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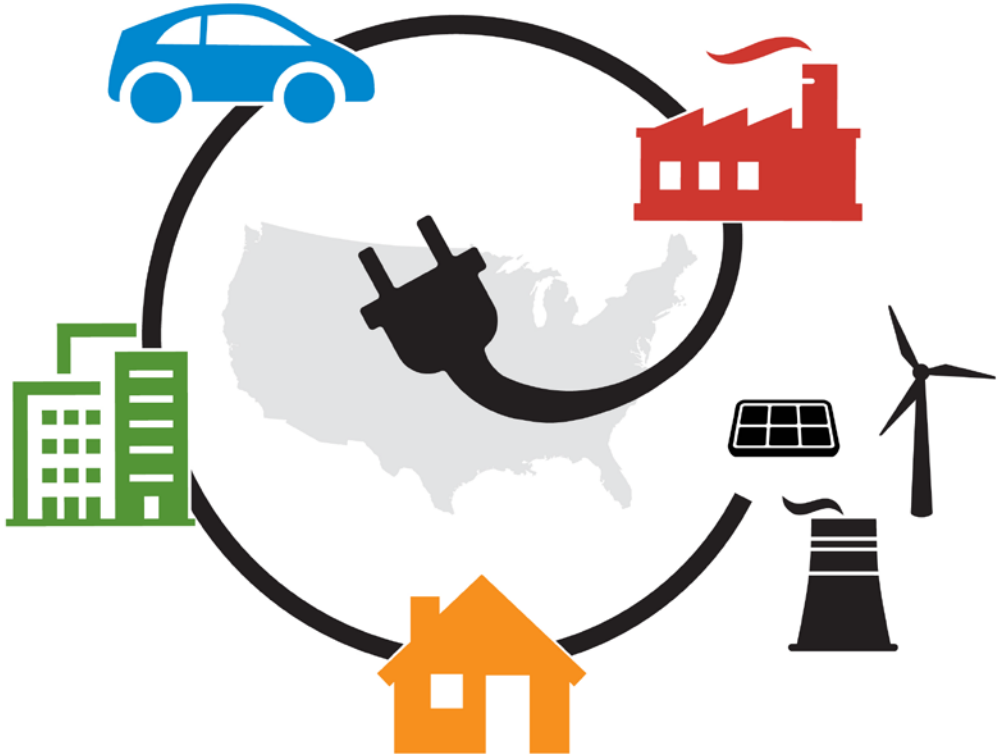
Electrification Futures Study: Scenarios for Demand-Side Adoption in the United States



Caitlin Murphy

Scenarios Forum 2019, Session 35
Denver, Colorado
March 13, 2019

nrel.gov/EFS

Key Take-Aways

Electrification is a highly complex research topic with a broad scope:

- Involves interactions among all sectors via numerous technologies
- Crosses many jurisdictions and levels of government/regulators
- Impacts both electric system investment and operational decisions

Quantifying the effects of electrification in a meaningful way requires applying high-resolution modeling (across this broad scope):

1. Technological resolution
2. Spatial resolution
3. Temporal resolution

What is the Electrification Futures Study (EFS)?

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EPRI

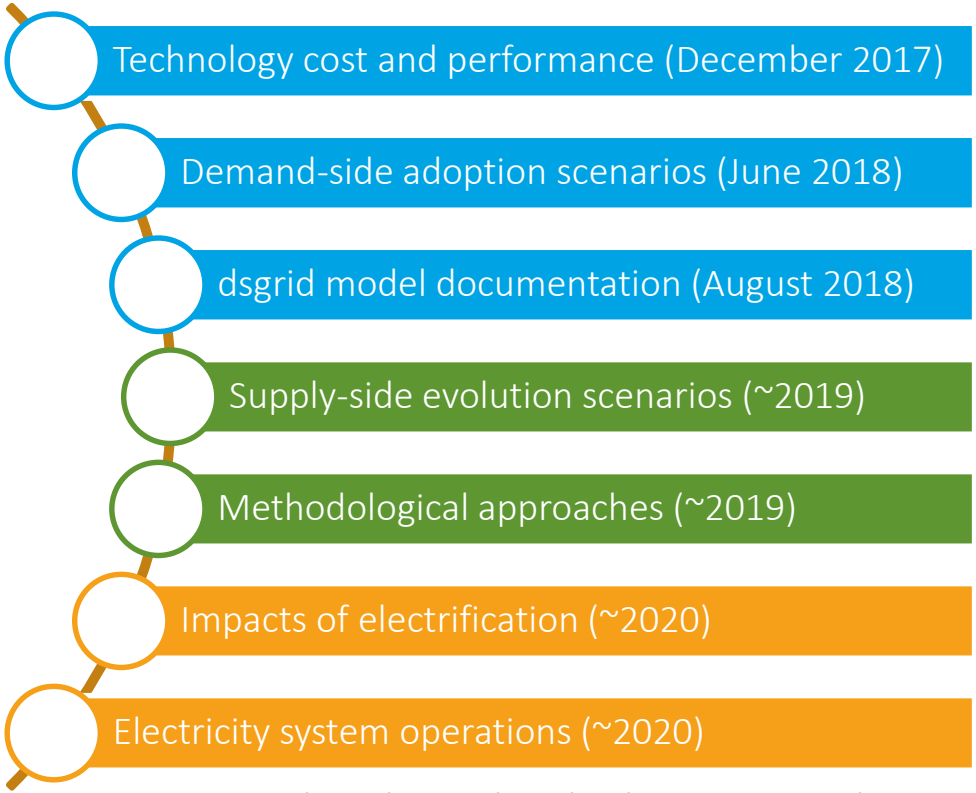
EVOLVED ENERGY RESEARCH

NORTHERN ARIZONA UNIVERSITY

OAK RIDGE National Laboratory

BERKELEY LAB
Lawrence Berkeley National Laboratory

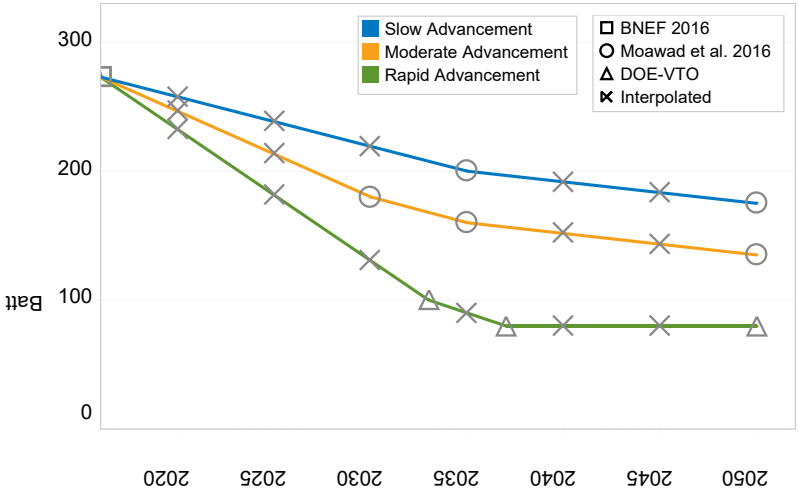
U.S. DEPARTMENT OF ENERGY



+ Planned research on distribution system and utility business model impacts (2020-21)

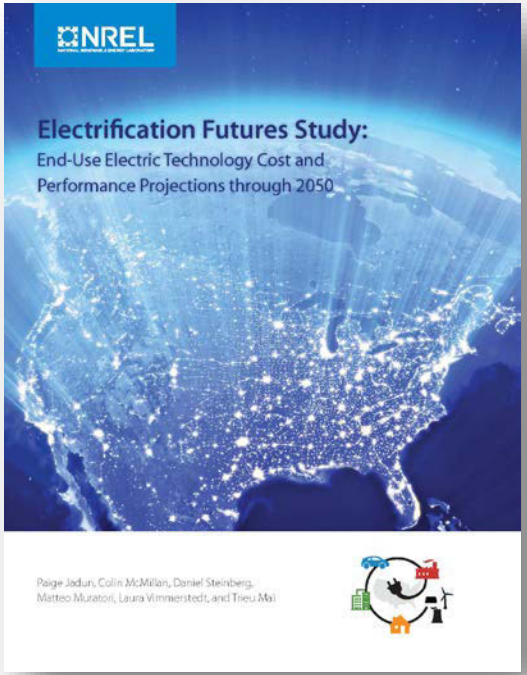
Study sponsored by U.S. DOE-EERE Office of Strategic Programs

Scenarios for end-use electric technology advancement



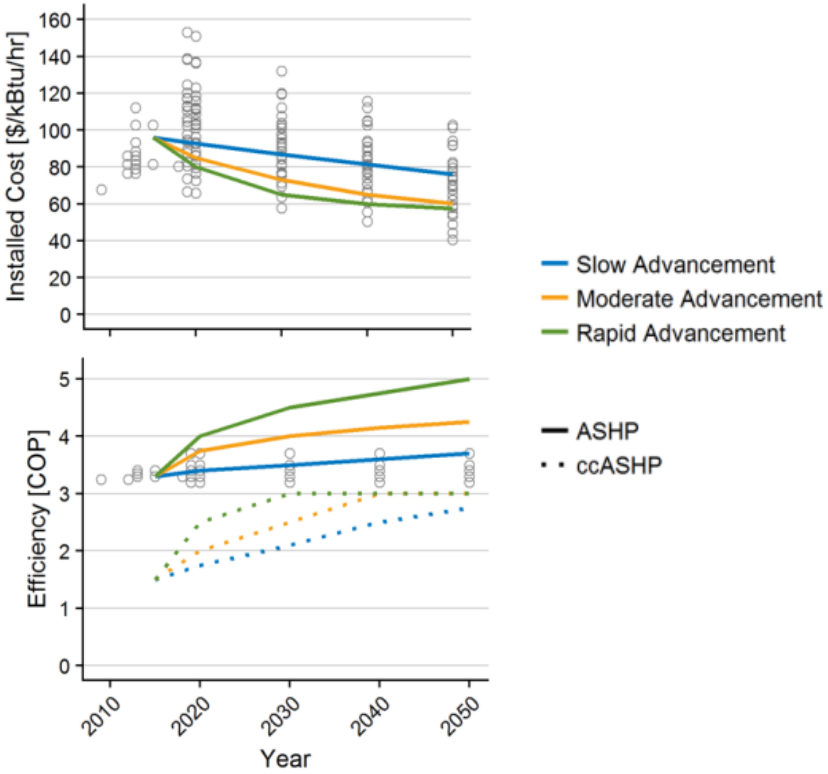
Technology data is foundational to cost-benefit assessments

- 3 trajectories (slow, moderate, rapid) for **buildings** and **transportation**
- Literature-based summary of **industrial** electrotechnologies

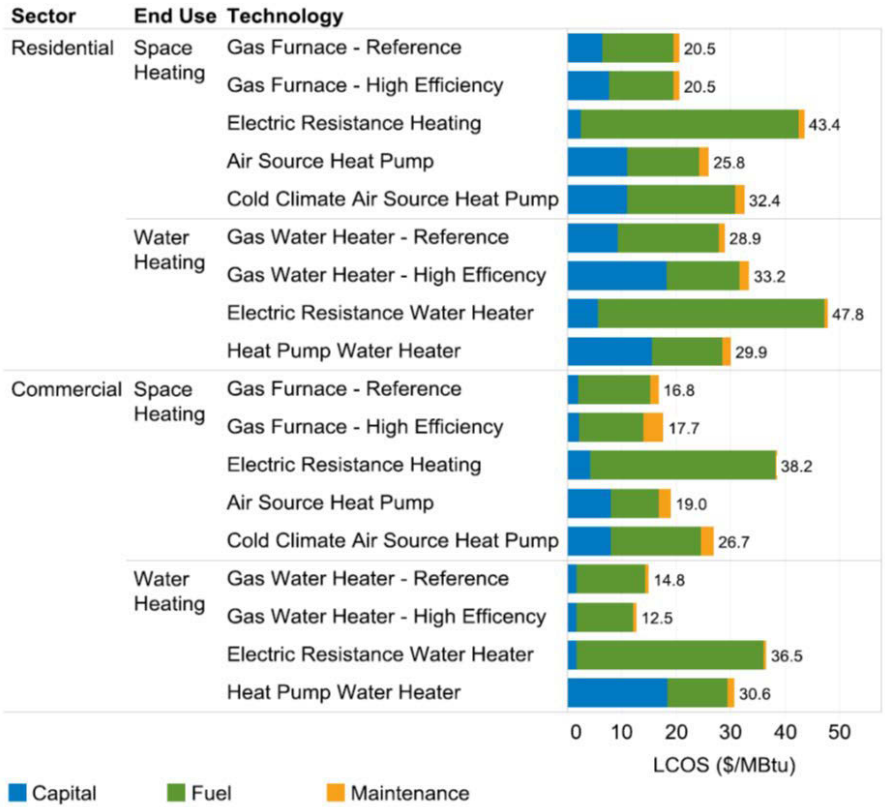


https://www.nrel.gov/docs/fy18osti/70485.pdf

End-use electric technology cost and performance

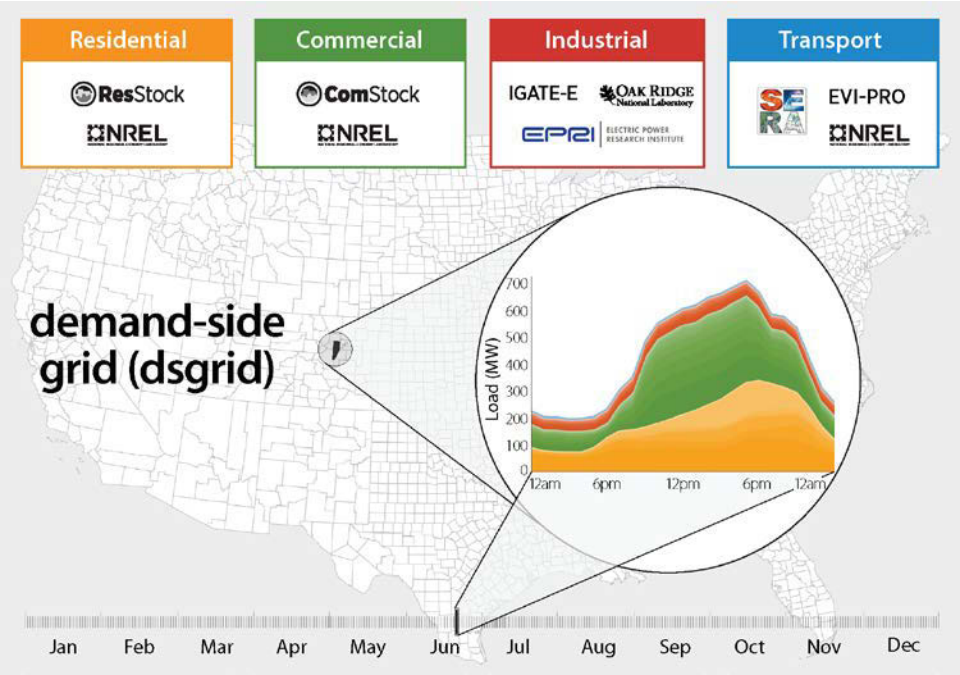


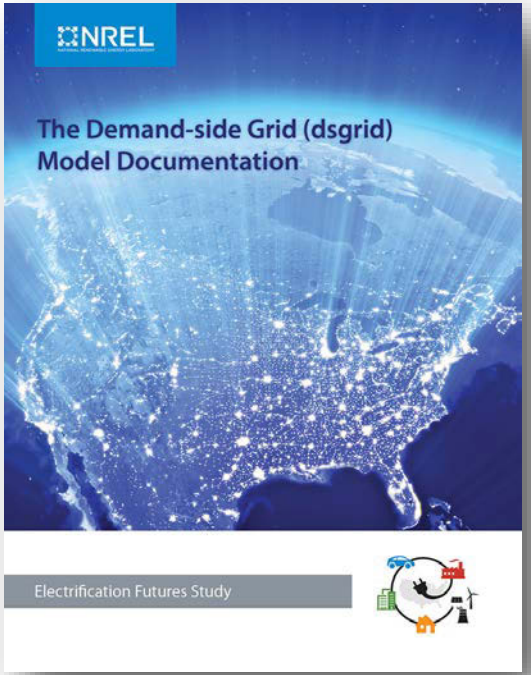
Commercial ASHPs
installed cost and efficiency projections



Levelized cost of services (2020 Moderate)

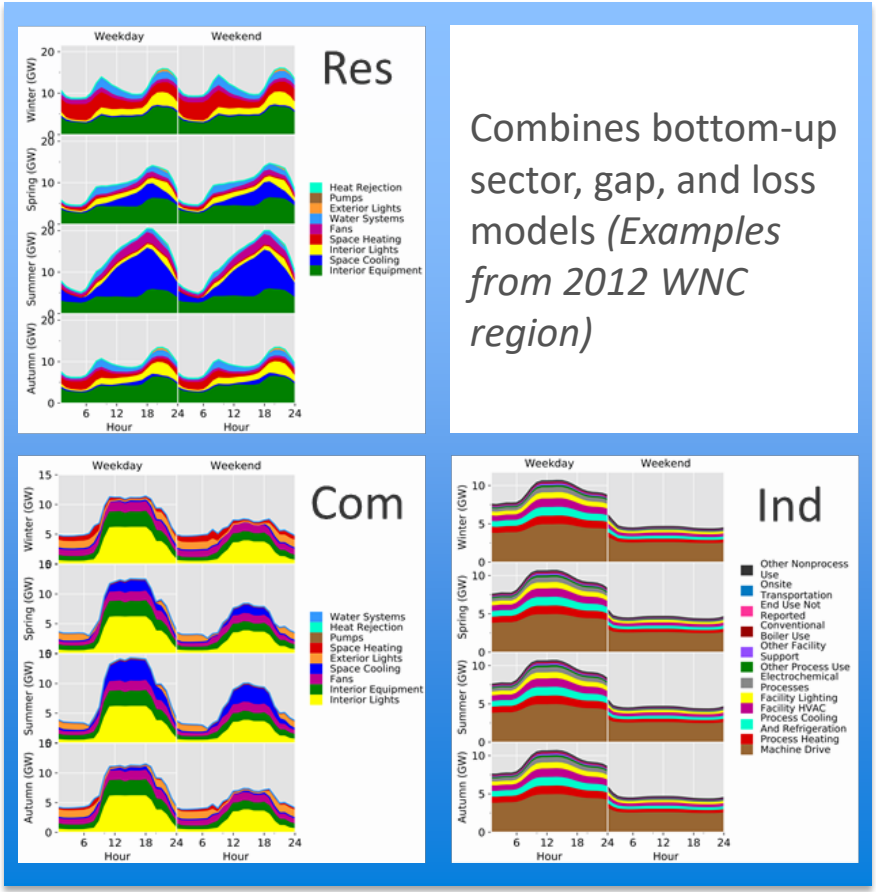
dsgrid: bottom-up engineering model to estimate hourly electricity consumption



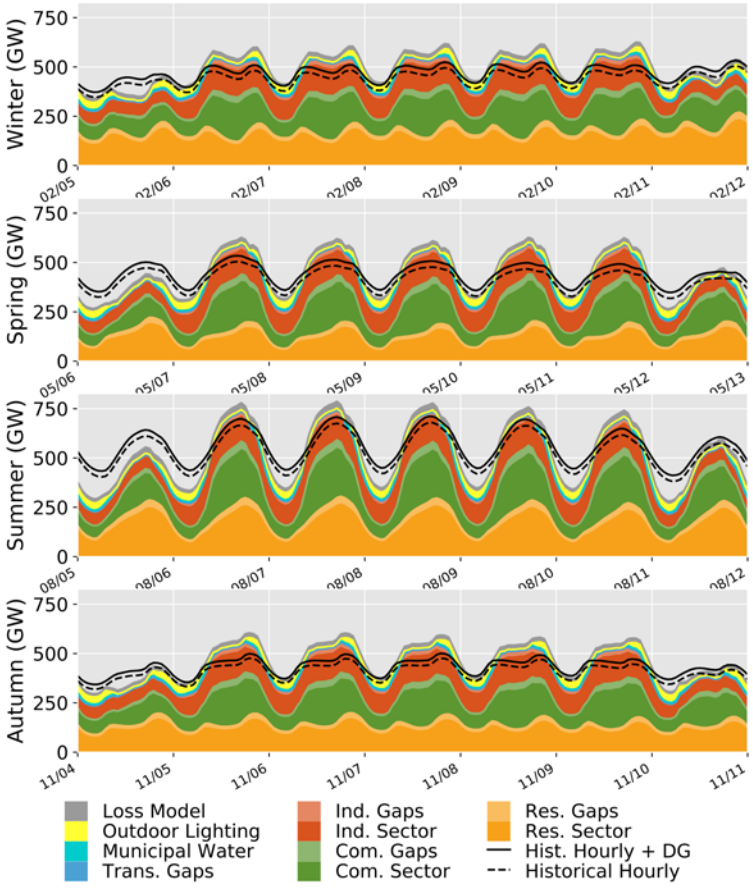


https://www.nrel.gov/docs/fy18osti/71492.pdf

Enables a detailed understanding of how equipment replacement could impact consumption



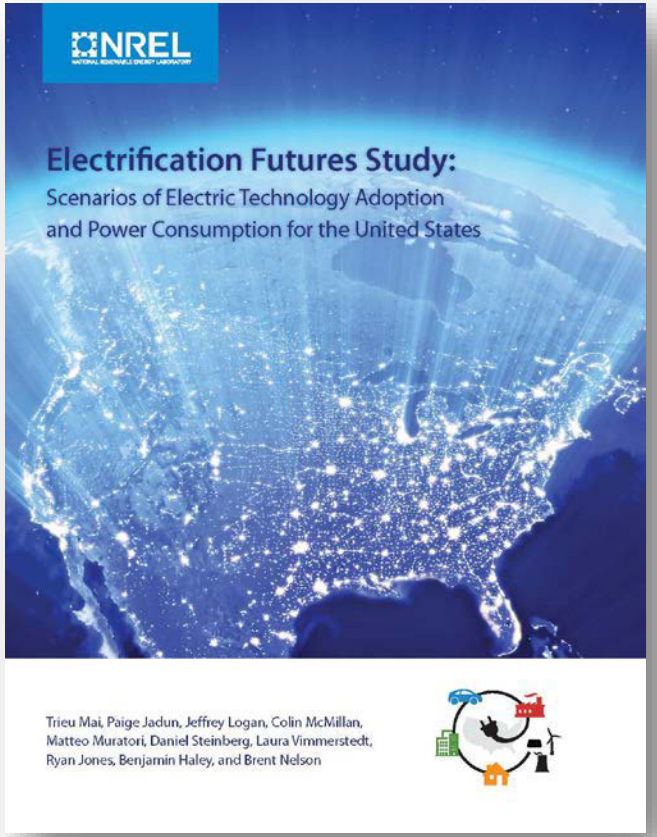
Combines bottom-up sector, gap, and loss models *(Examples from 2012 WNC region)*



Demand-Side Scenarios Report

(June 2018)

https://www.nrel.gov/docs/fy18osti/71500.pdf



Developing demand-side scenarios

OBJECTIVES

Characterize **changes to end-use sectors** under increasing levels of electrification

Quantify how electrification impacts **total electricity demand** and **consumption profiles**

APPROACH

Expert judgment **adoption projections** and **consumer choice modeling**

Bottom-up **stock and energy accounting model** (EnergyPATHWAYS)

SCENARIOS

Reference: Least incremental change (~AEO2017)

Medium: Widespread electrification among low(er)-hanging fruit opportunities

High: Transformational electrification

Buildings Sector Details

- In the combined buildings sector (residential + commercial) in 2050, electric equipment provides up to:
  - **61% of space heating**
  - **52% of water heating**
  - **94% of cooking services** (High scenario; right column)
- Appliance lifetimes limit total penetration

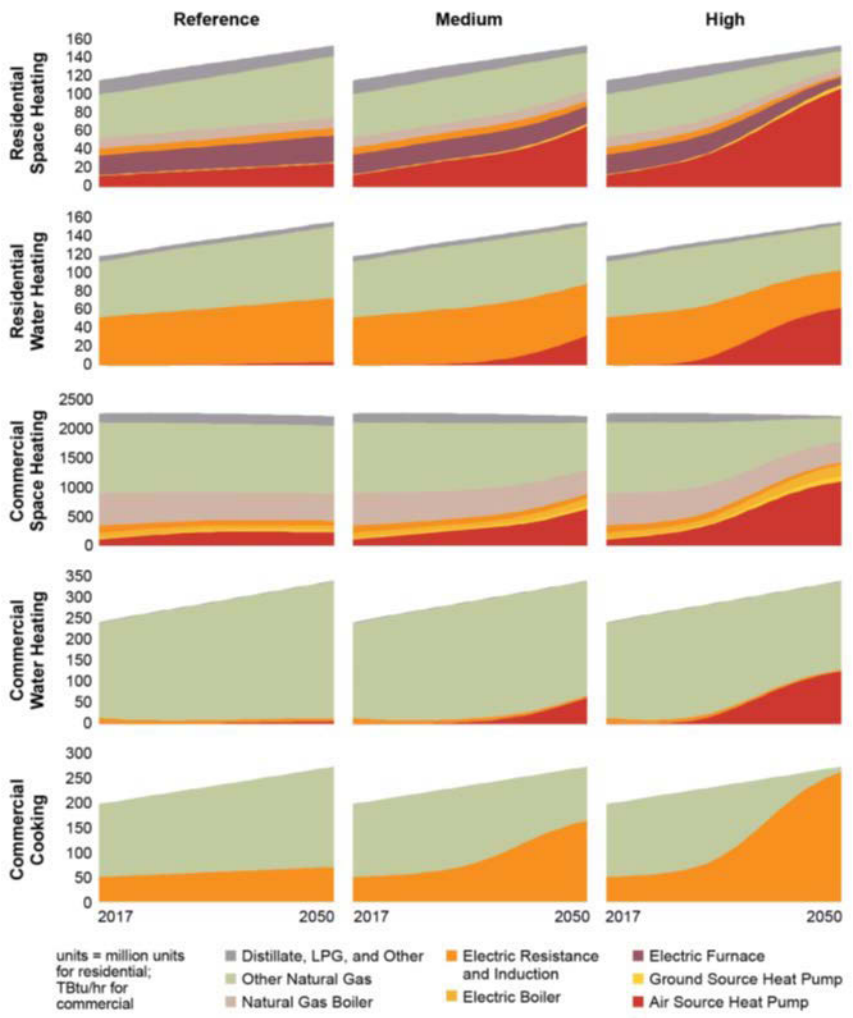
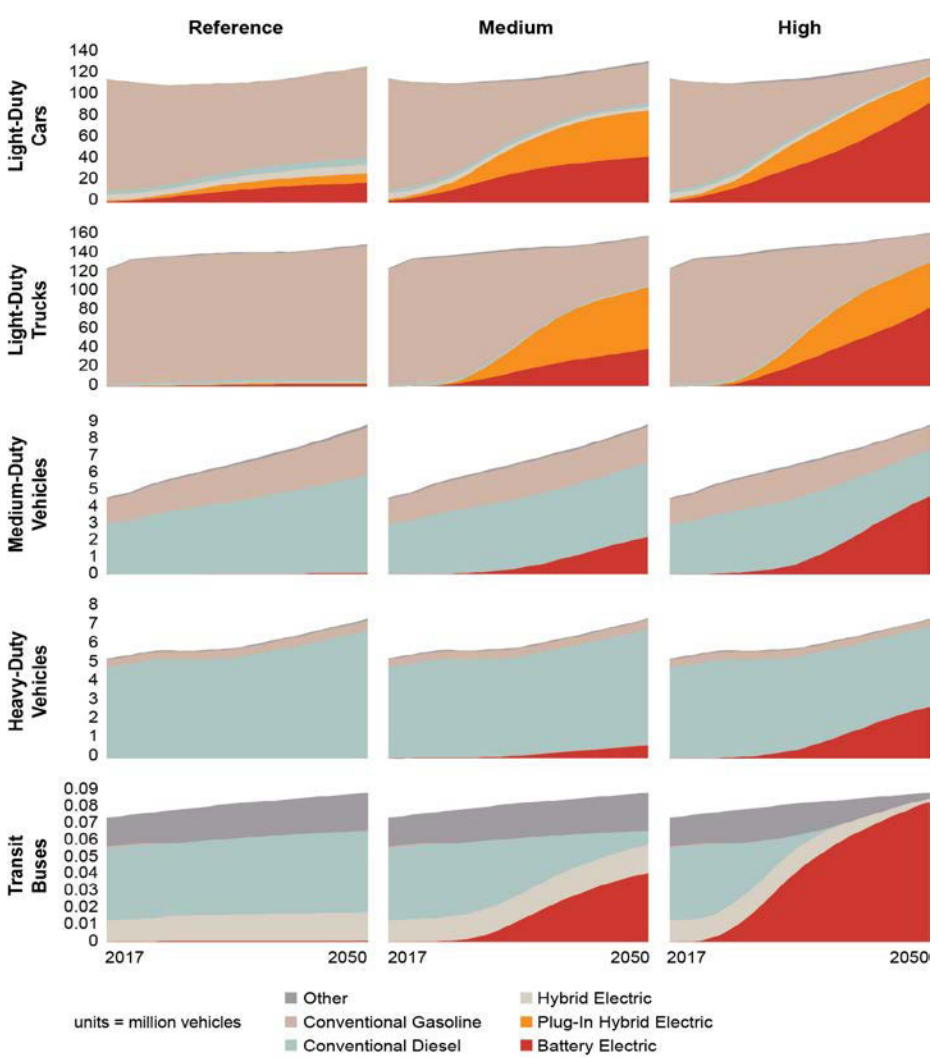


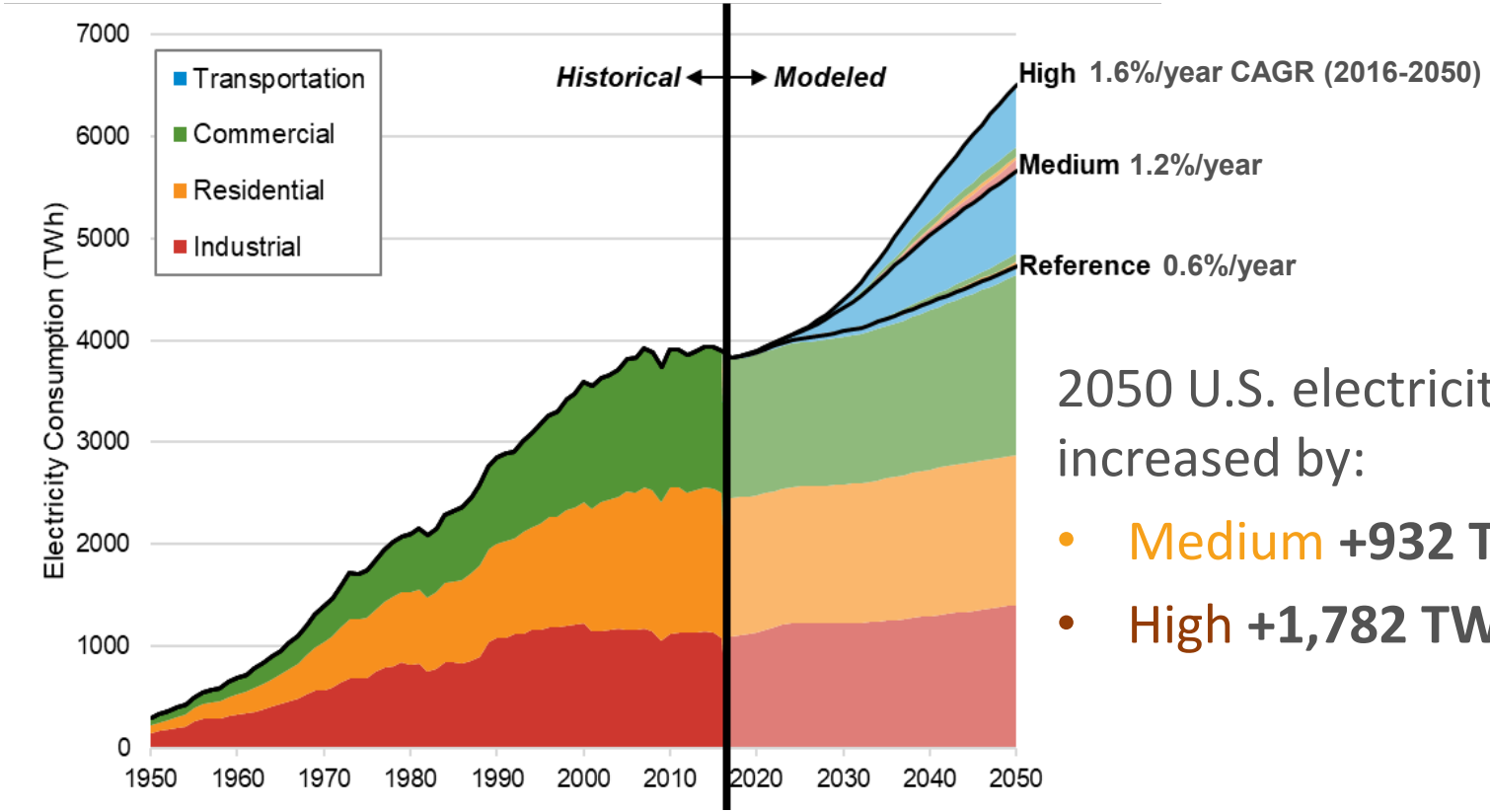
Figure 6.4. Buildings equipment stock in the electrification scenarios

Transportation Sector Details

- 2050 U.S. transportation fleet (High scenario):
  - **240 million** light-duty plug-in electric vehicles
  - **7 million** medium- and heavy-duty plug-in electric trucks
  - **80 thousand** battery electric transit buses
- Together these deliver up to **76%** of miles traveled from electricity in 2050



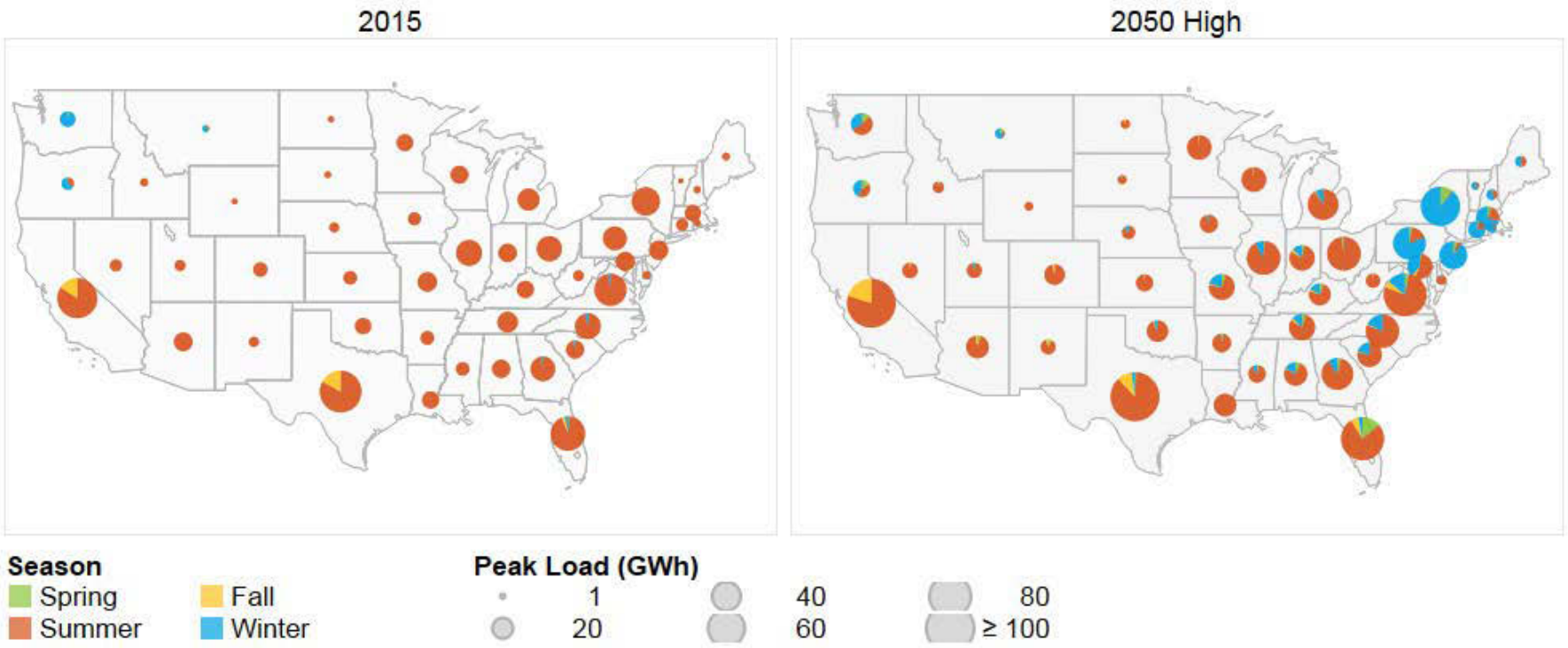
Vehicle electrification dominates incremental growth in *annual* electricity demand



2050 U.S. electricity demand increased by:

- Medium **+932 TWh (20%)**
- High **+1,782 TWh (38%)**

Electric space heating has the largest impact on the timing and magnitude of peak demand



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

Key Take-Aways from Demand-Side Scenarios

Electrification is a highly complex research topic with a broad scope:

- Involves interactions among all sectors via numerous technologies
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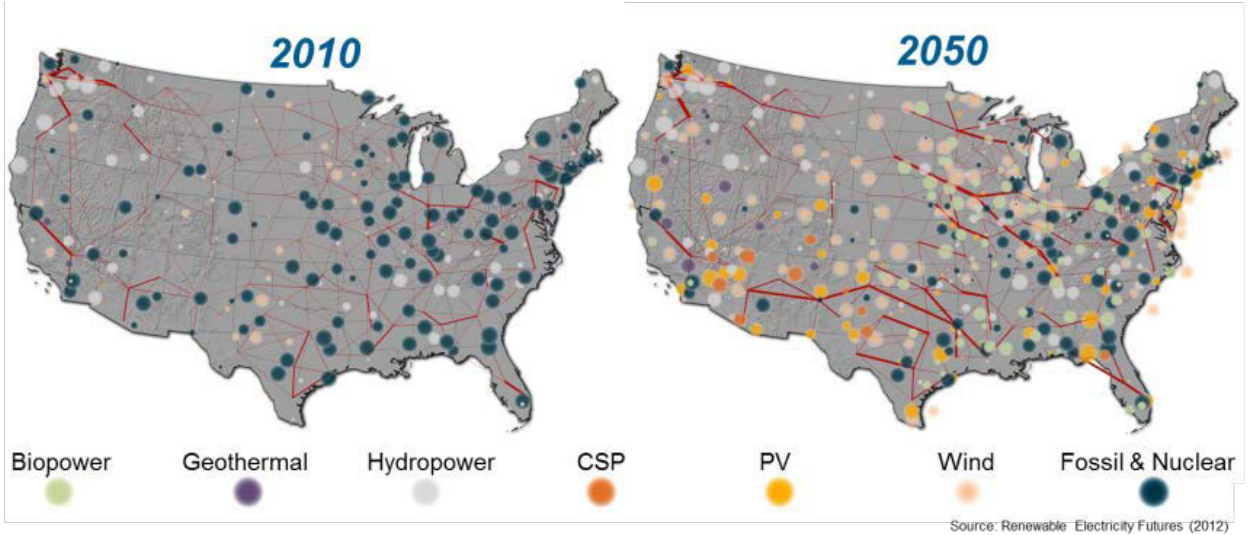
Quantifying the effects of electrification in a meaningful way requires applying high-resolution modeling (across this broad scope):

1. *Technological resolution*: End-use technology efficiency, load profiles
2. *Spatial resolution*: Service demand, alignment with generation portfolio/resources (e.g., resource sharing)
3. *Temporal resolution*: Annual, peak, and hourly electricity demand

Ongoing analysis involves using a detailed electricity system model to explore a range of supply-side portfolios

Regional Energy Deployment System (**ReEDS**)

Simulates the expansion and operation of the U.S. generation and transmission system

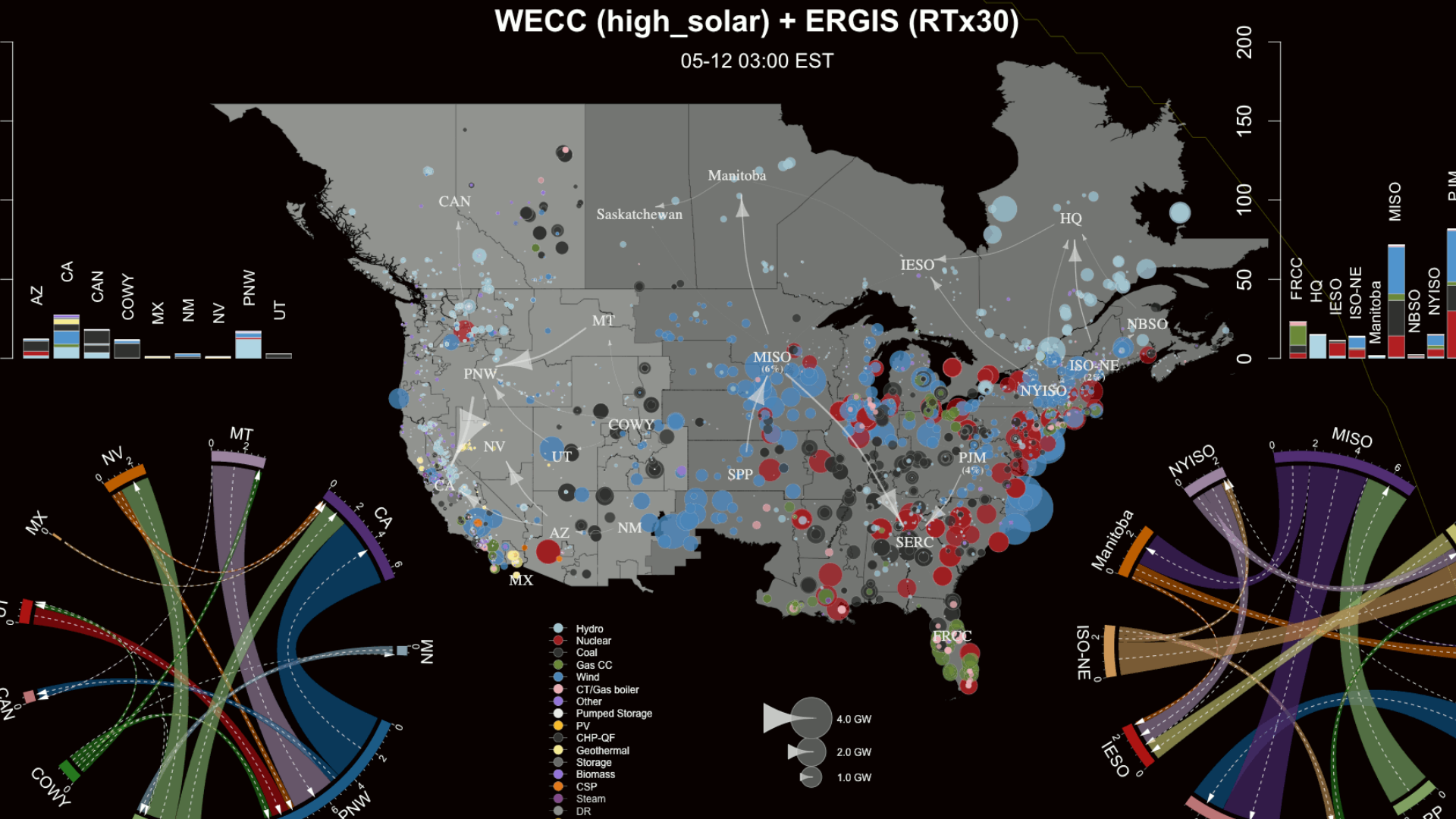


Model Improvements

- Energy-sector natural gas consumption and price
- Demand-side flexibility
- Peak demand management and capacity sharing

Supply side scenarios are designed to:

1) isolate the impacts of our electrification scenarios and demand-side flexibility
2) explore the relative impacts of different supply-side assumptions


WECC (high_solar) + ERGIS (RTx30)
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CAN
Saskatchewan
Manitoba
HQ
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ISO-NE
(2%)
NYISO
COWY
NV
UT
CA
SPP
PJM
(4%)
AZ
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SERC
MX
FRCC
Hydro
Nuclear
Coal
Gas CC
Wind
CT/Gas boiler
Other
Pumped Storage
PV
CHP-QF
Geothermal
Storage
Biomass
CSP
Steam
DR
4.0 GW
2.0 GW
1.0 GW

Thank you

caitlin.murphy@nrel.gov

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