Energy-Saving
HOMES, BUILDINGS, & MANUFACTURING

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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

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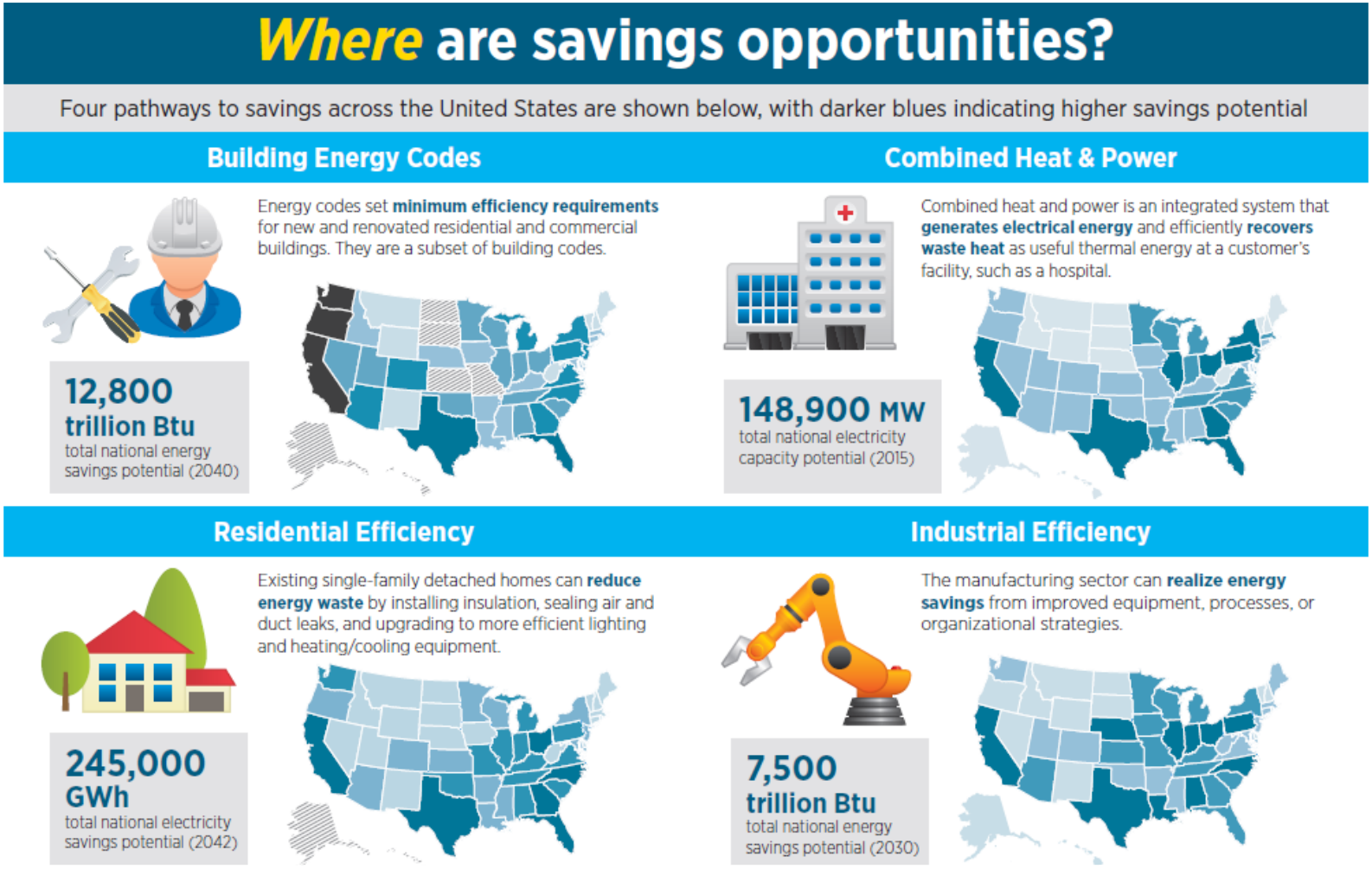
U.S. Department of Energy

October 31, 2017

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



Available at: energy.gov/eere/slsc/EEopportunities

Capturing Energy Efficiency Savings is Feasible

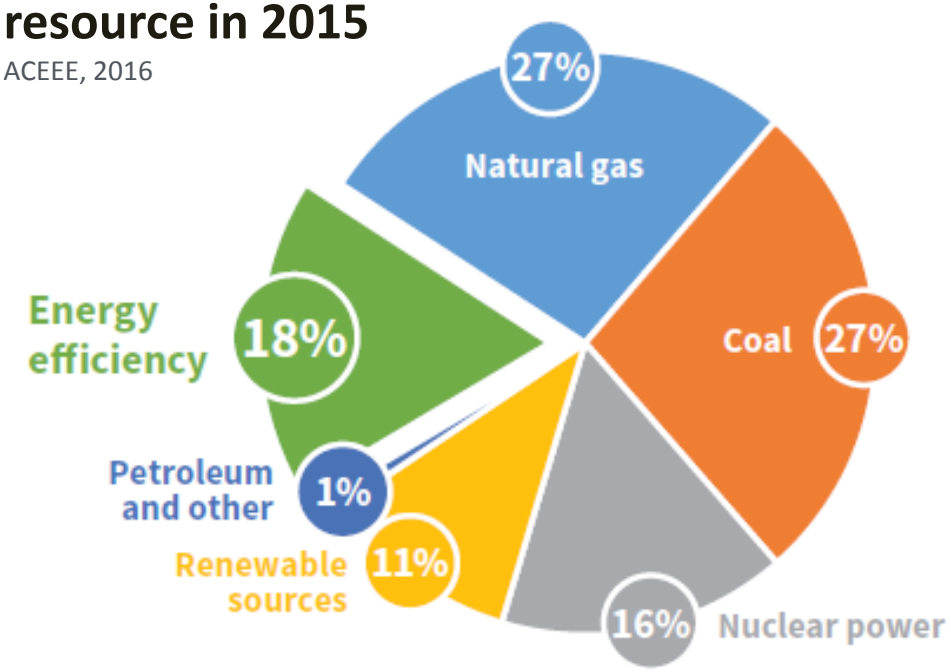
- 16 states (1/3) **achieving** ≥1% annual incremental electricity savings
- 15 additional states (2/3 combined) achieving ≥0.4%

Top 10 States

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

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

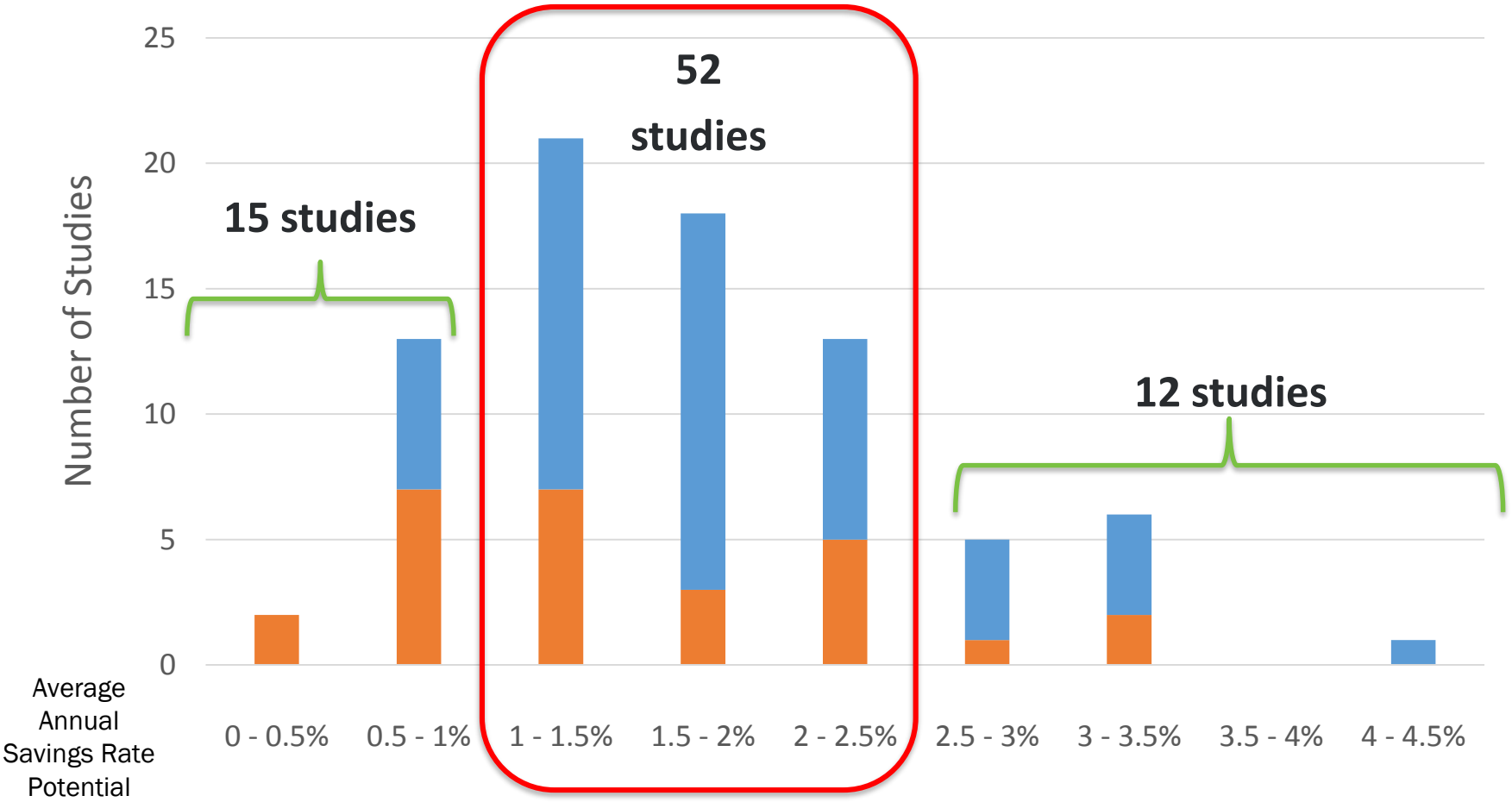
ACEEE, 2016



Sources: ACEEE, 2017, The 2017 State Energy Efficiency Scorecard. ACEEE, 2016, The Greatest Energy Story You Haven't Heard.

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

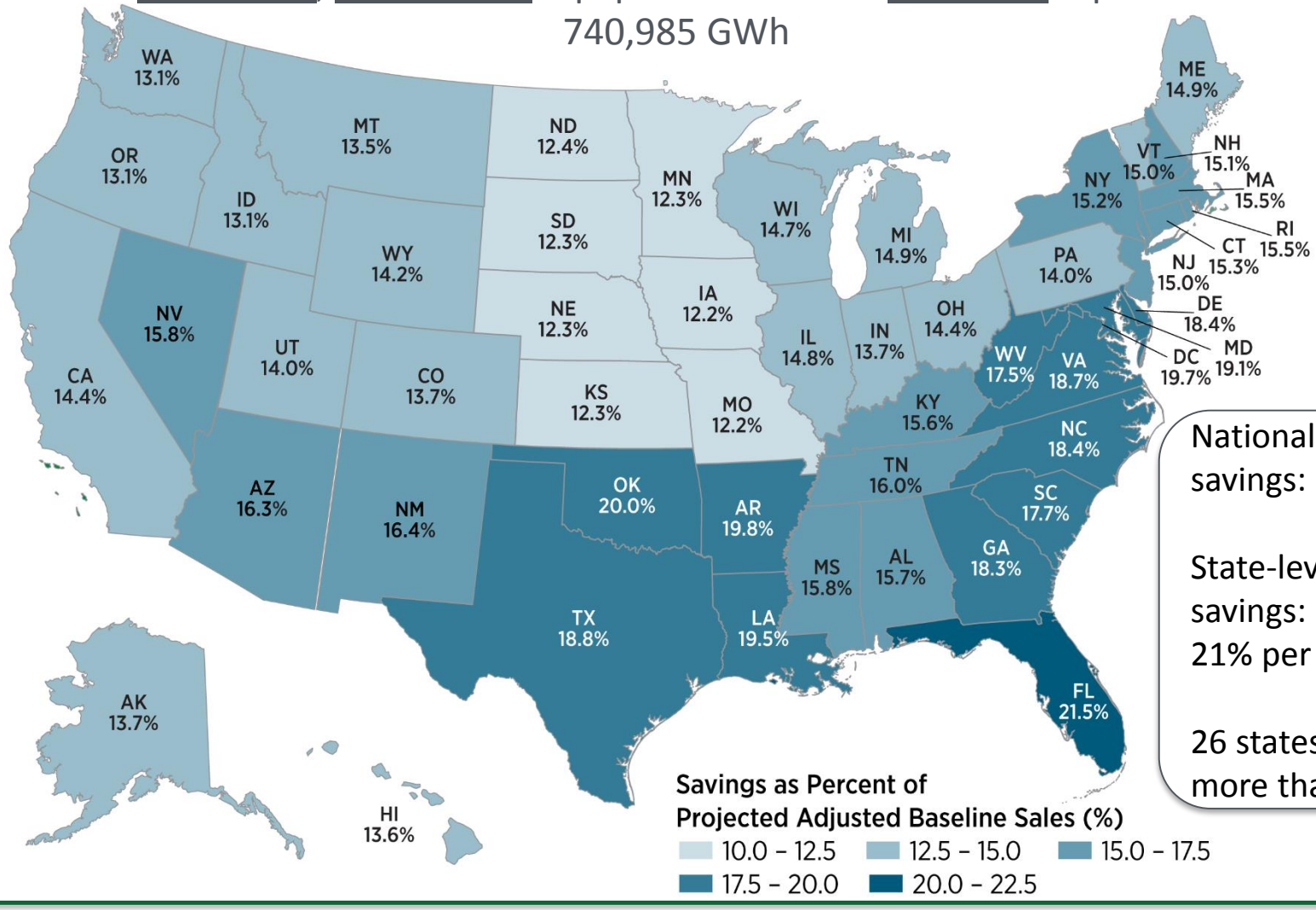
79 Energy Efficiency Potential Studies for 43 States + DC
Grouped by Average Annual Savings Rate for Economic and Achievable Potential



U.S. DOE, 2017, Energy efficiency potential studies catalog.

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



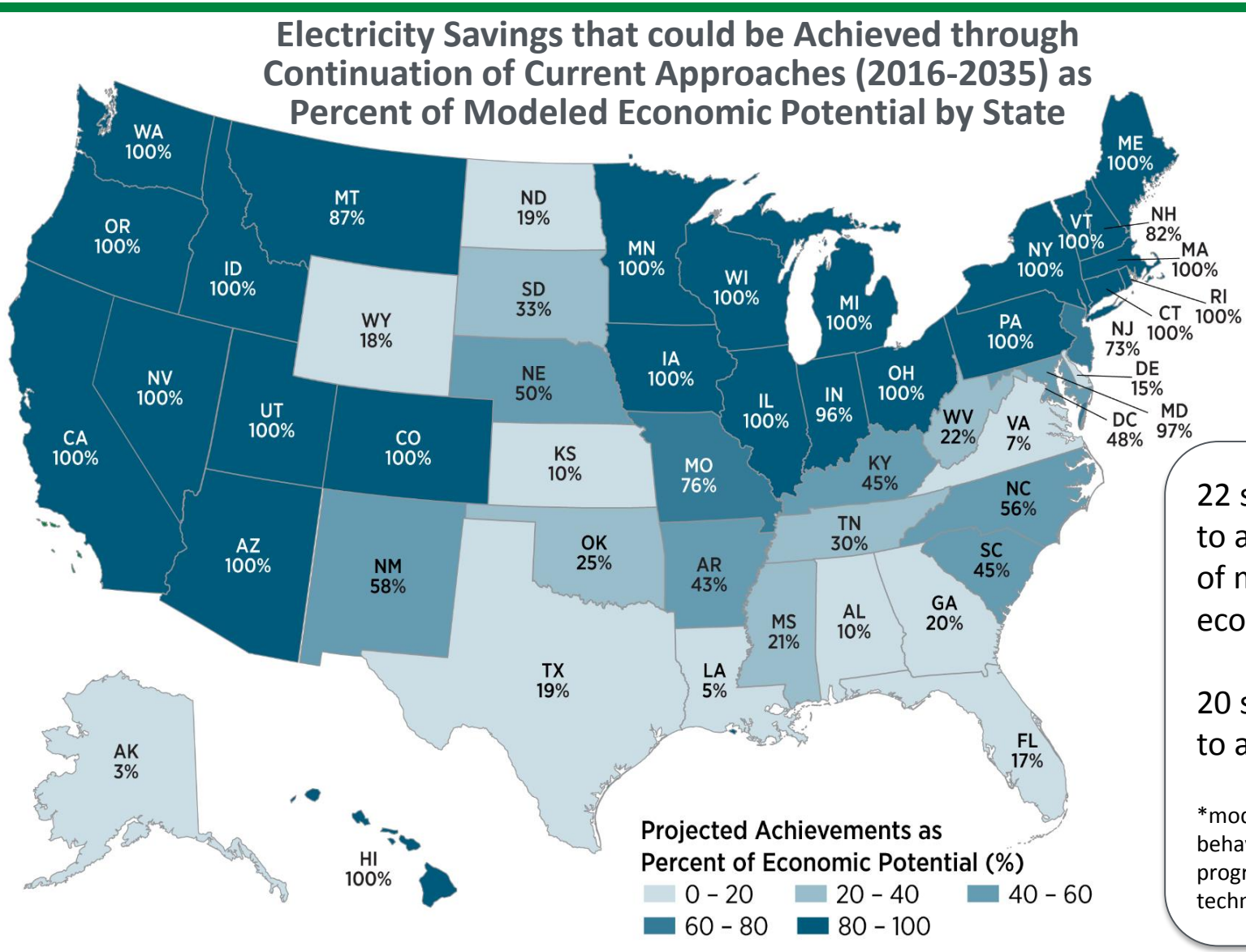
National savings: 16%

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

26 states with more than 15%

Source: Electric Power Research Institute (EPRI), 2017. *State-Level Electric Energy Efficiency Potential Estimates*

State Progress Towards Achieving EE Potential Varies Widely



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

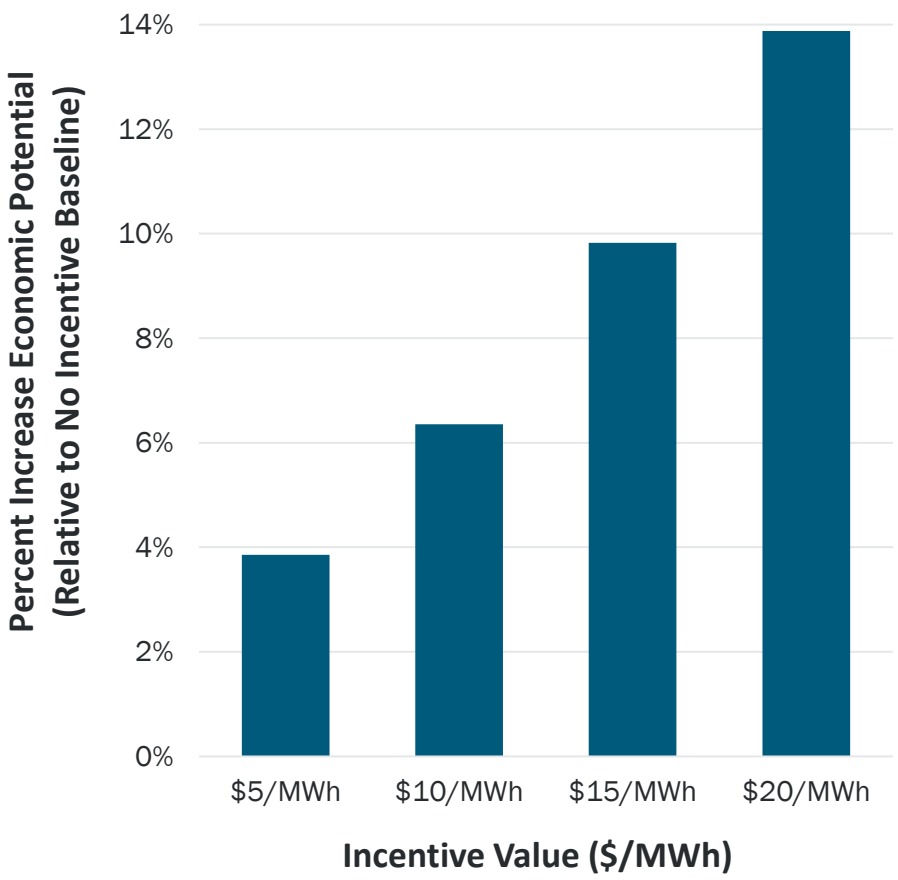
20 states on track to achieve <50%

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

Source: Electric Power Research Institute (EPRI), 2017. *State-Level Electric Energy Efficiency Potential Estimates*. Data on savings rates from ACEEE State Scorecard.

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

See Report for Additional Methodology, Results, Spreadsheets

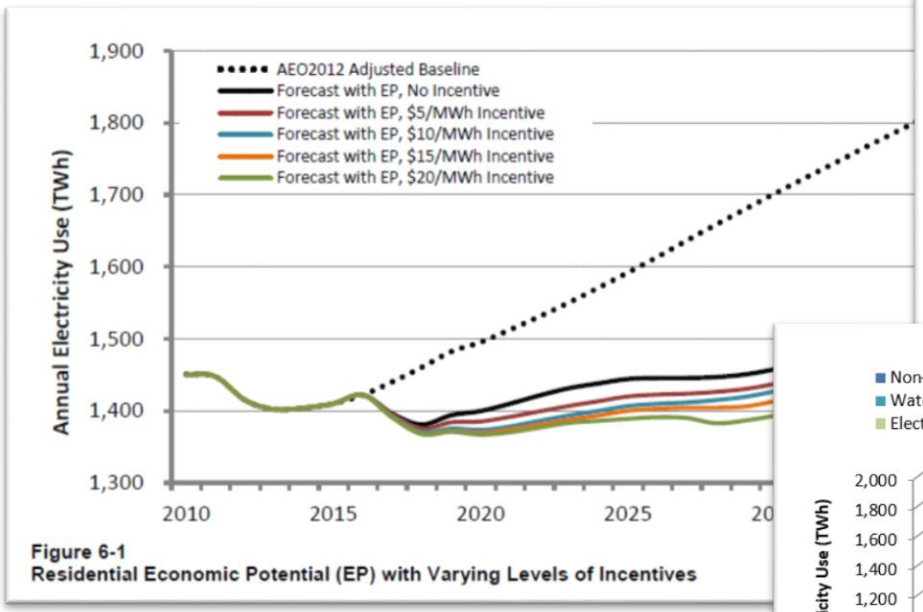


Figure 6-1
Residential Economic Potential (EP) with Varying Levels of Incentives

Table 6-2
Primary Differences in Residential Economic Potential with $20/MWh Incentive

Televisions	• 251% growth in savings relative to base, and 18% of cumulative savings growth. • ENERGY STAR® or better, 43% passing (avoided costs from efficient TV outweigh additional costs including program administration costs) in base case for South Census region, up to 99% passing with $20/MWh incentive. Did not pass at all in other regions in base case, but with $20/MWh incentive, 82% passing in the Midwest Census region—in both regions driven in part by relatively higher electricity use for electronics. • Use of a smart plug strip to eliminate standby power draw has 88% and 66% passing in South and Midwest Census regions respectively in base case. Increases to 100% passing in both with $20/MWh incentive, and 66% and 61% passing in Northeast and West Census regions.
Personal computers	• 88% growth relative to base, and 24% of cumulative savings growth. • ENERGY STAR or better with the following pass rate in each Census region in the base case: 61% Northeast, 65% South, 61% Midwest, and 12% West.

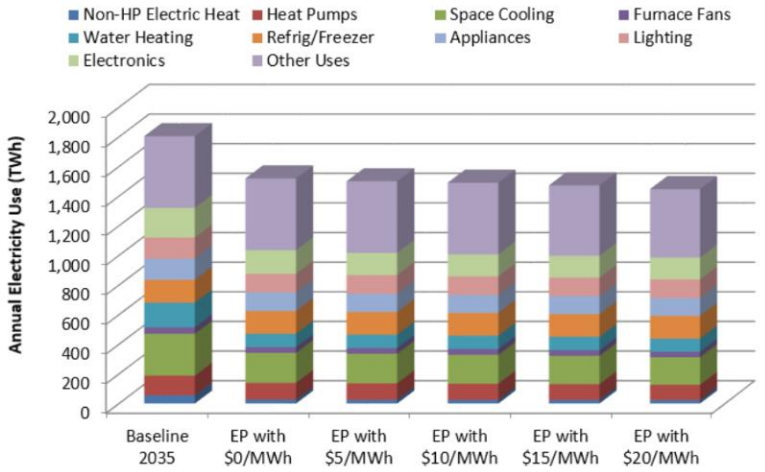


Figure 6-2
U.S. Residential Adjusted Baseline in 2035 and Forecast in 2035 with Impacts on Economic Potential (EP) for the Case without Incentives ($0/MWh) and with Four Levels of Incentives, by End Use

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

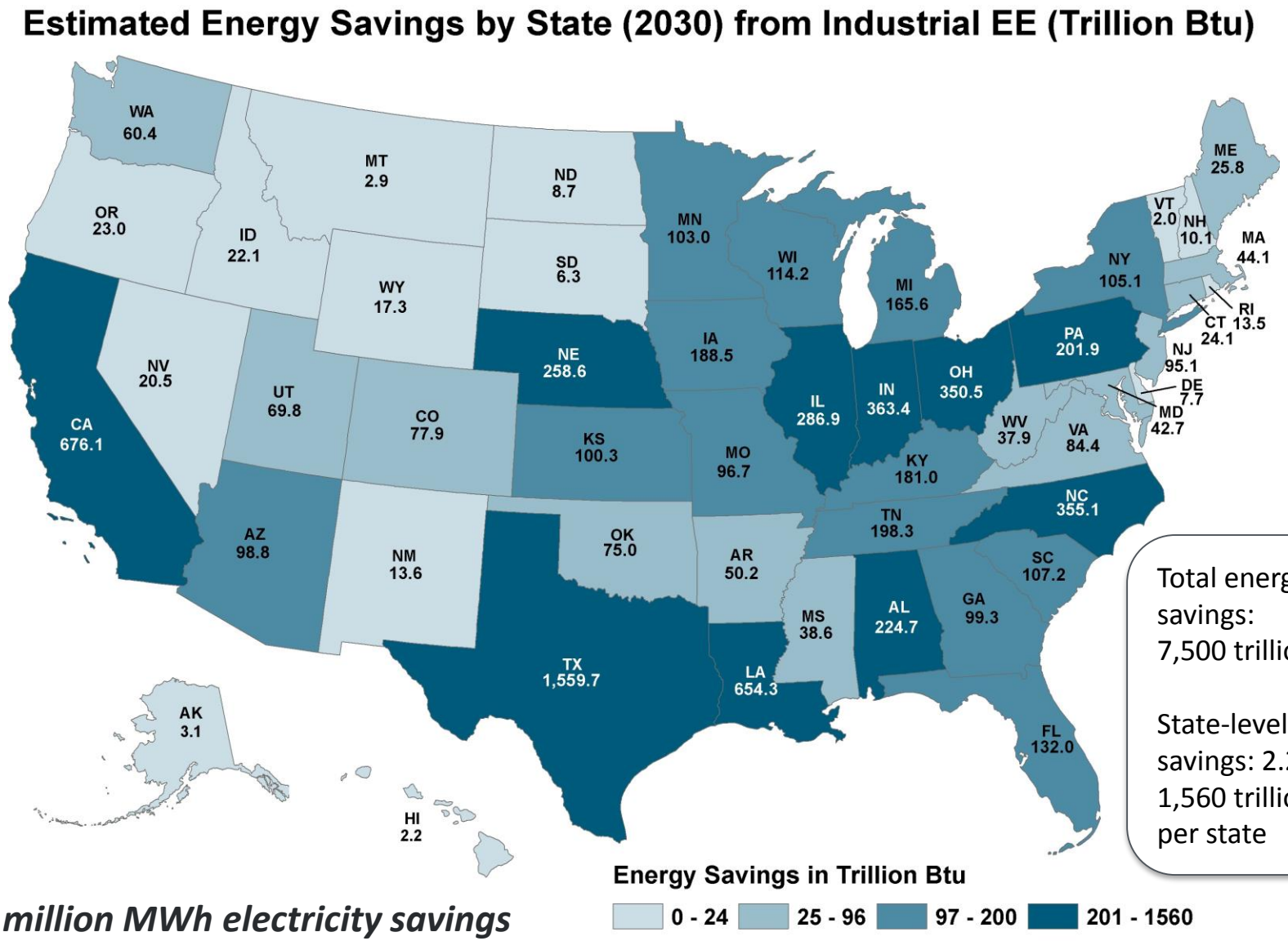
Combined Heat & Power

Energy Savings Performance Contracting

Building Energy Codes

City-Led Efficiency

State-Level Economic Industrial *Energy* Savings Estimates (All Fuels)



Total energy savings:
7,500 trillion Btu

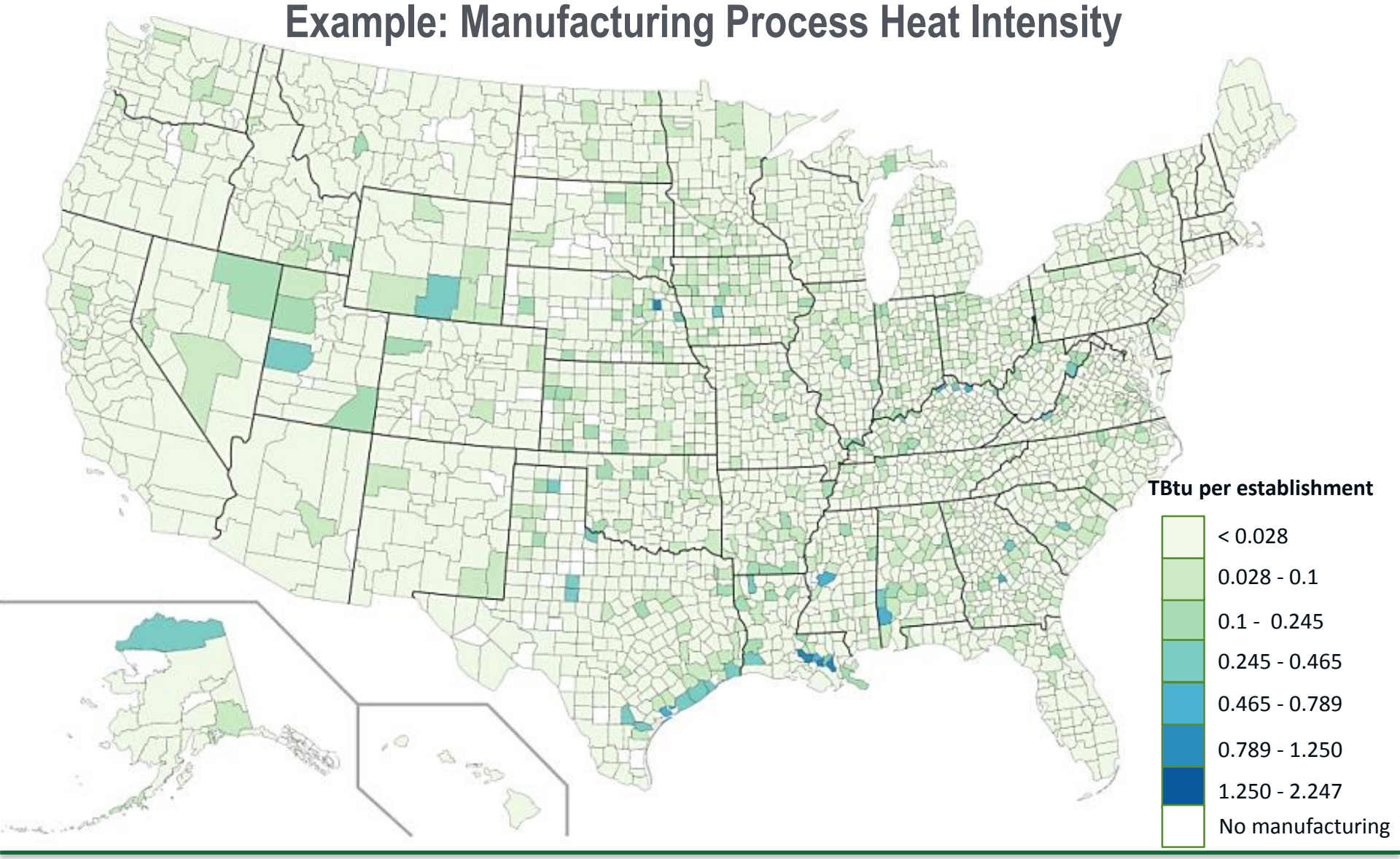
State-level energy savings: 2.2 to 1,560 trillion Btu per state

435.8 million MWh electricity savings

Source: DOE, 2017, energy.gov/eere/slsc/Eeopportunities.

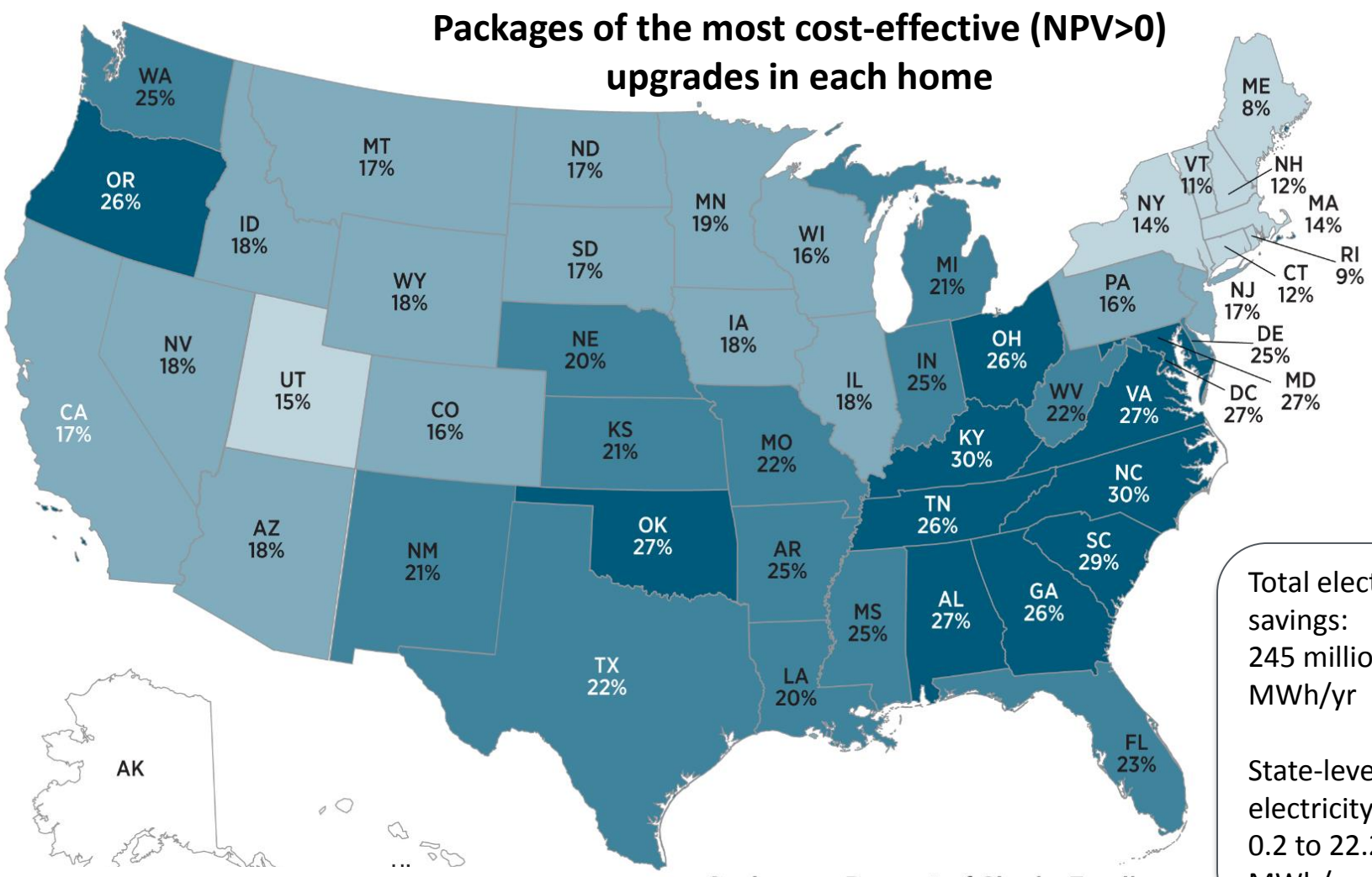
Estimated industrial energy consumption by sector, end use & county

Example: Manufacturing Process Heat Intensity



- Based on federal data for manufacturing, agriculture, mining, and construction
- McMillan, et al. "Industrial Energy Tool," NREL (public tool/paper, early 2018)

Residential Single-Family Detached Housing: Economic Potential
Electricity Savings (2042)



Total electricity savings: 245 million MWh/yr

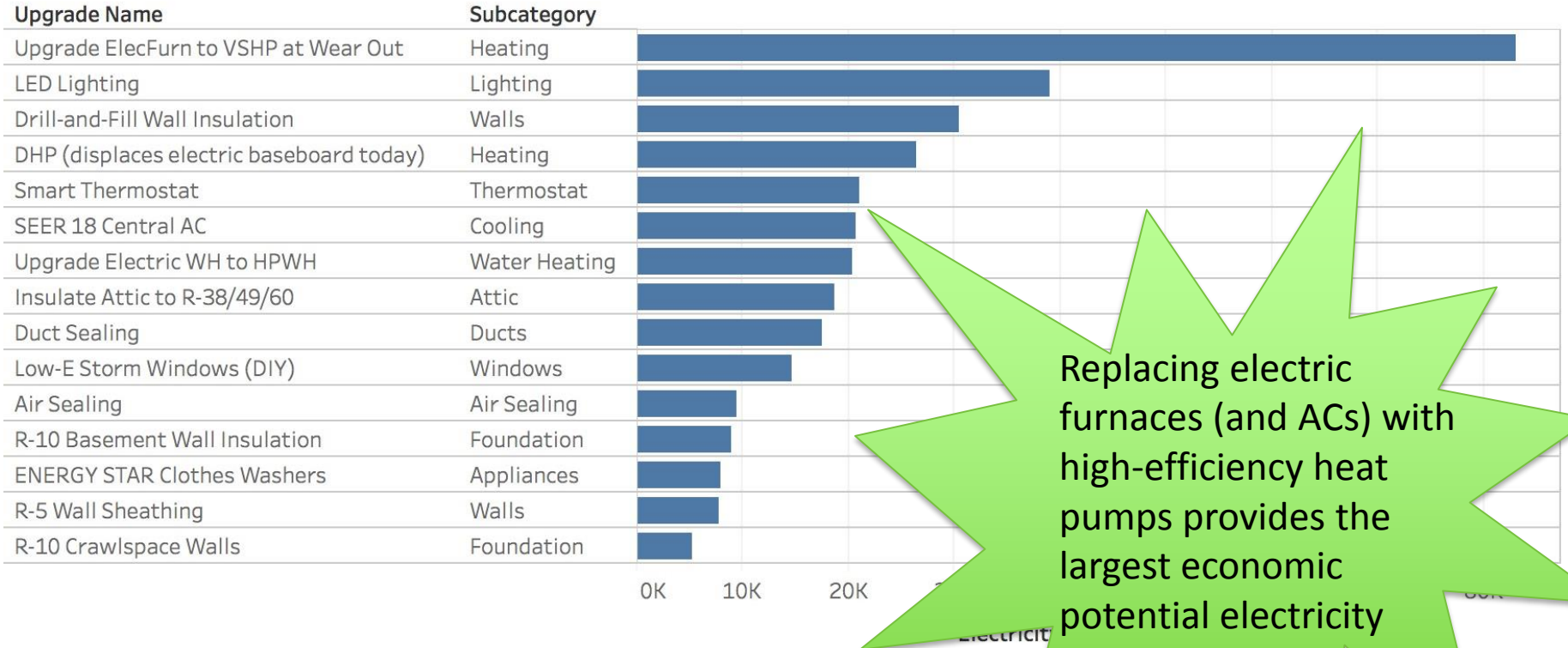
State-level electricity savings: 0.2 to 22.2 million MWh/yr per state

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

NREL, 2017. *Electric End-Use Energy Efficiency Potential in the U.S. Single-Family Housing Stock*, http://www.nrel.gov/docs/fy17osti/65667.pdf

Individual Improvements -- Economic Potential Electricity Savings

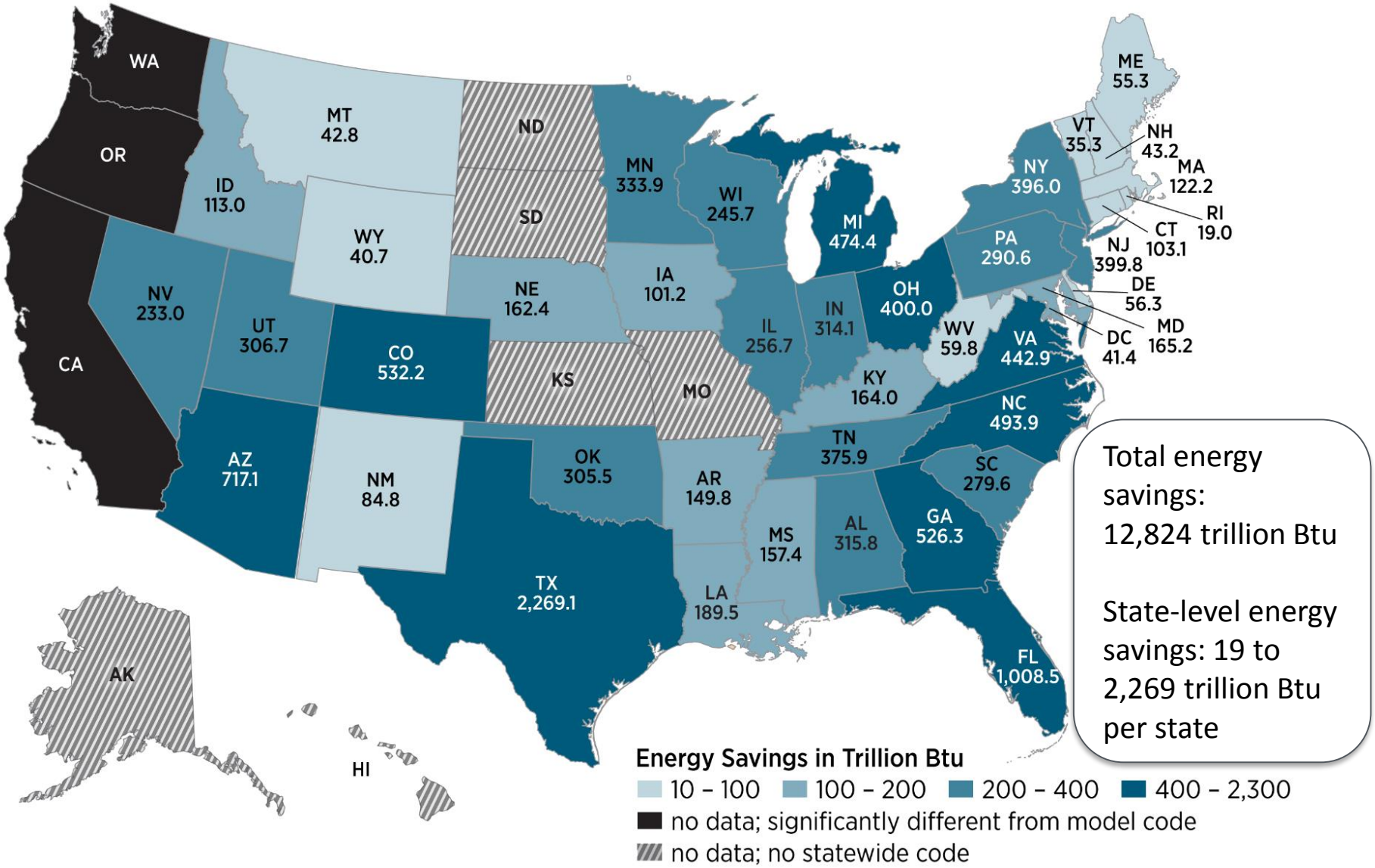
Efficiency Improvements with the Highest Cost-Effective Savings Potential Nationally (positive NPV)



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

See Report for Additional Methodology, Results, State Fact Sheets, etc.

Estimated Achievable Potential *Energy* Savings by State (2010-2040) Building Energy Codes (Trillion Btu) Res. & Comm. Bldgs.



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

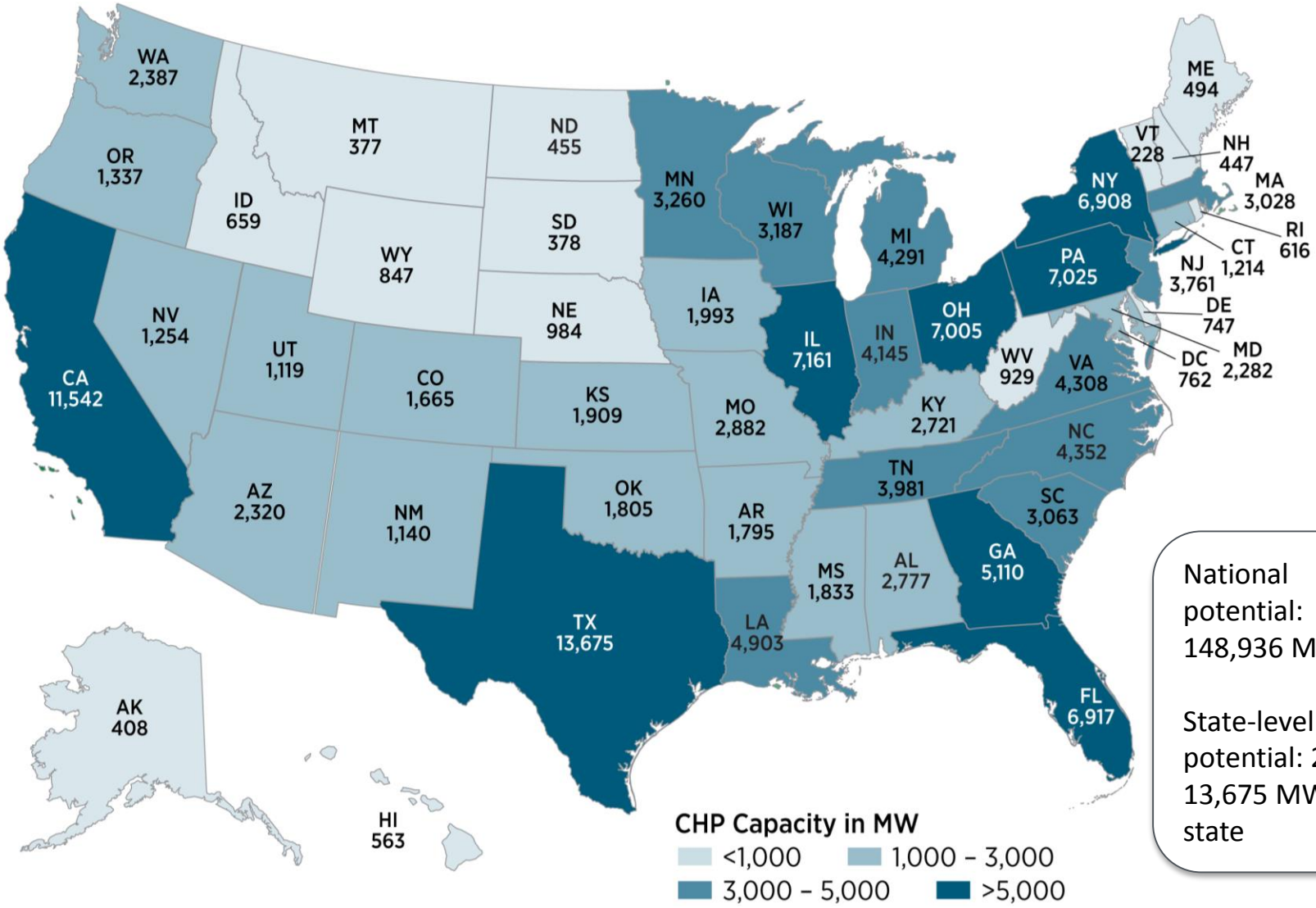
National Savings (2010-2040):

- **$126 billion** in energy cost savings
- **12.82 quads** of primary energy
- **841 MMT** of avoided CO_2 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)

Estimated On-Site Technical Potential by State from Combined Heat and Power (CHP) (MW) Ind. & Comm. Bldgs.



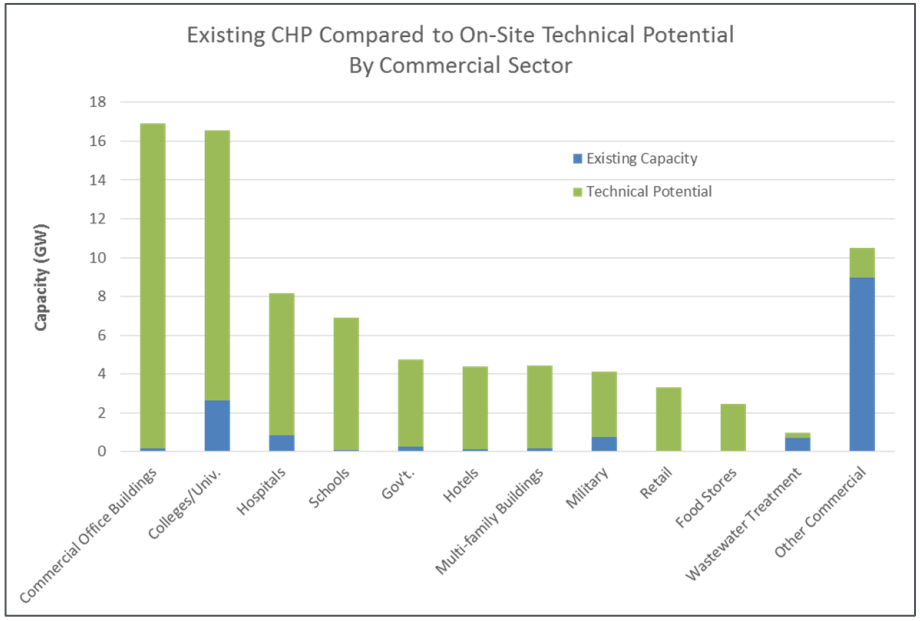
National potential: 148,936 MW

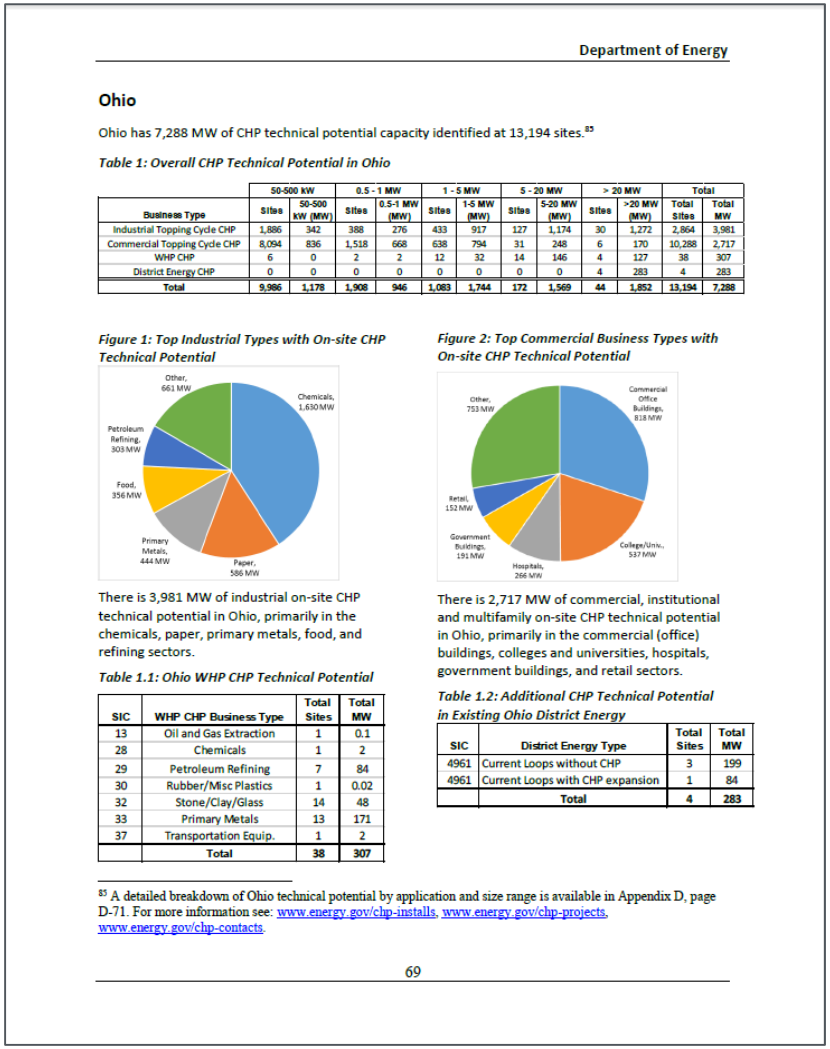
State-level potential: 228 to 13,675 MW per state

U.S. DOE, 2016, *Combined Heat and Power (CHP) Technical Potential in the United States*, http://energy.gov/chp-potential

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





Department of Energy

Ohio

Ohio has 7,288 MW of CHP technical potential capacity identified at 13,194 sites.[85]

Table 1: Overall CHP Technical Potential in Ohio

Business Type	50-500 kW Sites	50-500 kW (MW)	0.5 - 1 MW Sites	0.5-1 MW (MW)	1 - 5 MW Sites	1-5 MW (MW)	5 - 20 MW Sites	5-20 MW (MW)	> 20 MW Sites	>20 MW (MW)	Total Sites	Total MW
Industrial Topping Cycle CHP	1,886	342	388	276	433	917	127	1,174	30	1,272	2,864	3,981
Commercial Topping Cycle CHP	8,094	836	1,518	668	638	794	31	248	6	170	10,288	2,717
WHP CHP	6	0	2	2	12	32	14	146	4	127	38	307
District Energy CHP	0	0	0	0	0	0	0	0	4	283	4	283
Total	9,986	1,178	1,908	946	1,083	1,744	172	1,569	44	1,852	13,194	7,288

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.

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.

Table 1.1: Ohio WHP CHP Technical Potential

SIC	WHP CHP Business Type	Total Sites	Total MW
13	Oil and Gas Extraction	1	0.1
28	Chemicals	1	2
29	Petroleum Refining	7	84
30	Rubber/Misc Plastics	1	0.02
32	Stone/Clay/Glass	14	48
33	Primary Metals	13	171
37	Transportation Equip.	1	2
	Total	38	307

Table 1.2: Additional CHP Technical Potential in Existing Ohio District Energy

SIC	District Energy Type	Total Sites	Total MW
4961	Current Loops without CHP	3	199
4961	Current Loops with CHP expansion	1	84
	Total	4	283

[85] A detailed breakdown of Ohio technical potential by application and size range is available in Appendix D, page D-71. For more information see: www.energy.gov/chp-installs, www.energy.gov/chp-projects, www.energy.gov/chp-contacts.

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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

State-Level EE Potential Studies Catalog

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

SEE Action Guide for States

- Energy Efficiency as a Least-Cost Strategy to Reduce Greenhouse Gases and Air Pollution, and Meet Energy Needs in the Power Sector Includes case studies, expected savings, common protocols, sources of info.

SEE Action EM&V Portal

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

Energy Modeling 101 Presentation

- 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.

U.S. Energy & Employment State Report

- 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.

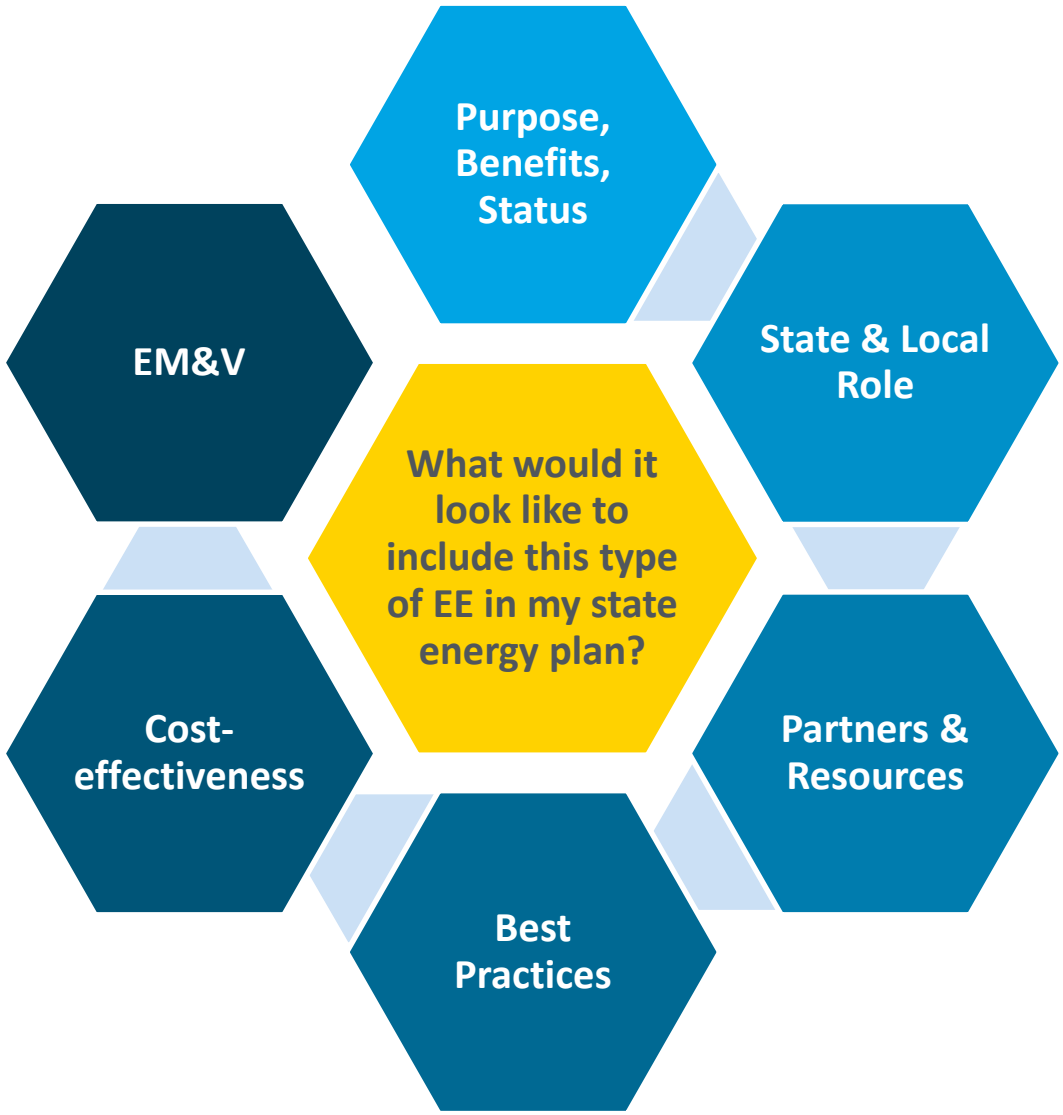
DOE Programs and Resources

- 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 Technical Assistance Gateway

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

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**

energy.gov/eere/slsc/EEopportunities

Question and Answer

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

To Follow Up Further, Contact:

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APPENDIX

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

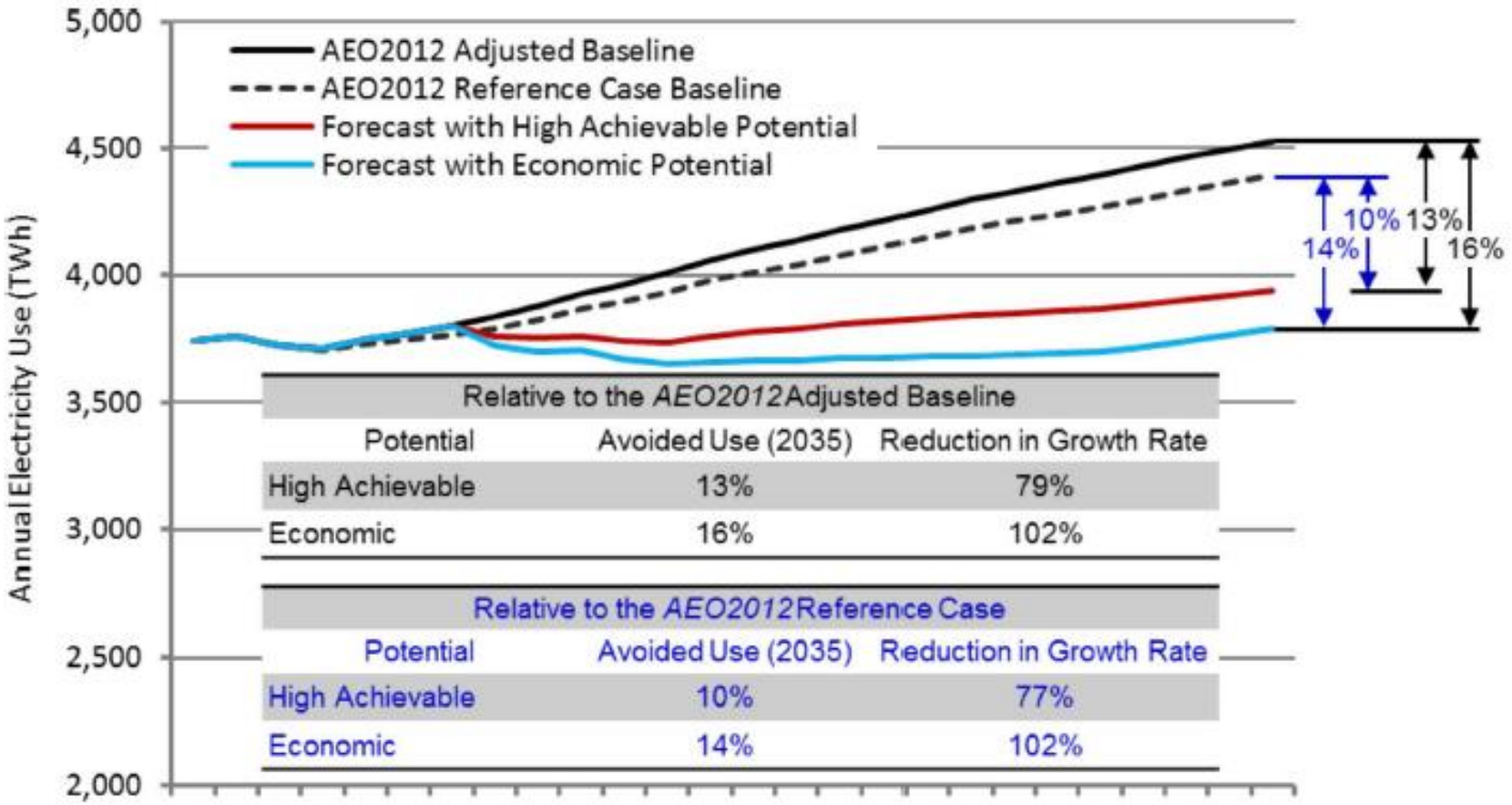
Industrial:

- 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



Relative to the *AEO2012* Adjusted Baseline		
Potential	Avoided Use (2035)	Reduction in Growth Rate
High Achievable	13%	79%
Economic	16%	102%

Relative to the *AEO2012* Reference Case		
Potential	Avoided Use (2035)	Reduction in Growth Rate
High Achievable	10%	77%
Economic	14%	102%

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

National EPRI Study Appendix – National Results by Sector

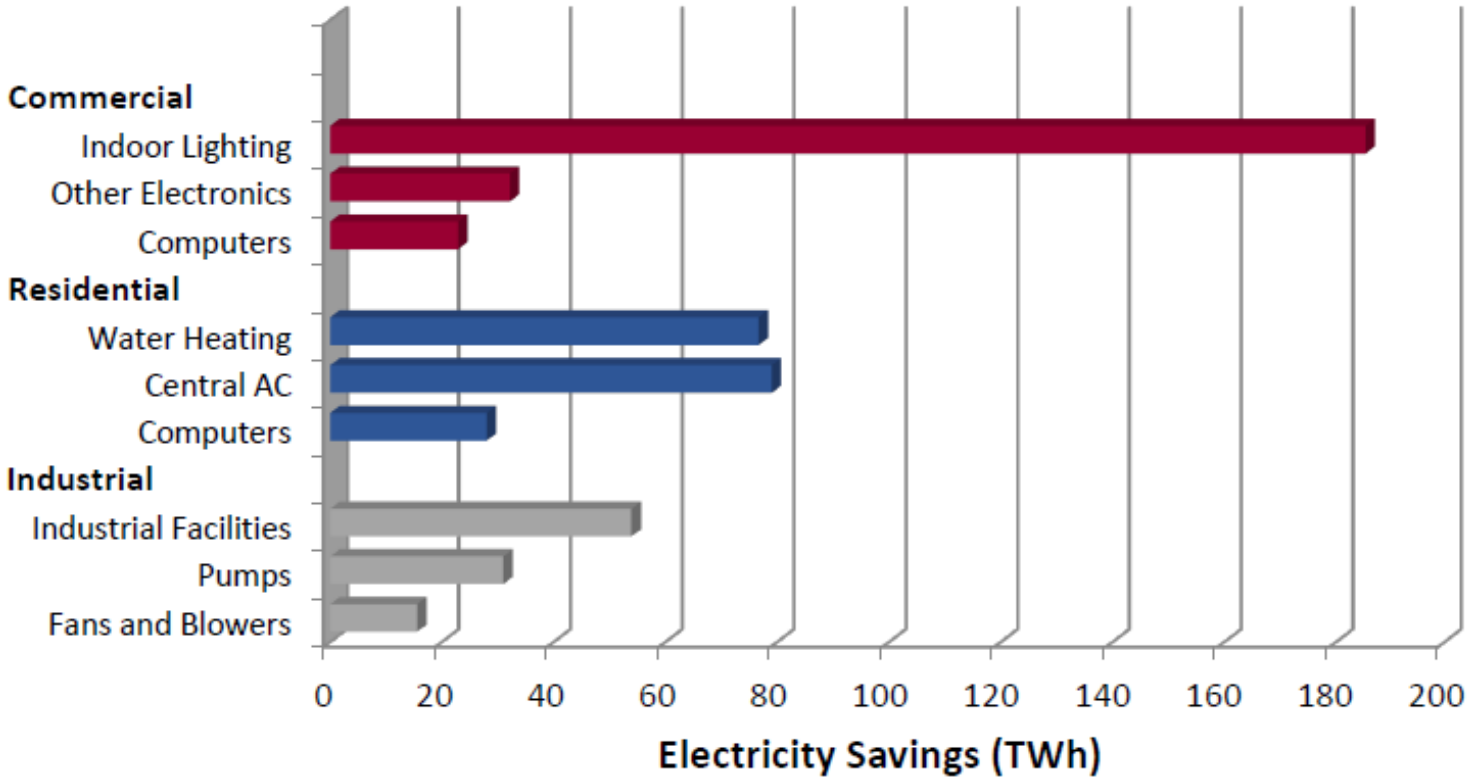


Figure 3-2
Top Three End Uses in Each Sector for Economic Potential (EP) Energy Savings, 2035

National EPRI Study Appendix – EPRI Model
Performance and Cost Assumptions

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

$$CostMultiplier = \frac{1}{(1+g)^{y}}$$

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

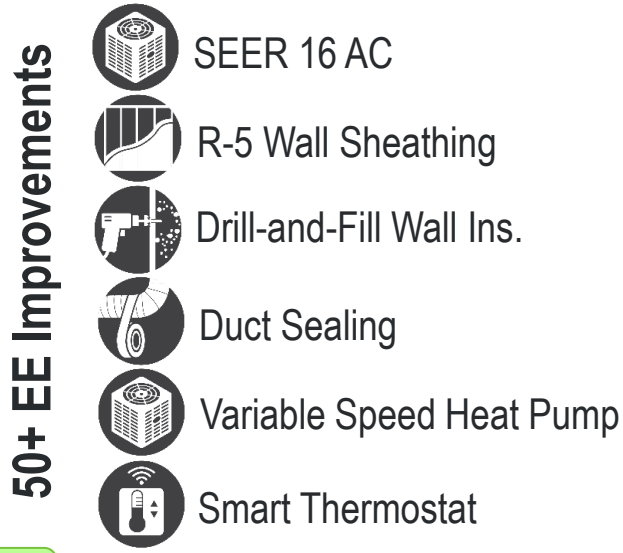
- U.S. Energy Information Administration 2014 Annual Energy Outlook
- Baseline data:
  - For NAICS 21, 23, & 31-33: Value of shipments data from the U.S. Census Bureau 2012 Economic Census
  - For NAICS 11 (Agriculture): Value of shipments data from the U.S. Census Bureau 2012 Survey of Business Owners
- 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



Tailored Packages for Each of the 350,000 Representative Homes

- 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

Full Report: Electric End-Use Energy Efficiency Potential in the U.S. Single-Family Housing Stock

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 CO_2)

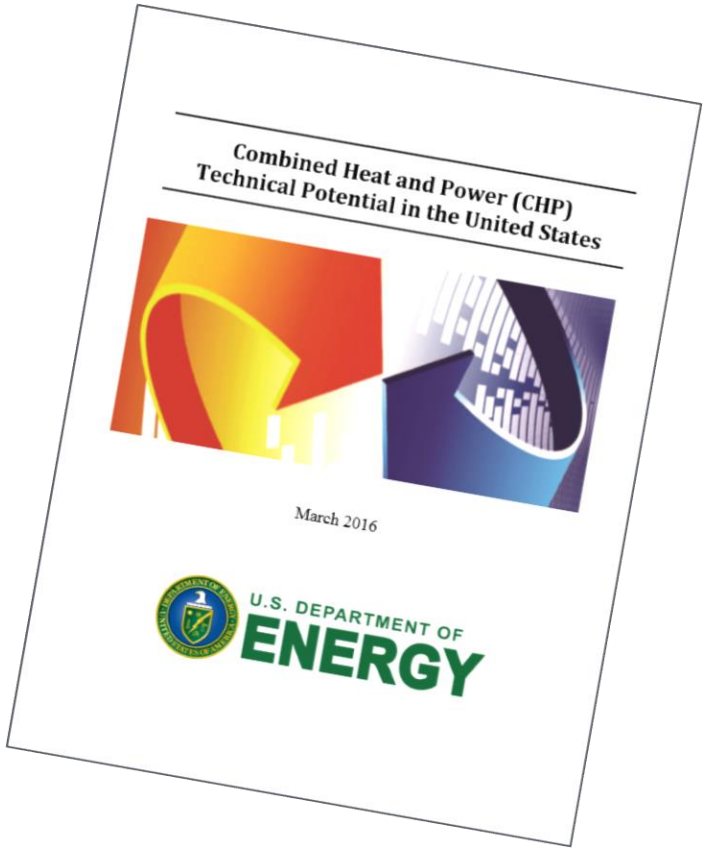
Takes into account all three phases of codes:

- **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

CHP Appendix -- Technical Potential Approach

- 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