

# The Electrification Futures Study

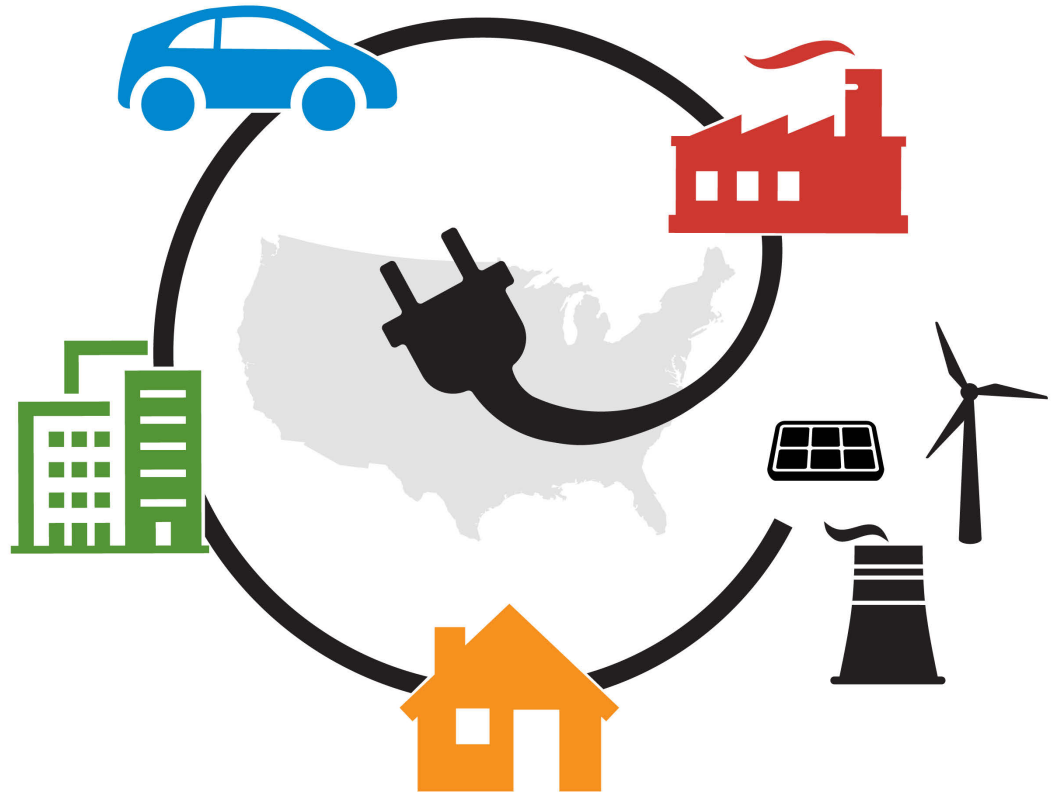
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Caitlin Murphy

December 10, 2019

NERC Planning Committee Meeting  
Atlanta, Georgia

[nrel.gov/EFS](https://nrel.gov/EFS)



# Answering crucial questions about:



## Technologies

What electric technologies are available now, and how might they advance?



## Consumption

How might electrification impact electricity demand and use patterns?



## System Change

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



## Flexibility

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



## Impacts

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



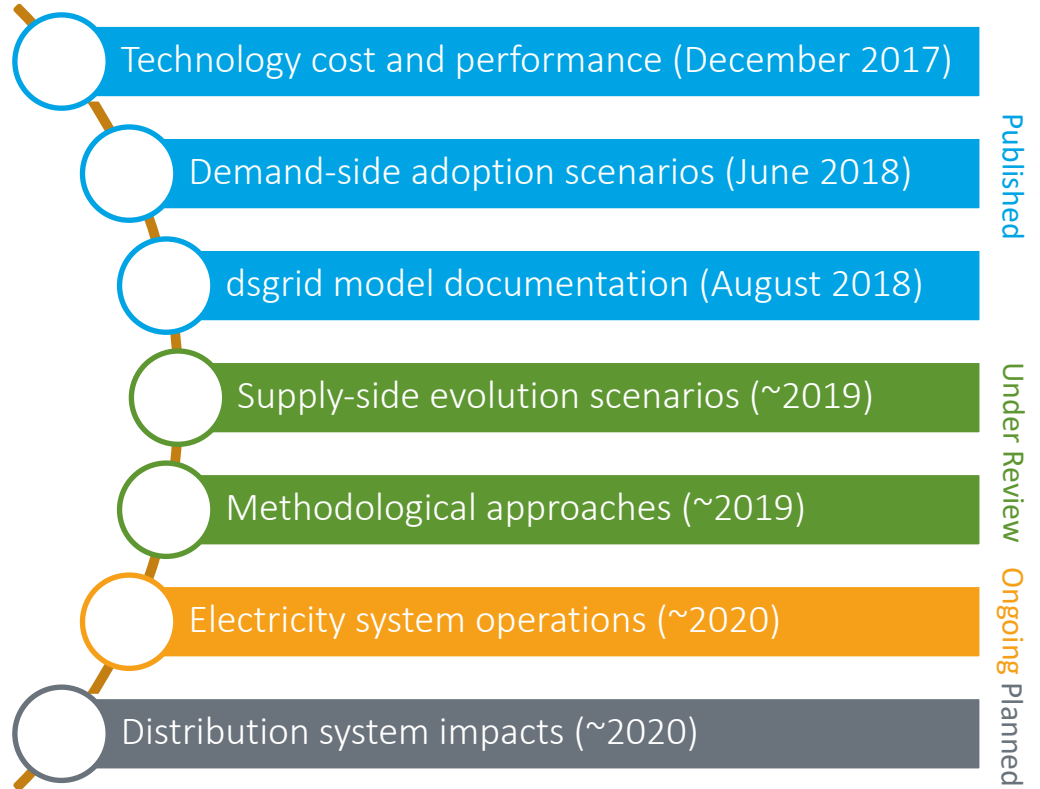
# NREL-led collaboration, multi-year study



NATIONAL RENEWABLE ENERGY LABORATORY



EVOLVED  
ENERGY  
RESEARCH

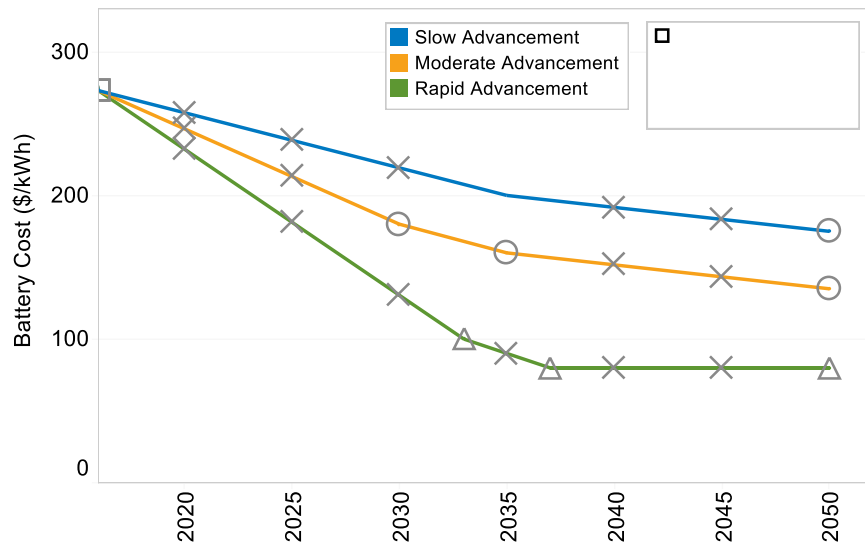


# Foundational data and tools

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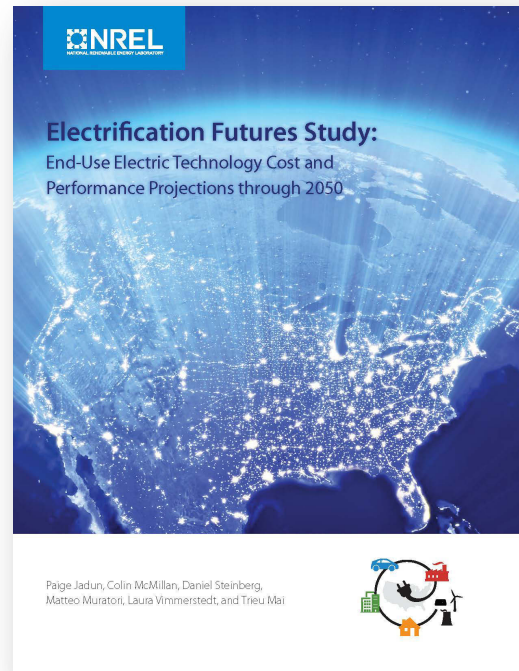
- End-use technology cost and performance data
- Demand-side grid load modeling

# Projections of end-use electric technology advancement



Technology data is foundational to cost-benefit assessments

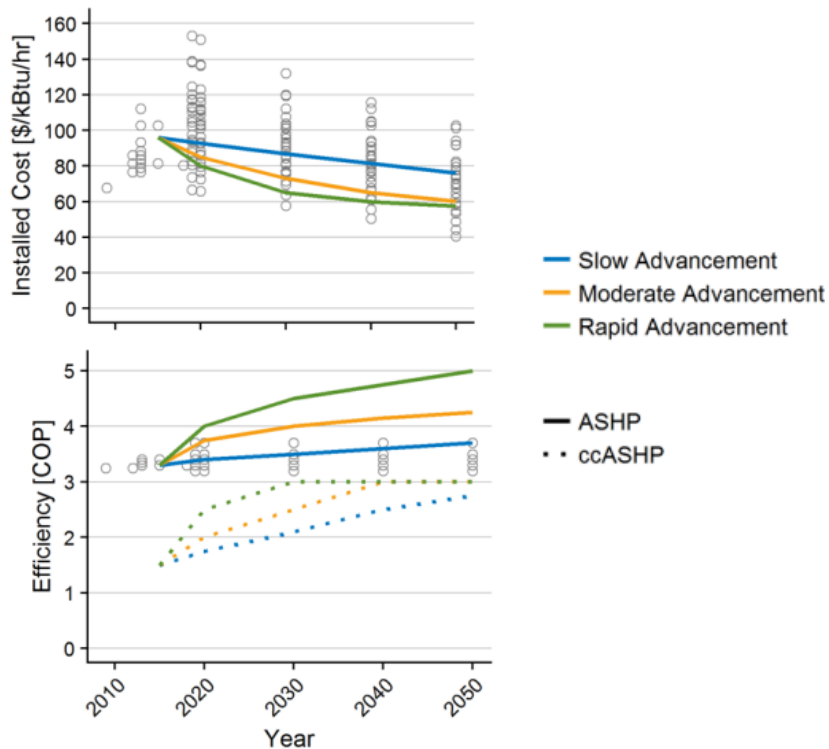
- 3 trajectories (**slow**, **moderate**, **rapid**) for **buildings** and **transportation**
- Literature-based summary of **industrial** electrotechnologies



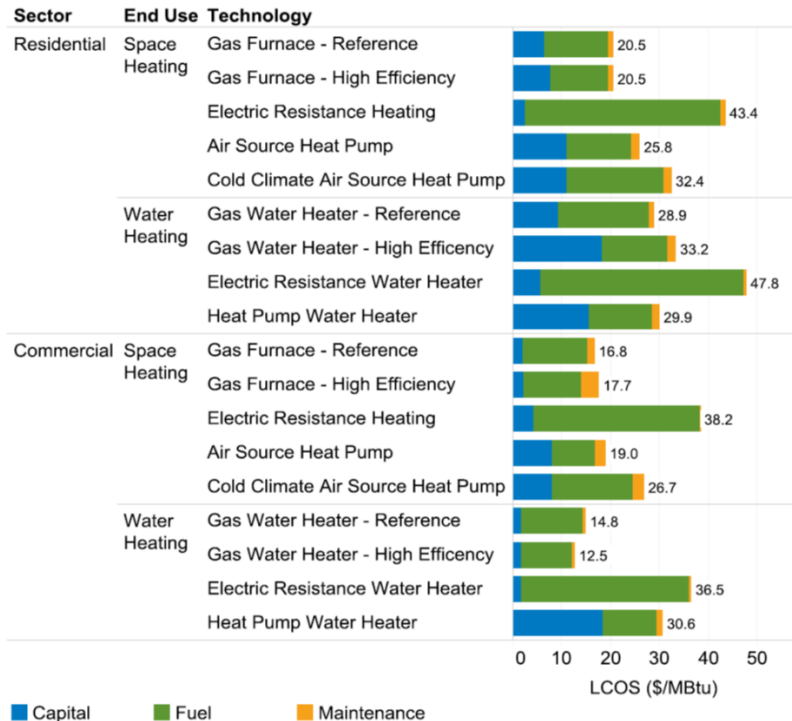
[nrel.gov/docs/fy18osti/70485.pdf](https://nrel.gov/docs/fy18osti/70485.pdf)



# End-use electric technology cost and performance

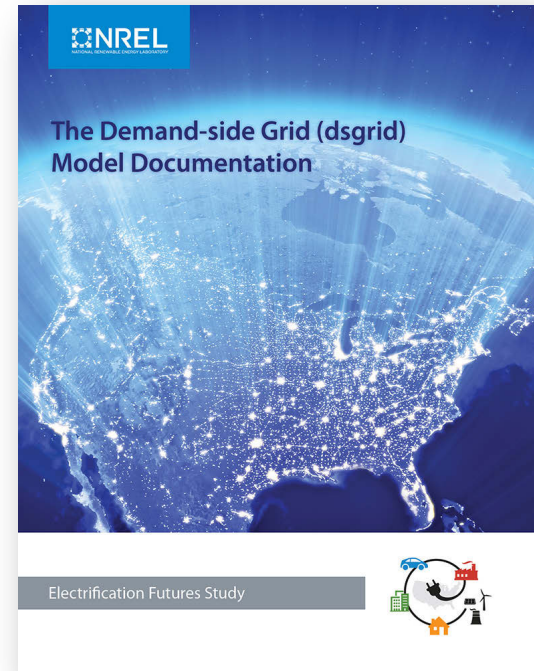
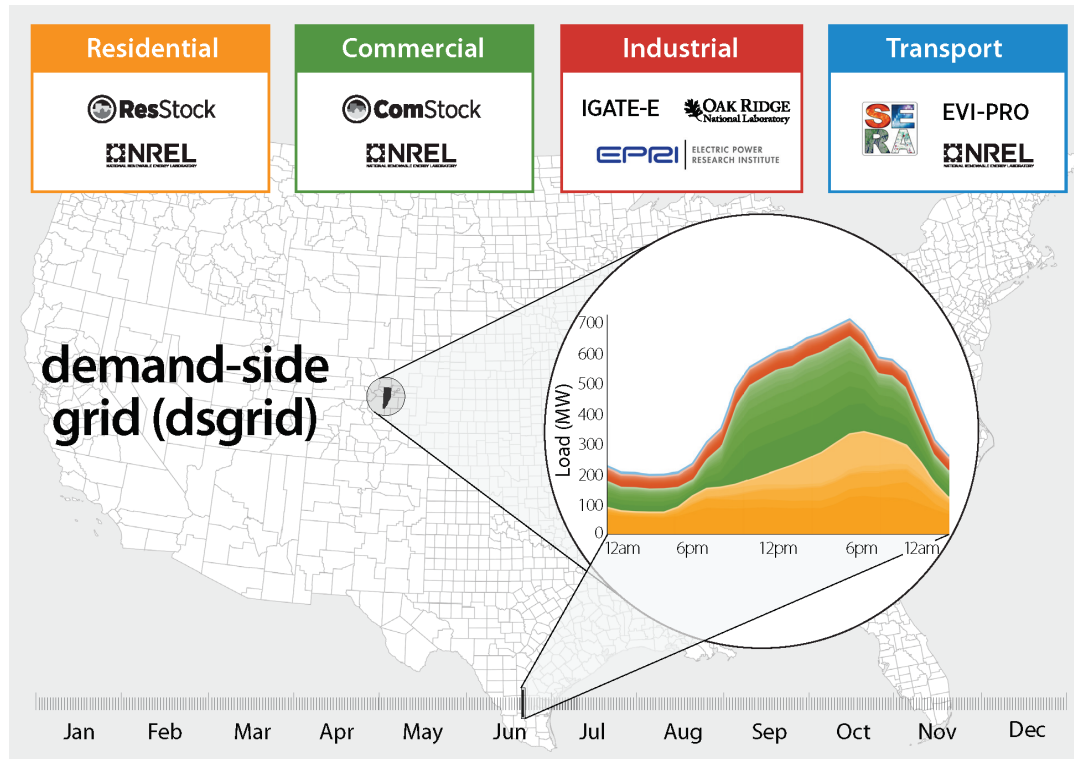


Commercial ASHPs installed cost and efficiency projections



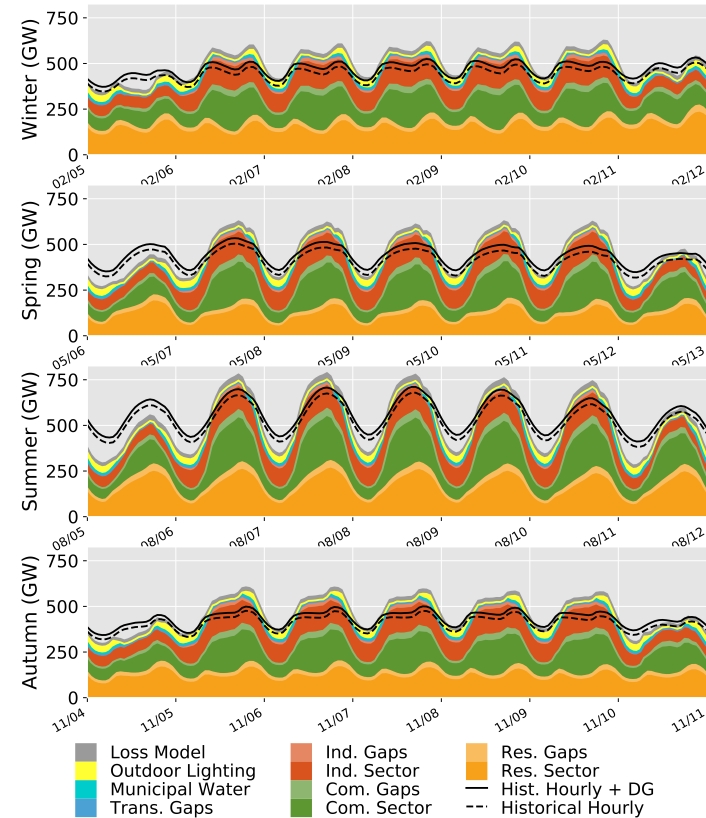
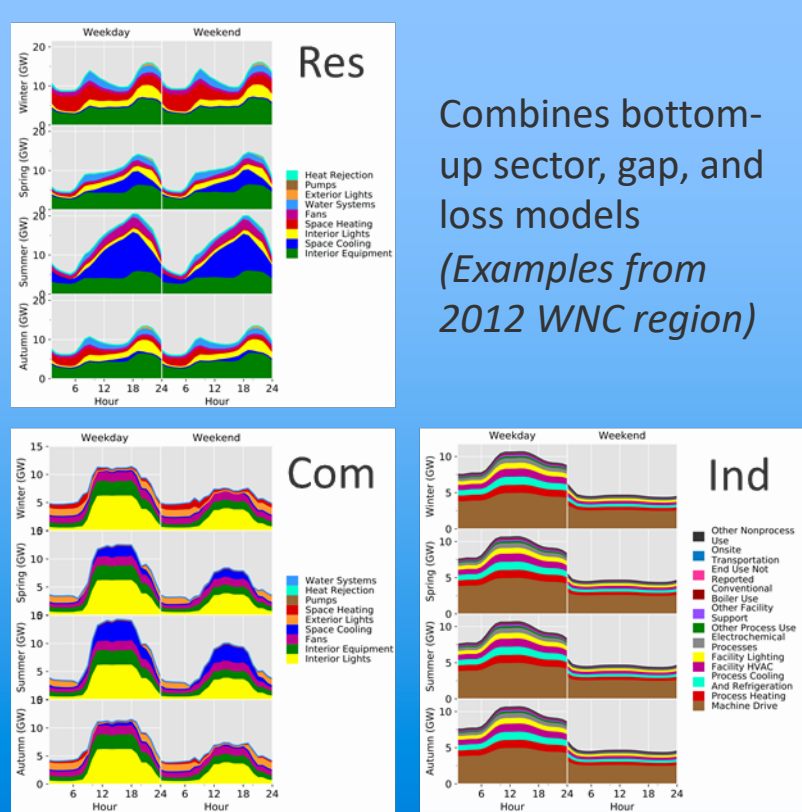
Levelized cost of services (2020 Moderate)

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



[nrel.gov/docs/fy18osti/71492.pdf](https://nrel.gov/docs/fy18osti/71492.pdf)  
[nrel.gov/analysis/dsgrid.html](https://nrel.gov/analysis/dsgrid.html)

# Enables a detailed understanding of how equipment replacement could impact consumption



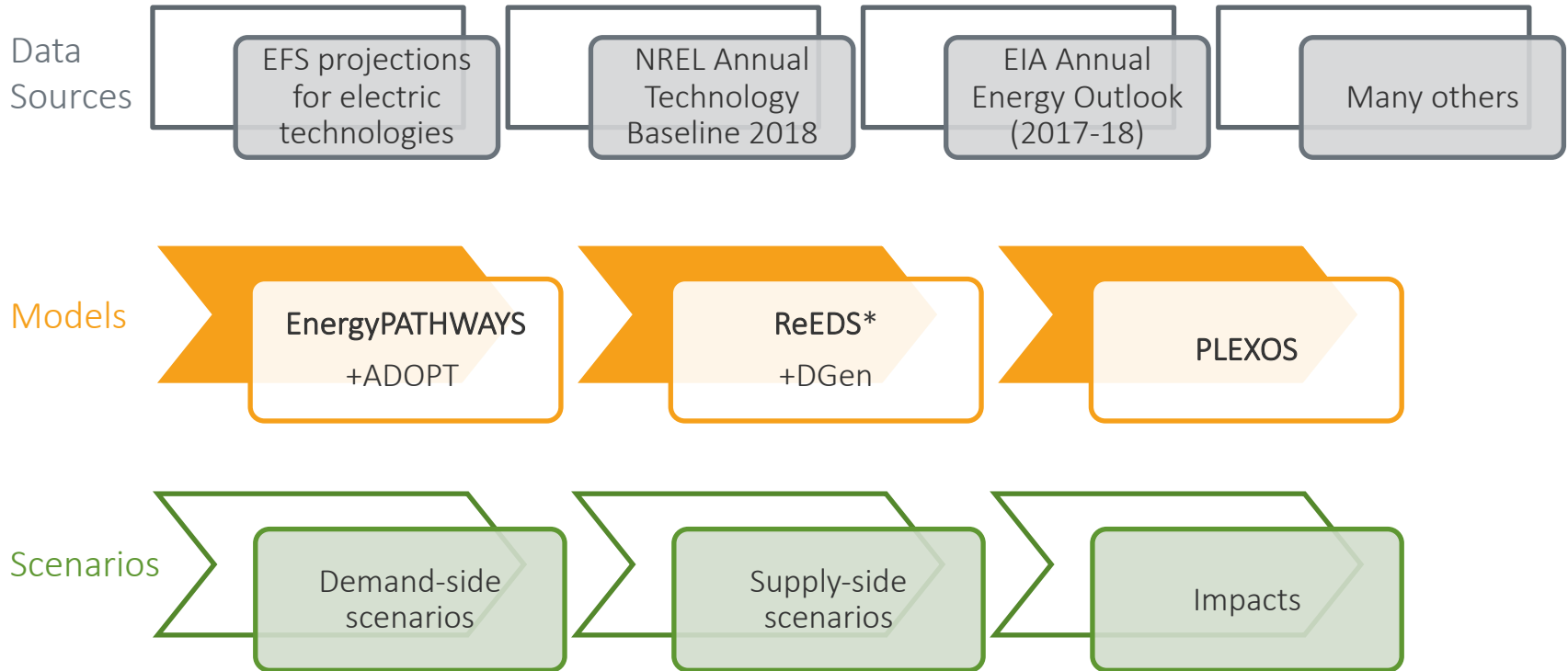


# EFS scenarios and impacts

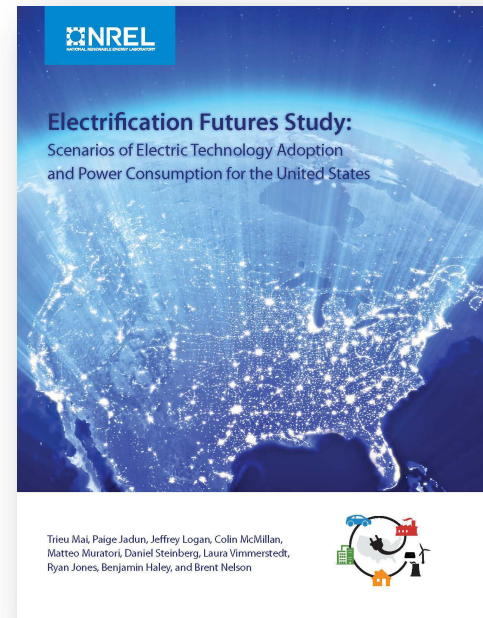
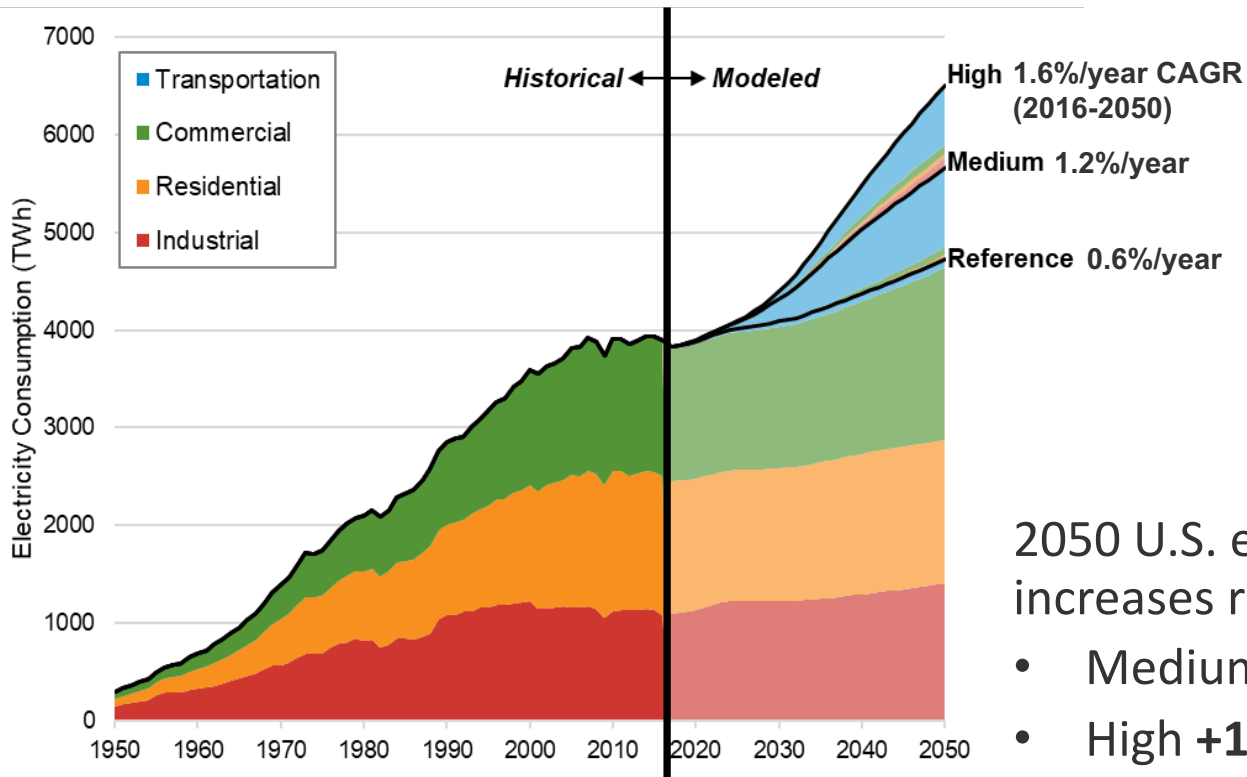
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- Demand-side adoption scenarios
- Methodological approaches
- Supply-side evolution scenarios

# EFS models and data flow



# Demand-side adoption scenarios



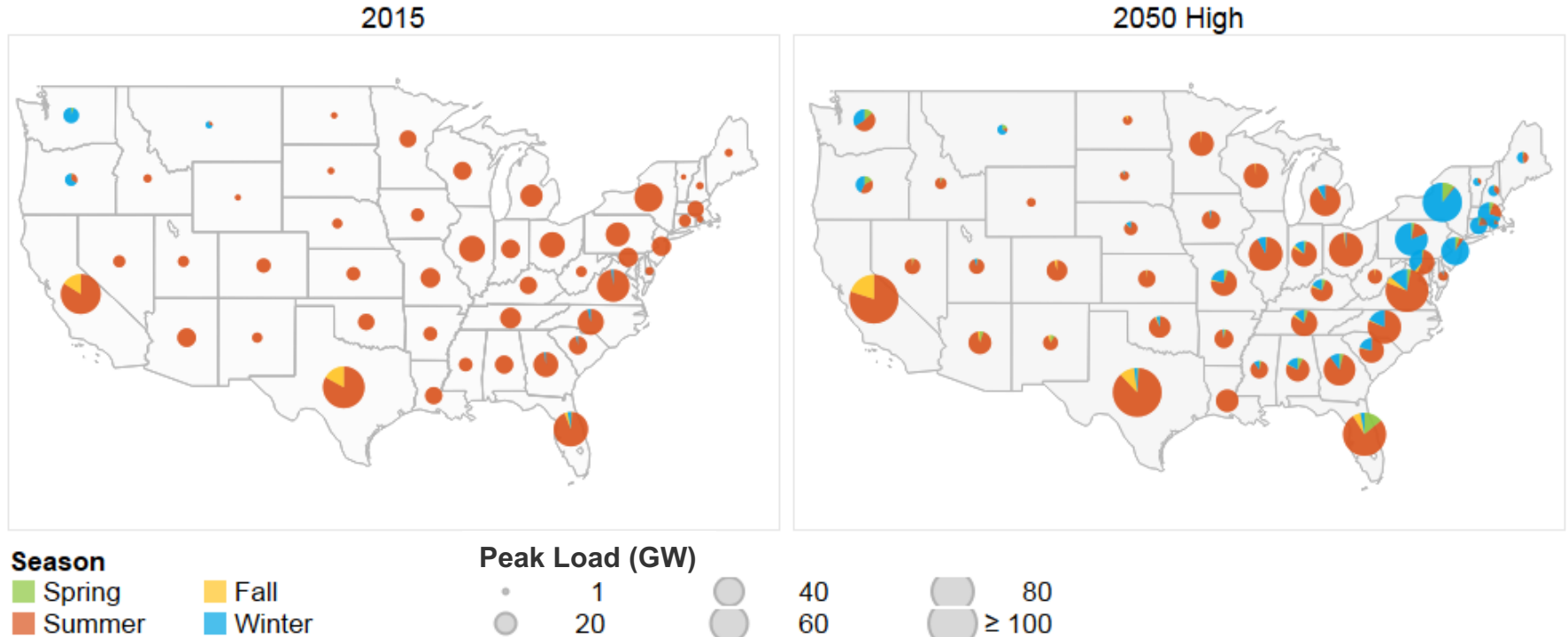
[nrel.gov/docs/fy18osti/71500.pdf](https://www.nrel.gov/docs/fy18osti/71500.pdf)

2050 U.S. electricity consumption increases relative to Reference

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



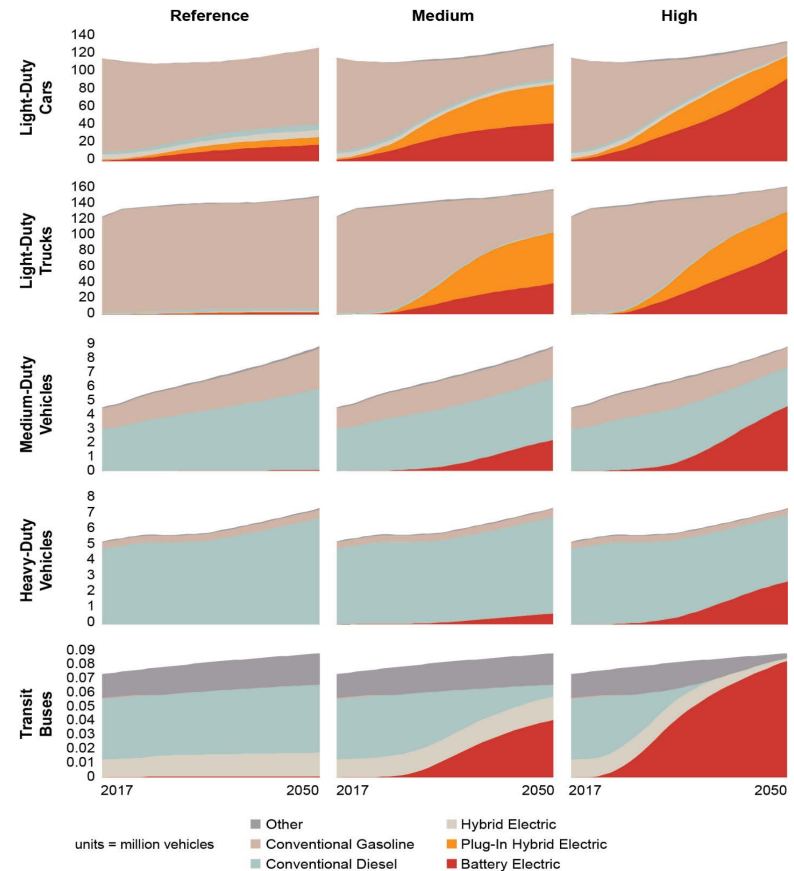
# Planning for electrification requires considering the impacts to annual consumption and load shapes



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

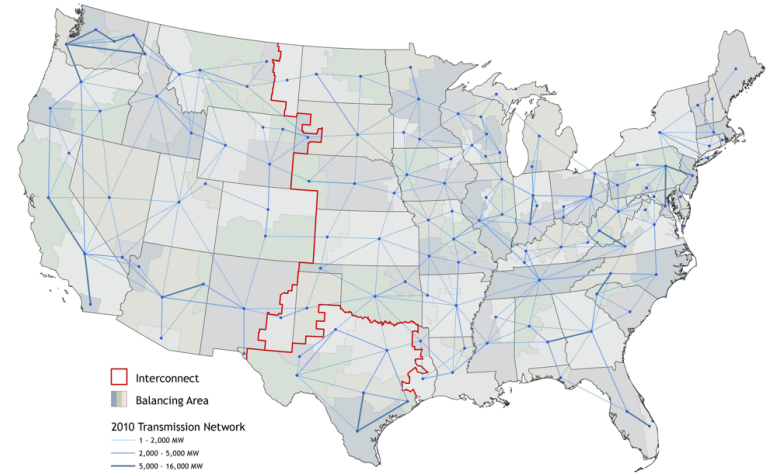
# Transportation sector details

- 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
- 138,000 DCFC stations (447,000 plugs) and 10 million non-residential L2 plugs for light-duty vehicles
- + Changes to buildings and industrial sectors

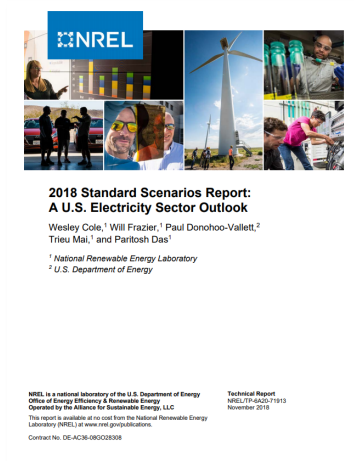
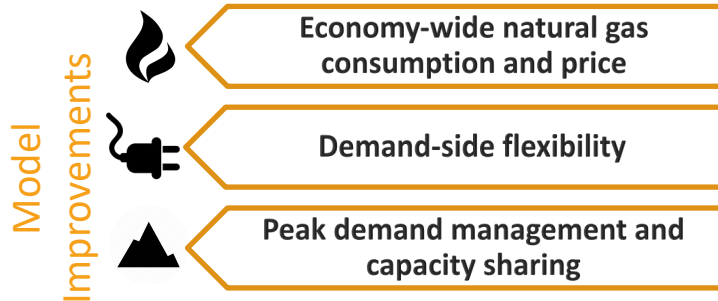


Vehicle stock

# Power sector modeling methods



- **Regional Energy Deployment System (ReEDS)**
  - Long-term capacity expansion model of the electricity system in the contiguous United States
- **Base model = 2018 final release version**
  - Consistent with 2018 Standard Scenarios report
  - Key assumptions from ATB 2018 and AEO 2018
- **New electrification-specific methodological improvements**





# Supply-side evolution research questions

- What are the impacts of electrification on the mix, magnitude, location, and timing of **new bulk power system infrastructure development** in the United States?
- How could widespread end-use electrification impact the **generation mix and utilization** of different classes of generators and transmission assets?
- What are the impacts of electrification on **costs, energy consumption, and air emissions** for the electric and broader energy systems?

If widespread electrification occurs, how would the U.S. power system need to evolve, and what are some broader implications?

# 29 supply-side scenarios modeled

- Designed to **isolate the impacts** of electrification
- **Sensitivities across multiple dimensions** in demand sectors and future supply uncertainties
- Presents **power system impacts** (when appropriate) and **broader energy system impacts** (whenever possible)

Electrification Level	
<ul style="list-style-type: none"><li>• Reference</li><li>• Medium</li><li>• High</li></ul>	
Demand-side Variations	Supply-side Variations
<b>End-use Electric Technology Advancement</b> <ul style="list-style-type: none"><li>• Slow</li><li>• Moderate*</li><li>• Rapid</li></ul>	<b>Fuel &amp; Technology</b> <ul style="list-style-type: none"><li>• Smaller NG Resource</li><li>• Base NG Resource*</li><li>• Larger NG Resource</li><li>• Lower RE Costs</li><li>• Base RE Costs*</li><li>• Constant RE Costs</li></ul>
<b>Demand-side Flexibility</b> <ul style="list-style-type: none"><li>• Current</li><li>• Base*</li><li>• Enhanced</li></ul>	<b>System Constraints</b> <ul style="list-style-type: none"><li>• Retirement Constraints</li><li>• Emissions Constraints</li><li>• Transmission Constraints</li></ul>

\* Refers to "Base Case" or default assumptions

# Thank You from the EFS Team



Elaine Hale



Kelsey Horowitz



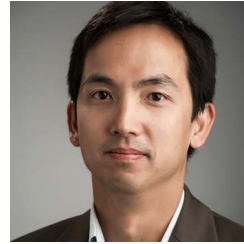
Ry Horsey



Paige Jadun



Jeff Logan



Trieu Mai



Colin McMillan



Matteo Muratori



Caitlin Murphy



Dan Steinberg



Yinong Sun



Laura Vimmerstedt



Eric Wilson



Ella Zhou



Devonie  
McCamey



Mike  
Meshek

Strategic Energy Analysis  
Buildings & Thermal Sciences  
Transportation & Hydrogen Systems  
Communications & Public Affairs

+ Many other NREL,  
non-NREL contributors  
& 19-member TRC



Questions? Thank you.

[Trieu.mai@nrel.gov](mailto:Trieu.mai@nrel.gov)

+ EFS team

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[www.nrel.gov/efs](http://www.nrel.gov/efs)

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