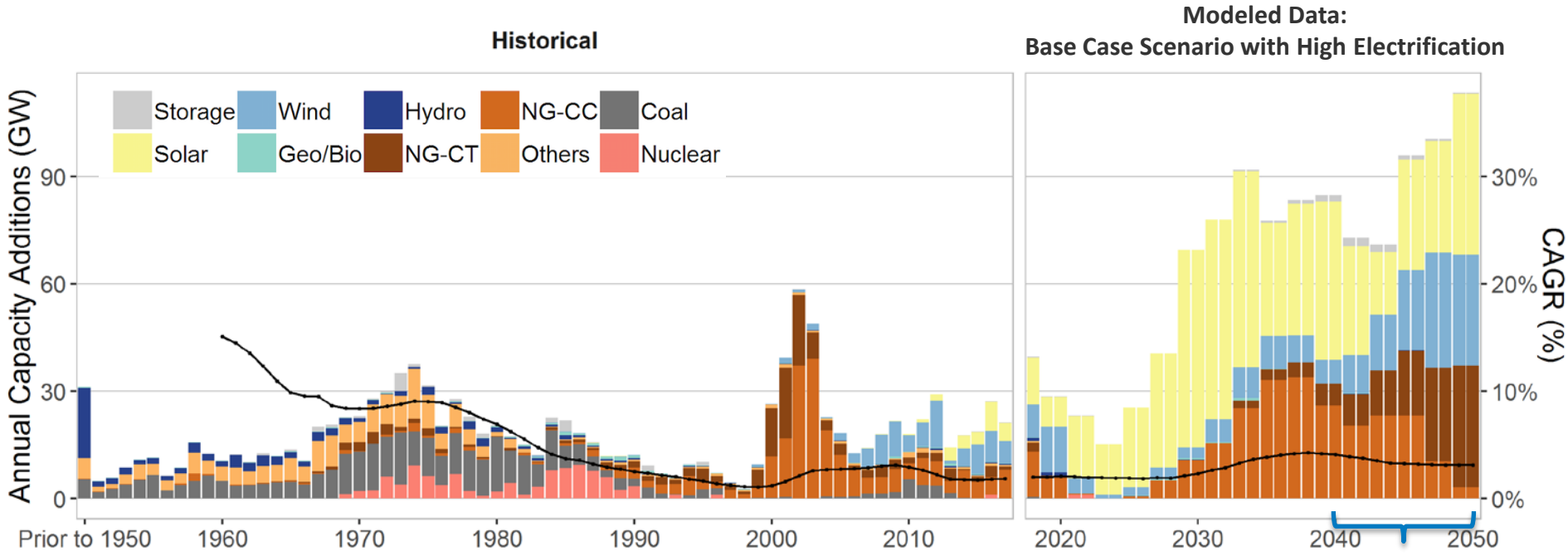
Source: Mai et al. 2018, Murphy et al. 2021, Sun et al. 2020, Zhou and Mai. 2021

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

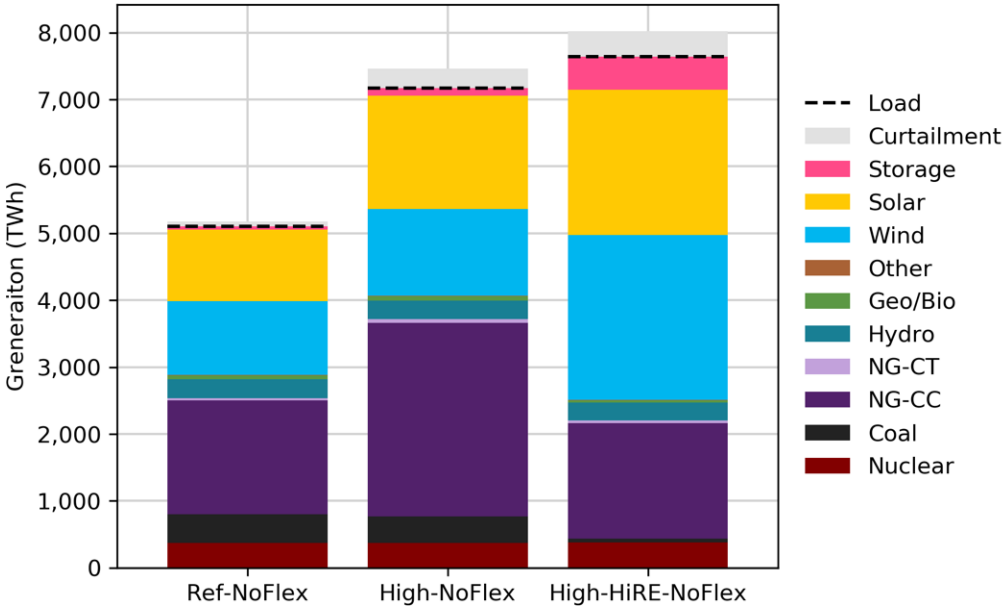


Solar: ~30-45 GW/yr
Natural Gas: ~35 GW/yr
Wind: ~20 GW/yr
even higher rates in some scenarios

Murphy et al. (2021), https://www.nrel.gov/docs/fy21osti/72330.pdf

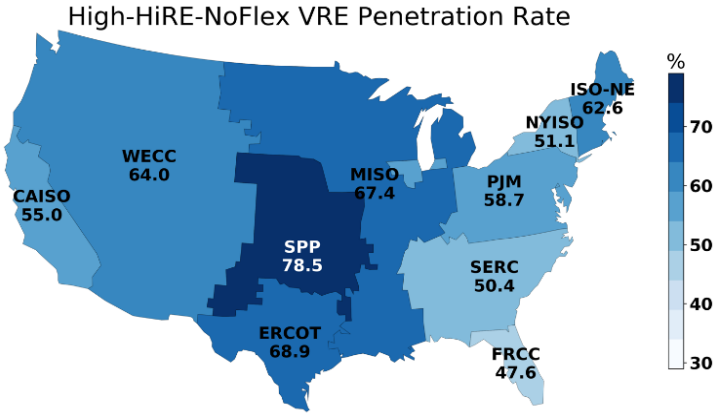
Operation: Modeled portfolios are resource adequate

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

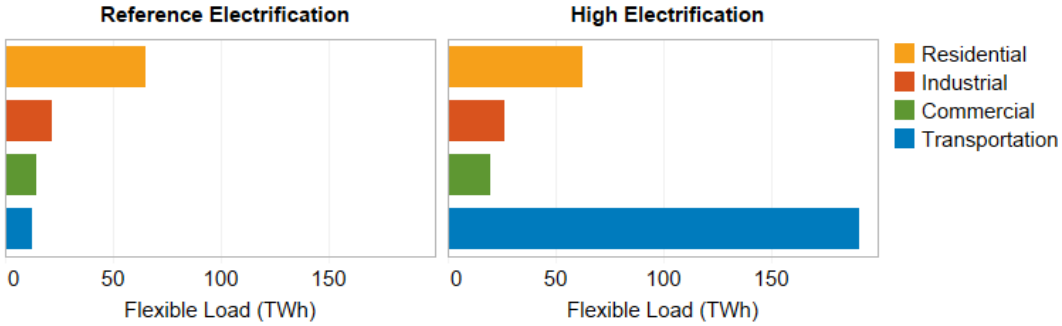


Modeling demand-side flexibility (DSF)

- 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	0% High-NoFlex | High-HiRE-NoFlex
2% Ref-LoFlex	4% High-LoFlex | High-HiRE-LoFlex
7% Ref-HiFlex	17% High-HiFlex | High-HiRE-HiFlex

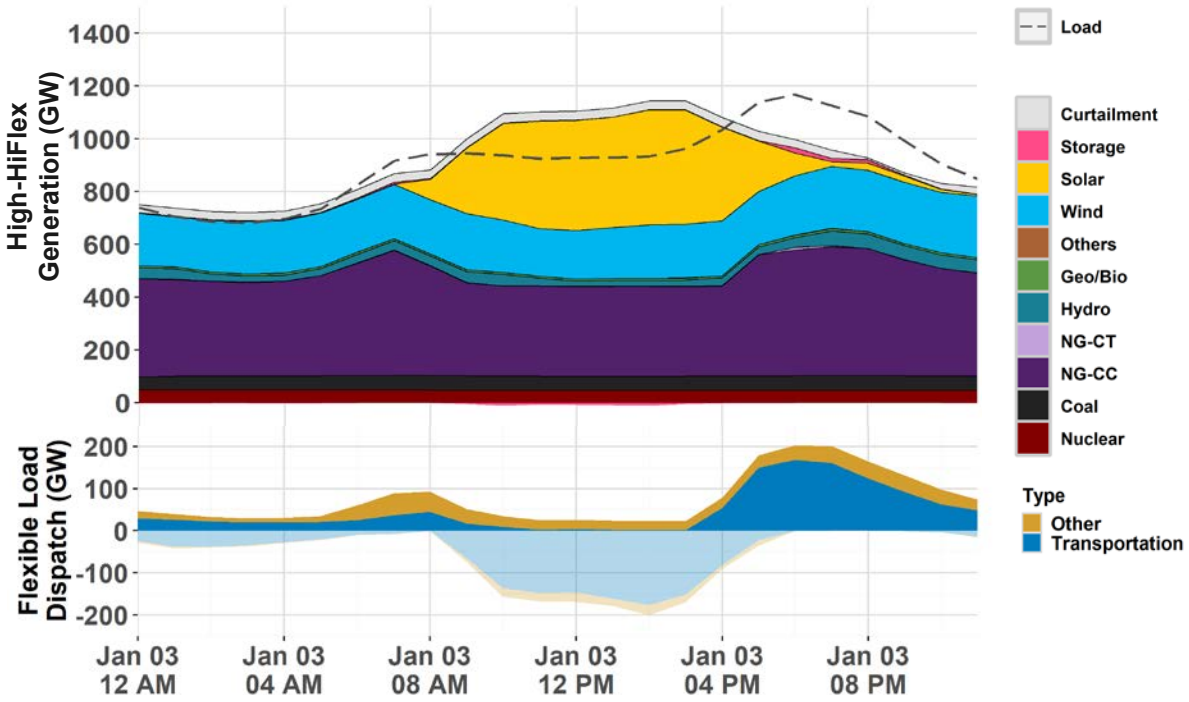


Murphy et al. (2021), https://www.nrel.gov/docs/fy21osti/72330.pdf

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)

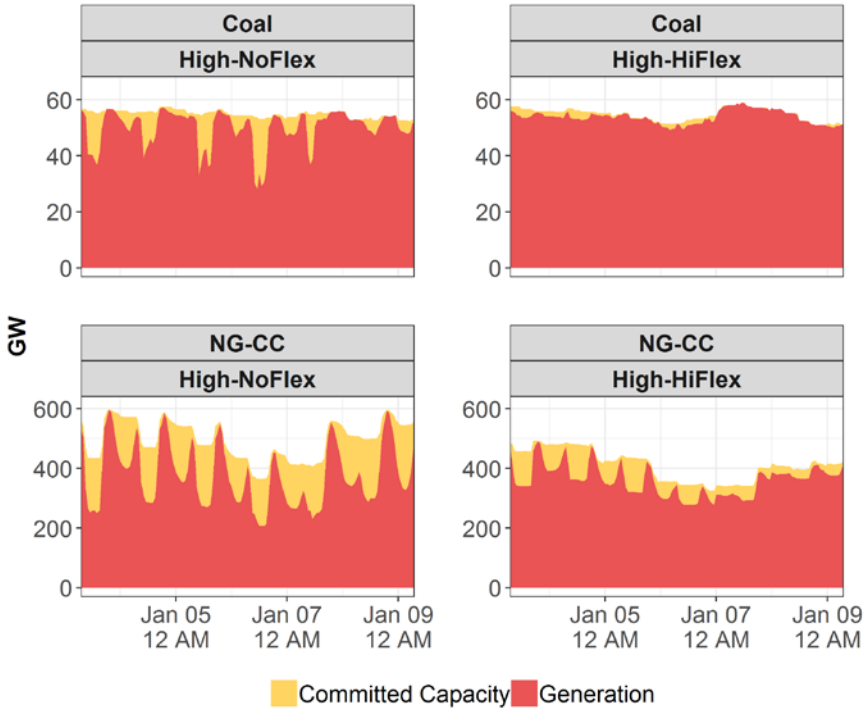
Bottom: Zoom-in of DSF dispatch for the same time period. Positive generation indicates reduced consumption.

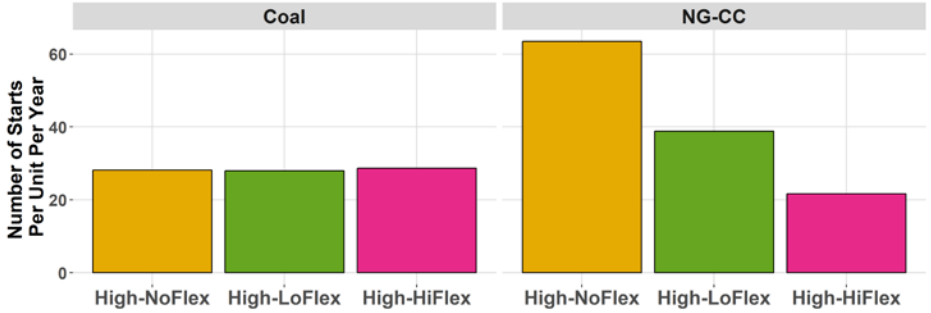


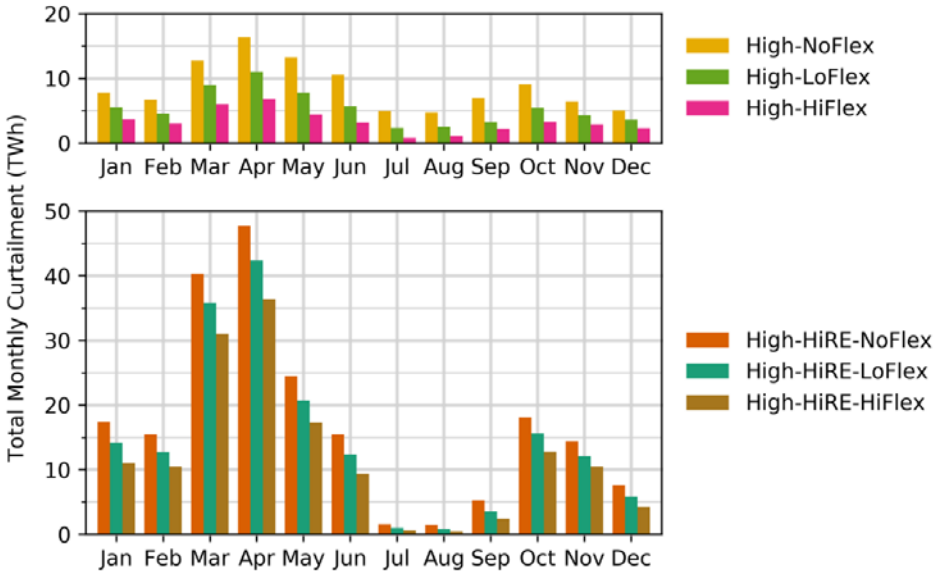
Dotted line shows original static load from High-NoFlex

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

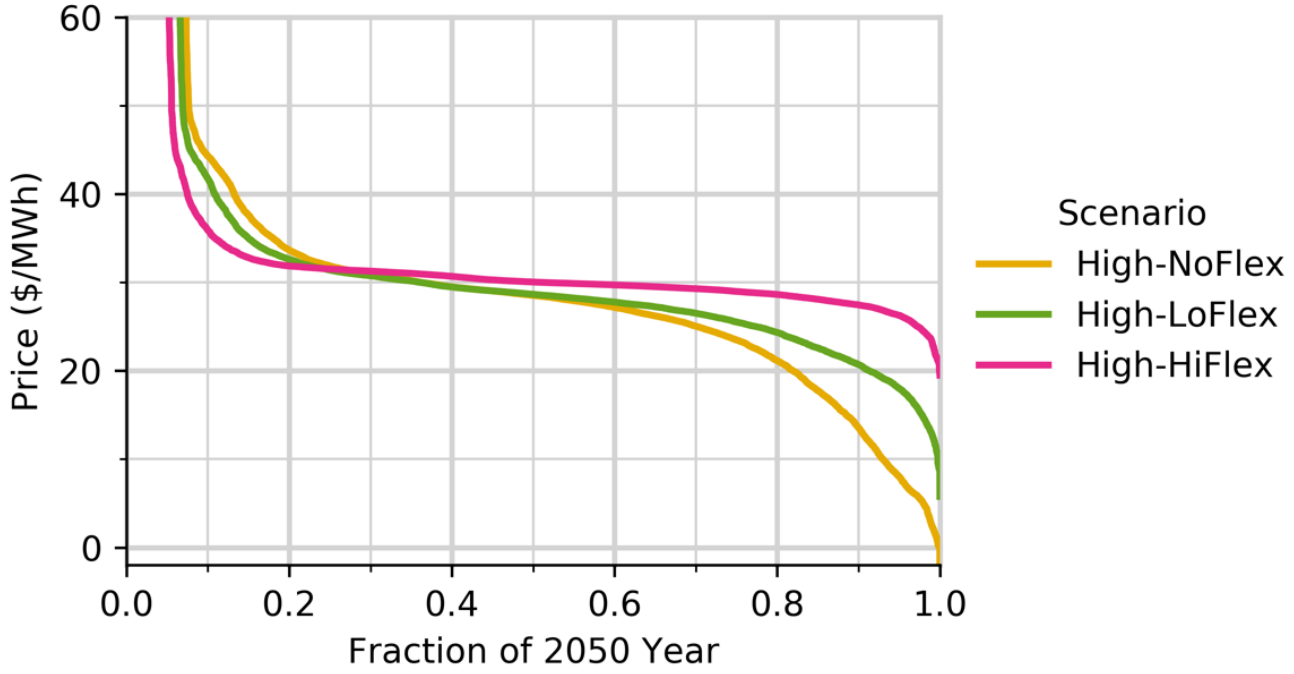






Demand-side flexibility reduces price volatility

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

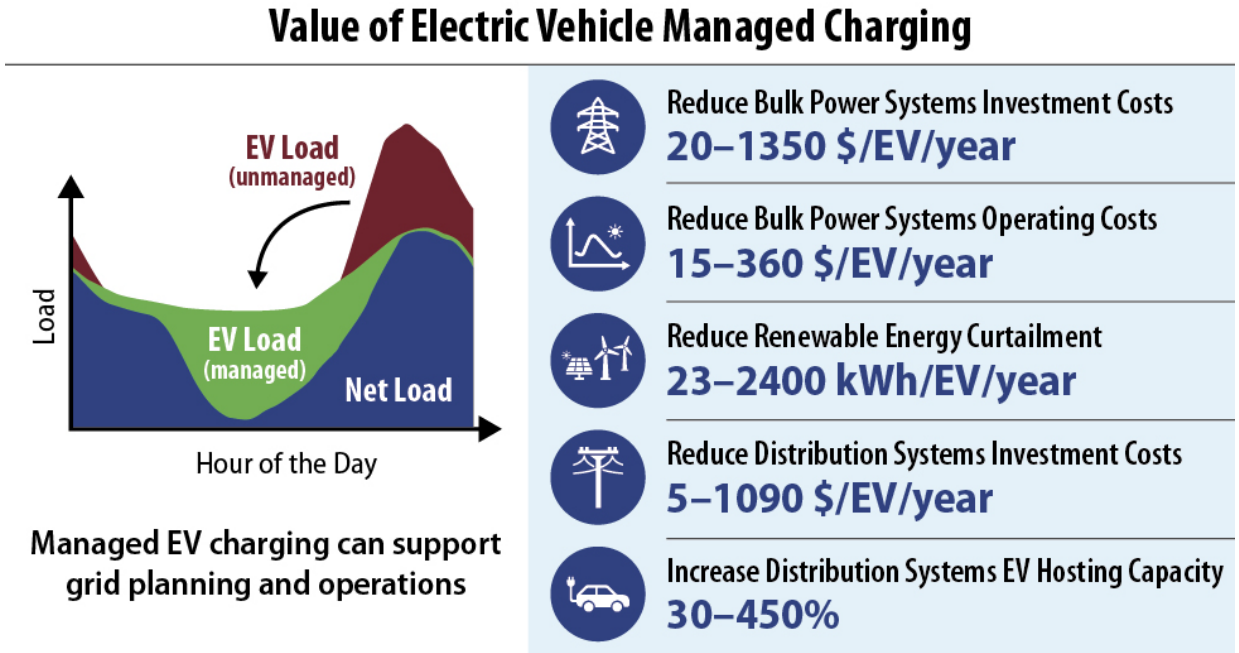


Flexible loads provide value by mitigating power sector **infrastructure** needs, systems costs, and price volatility

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



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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www.nrel.gov/efs

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