Developments in Electrification and Implications for the United States Electric Industry
U.S. Department of Energy Perspective

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The mission of the Energy Department is to ensure America’s security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions.
Electrification definitions

**New energy services**
- New technologies
- Smartphones, datacenters

**Same energy service**
- “Fuel switching”
- Heat pumps instead of fuel oil

**Economic growth**
- More demand for the same service
Predicting electricity trends used to be easy…

Historical (1970-2005)

AEO 2005
... but increasing technology performance...
... and efficiency are making it difficult
What does the future look like?

Historical

Electrification?
AEO 2017
Efficiency?
Many studies forecast a significant increase in electricity demand due to end-use electrification. Growth in demand could support electric utilities.

The chart shows the total U.S. generation (TWh) from 1990 to 2050. The data points indicate historical trends and projections from various models (E3, MCS, PNNL, NREL). The chart highlights the projected doubling of electricity demand by 2050 and tripling beyond that.
Newer homes in milder climates are increasingly fully electrified

Percentage of homes by number of fuels used in the home by survey year

- Electric Only
- Electric and 1 other fuel
- Electric and 2+ other fuels

1993 2005 2015
Northeast

1993 2005 2015
Midwest

1993 2005 2015
West

1993 2005 2015
South
Transportation today is almost completely non-electric…

![Transportation Energy Consumption Chart]

Source: EIA, Annual Energy Outlook 2017
...and vehicle electrification is in infancy...

- Residential (44%)
- Commercial (51%)
- Transport (0.2%)

Source: EIA, Monthly Energy Review

*excludes residential EV charging
Electric vehicle miles traveled (eVMTs) show significant growth over the past 3 years. eVMTs in 2014 totaled 3.3 billion miles or 0.1% of total VMTs.
...battery costs are dropping...

Historical

Projected

2014 US$ per kWh

2005  2010  2015  2020  2025  2030

DOE Goal $125/kW

Source: Nykvist et al. (2015)
...and electric car options are expanding rapidly

**Electric-Car Boom**
Models by style and range available through 2020
Significant opportunities exist for electrification through fuel switching

Residential Energy Consumption by End-Use and Fuel-Type (with % Electrified)

- Space Heating: 8%
- Water Heating: 26%
- Electronics: 100%
- Space Cooling: 97%
- Refrigeration: 100%
- Cooking: 32%
- Clothes Dryers: 80%
- Other: 82%

Industrial Process Energy Consumption by End-Use and Fuel-Type (with % Electrified)

- Process Heating: 5%
- Machine Drives: 74%
- Other Process: 12%
- Electro-Chemical: 100%
- Process Cooling: 61%
**Goal:** explore potential & impact of electrification of U.S. economy

**Project Lead:** NREL led collaboration with ORNL, LBNL, EPRI, Evolved Energy Research

**Timeline:** FY17 through FY19, budget depending

**Outcomes:**
- Integrated demand-side model
- Power sector evolution
- Electrification enabled flexibility
- Energy, pollution, water impacts
- Costs: households, system, electricity
EFS – Products & Publications

End-Use (FY18 Q2)
- Technology costs & performance
- Highly resolved demand model (dsgrid)
- Energy consumption under electrification scenarios

Power Sector Impacts
- Electric system evolution
- Electricity consumption patterns
- Operational impact of demand flexibility

Impacts Assessment
- Costs
- Infrastructure
- Pollution and water
EFS – Research Questions

End-Use Services & Technologies

• What end-use services could be electrified?
• To what extent might they plausibly be electrified?
• What are the cost and performance projections for electro-technologies?

Power Sector

• How would national & regional consumption change?
• How would generation evolve to meet electrification?
• How would the grid operate with varying levels of demand flexibility?
• Impacts on existing generators & markets?

Impacts (full scope tdb)

• What are system costs?
• What are environmental impacts – air quality, ghg emissions, water?
THANK YOU