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

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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)?

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

- Technology cost and performance (December 2017)
- Demand-side adoption scenarios (June 2018)
- dsgrid model documentation (August 2018)
- Supply-side evolution scenarios (~2019)
- Methodological approaches (~2019)
- Impacts of electrification (~2020)
- Electricity system operations (~2020)

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

![dsgrid diagram](https://www.nrel.gov/docs/fy18osti/71492.pdf)
Enables a detailed understanding of how equipment replacement could impact consumption

Res

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

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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
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
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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
Thank you
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www.nrel.gov/efs

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