Customer Choice: End-Use Energy

EPRI’s 2018 National Electrification Assessment
Committee on Critical Infrastructure
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External Relations and Technical Resources

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EPRI Study Finds that a Consumer-Driven Increase in Electrification Provides Lower Cost, Less Energy Use, and Fewer Emissions
What is the objective of EPRI’s assessment?

Customer Choices for End-Use Energy:

- Economy-wide assessment - Residential, commercial, industrial and transport
- Customers have broad technology choices and control
- Customer decisions integrated with detailed electricity supply model

Source: EPRI 3002009917
February 2017
Power System Evolution...

PRODUCE CLEAN ENERGY

EVOLVE TO DYNAMIC GRID

ADOPT ELECTRIC END-USES
End Use (Final) Energy Use By Sector

*Excludes upstream and midstream energy use, e.g., power generation, oil and gas extraction, refining, and pipelines*
## EPRI’s US National Electrification Assessment Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONSERVATIVE</strong></td>
<td>Slower Technology Change</td>
<td>• AEO 2017 growth path for GDP and service demands, and primary fuel prices</td>
</tr>
<tr>
<td><strong>REFERENCE</strong></td>
<td>Reference Technology</td>
<td>• EPRI assumptions for cost and performance of technologies and energy efficiency over time</td>
</tr>
<tr>
<td><strong>PROGRESSIVE</strong></td>
<td>Reference Technology + Moderate Carbon Price</td>
<td></td>
</tr>
<tr>
<td><strong>TRANSFORMATION</strong></td>
<td>Reference Technology + Stringent Carbon Price</td>
<td>• Existing state-level policies and targets</td>
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</tbody>
</table>
Efficient Electrification: Reference Scenario

Final Energy

Electricity Demand

TWh

GDP Growth (AEO)

Structural Change (AEO)

Efficiency Improvements

Electrification

Other Non-Electric Energy

Natural Gas

Electric Share

21%

36%

Increased Electricity

Electricity Generation

+32% Growth

2015 → 2050

Electricity Generation

Vehicles

Buildings

Industry

Efficiency Improvements

Electrification

Natural Gas

Electricity

Other Non-Electric Energy

Structural Change (AEO)

GDP Growth (AEO)

2015

2020

2025

2030

2035

2040

2045

2050

Quad Btus Final Energy

TWh Electricity Demand

2015

2020

2025

2030

2035

2040

2045

2050

Electricity Generation

Buildings (before electrification)

Industry (before electrification)

Increased Electricity

Electricity

Natural Gas

Other Non-Electric Energy

Efficiency Improvements

Electrification

Structural Change (AEO)

GDP Growth (AEO)
Efficient Electrification: Transformation (tight carbon target)

**Final Energy**

GDP Growth (AEO)

Structural Change (AEO)

Efficiency Improvements

Electrification

Other Non-Electric Energy

Natural Gas

Electricity

Increased Electricity

Electric Share 21%

47%

Electricity Generation

+52% Growth

2015 → 2050

Vehicles

Buildings

Industry

Increased Electricity (before electrification)

Electricity (before electrification)

Electricity Generation (AEO)
U.S. National Electrification Assessment (USNEA) - Results

**SCENARIO** (Electricity Portion of Final Energy in 2015 & 2050)

- **CONSERVATIVE** (21% & 32%)
  - Total Final Energy: 20%
  - Electric Load: 24%
  - Natural Gas: 33%
  - Economy Wide: 19%

- **REFERENCE** (21% & 36%)
  - Total Final Energy: 22%
  - Electric Load: 32%
  - Natural Gas: 40%
  - Economy Wide: 20%

- **PROGRESSIVE** (21% & 39%)
  - Total Final Energy: 27%
  - Electric Load: 35%
  - Natural Gas: 31%
  - Economy Wide: 57%

- **TRANSFORMATION** (21% & 47%)
  - Total Final Energy: 32%
  - Electric Load: 52%
  - Natural Gas: 18%
  - Economy Wide: 67%
What are the Implications for end-use energy, electricity, CO2 and gas?

**SCENARIO** (Electricity Portion of Final Energy in 2015 & 2050)

**REFERENCE** (21% & 36%)

- Total Final Energy: 22%
- Electric Load: 32%
- Natural Gas: 40%
- Economy Wide: 20%

Overall Economy-wide Energy Efficiency Decreases Total End-Use Energy – Electricity and Natural Gas are a Larger % of End-Use Energy
Overall, cost of end-use energy is less, but the electricity and natural gas components are a larger part of final energy and, thus, a larger part of the energy costs.
Efficient Electrification...Reference Scenario

- Energy-related CO₂ Emissions: 4.6 (1987), 5.3 (2015), $36T (2050)
- Total Final Energy Use: 51 (1987), 61 (2015), 47 Quads (2050)
Energy Efficiency + Cleaner Electricity = Efficient Electrification

Mobility  Heating and Cooling  New Applications
US EV sales exceed 782k through end of February 2018

Other
Nissan
Tesla
BMW
Chevrolet
Ford
PHEV total
BEV total

Number of EVs
- 1
- 2,000
- 4,000
- 6,314

Graph showing the growth of EV sales in the US from December 2010 to December 2017, with a focus on the increase in sales up to the end of February 2018.
Range of battery electric vehicles (BEVs) is also increasing.
Reference Projections for US Light-Duty Vehicles

Service Demand

Final Energy

Efficiency Improvements

Electrification

Liquid Fuels

Electricity

Billion VMT

Quad Btus

2015 2020 2025 2030 2035 2040 2045 2050
Critical Trends – Electric Vehicle

TRANSPORT MARKET PROFILE

44% PERCENTAGE OF FINAL ENERGY

96% PERCENTAGE OF FINAL ENERGY PROVIDED BY FOSSIL FUEL

66% ENERGY CONSUMED BY LIGHT DUTY VEHICLES

SIGNPOSTS

1 POLICY & REGULATION
2 AUTONOMOUS VEHICLE
3 INCREASE IN MODEL OPTIONS
4 EXPANDING PUBLIC INFRASTRUCTURE
5 INNOVATION IN FAST CHARGING
6 LI-ION BATTERY COSTS
Comparison for Final End-Use Energy Sectors

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Percentage of Final Energy</th>
<th>Percentage of Final Energy Provided by Fossil Fuel</th>
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</thead>
<tbody>
<tr>
<td>TRANSPORT</td>
<td>44%</td>
<td>96%</td>
</tr>
<tr>
<td>BUILDINGS</td>
<td>30%</td>
<td>56%</td>
</tr>
<tr>
<td>INDUSTRY</td>
<td>26%</td>
<td>61%</td>
</tr>
</tbody>
</table>
Key Take Away Messages from National Electrification Assessment

**Electrification Trend Continues**
- Driven by technological change and consumer choice, further bolstered by policy

**Efficiency Increases Emissions Decrease**
- Efficient electrification + end-use efficiency lead to falling final energy use

**Natural Gas Use Grows**
- Remains a key fuel for end-use and electric generation

**System Impacts**
- Changing load shapes and new flexible loads create challenges and opportunities
Meeting Future Customer Energy Expectation

Integration can Improve Reliability, Increase Efficiency, Create New Opportunities, and Expand Customer Choice

IEN leads to an increasing societal reliance on electrification and resiliency will be key cyber and physical resiliency against man-made and natural disaster
Critical Trends – Data Analytics/Artificial Intelligence

1. Processing Power
2. Big Data – Sensors and Internet of Things
3. Mainstreaming of Analytics (Machine Learning) Platform

SIGNPOSTS

1. Processing Power
2. Big Data – Sensors and Internet of Things
3. Mainstreaming of Analytics (Machine Learning) Platform
Critical Trends: “Shared” Integrated Grid

Customer Engagement  Connected Devices = Shared Economy  Community Resiliency
Does EPRI’s Research Have Policy Implications?

- Increased Energy-Efficiency
- Cleaner Energy
- Affordable Customer Choice

Will need an economy-wide perspective of final energy use

- Cleaner Energy Production
- Grid Modernization and Protection
- Continuous Technology Advances
- Integrated Regulation, Codes and Standards
- Cost Benefit Models and Metrics
- Market Designs
Efficient Electrification Benefits/Cost Framework… Leveraging Efficiency Cost-Effectiveness Tests…

**KEY QUESTIONS**

- **IS THE PARTICIPANT BETTER OFF?** (PCT)
- **IS RESOURCE EFFICIENCY IMPROVED?** (TRC)
- **ARE RATES LOWERED?** (RIM)
- **ARE SOCIETAL COSTS LOWER?** (SCT)
- **ARE REVENUE REQUIREMENTS LOWERED?** (PAC)

**LEVERAGE EFFICIENCY COST EFFECTIVENESS TESTS…FOCUS ON REGULATORY SUPPORT**
State and Utility Electrification Projects in Development

Are Future Assessments Planned?

CA Project
Start: April 6, 2018

Key – State Project Status
- Green: Funding Commitment
- Yellow: Interested

FOCUS:
- Economics
- Air Quality
- Grid Impact
- Implementation

NY Project
Start: Feb 8, 2018

PA Project
Start: Apr 4, 2018

GA Project
Start: Mar 22, 2018

WI Project
Start: Mar 23, 2018

IL Project
Start: June 2018

Project Start Dates:
- CA Project: April 6, 2018
- PA Project: Apr 4, 2018
- GA Project: Mar 22, 2018
- WI Project: Mar 23, 2018
- IL Project: June 2018
- NY Project: Feb 8, 2018
SAVE THE DATE
AUGUST 20-23, 2018 LONG BEACH, CALIFORNIA

• To gain an understanding of the quantifiable customer and environmental benefits of efficient electrification
• To learn about best practices for implementing efficient electrification programs to maximize customer benefit
• To experience the latest electrification-related technologies in action
• To collaborate with industry, government, and academic leaders

For more information, contact Info@Electrification2018.com
Together...Shaping the Future of Electricity