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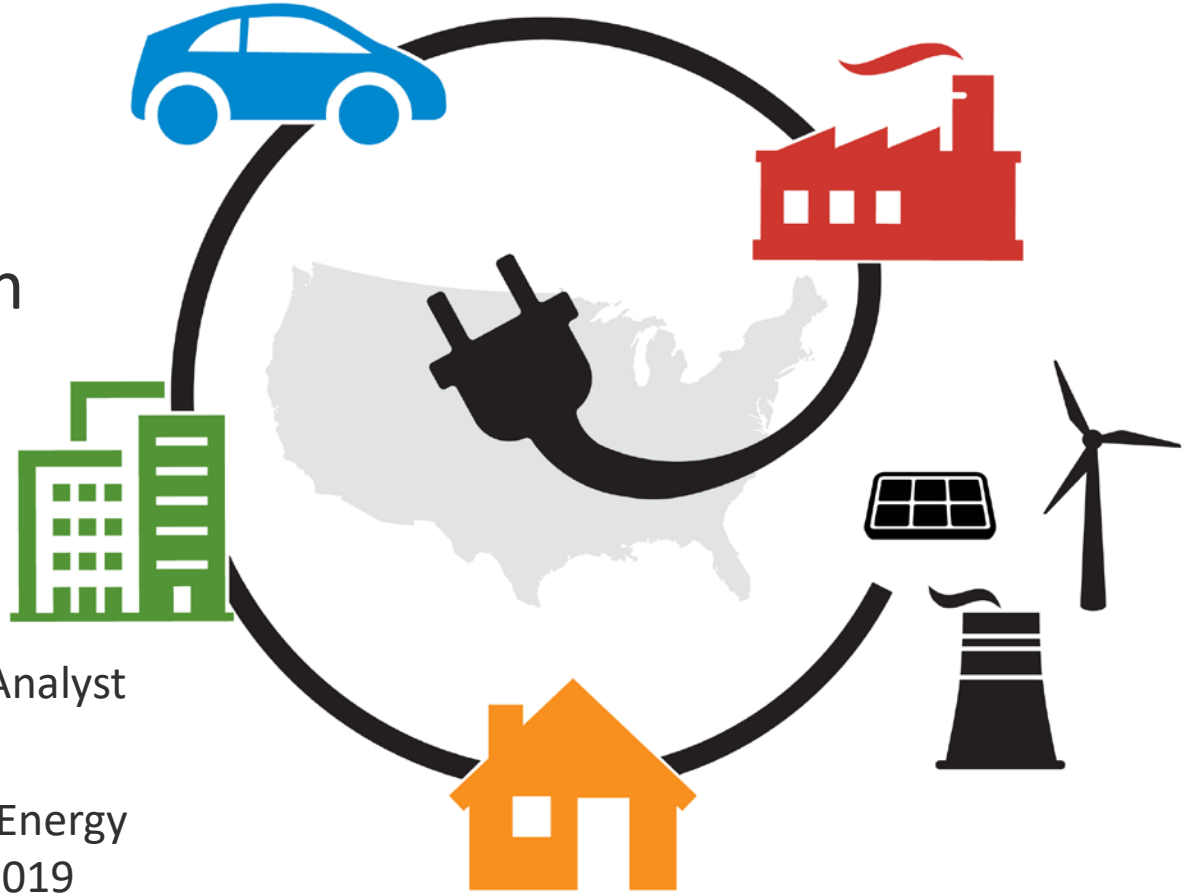
NREL's Electrification Futures Study



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Presentation for the California Energy Commission – September 24, 2019

nrel.gov/EFS

NREL-led collaboration, multi-year study

EPRI

EVOLVED ENERGY RESEARCH

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

- Strategic Energy Analysis
- Transportation and Hydrogen Systems
- Buildings and Thermal Systems

NORTHERN ARIZONA UNIVERSITY

OAK RIDGE National Laboratory

BERKELEY LAB
Lawrence Berkeley National Laboratory

U.S. DEPARTMENT OF ENERGY

+ **Technical Review Committee** of 19 experts from industry and consultants, labs, government, NGOs

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

Answering **crucial questions** about:

Technologies

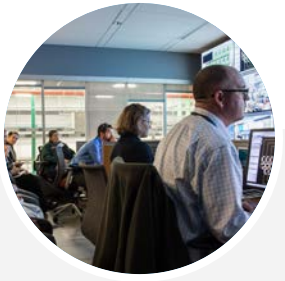
What electric technologies are available now, and how might they **advance**?

Consumption

How might electrification impact electricity **demand** and **use patterns**?

System Change

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



Flexibility

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

Impacts

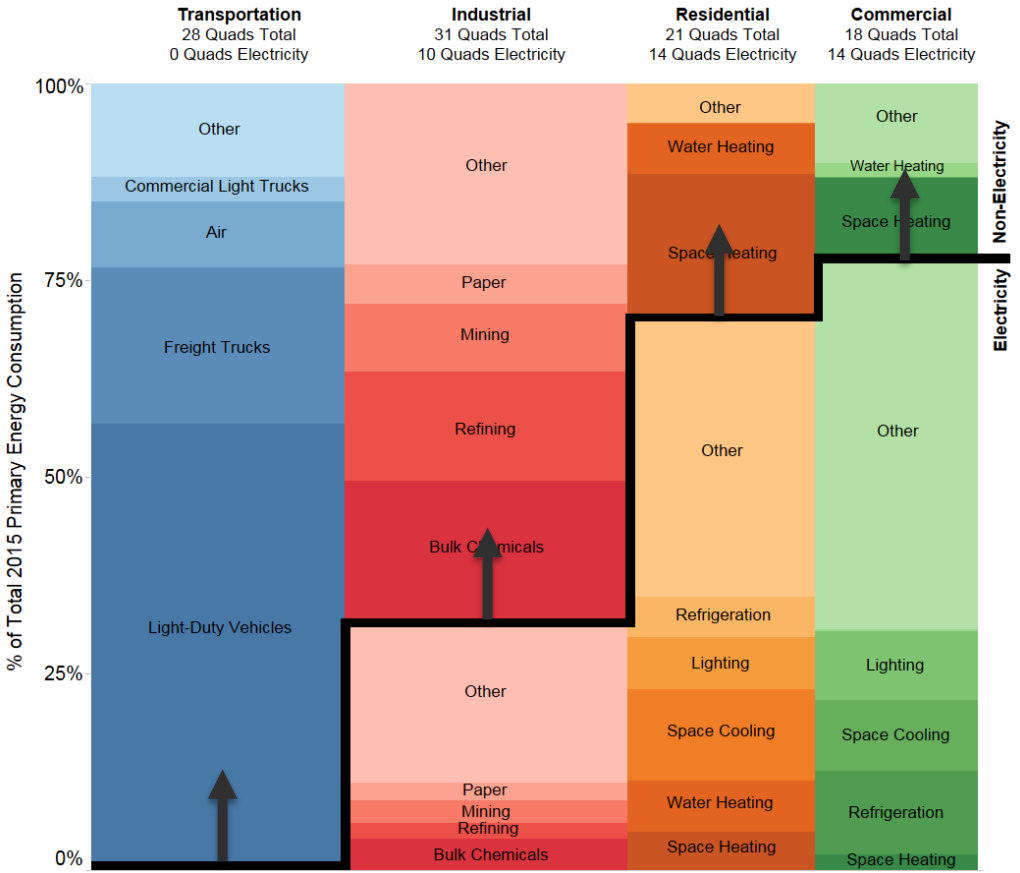
What are the potential **costs, benefits, and impacts** of widespread electrification?

Scope and definitions

- **Electrification**: the shift from any non-electric source of energy to electricity at the point of final consumption
  - Direct electric technologies only
  - Not exploring new sources of demand
  - Isolating electrification from other changes

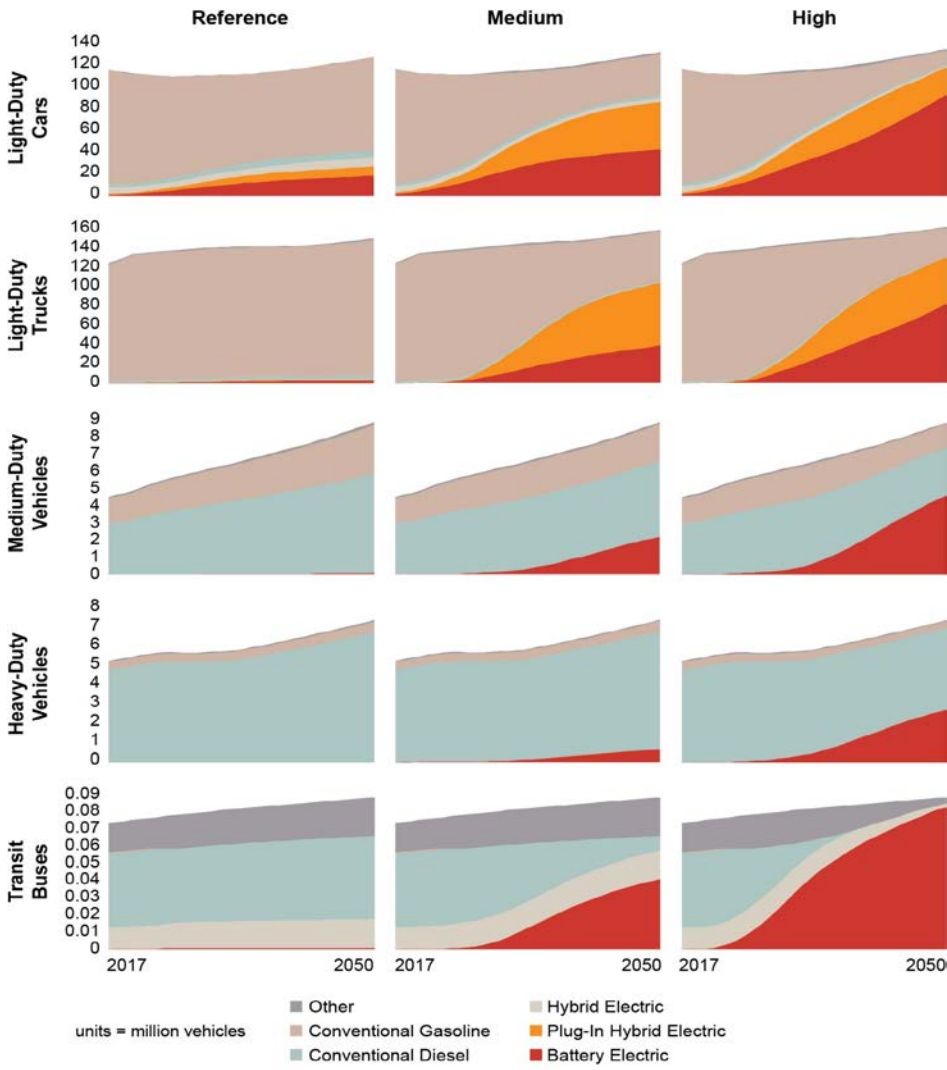
- **Contiguous U.S. energy system**, including transportation, residential and commercial buildings, industry
  - Sectors cover **74% of primary energy in 2015** (79% of energy-related CO_2)
  - Excludes air, petroleum refining and mining, CHP, outdoor cooking

- **Focus on 2050**, but transition modeled as well

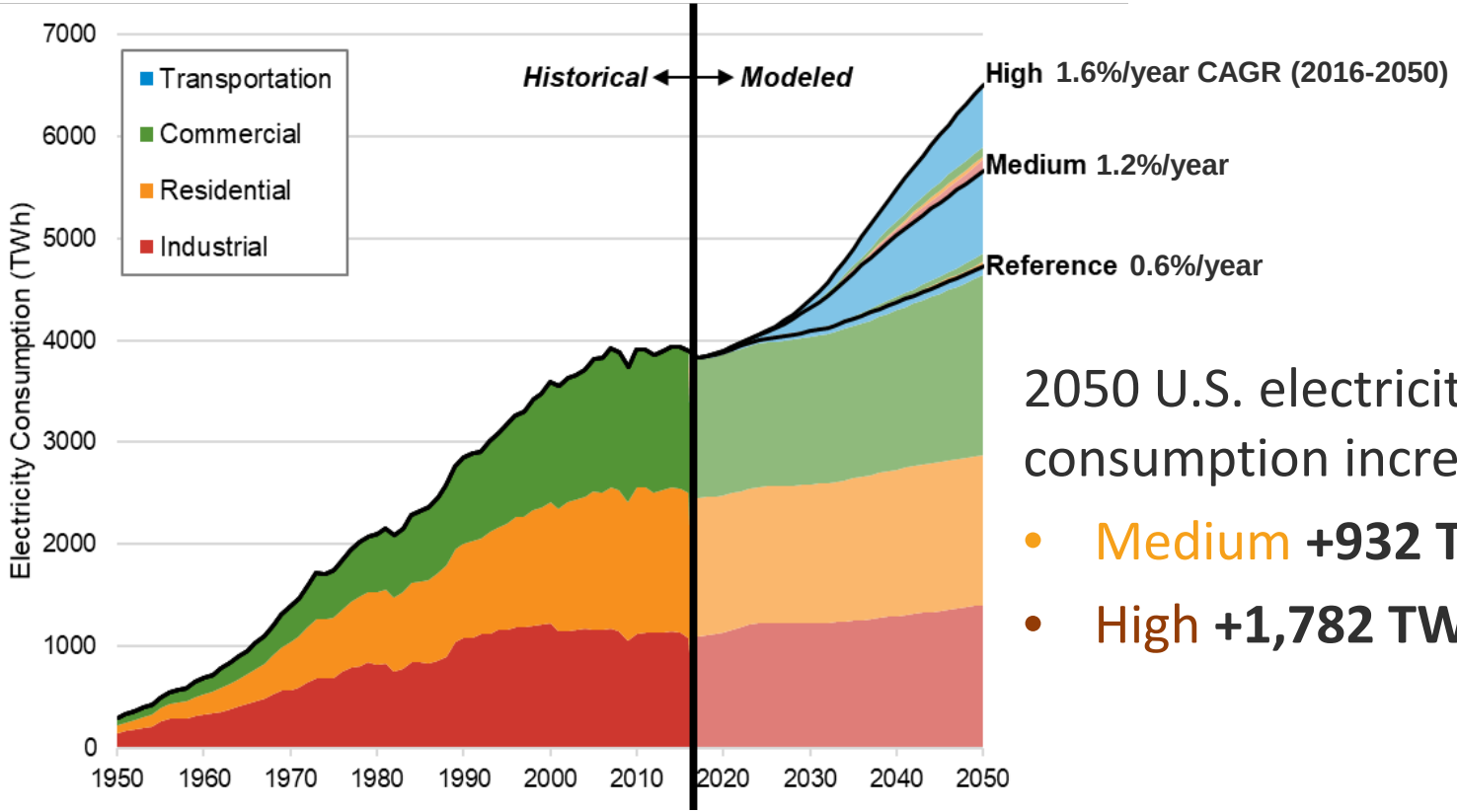


Transportation electrification insights

- **Light-duty plug-in electric cars and trucks** drive the greatest overall electrification impact in all scenarios
- But **electric freight trucks** can play a major role, particularly for short-haul applications and in more transformational scenarios
- **Transit buses** are prime candidates for electrification
- Beyond the transportation sector, air-source **heat pumps** are key electrification technologies



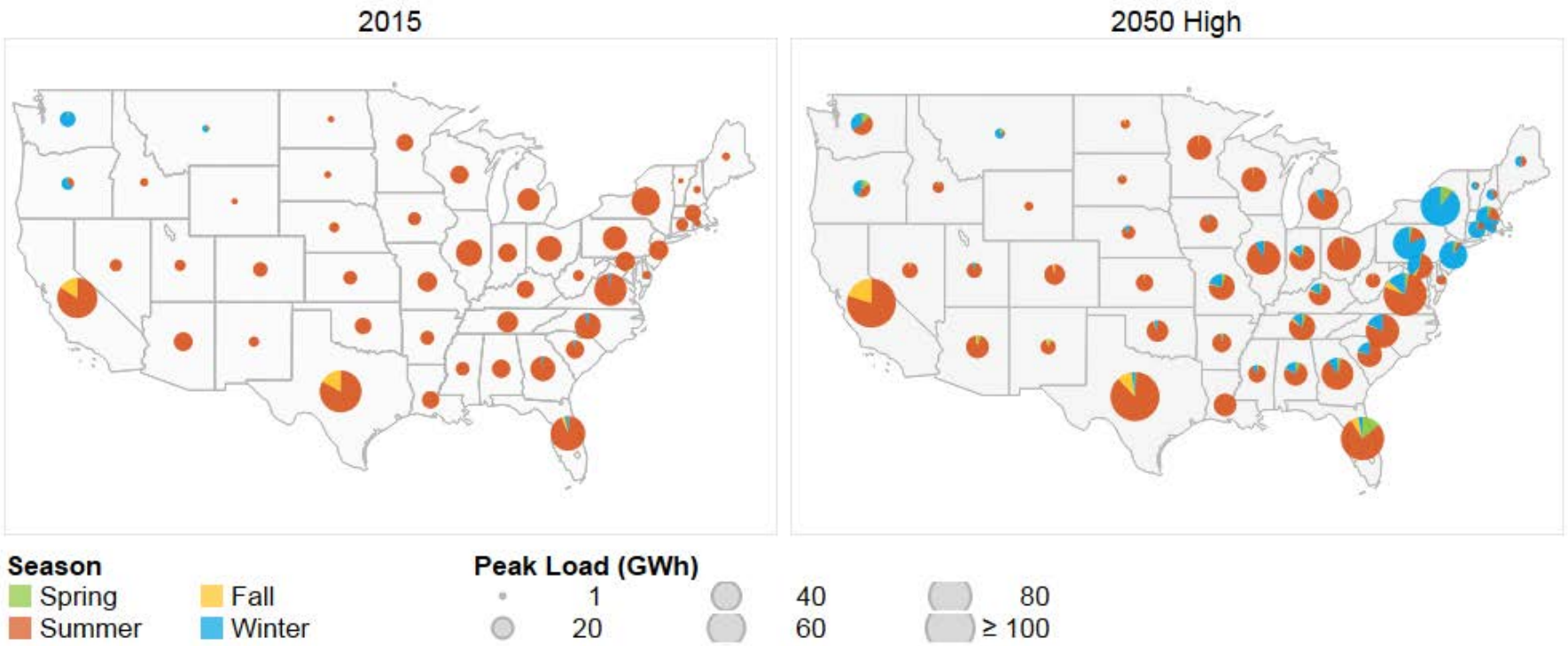
Vehicle electrification dominates incremental growth in **annual** consumption



2050 U.S. electricity consumption increases

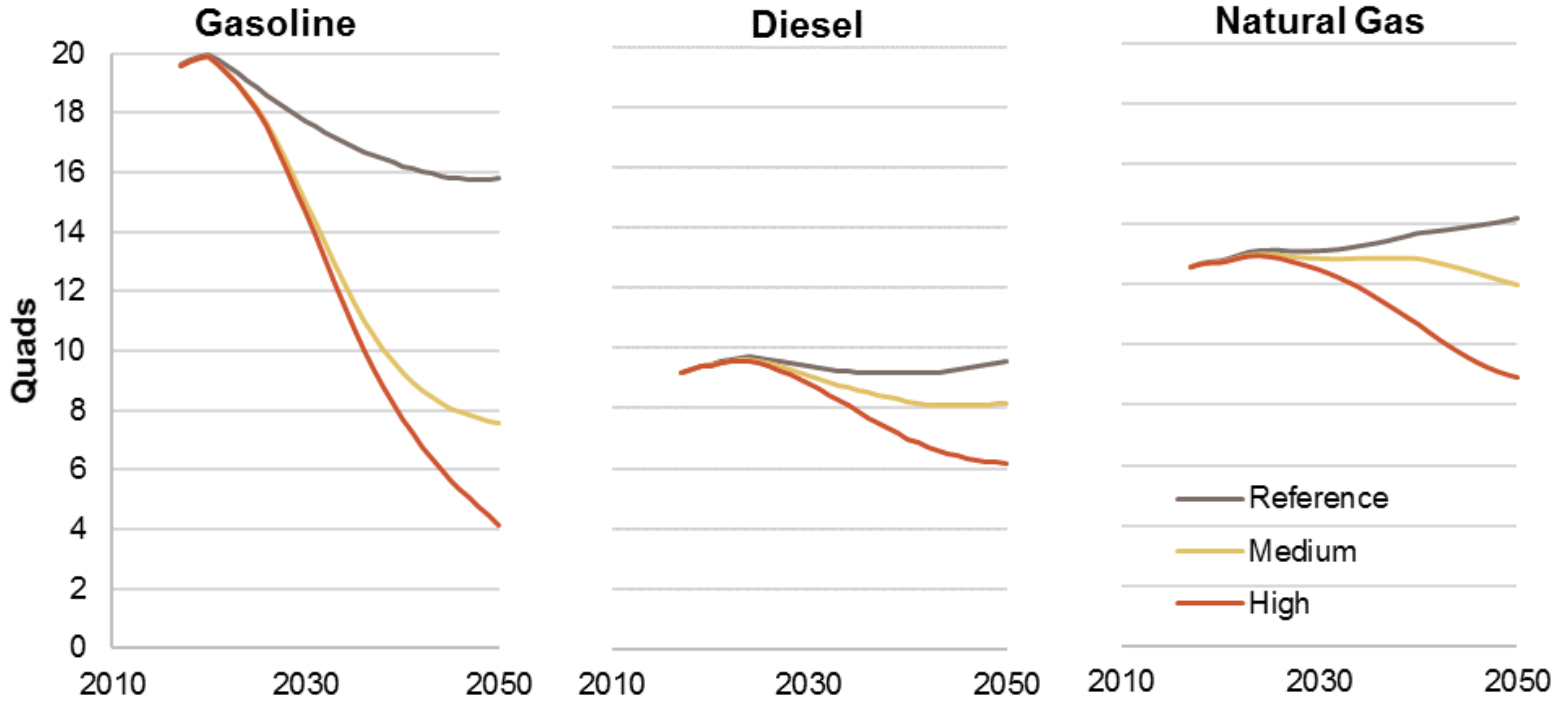
- Medium **+932 TWh (20%)**
- High **+1,782 TWh (38%)**

However, electric space heating more significantly changes the timing and magnitude of **peak demand**



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

Estimated **fuel use** reductions



- Domestic onsite fuel use reductions: **74% gasoline**, **35% diesel**, **37% natural gas** in 2050 (High scenario)

Some key questions in electrification

- Will **EVSE infrastructure** enable or impede electrification?
- How will **ownership models**—for vehicles and chargers—evolve and impact utility planning? How might **utility-controlled charging** and **vehicle-to-grid services** affect energy use and adoption?
- Will new technologies facilitate electrification in **retrofits** and new buildings?
- How might **challenges** to buildings electrification—cultural acceptance, familiarity, landlord-tenant issues—be overcome?
- How might **value streams** through "smart" and "grid-connected" appliances affect consumer adoption?
- Can cost-effective technologies for **high-temperature industrial** applications be developed?
- How might the interplay between **long equipment lifetimes** and manufacturers' profit-driven decisions impact the technology transition rate?

Thank you

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