New National Estimates of State-by-State Energy Efficiency Potential

Danielle Sass Byrnett
U.S. Department of Energy

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Recent State-Level Energy Efficiency Potential Studies

Develop resources to assist in state-level planning

Provide consistent data to complement existing state and utility resources

Where are savings opportunities?

Four pathways to savings across the United States are shown below, with darker blues indicating higher savings potential

**Building Energy Codes**
- Energy codes set minimum efficiency requirements for new and renovated residential and commercial buildings. They are a subset of building codes.

**Combined Heat & Power**
- Combined heat and power is an integrated system that generates electrical energy and efficiently recovers waste heat as useful thermal energy at a customer’s facility, such as a hospital.

**Residential Efficiency**
- Existing single-family detached homes can reduce energy waste by installing insulation, sealing air and duct leaks, and upgrading to more efficient lighting and heating/cooling equipment.

**Industrial Efficiency**
- The manufacturing sector can realize energy savings from improved equipment, processes, or organizational strategies.

12,800 trillion Btu
- Total national energy savings potential (2040)

148,900 MW
- Total national electricity capacity potential (2015)

245,000 GWh
- Total national electricity savings potential (2042)

7,500 trillion Btu
- Total national energy savings potential (2030)

Available at: [energy.gov/eere/slsce/EEopportunities](energy.gov/eere/slsce/EEopportunities)
Capturing Energy Efficiency Savings is Feasible

- 16 states (1/3) achieving ≥1% annual incremental electricity savings
- 15 additional states (2/3 combined) achieving ≥0.4%

### Top 10 States

<table>
<thead>
<tr>
<th>State</th>
<th>2016 net incremental savings, MWh</th>
<th>% of 2016 retail sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>1,569,661</td>
<td>3.00%</td>
</tr>
<tr>
<td>RI</td>
<td>214,329</td>
<td>2.85%</td>
</tr>
<tr>
<td>VT</td>
<td>138,318</td>
<td>2.52%</td>
</tr>
<tr>
<td>WA</td>
<td>1,358,095</td>
<td>1.54%</td>
</tr>
<tr>
<td>CA</td>
<td>3,909,215</td>
<td>1.54%</td>
</tr>
<tr>
<td>CT</td>
<td>442,250</td>
<td>1.53%</td>
</tr>
<tr>
<td>AZ</td>
<td>1,108,273</td>
<td>1.42%</td>
</tr>
<tr>
<td>ME</td>
<td>157,921</td>
<td>1.38%</td>
</tr>
<tr>
<td>HI</td>
<td>124,399</td>
<td>1.32%</td>
</tr>
<tr>
<td>MN</td>
<td>847,830</td>
<td>1.31%</td>
</tr>
</tbody>
</table>

### Share of U.S. electricity generation by resource in 2015

ACEEE, 2016

Energy Efficiency Potential Studies Catalog
Diverse State/Utility Analyses Show 1.0-2.5% Avg. Annual EE Potential

79 Energy Efficiency Potential Studies for 43 States + DC
Grouped by Average Annual Savings Rate for Economic and Achievable Potential

Total Economic Electricity Savings Potential (2016-2035) as Percent of Projected Adjusted Baseline Sales by State

First consistent economic EE potential study across all states: residential, commercial equipment turnover industrial top down

740,985 GWh

National savings: 16%

State-level savings: 12% to 21% per state

26 states with more than 15%

Electricity Savings that could be Achieved through Continuation of Current Approaches (2016-2035) as Percent of Modeled Economic Potential by State

22 states on track to achieve 100% of modeled* economic savings

20 states on track to achieve <50%

*model excludes behavior-based programs, program efficiency; coarse technology improvement

Additional Measures are Nearly Cost-Effective, Esp. Residential

$20/MWh incentive increases 2035 economic potential by 102,848 GWh, to 19%

Impact largest in residential sector
- Economic potential **increased 25%** with $20/MWh incentive for residential sector
  - ex: Television, computers, heat pumps
- Commercial (and industrial) sector economic potential increases 7%
  
  “Incentive” can be proxy for:
  - Lower technology costs
  - Lower program administration costs
  - Higher avoided costs
  - Monetizing co-benefits

Percent Increase Economic Potential (Relative to No Incentive Baseline)

<table>
<thead>
<tr>
<th>Incentive Value ($/MWh)</th>
<th>Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>$5/MWh</td>
<td>0%</td>
</tr>
<tr>
<td>$10/MWh</td>
<td>2%</td>
</tr>
<tr>
<td>$15/MWh</td>
<td>4%</td>
</tr>
<tr>
<td>$20/MWh</td>
<td>14%</td>
</tr>
</tbody>
</table>

$20/MWh incentive increases 2035 economic potential by 102,848 GWh, to 19%
A lot of data!

- 247 passing measure tests for each measure considered

Spreadsheets available at: https://energy.gov/eere/analysis/downloads/state-level-electric-energy-efficiency-potential-estimates-0
Opportunities to Increase Energy Efficiency through Pathways

- Ratepayer-Funded Programs
- Industrial Efficiency
- Combined Heat & Power
- Energy Savings Performance Contracting
- Building Energy Codes
- City-Led Efficiency
State-Level Economic Industrial Energy Savings Estimates (All Fuels)

Estimated Energy Savings by State (2030) from Industrial EE (Trillion Btu)

Total energy savings: 7,500 trillion Btu
State-level energy savings: 2.2 to 1,560 trillion Btu per state

435.8 million MWh electricity savings

Estimated industrial energy consumption by sector, end use & county

Example: Manufacturing Process Heat Intensity

- Based on federal data for manufacturing, agriculture, mining, and construction
Residential Single-Family Detached Housing: Economic Potential

Electricity Savings (2042)

Packages of the most cost-effective (NPV>0) upgrades in each home

Would also save 4,200 trillion Btu of source energy (24% of consumption)

Total electricity savings:
245 million MWh/yr

State-level electricity savings:
0.2 to 22.2 million MWh/yr per state

Savings as Percent of Single-Family Residential Energy Use (%)

8 - 15  16 - 19  20 - 25  26 - 30

Replacing electric furnaces (and ACs) with high-efficiency heat pumps provides the largest economic potential electricity savings nationally.


Total energy savings: 12,824 trillion Btu

State-level energy savings: 19 to 2,269 trillion Btu per state

Learn More: https://energy.gov/eere/slsc/EEopportunities
Building Energy Codes

National Savings (2010-2040):

- $126 billion in energy cost savings
- 12.82 quads of primary energy
- 841 MMT of avoided CO₂ emissions

Additional details available, including a breakout of residential and commercial sector estimates, state estimates, 2010-2030 timeframe, and more:

www.energycodes.gov/about/results (full report)

National potential: 148,936 MW

State-level potential: 228 to 13,675 MW per state

Where is the Remaining Potential for CHP?

- Report includes national summaries and detailed state profiles and tables that include CHP opportunities by
  - Sector
  - Facility type
  - Size range

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**Table 1: Overall CHP Technical Potential in Ohio**

<table>
<thead>
<tr>
<th>Sector Type</th>
<th>&lt;0.1 MW</th>
<th>0.1-1 MW</th>
<th>1-5 MW</th>
<th>5-10 MW</th>
<th>&gt;10 MW</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Topping Cycle CHP</td>
<td>1,186</td>
<td>362</td>
<td>256</td>
<td>129</td>
<td>1</td>
<td>1,863</td>
</tr>
<tr>
<td>Commercial Topping Cycle CHP</td>
<td>4,904</td>
<td>365</td>
<td>551</td>
<td>215</td>
<td>4</td>
<td>6,835</td>
</tr>
<tr>
<td>Gas CHP</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>6,190</td>
<td>433</td>
<td>912</td>
<td>444</td>
<td>5</td>
<td>7,954</td>
</tr>
</tbody>
</table>

**Figure 1: Top Industrial Types with On-Site CHP Technical Potential**

There is 3,981 MW of industrial on-site CHP technical potential in Ohio, primarily in the chemicals, paper, primary metals, food, and refining sectors.

**Table 1:1: Ohio WHIP CHP Technical Potential**

<table>
<thead>
<tr>
<th>Area</th>
<th>CHP Business Type</th>
<th>Total Sites</th>
<th>Total MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Oil and Gas Extraction</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>28</td>
<td>Chemicals</td>
<td>1</td>
<td>2.2</td>
</tr>
<tr>
<td>29</td>
<td>Petroleum Refining</td>
<td>2</td>
<td>8.6</td>
</tr>
<tr>
<td>30</td>
<td>Rubber/Misc Plastics</td>
<td>1</td>
<td>0.02</td>
</tr>
<tr>
<td>32</td>
<td>Stone/Clay/Glass</td>
<td>14</td>
<td>48</td>
</tr>
<tr>
<td>33</td>
<td>Primary Metals</td>
<td>13</td>
<td>371</td>
</tr>
<tr>
<td>37</td>
<td>Transportation Equip</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>58</td>
<td>807</td>
</tr>
</tbody>
</table>

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**Figure 2: Top Commercial Business Types with On-Site CHP Technical Potential**

There is 2,717 MW of commercial, institutional, and multifamily on-site CHP technical potential in Ohio, primarily in the commercial (office) buildings, colleges and universities, hospitals, government buildings, and retail sectors.

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Additional DOE Analyses & Updates Underway / Pending

• Industrial (to county level) --- Spring 2018
• Low income residential --- Winter 2017/2018
• Low rise multifamily --- 2018
• City- / locally-led efficiency --- 2018
• Public buildings (energy savings performance contracting) --- 2018
Get More Information on How Others Have Used EE and Find Resources to Support State Energy Planning

energy.gov/eere/slsc/EEopportunities

- Compilation of energy efficiency potential studies published by states, utilities, and non-governmental organizations between 2007 and 2017.

State-Level EE Potential Studies Catalog

  Includes case studies, expected savings, common protocols, sources of info.

SEE Action Guide for States

- Evaluation, monitoring & verification (EM&V) tools and approaches that can be applied nationally, address EM&V consistency, and are widely recognized.

SEE Action EM&V Portal

- PPT on the basics of power sector capacity expansion modeling that briefly touches on other types of modeling and analytical tools available to provide data on the electric power system, including EE.

Energy Modeling 101 Presentation

- The 2017 USEER State Report provides a demographic and sector analysis of direct energy employment across four categories for each state: power generation, transmission, EE, vehicles.

U.S. Energy & Employment State Report

- Brief synopsis presentation of current DOE programs and resources (documents, tools) by sector that can support program administrators and planners interested in pursuing energy efficiency.

DOE Programs and Resources

- Provides an access point to DOE's technical assistance and cooperative activities with state, local, and tribal officials.

DOE Technical Assistance Gateway
What Next? Review Concise Pathway Presentations (15-20 slides each)

Learn how to access your state's EE potential or use as a starting point for familiarizing stakeholders

*All updated in 2017*

- How energy efficiency programs can support state energy planning
- Building energy codes
- City-led energy efficiency
- Combined heat and power
- Energy savings performance contracting
- Industrial energy efficiency
- Ratepayer-funded energy efficiency
- Residential energy efficiency

Learn how to access your state's EE potential or use as a starting point for familiarizing stakeholders.

energy.gov/eere/slsce/EEOpportunities
Question and Answer

All resources in this presentation are available at energy.gov/eere/slsc/EEopportunities

To Follow Up Further, Contact:

Danielle Sass Byrnett, danielle.byrnett@ee.doe.gov
Kara Podkaminer (DOE/EPRI Multi-sector), kara.podkaminer@ee.doe.gov
Sandy Glatt (Industrial EE), sandy.glatt@ee.doe.gov
Erin Boyd (Residential EE), erin.boyd@hq.doe.gov
Jeremy Williams (Building Energy Codes), jeremiah.williams@ee.doe.gov
Anne Hampson (CHP), anne.hampson@icf.com
National EPRI Study Appendix – Building off the 2014 EPRI National EE Assessment

Based upon the 2014 EPRI national potential study
• Analyzed updated timeframe: 2016-2035
• Updated avoided costs
• Used AEO2012 baseline and technology costs

Key analyses in the updated study:
• State level results disaggregated from national / regional potential
• Benchmark analysis – comparison to historical achievements
• Incentive analysis – potential assessed with $5–$20/MWh incentive

Commercial and Residential Sectors:
• Bottom up, stock turnover model for equipment, tested for cost-effectiveness at end of useful life; estimates controls and shell improvements

Industrial:
• Top down approach, estimating savings with the EIA Plant Energy Profiler tool

Note: excludes behavioral or program efficiency; coarse technology improvement
National EPRI Study Appendix – National Results
740,985 GWh of Cost-effective Electric Energy Efficiency Potential from 2016 to 2035

Figure 3-1
U.S Economic (EP) and High Achievable Potential (HAP) Energy Efficiency, 2016-2035
Figure 3-2
Energy efficiency measures database

- Started in the 2009 EPRI national EE potential study, survey of previous potential studies
- Compared to Database for Energy Efficiency Measures (DEEM) maintained by Global Energy Partners
- Updated over time for 2014 national study

- Future technologies phased in beginning in 2020
- Coarse representation of technology cost decreases, beginning in 2020

\[
\text{CostMultiplier} = \frac{1}{(1 + g)^y}
\]

Where \( g \) is the savings growth rate (1.5%) and \( y \) is the current year minus the base year (2020)

*Full details provided in the appendices of the 2014 report*
Industrial EE Appendix – State-Level Industrial Savings Methodology

- Analysis uses historical growth averages for value of shipments to project economic growth out to 2030 for sectors within each state.
- This projection is combined with energy intensity projections to estimate future state energy consumption for two different scenarios:
  1. The BAU scenario utilizes EIA’s projections in energy efficiency out to 2030; for example, EIA’s industry-wide BAU rate is 1.2%.
  2. The second scenario estimates savings by 2030 if each sector were to double their BAU rate of energy efficiency improvement, which would be 2.4% industry-wide.
- Results indicated 435.8 million MWh in electricity savings and 7,500 trillion Btu in total fuel savings could be achieved by 2030.

To perform the analysis, some assumptions had to be made:
- Fuel consumption for specific 3-4 digit NAICS codes is not available at the state level; therefore, this analysis assumed that the sectors in each state have the same electricity intensity as the national average.
- This analysis assumed that economic growth out to 2030 would be consistent with the historical growth seen in that sector from 2004-2012.
  - We wanted our estimate to utilize a conservative approach in projecting economic growth. Therefore, 2004-2012 was used since economic cycles tend to last approximately 8 years, and this period incorporates a full economic cycle, including both a period of growth and recession.
Industrial EE Appendix – Data Sources

• U.S. Energy Information Administration 2014 Annual Energy Outlook
• Baseline data:
  – For NAICS 21, 23, & 31-33: Value of shipments data from the U.S. Census Bureau 2012 Economic Census
  – For NAICS 11 (Agriculture): Value of shipments data from the U.S. Census Bureau 2012 Survey of Business Owners
• Projecting growth multiplier to 2030:
  – For NAICS 31-33: Annual change in value of shipments data from the U.C. Census Bureau Annual Survey of Manufactures (ASM)
  – For NAICS 11, 21, & 23: Average annual change in Gross Domestic Product (GDP), using data from The U.S. Department of Commerce Bureau of Economic Analysis (BEA)
Residential EE Appendix -- ResStock Improvements and Packages

Data-driven, physics-based simulation of the U.S. single-family detached building stock

using large public and private datasets and modern scientific computing resources

to achieve unprecedented granularity in modeling building energy use and demand

• State level results with potential to add higher resolution to future analysis

• Analysis covers all of the residential fuel types—electricity, natural gas, propane, and fuel oil

Tailored Packages for Each of the 350,000 Representative Homes

Building Energy Codes Appendix -- Methodology

Annual and cumulative projections (2010-2030 and 2010-2040)
- Residential & commercial buildings
- National and state-level perspectives
- Excludes states without statewide codes (AK, HI, KS, MO, MS), or that fundamentally differ from the model codes (CA, OR, WA)
- Some ‘home rule’ states rely on data from populous jurisdictions as a surrogate for state compliance (AZ, CO, WY)
- Residential compliance rates based on recent DOE field studies—commercial based on past DOE and external studies
- Incremental savings are scaled by new floor space to calculate statewide and national savings (AEO 2015)
- Several metrics reported (site, primary, FFC, cost, and CO₂)

*Takes into account all three phases of codes:*
- **Development:** Code-to-code savings—represents potential savings based on updated model codes
- **Adoption:** Future adoption projected based on historical state adoption trends
- **Compliance:** Savings de-rated based on what is achieved in the field
• Technical potential for CHP in U.S. industrial facilities and commercial buildings based on 2015 building stock

• Total U.S. CHP Technical Potential = 240.6 GW at over 291,000 sites
  – Onsite Potential = 148.9 GW
  – Export Potential = 91.7 GW

Technical potential is an estimation of the market size for “topping cycle” CHP, waste heat to power CHP (WHP CHP), and district energy CHP when constrained only by technological limits —without regard to economic or market factors.

To obtain a copy, visit http://energy.gov/chp-potential