Potential roles for demand response in more-electrified futures

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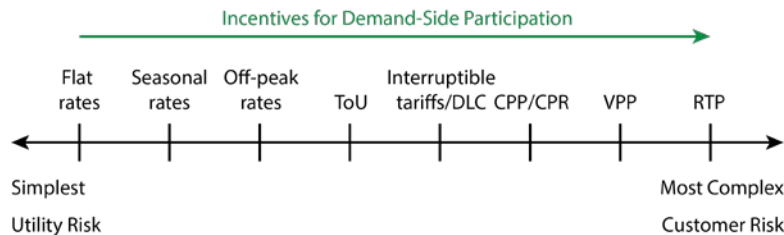2019 INFORMS Annual Meeting

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What is demand response?

Demand-side operational changes to provide a grid service/better align electricity load with supply.
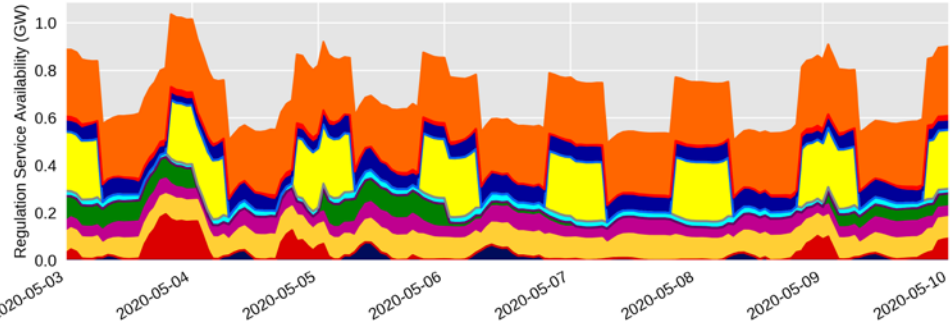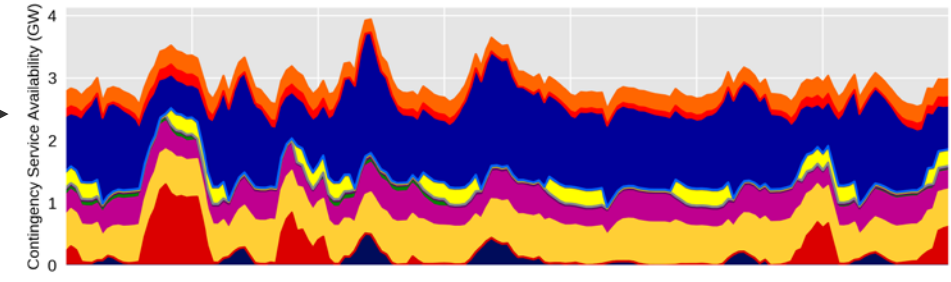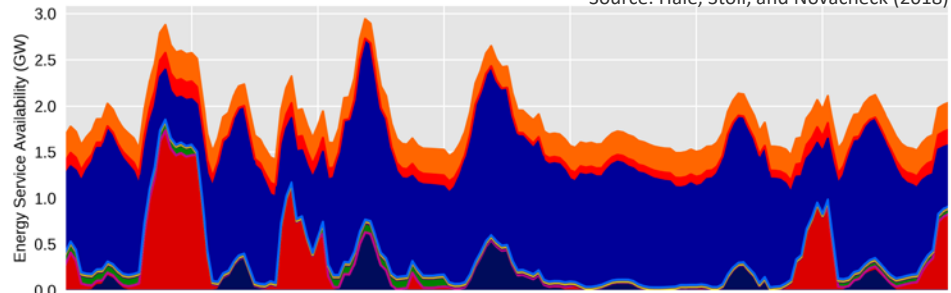
Perhaps enabled via retail programs or tariffs

Multiple End-uses →

Multiple Grid Services

Source: Hale, Stoll, and Novacheck (2018)

Legend: residential hotwater, residential heating, residential cooling, municipal waterpumping, municipal wastewaterpumping, municipal outdoorlighting, industrial manufacturing, industrial refrigeratedwarehouses, industrial datacenters, industrial agriculture, commercial ventilation, commercial lighting, commercial heating, commercial cooling
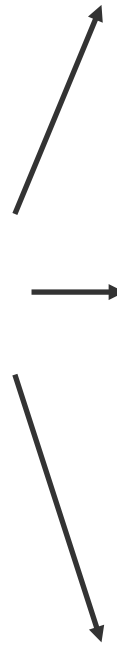
Dynamic pricing schemes; Source: Hale et al. (2018)

Demand response is more valuable in systems with higher levels of variable generation

Source: Stoll (2017)

Why?
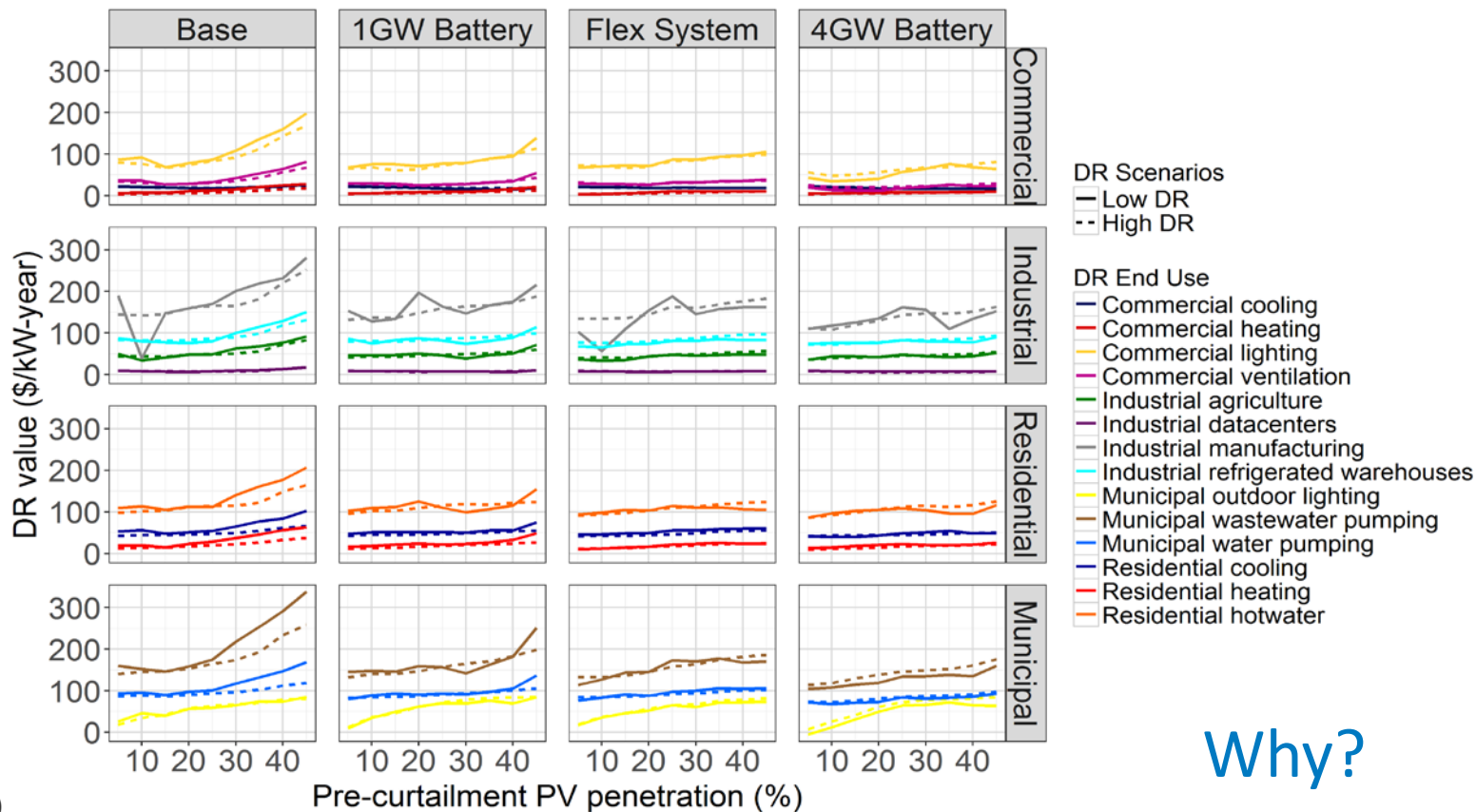
In a least-cost framework, additional resources can only reduce operational costs
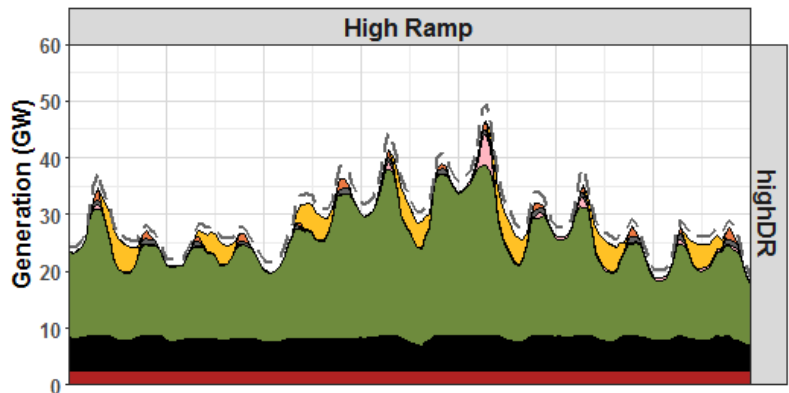
Source: Model runs for Hale, Stoll and Novacheck (2018)

5% PV
1 GW Battery
High DR
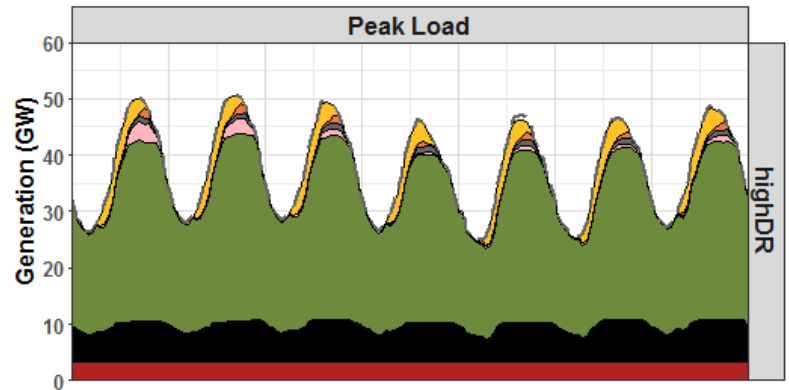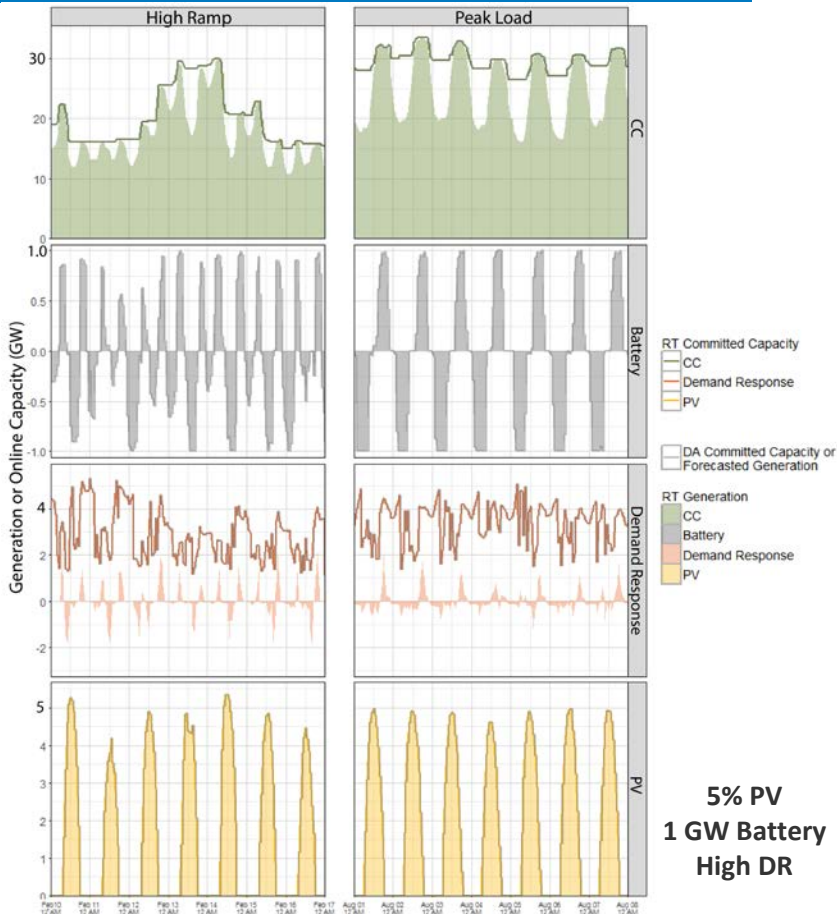
With higher levels of PV there are more net-load balancing opportunities

Source: Model runs for Hale, Stoll and Novacheck (2018)

30% PV
1 GW Battery
High DR
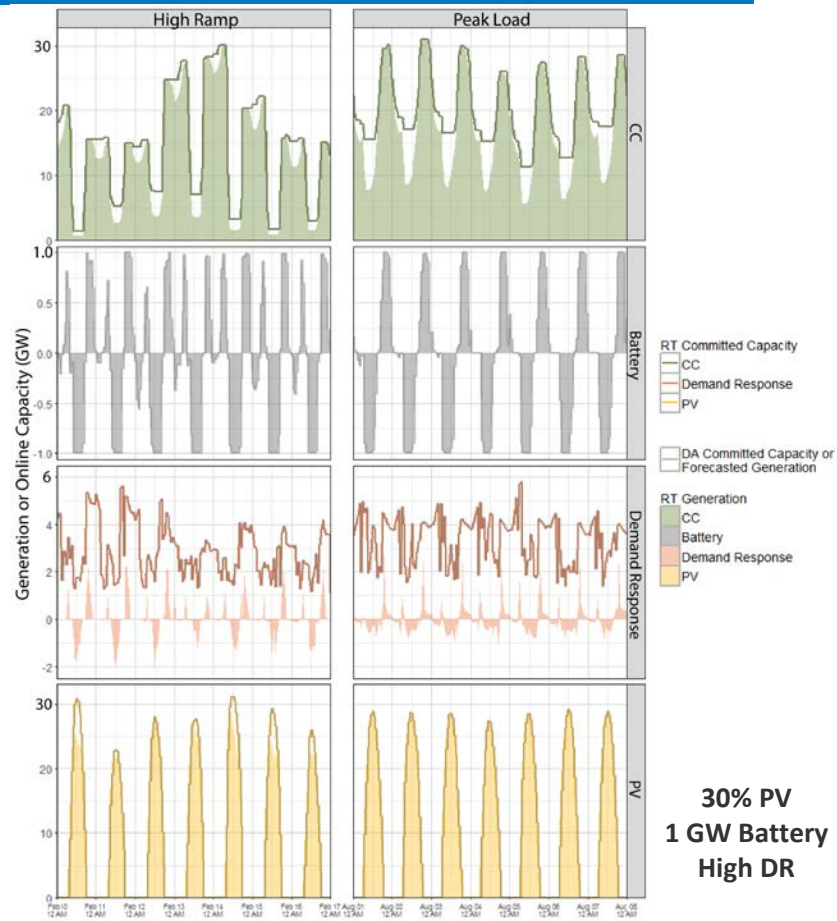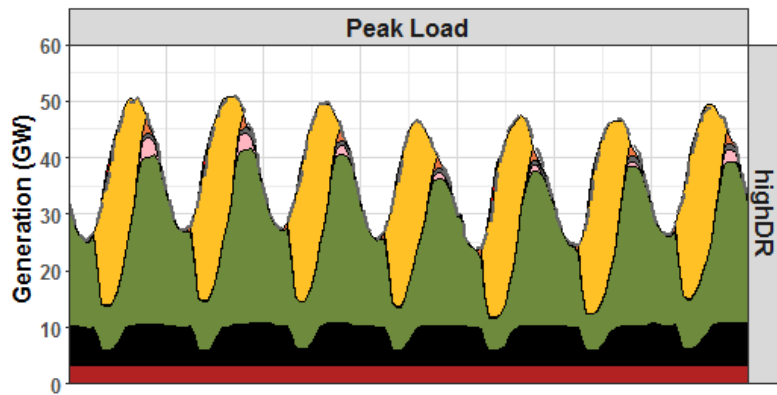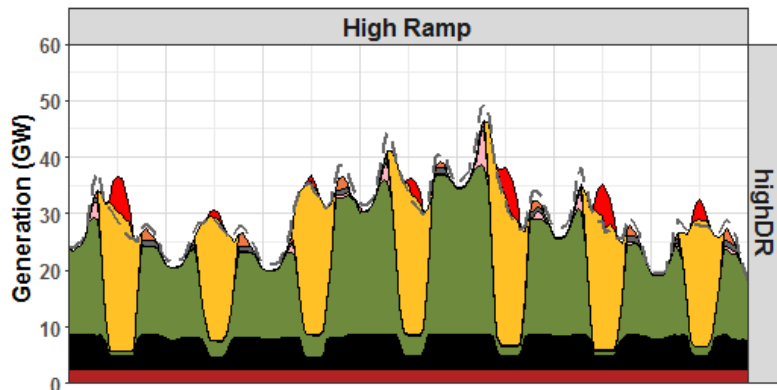
Many jurisdictions have ambitious goals
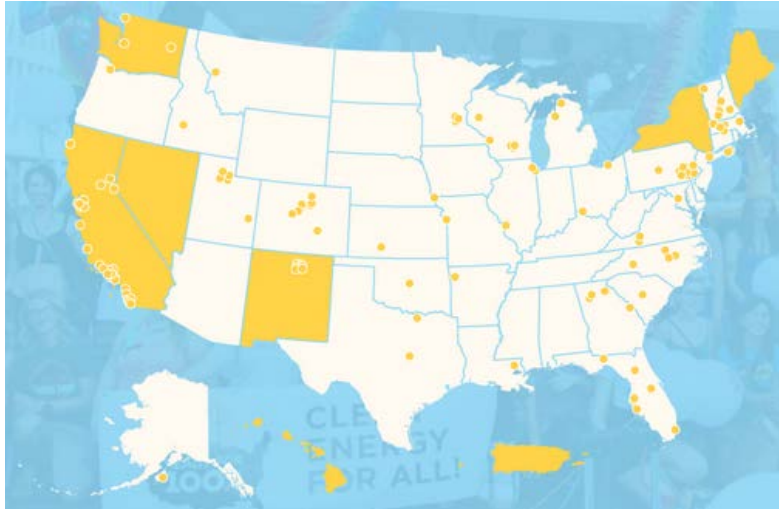
Cities and states with 100% goals.
State goals are a mix of renewable / clean /
carbon-neutral, are mostly about electricity,
some economy-wide provisions
Source: Sierra Club (2019)

Clean Energy Standards & Renewable Portfolio Standards

State climate mandates
- Clean Energy Standard in place
- Renewable Portfolio Standard in place
- Clean Energy Standard under consideration (RPS in place)

(updated 16 April 2019)

THE BREAKTHROUGH
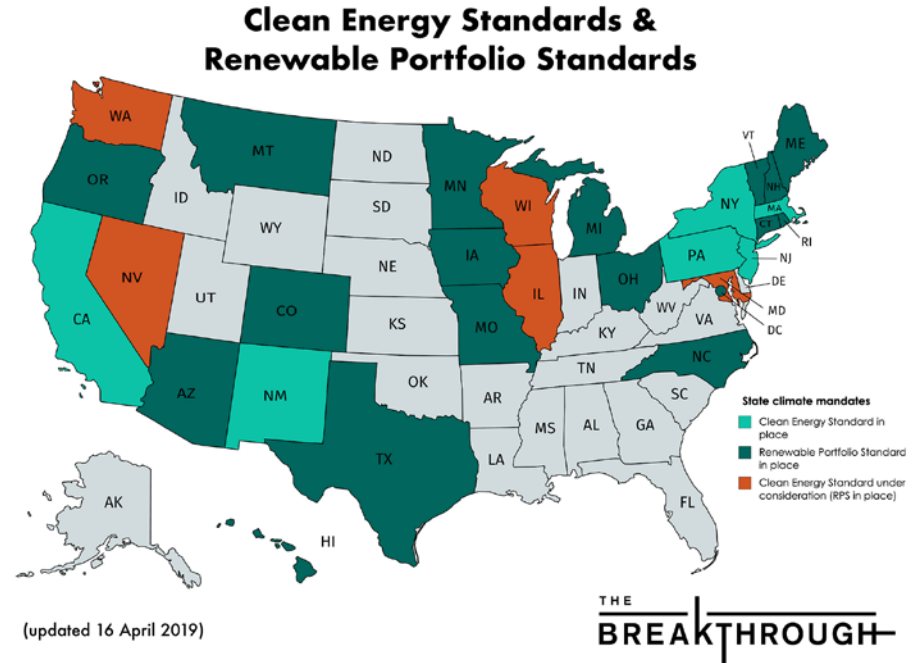
Source: McBride (2019)
Data sources: Center for Climate and Energy Solutions and
National Council of State Legislatures

Demand response is one potential source of flexibility that can increase the economic carrying capacity (ECC) of (e.g.) PV

Increase from Base under AEO Low NG prices

Source: Hale, Stoll, and Novacheck (2018)
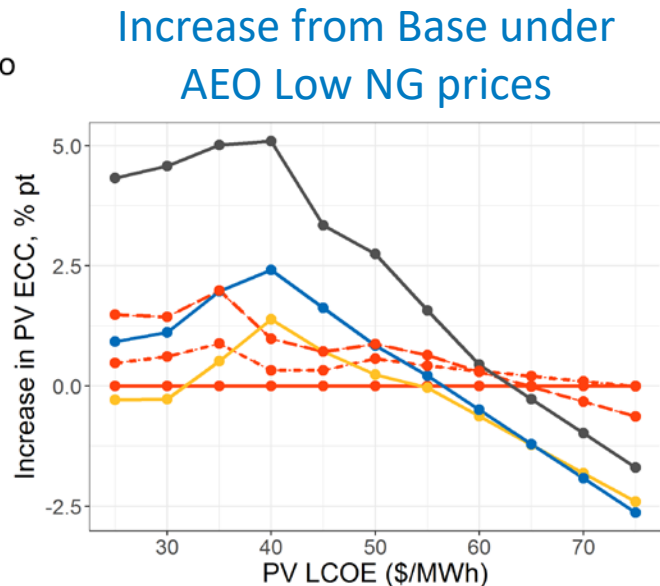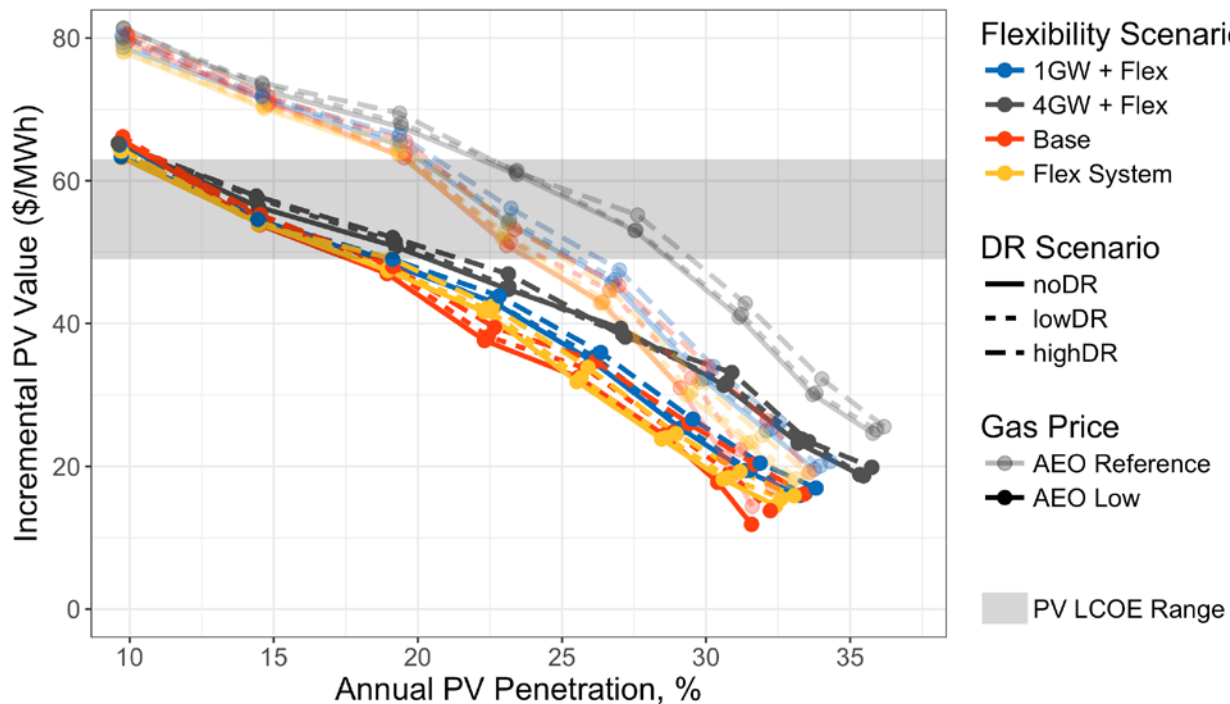
The relationship between demand response and emissions is contingent on the overall system
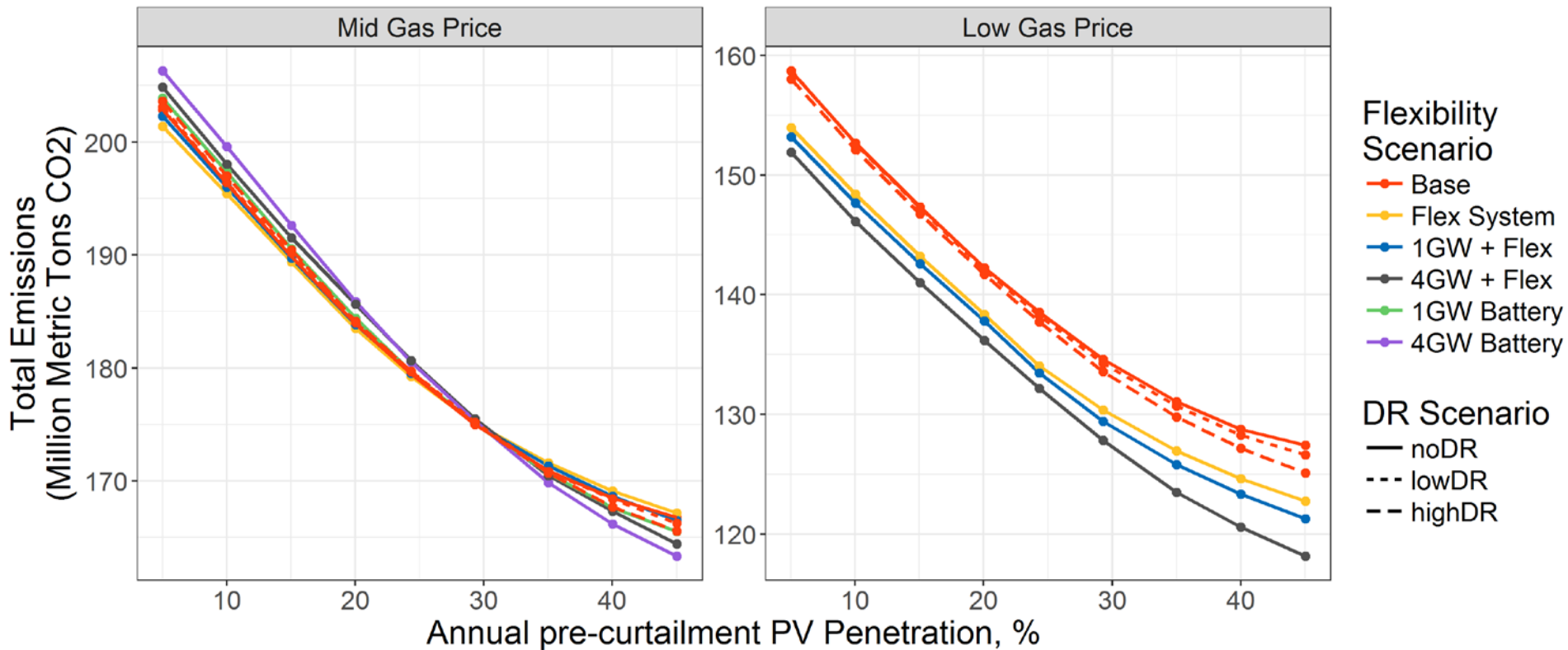
Source: Hale, Stoll, and Novacheck (2018)

What might a more-electrified future look like?
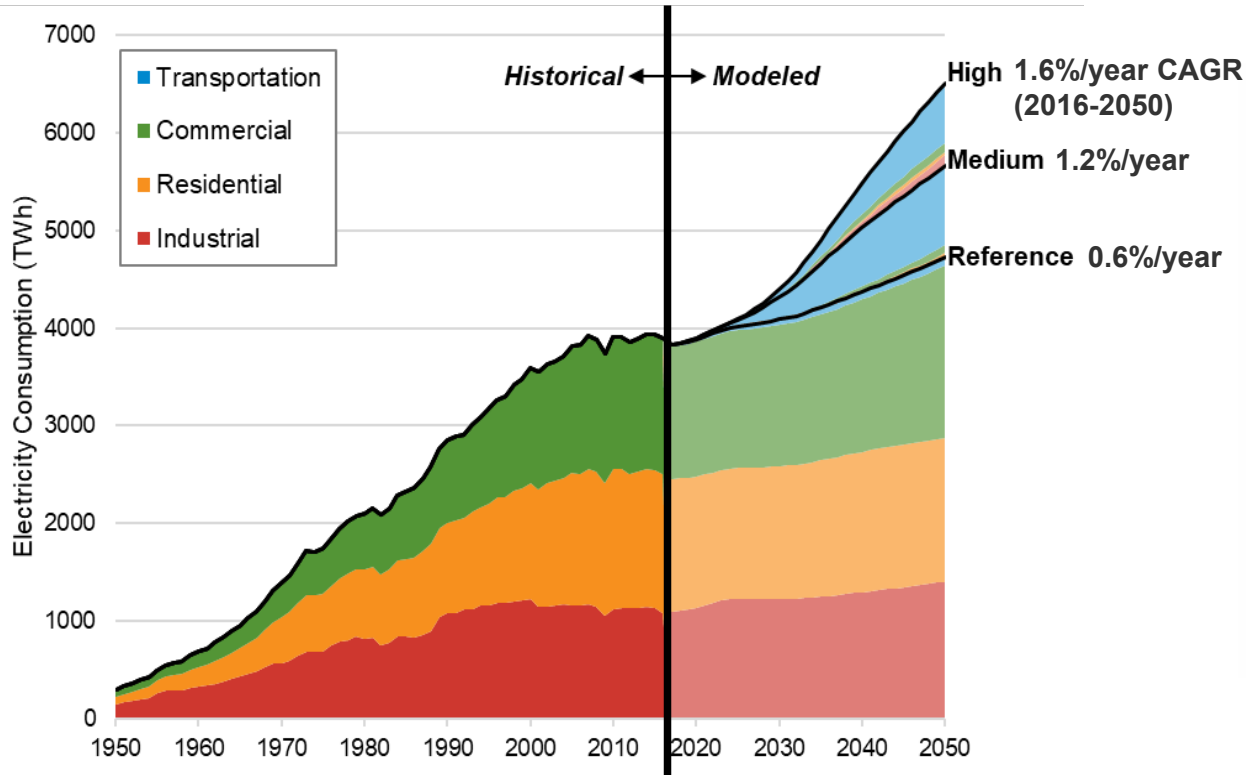
Electric vehicle charging may be a first-order driver

National Plug-In Electric Vehicle
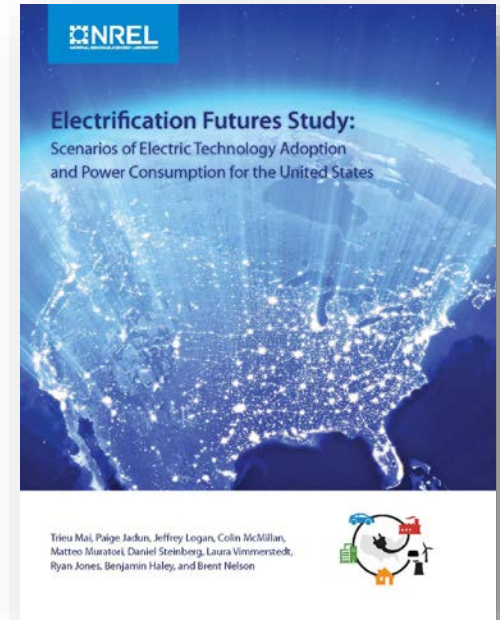Infrastructure Analysis

September 2017

159 BEV owners and 156 PHEV owners responded to the 2016 California Vehicle Survey about when they charged their vehicles on a typical weekday
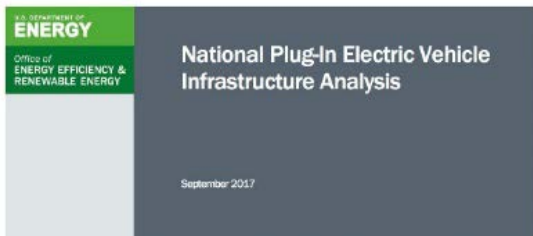
Challenging to serve?
Opportunity to shift?
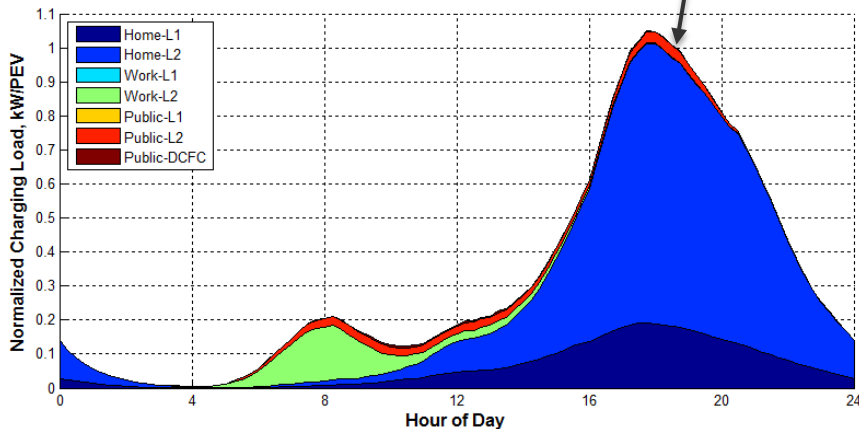
Source: Wood et al. 2017; Model: NREL's EVI-Pro; POC: Eric Wood (NREL)
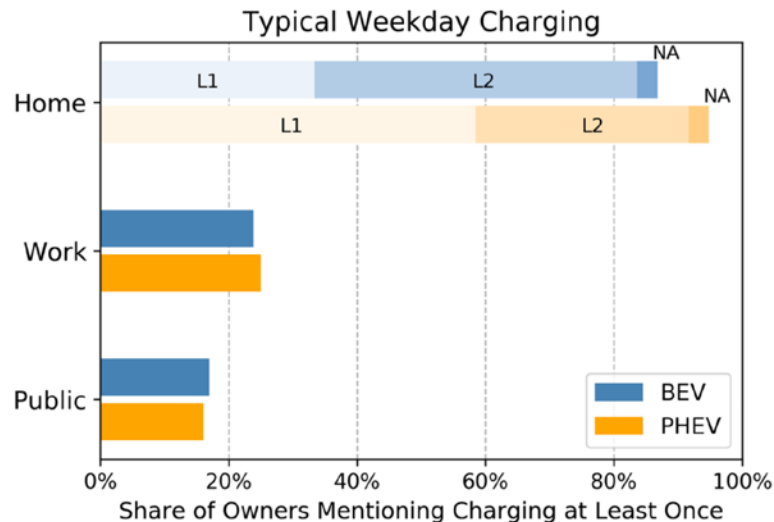
Source: Muratori 2018

NREL is actively working to incorporate demand-side understanding into grid models ...

The demand-side grid (dsgrid) model provides bottom-up modeling of buildings, industry, and electric vehicles to enable:

- Future projections and what-if scenarios **for load shape** in addition to magnitude
- Realistic estimates of potential **load flexibility** (i.e., demand response)
- Understand **interactions** between energy efficiency and demand response potential (also renewables and DERs)
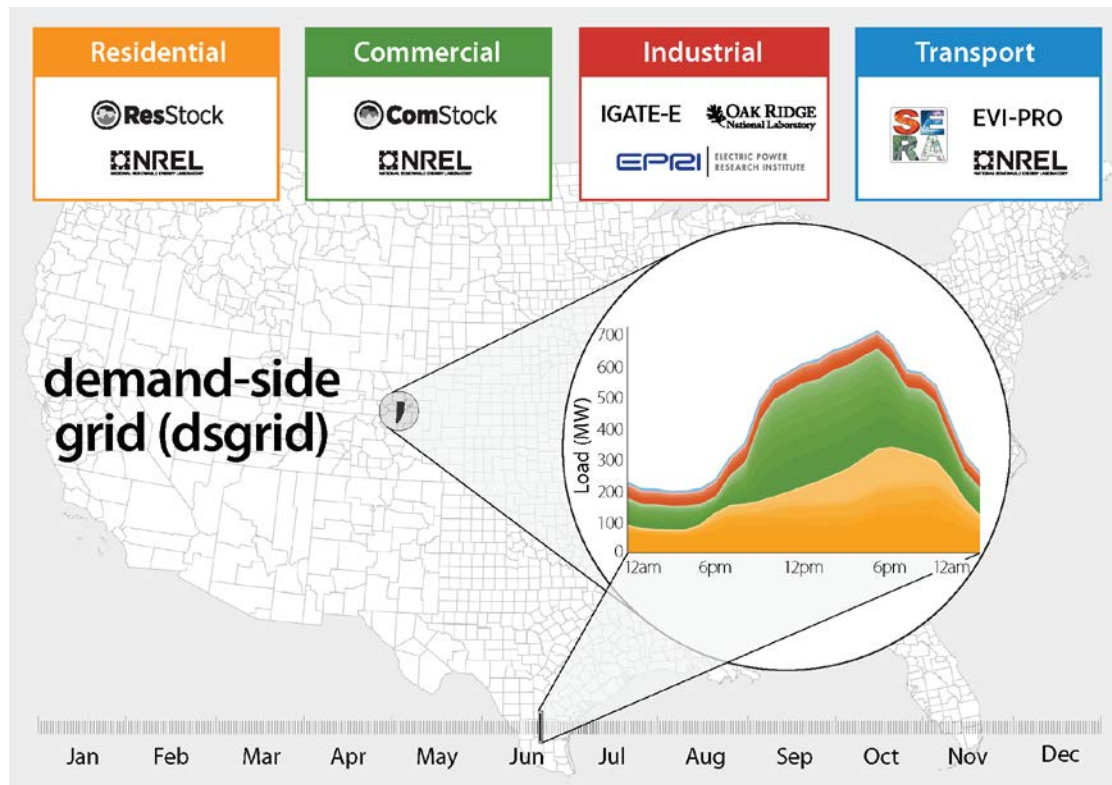
https://www.nrel.gov/analysis/dsgrid.html; POC: Elaine Hale (NREL)

... and grid understanding into demand-side models

Cambium is a new data product that will provide <u>hourly data</u> that describe <u>future</u> grid conditions modeled in NREL's Standard Scenarios

- Marginal costs (separated into energy, capacity, ancillary services, etc.)
- Emission rates (marginal and average)
- Load and net load
- Dispatch stacks

An interface for users to query the data

- Users specify region and timeframe (e.g. Colorado for 2020-2050), Cambium returns year-over-year, present-values, and annualized values.

NREL Standard Scenarios: https://www.nrel.gov/analysis/standard-scenarios.html ; POC: Pieter Gagnon (NREL)
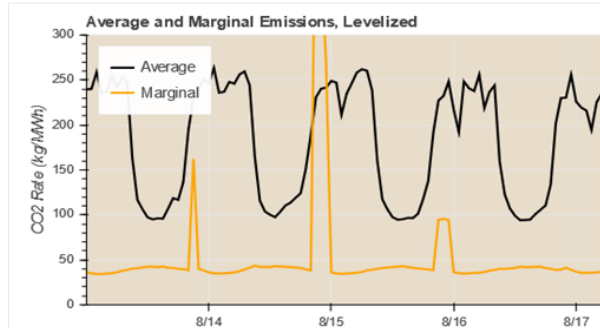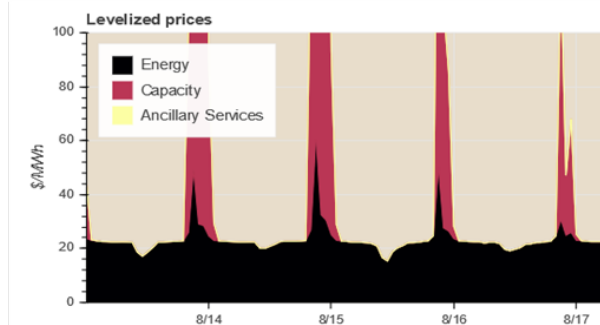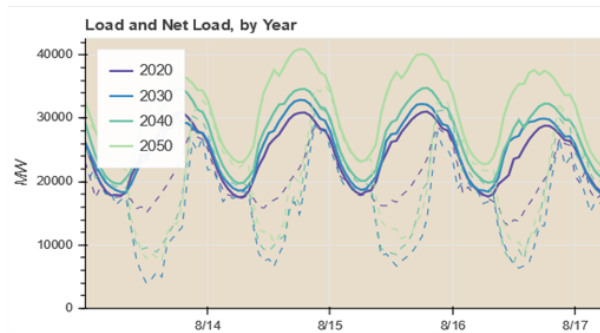
Current projects aim to increase modeling accuracy and close gaps

- LA100 Study
  - Bottom-up load modeling
  - Demand response modeling
- Physical accuracy of aggregate energy-shifting (e.g., non-100% roundtrip efficiencies for thermal storage)
- Impact of dispatch mechanisms and aggregation level
- Interaction between energy efficiency and demand response

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Q&A

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