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Peak Demand Savings from Efficiency: Opportunities and Practices

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Authors

Frick, Natalie Mims

Murphy, Sean

Miller, Cesca

et al.

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Peak Demand Savings from Efficiency: Opportunities and Practices

Natalie Mims Frick, Sean Murphy, and Cesca Miller

Additional contributions: Greg Leventis, Kristina LaCommare, Chuck Goldman and Lisa Schwartz
Electricity Markets and Policy Department

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Acronyms

Commercial and industrial	C&I
Cost of saving electricity	CSE
Cost of saving peak demand	CSPD
Heating, Ventilation and Air-Conditioning	HVAC
Energy Information Administration	EIA
Program administrator	PA

Contents

- Summary
- Project Background
- Project Approach
- Results
 - ▣ Program Level Peak Demand Impacts
 - ▣ Cost of Saving Peak Demand and Cost of Saving Energy by State, Market Sector and for Select Programs
 - ▣ Cost of Saving Peak Demand Using a Standard Peak Period
- Opportunities to Improve and Standardize Peak Demand Reporting
- Potential Future Analysis
- Appendix



Summary



Context

- State public utility commissions, utility resource planners, efficiency utility/program administrators and implementers are increasingly interested in peak demand reductions from electricity efficiency programs to ensure electricity system reliability at the most affordable cost.
- In November 2019, Berkeley Lab published a [first of its kind analysis](#) on the *first-year cost to program administrators* (PAs) of peak demand reductions from efficiency programs funded by utility customers.
- This new study explores the **levelized cost of saving peak demand (CSPD) for PAs*** and introduces a new typology, informed by interviews with states, for consideration when reporting efficiency program impacts.
- The findings improve understanding of what energy efficiency programs produce peak demand savings and the cost of saving a kilowatt.
- The analysis also provides updated values for the PA levelized cost of saving electricity (CSE) to inform savings potential and design and implementation of efficiency programs and resource adequacy planning.

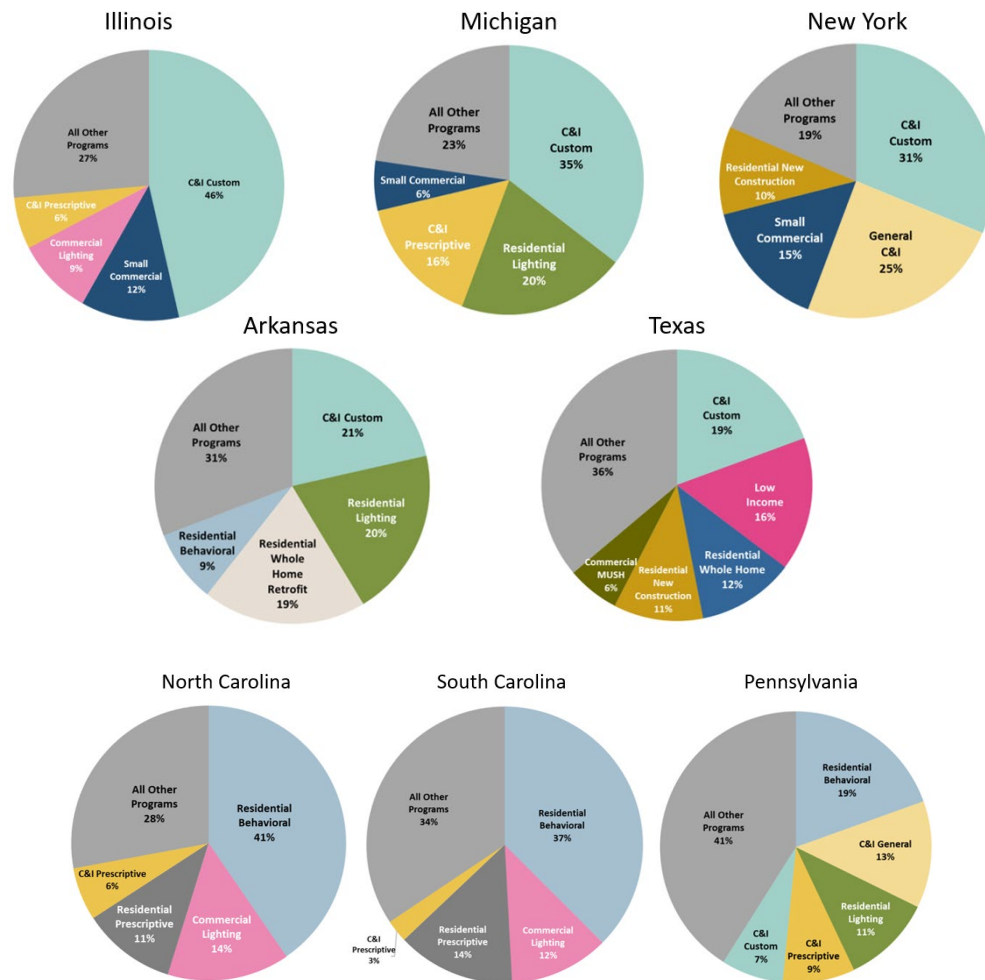
*See slide 28-29 for more information on the PA CSPD. All analysis in this study is from the PA perspective.

Approach

- We collected data on costs, energy savings, and peak demand savings for electricity efficiency programs for 52 PAs in 15 states for 2014-2018.
- We focused on seven residential and commercial programs that represent 68% of the peak demand savings of the programs studied.
- We organized the analysis into three categories:
 - ▣ Program-level peak demand impacts (kW)
 - ▣ Levelized CSE (\$/kWh) and CSPD (\$/kW) by state, region, market sector and for select programs
 - ▣ Program CSPD (\$/kW) using a standard peak period
- We conducted interviews with six states to understand how peak demand reductions from energy efficiency programs are defined, estimated and used in electricity planning processes. These interview questions serve as the foundation of our typology that characterizes peak demand reductions.

Summary of Findings: Program-level Peak Demand Impacts

- Programs delivering the most peak demand savings vary by region.
 - ▣ Midwest and Northeast – C&I programs
 - ▣ South – Residential programs
 - ▣ West – Programs supporting codes and standards
- Program types accounting for the largest share of portfolio* demand reductions also vary by state.
 - ▣ Residential behavioral and C&I custom programs produce the most peak demand reductions—19-41% and 19-46%, respectively—in eight of the states included in our study (AR, IL, MI, NC, NY, PA, SC, TX).
 - ▣ Residential lighting programs account for more than 10% of demand savings in eight states (AR, AZ, CO, MA, MD, MI, MN, PA), and commercial lighting programs account for more than 10% of demand savings in six states (CO, FL, IL, MN, NC, SC).



*Portfolio demand reductions are the sum of all program impacts over all years of the study.

Summary of Findings: CSPD and CSE by State, Region, Market Sector and Program (1)

- The levelized CSPD and CSE generally have a linear relationship.
 - ▣ Exceptions include Florida, with a low CSPD relative to its CSE.
- Arizona has the lowest CSPD of all states and is second to Illinois for lowest CSE.
 - ▣ Almost 75% of the state's peak demand reductions during the study period are from four Arizona Public Service programs: Large Existing Facilities (37% of total demand reductions), Consumer Products (14%), Conservation Behavior (13%) and Codes (11%).
- Massachusetts has the highest CSPD and the second highest CSE.
 - ▣ Residential lighting, C&I custom, and small commercial programs produce more than half of the peak demand savings in the state during the study period.
- Among residential programs studied, lighting has the lowest CSPD and CSE.
- For the C&I sector, custom programs have the lowest CSPD, and prescriptive programs have the lowest CSE.
- Low-income programs cost more than programs for other market sectors, for both energy and demand savings.

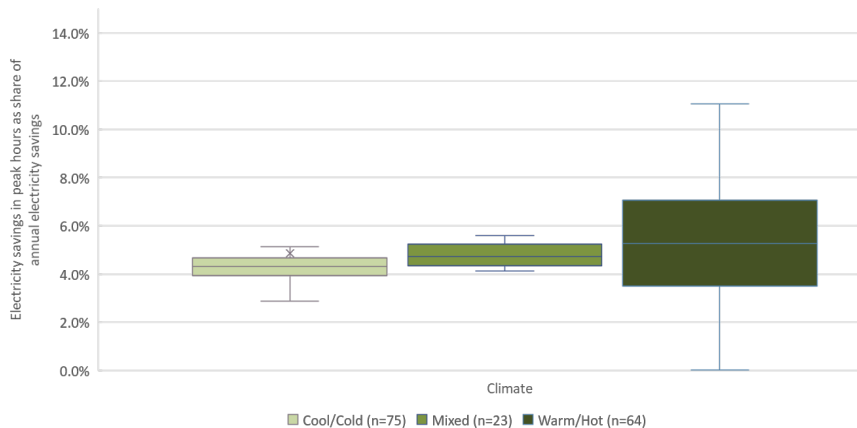
Summary of Findings: CSPD and CSE by State, Region, Market Sector and Program (2)

- CSPD and CSE varied within and across program types during the study period.
 - The median CSPD decreased overall for low income (27%), C&I prescriptive rebate (29%), residential lighting (18%), whole home retrofit (14%) and C&I small commercial (14%). For residential HVAC and C&I custom rebate, the median levelized CSPD increased by 16% and 11%, respectively, between 2014 and 2018.
 - The largest overall reductions in median CSE were for C&I prescriptive rebate (41%) and low-income programs (32%). The median CSE for small commercial and residential whole home retrofits declined 20% and 19%, respectively. Residential lighting had the least variation, with median CSE declining by 0.5%.
- About half of all program demand savings are available at a CSPD of less than \$100/kW, and three-quarters of all demand savings are available at a CSPD of less than \$200/kW.
 - Residential consumer products, C&I custom and C&I prescriptive programs all have a CSPD below \$175/kW. Collectively, these three programs contribute more than 40% of the demand savings for all programs studied during the study period.
 - Among cross-cutting programs (e.g., spending in such areas as codes and standards, market research and planning, and programs that reported costs but not savings), depending on the state, programs supporting codes and standards have either the highest CSPD (Illinois, Pennsylvania, California) or lowest CSPD (California and Arizona). Marketing, education, and outreach and market transformation programs have a higher CSPD for our sample and study period.

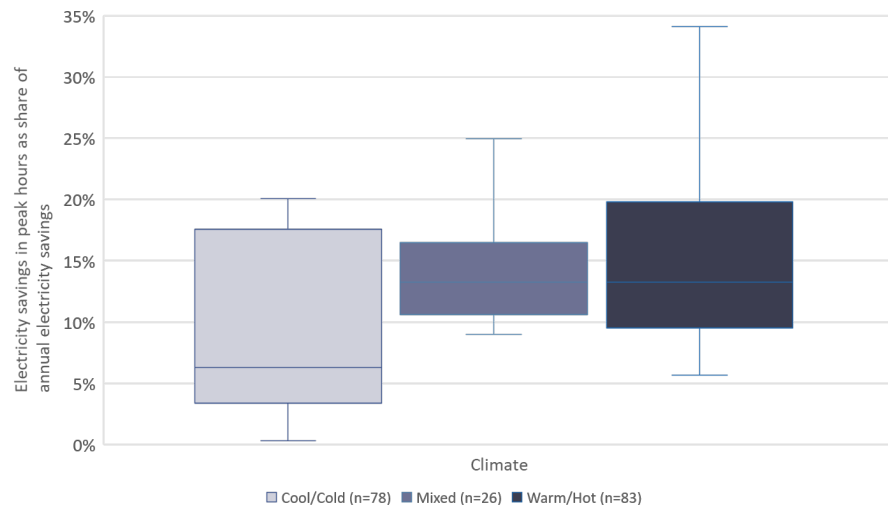
Summary of Findings: Program CSPD Using a Standard Peak Period

- Peak demand savings are climate sensitive.
 - To readily observe this we created standard peak periods and compared savings for four program types across regions.
 - Residential lighting programs display the least climate sensitivity and residential HVAC programs display the most climate sensitivity.

Residential lighting
(see slide 56 for larger view)



Residential HVAC
(see slide 58 for larger view)



Summary of Options to Improve and Standardize Peak Demand Reporting

Characteristic	Description	Metric
Program impacts	<ul style="list-style-type: none"> What approach is used to estimate or measure peak demand savings (e.g., engineering/deemed, metered)? If applicable, what is the source of the estimate? How frequently are peak demand savings estimates updated? How are the impacts calculated (e.g., average over the period, highest savings during the period)? 	<p>Peak period definition (for both summer and winter, if applicable) used to determine program impacts</p> <ul style="list-style-type: none"> Peak period start hour Peak period end hour Peak period start month Peak period end month <p>Gross peak demand saving (e.g., summer and winter kW)</p>
Contribution to resource adequacy and meeting infrastructure needs	<ul style="list-style-type: none"> Do efficiency peak period definition(s) align with other system planning peak definitions (e.g., ISO/RTO, distribution system peak)? Are peak demand impacts reported in energy efficiency documentation used in electricity system planning processes such as integrated resource planning and distribution system planning? 	Document peak demand impacts, using a clear and consistent definition, in all relevant electricity system planning processes.
Contribution to state energy or utility/PA goal	Do peak demand reductions from efficiency programs contribute to state energy goals or program administrator performance incentives (e.g., energy efficiency resource standards, peak demand reductions, air pollutant emissions reductions)?	Identify contribution, in capacity (kW) or air pollutant emissions reductions (e.g., tons, ppm), toward achieving state or utility energy, capacity or emissions reduction goals.
Motivation	What is the driver for the energy efficiency program (e.g., reduce peak demand or reduce energy savings, meet all cost-effective requirement, reduce air pollutant emissions)?	Stated driver for the program or portfolio in state law or PUC order, or stated goal of the program in a planning process.
Demand Flexibility	How can technologies included in an energy efficiency program provide dispatchable savings to contribute to demand flexibility as utility system peak periods shift over time?	Document technologies included in the program that provide demand flexibility in PA reporting.

Potential Future Analysis

- *Reporting template and guidance documents.* Build on Berkeley Lab tools for data collection and reporting on efficiency program costs and savings ([Rybka et al. 2015](#)) to provide templates for states, utilities, and other program administrators to improve reporting on peak demand savings and costs. In particular, we could collaborate with state PUCs, investor-owned and public power utilities, and stakeholders to develop guidance for consistent methods to define peak periods and calculate and report peak demand savings.
- *Broaden data collection to include demand response programs.* Expand CSPD data collection to include utility demand response data for one region (e.g., MISO). To better understand the full picture of demand response savings this research would also identify the ISO/RTO demand response offerings and, if available, collect program cost and impact information. This research would explore the ability to aggregate demand response program data from utilities and ISO/RTOs for comparison and quantify the CSPD for both program types if possible.
- *Bigger and more diverse sample.* Collect and analyze data on peak demand savings for efficiency programs from additional states to *provide broader geographic* representation, larger sample size, more diversity and greater confidence in results. Additional data collection could focus on PAs with winter peaking systems. Our analysis thus far has focused on the cost of saving peak demand for summer peaking utilities.
- *Additional program specific analysis.* Focus program specific analysis on programs that have many measures but produce significant peak demand reductions (e.g., C&I custom, C&I general) to better understand what measures or end-uses are driving reductions. A case study approach could be used for a subset of PAs.



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Project Background



ENERGY TECHNOLOGIES AREA

ENERGY ANALYSIS AND ENVIRONMENTAL IMPACTS DIVISION

Why the Cost of Saving Electricity and Cost of Saving Peak Demand Matter

Program Administrator (PA) Cost of Saving Electricity (CSE) is expressed in dollars per kilowatt-hour (\$/kWh)

PA Cost of Saving Peak Demand (CSPD) is expressed in dollars per kilowatt (\$/kW)

The PA CSE and CSPD are each calculated based on the entire program administrator program cost. This means the results cannot be combined because it would double the program cost. Each metric must be considered separately.

- To help ensure electricity system reliability at the most affordable cost as part of resource adequacy planning and implementation activities
- To project efficiency's impact on electricity load forecasts
- To benchmark utility's program results with regional and national estimates
- For initial screening of electricity resource alternatives for meeting future demand
- To evaluate how program cost performance are likely to change over time with funding levels and participation

Why the Cost of Saving Electricity and Cost of Saving Peak Demand Matter

Notes for slide 15

- Energy efficiency can reduce both annual energy consumption and peak demand for electric power systems. Historically, electric utilities in most states have paid more attention to quantifying the cost and value of first-year and lifetime energy savings of electricity efficiency programs they operate, rather than peak demand impacts. However, utilities and state PUCs in a number of states are starting to assess and report the peak demand impacts of these programs. This phenomenon is driven primarily by: (1) state-level policy drivers, (2) design of centrally organized wholesale energy and capacity markets, and (3) increasing penetration of distributed energy resources (DERs) and their impact on distribution system needs, as well as on the bulk power system.
- In the [2019 study](#), the key metrics of interest are the levelized PA CSE and first-year PA CSPD. The CSE is expressed in dollars per kWh of electricity savings, and the first-year CSPD is expressed in dollars per kW. These metrics measure activities from a utility's perspective. They are useful for comparing relative costs of various types of efficiency programs and comparing efficiency options to other demand and supply choices for serving electricity needs.

Berkeley Lab studies on Cost of Saving Energy

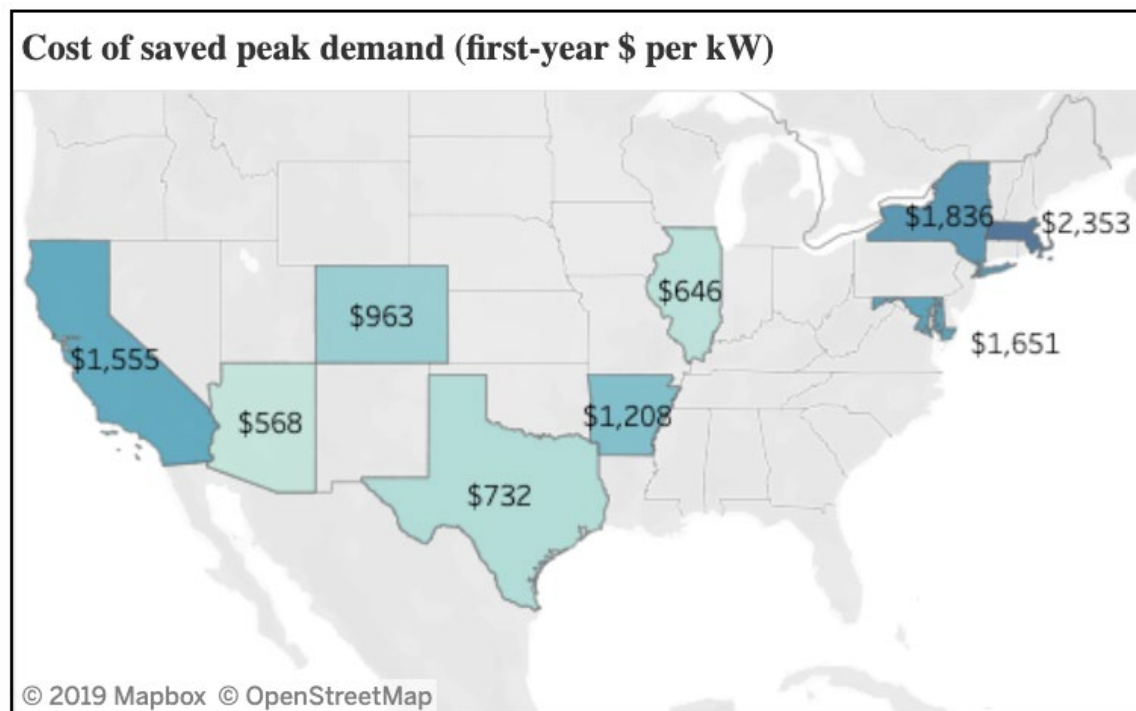
- Program typology ([2013](#))
- First study on program administrator (PA) cost of saving energy ([2014](#))
 - ▣ Natural gas and electric investor-owned utilities (IOUs)
 - ▣ Program administrator (PA) cost – cost to utility or third-party administrator
 - This metric does not include any contributions from program participants.
 - ▣ Analysis at program level
- Updated analysis for electricity in [2015](#), including total cost
 - ▣ Total cost = PA cost + participant cost contributions
- Most recent electricity analyses for IOUs
 - ▣ 116 PAs in 41 states, 2009-2015 ([2018](#) study)
 - ▣ Cost of saving peak demand, 9 states, 2014-2017 ([2019](#) study)
- Analysis for publicly owned electric utilities ([2019](#))
 - ▣ 111 PAs, representing 219 publicly owned utilities in 14 states, 2012-17
 - ▣ Analysis at market-sector level
- Study on cost of saving gas, 12 states, 2012-2017 ([2020](#))

<https://emp.lbl.gov/projects/what-it-costs-save-energy>

- The [2019 study](#) built on Berkeley Lab's unique body of work to collect, standardize and analyze data for efficiency programs funded by utility customers and use the information to help decision makers assess the cost performance of programmatic efficiency initiatives across geographic regions, states, market sectors, and program types. We also build on our new line of research on the time-sensitive value of efficiency ([Frick and Schwartz 2019](#), [Mims, Eckman and Goldman 2017](#) and [Mims, Eckman and Schwartz 2018](#)).
- In previous reports, we quantified the program administrator cost of saving energy for electricity and natural gas efficiency programs implemented between 2009 and 2011 ([Billingsley et al. 2014](#)), the total cost of saving electricity (including participant costs) for program years 2009-2013 ([Hoffman et al. 2015](#)), trends in the program administrator cost of saving electricity over time ([Hoffman et al. 2017](#)), and the program administrator and total cost of saving electricity for 41 states through 2015 ([Hoffman et al. 2018](#)).

Berkeley Lab's Cost of Saving Peak Demand – 2019 study

- First-of-its kind analysis that explored the following questions:
 - To what extent are utilities and other program administrators reporting information on the peak demand impacts of their electricity efficiency programs?
 - How do program administrators define peak demand and calculate peak demand savings for their electricity efficiency (EE) programs?
 - For the nine selected states, what are the cost of saving electricity and the cost of saving peak demand at the portfolio level and for selected types of EE programs?



Links to [Report](#) and [Infographic](#)

- In the 2019 study, we explore the following questions and issues:
 - To what extent are utilities and other program administrators reporting information on the peak demand impacts of their electricity efficiency programs?
 - How do program administrators define peak demand and calculate peak demand savings for their electricity efficiency programs?
 - For the nine selected states, what are the cost of saving electricity and first-year cost of saving peak demand at the portfolio level and for selected types of programs?

- In the 2019 study, Berkeley Lab explored a new metric, the first-year PA CSPD. We collected data on costs, energy savings and peak demand savings for electricity efficiency programs for 36 investor-owned utilities and other PAs in nine states (Arizona, Arkansas, California, Colorado, Illinois, Massachusetts, Maryland, New York, and Texas) for 2014 to 2017. In some states, third parties administer these programs. However, utilities administer most programs, so we use the term “utilities” for convenience throughout this report.

- We calculated the PA CSE for each individual program in our dataset and used these values as points of reference throughout. Expressed in dollars per kilowatt-hour (kWh) of electricity savings, this metric measures activities from a utility's perspective. Several Berkeley Lab studies have documented this metric. We then calculated the *first-year PA cost of saving peak demand*— expressed in dollars per kilowatt (kW) — at the state level and for specific programs. We also analyzed this metric by climate zone to assess how it varies for programs with weather-sensitive measures.

2019 Study Results: Cost of Saving Peak Demand and Cost of Saving Electricity, for Select Programs

Program Type	First-Year Savings-Weighted Average CSPD (2017\$/kW)	First-Year Median CSPD (2017\$/kW)	Savings-Weighted Average CSE (2017\$/kWh)	Median CSE (2017\$/kWh)
Residential Lighting	733	738	0.013	0.013
C&I Prescriptive Rebate	1,331	1,332	0.026	0.027
Small Commercial	2,071	1,993	0.050	0.042
Residential HVAC	2,331	2,202	0.078	0.094
Whole-Home Retrofit	2,543	1,960	0.056	0.072
C&I Custom Rebate	3,339	1,784	0.023	0.029
Low Income	5,751	2,099	0.135	0.091

Additional 2019 results are in the appendix, slide 74.

2019 Study Results: Cost of Saving Peak Demand and Cost of Saving Electricity, for Select Programs

Notes for slide 20

- We summarized the first-year PA CSPD for selected types of efficiency programs for a portion of our dataset: residential heating, air conditioning, and ventilation (HVAC); residential lighting; whole-home retrofit programs; low-income programs; programs targeted at small commercial customers; prescriptive rebates for medium and large commercial and industrial (C&I) customers; and custom rebate programs for large C&I customers. These seven program types account for 58% of total peak demand savings of our dataset. Importantly, these types of programs are designed for kWh reductions; they also happen to reduce peak load.
- Residential lighting programs have the lowest first-year PA CSPD across the utilities studied (\$730 to \$740/kW), followed by prescriptive rebates for medium and large C&I customers (\$1,330/kW). Several programs — whole home retrofit, small C&I programs and residential HVAC — have savings-weighted average or median values in the \$1,800 to \$2,500/kW range. Results are more difficult to explain for C&I custom rebate programs, with a first-year median PA CSPD of \$1,780/kW and savings-weighted average of \$3,340/kW — almost twice as high. A possible explanation for the difference between median and savings-weighted average values is that C&I custom programs are heterogeneous among utilities (e.g., some programs focus on installing HVAC equipment and controls for commercial customers; others target process improvement projects for industrial customers). Specifically, program years for which peak demand (kW) savings data are reported (1,901 program years).
- Based on our 2019 study, electricity efficiency programs appear to be a relatively low-cost way for utilities to meet peak demand, compared to the capital cost of other resources ([Lazard 2018](#); [EIA 2019](#)) that can be used to meet peak demand. However, many energy efficiency technologies, such as more efficient light bulbs, are “passive” and are not dispatchable. In such cases, efficiency resources do not provide the same services as a natural gas peaking turbine, making comparisons between these resources complex. At the same time, our results suggest that electricity efficiency programs that reduce peak demand merit strong consideration by utilities and regional grid operators. Further, “active” efficiency measures such as lighting controls enable active management of efficiency resources, offering additional grid services.
- Information on the CSPD and CSE by state from the 2019 analysis can be found on slide 74.



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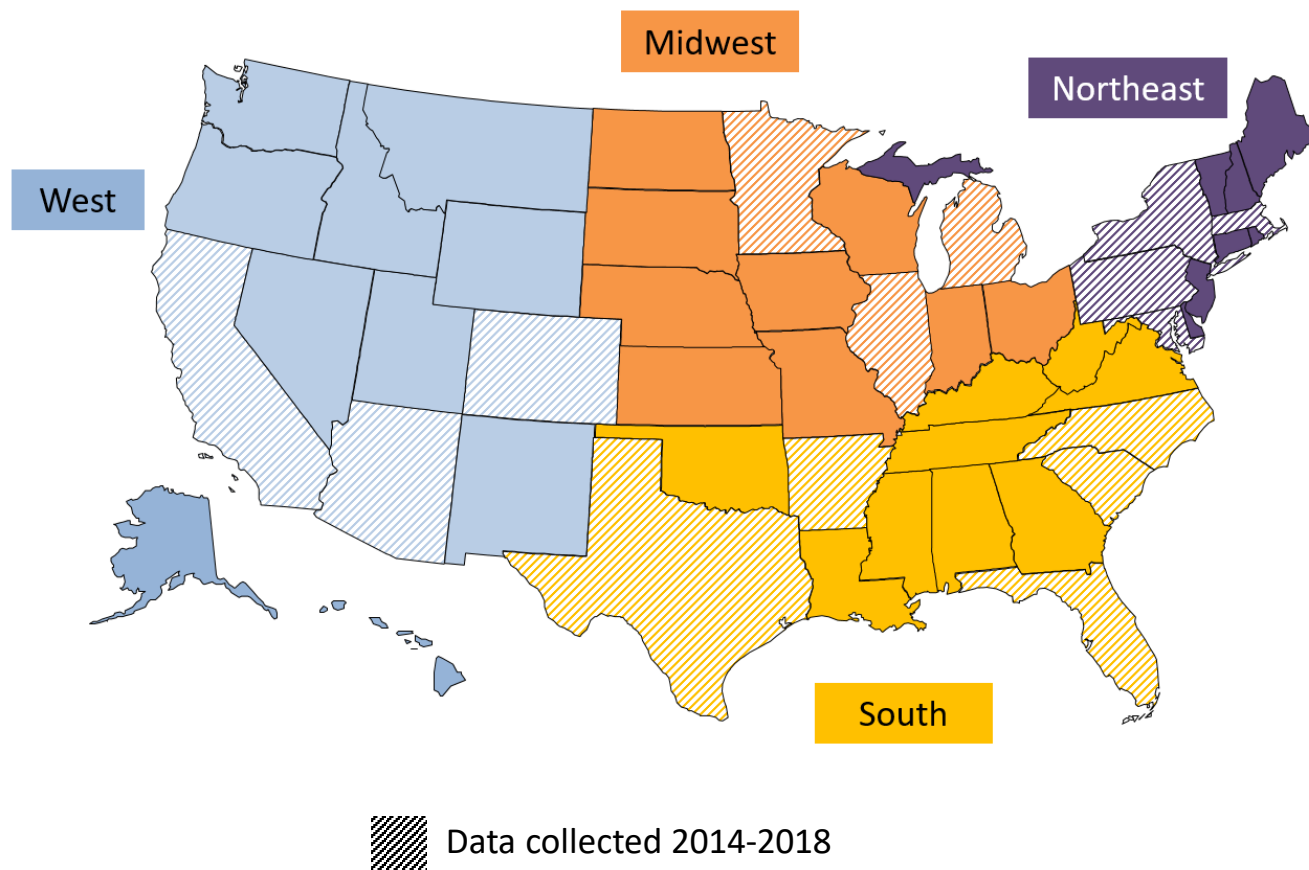


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Project Approach



States Included in the 2020 Study



- States were selected based on several characteristics: geographic diversity, quantity of energy efficiency savings, peak demand reduction policy guidance and leveraging prior data collection.
- The 52 utilities/program administrators represent ~60% of annual national spending on energy efficiency and ~59% of peak demand reductions in 2018, based on annual savings reported by utilities to [EIA](#).

- We identified and selected states for this study based on policy requirements, data availability, geographic diversity, and utility spending on efficiency programs. In our 2019 analysis, we identified states that have a policy requirement for investor-owned utilities to achieve peak demand reductions, or where utilities record demand reductions in efficiency program regulatory filings. From these states, we chose a sample of nine states that are diverse in terms of climate zones and geography, which we defined as representation from several ISO/RTOs. We prioritized data gathering from states where utilities were members of ISO/RTOs because some ISOs (e.g., PJM, ISO-NE) allow utilities (and load aggregators) to participate in forward capacity markets and bid in program savings during defined peak periods. Where possible, we included states with significant spending on energy efficiency (e.g., California, Illinois, Massachusetts, and New York).
- In this analysis, we built on the 2019 dataset. We expanded data collection for our initial nine states through 2018 and then added data from six additional states for 2014-2018.

Research Approach

- Building on Berkeley Lab's initial research on peak demand reductions from efficiency, collect new data from 15 states for 2014-2018 and add to our Cost of Saving Energy database
 - ▣ Program type
 - ▣ Program costs
 - ▣ Savings by program (kWh and kW)
 - ▣ Summer and winter kW recorded, where available
- Calculate CSE and CSPD by state, region and market sector for select efficiency program types
 - ▣ CSPD results are based on summer peak. Our sample did not include a winter peaking utility.
- Conduct sensitivity analysis on program costs and peak demand reductions
- Interview state representatives on data collection, quantification, and use of peak demand reductions from efficiency in electricity system planning
 - ▣ Identify themes for characterizing how peak demand savings from program administrator reports are used in utility planning to develop program typology
- Informed by interviews and review of PA reports, identify metrics documenting program characteristics

- With few exceptions, our data collection relied on 2014-2018 annual reports filed by utilities (and other program administrators) with state public utility commissions. Our sample for this study includes 52 utilities and more than 6,878 program years of data. Approximately 3,713 of the program records (or program years) include peak demand impacts. Data fields for each program year include the program name, spending information (e.g., actual expenditures), peak demand savings, and annual and lifetime gross and net energy savings, where available. Spending on electricity efficiency programs in the 15 states represents about 60% to 72% of national spending during the 2014-2018 period. Our estimates of national spending are based on [EIA 861](#) data.
- We standardized, validated and analyzed the efficiency program data consistent with practices used in prior [Berkeley Lab studies](#) (Billingsley et al. 2014; Hoffman et al. 2015; Hoffman et al. 2017; Hoffman et al. 2018).

Cost of Saving Electricity and Peak Demand

- We calculate average and median cost of saving electricity and cost of saving peak demand by portfolio and for seven program types.
 - ▣ The PA CSE calculation is levelized and takes into account the economic lifetime* of the actions taken as a result of a program.
 - ▣ In our initial (2019) peak demand report, we calculated first-year PA CSPD (hereafter referred to as *first-year CSPD*) and levelized CSE.

Program Administrator Cost of Saving Electricity *or* Peak Demand =
Capital Recovery Factor * (Program Administrator Costs)
Annual Electricity Savings (in kWh) *or*
Annual Peak Demand Saving (in kW)

where the Capital Recovery
Factor (CRF) is:

$$CRF = \frac{r(1+r)^N}{(1+r)^N - 1}$$

and

r = the discount rate

N = estimated program lifetime in years and
calculated as the savings-weighted lifetime of
measures or actions installed by participating
customers in a program

- ▣ In this new study, we calculate the:
 - ▣ levelized CSE
 - ▣ first-year CSPD
 - ▣ **levelized CSPD**

* Measure life used in CSPD calculations is provided in the appendix, slide 76.

Cost of Saving Electricity and Peak Demand

Notes for slide 28

- The metric we use to evaluate efficiency program costs is the levelized PA CSE and PA CSPD. The PA perspective represents the cost to implement an energy efficiency program to a utility or third party administrator. The levelized CSE and CSPD are the cost of achieving electricity savings over the economic lifetime of the actions taken as a result of a program, amortized over that lifetime, and discounted back to the year in which the costs are paid and the actions taken. The CSE and CSPD account for expenditures in planning, administering, designing, and implementing programs and providing incentives to market allies and end users to take actions that result in energy savings and peak demand reductions, as well as the costs of verifying those savings.
- In calculating the CSPD results at the portfolio level, we excluded programs that reported costs, but not peak demand savings, or programs that are cross-cutting. Approximately 5% of the programs in our sample had data on energy savings and program costs, but did not report peak demand savings. In these cases, it is not clear whether the program did not achieve peak demand savings or if the utility did not report peak demand savings. Thus, in calculating the first-year CSPD at the portfolio level, we included only those programs that reported both costs and peak demand savings. In future versions of this analysis, and as we gather more data on peak demand reductions from efficiency, we may include all costs in our calculation of the CSPD at the portfolio level.
- We recorded winter peak demand reductions in our database, but excluded these impacts from this analysis.
- We included EM&V costs at the portfolio-level and for specific programs (if reported at the program level). Some ancillary costs associated with investments in energy efficiency are not included because they are either not reported or not included in annual reports to public utility commissions. These costs include performance incentives for the utility or other program administrator, the time and transaction costs incurred by participants (e.g., analyzing potential efficiency investments, getting the work done), and tax credits.
- We used our standard approach to calculating CSE to provide readers with a reference point when discussing the CSPD metric. We used a 6% real discount rate as an approximation of the weighted-average cost of capital for an investor-owned electric utility. We adjusted to 2018 dollars program spending that was reported in nominal dollars. We used gross savings to calculate the program administrator CSE and CSPD, primarily because net savings are not universally reported or uniformly defined. As in previous Berkeley Lab CSE reports, when we report the CSE at the portfolio level, we included costs of cross-cutting programs (e.g., spending in such areas as market research and planning, and programs that reported costs but not savings).
- We use a real discount rate because inflation already is accounted for in the use of constant dollars (2019\$). Our real discount rate is a proxy for a nominal rate in the range of 7.5% to 9%, typical values for a utility weighted-average cost of capital (WACC). A utility WACC is the average of the cost of payments on the utility's debt (bonds) and its equity (stock), weighted by the relative share of each in the utility's funds available for capital investment. The utility WACC is often used by investor-owned utilities in their economic screening of efficiency programs.
- In addition, inconsistencies in defining and estimating net savings add more uncertainty to those already embedded in estimates of energy savings and peak demand impacts. See Billingsley et al. (2014) and Hoffman et al. (2018) for a more in-depth discussion of our rationale for using gross savings estimates. The first-year CSPD for efficiency is the cost of achieving summer peak demand savings in the first year that the efficiency measures are implemented in the program. We use first-year program costs and peak demand savings to simplify this first-ever analysis. In future studies, we may quantify and calculate the CSPD over the expected lifetime of the peak demand savings (i.e., a levelized CSPD). We use *summer* peak demand savings values for this study because all utilities and program administrators included in the analysis reported it. A limited set of utilities and program administrators provide winter peak demand savings values.
- Program costs include expenditures in planning, administering, designing and implementing programs and providing incentives to market allies and end users.
- In Hoffman et al. 2018, we note that measure lifetimes are essential to calculating the levelized cost of saving electricity, although only 27% of program administrators reported measure lifetime or lifetime savings, or both. This data limitation means that we had to impute program average measure lifetimes for over half of the program years based on average values from programs where utilities reported this information.

Interview Questions

- How does your utility or state define the peak demand period for energy efficiency program savings?
- Is the peak demand period for energy efficiency program impacts different than how the utility or state defines the peak demand period for other purposes (rates, planning)?
- Does your utility or state have a goal or requirement to reduce peak demand with efficiency or other DERs?
- What approach(es) is (are) used to estimate the peak demand savings from energy efficiency programs?
- How often are your estimated peak demand savings from energy efficiency programs updated?
- How are your peak demand savings from efficiency programs verified?
- Are the reported peak demand savings from energy efficiency programs used in utility planning processes?
- Are your peak demand savings used for performance incentives or count towards achieving energy goals?

A list of organizations interviewed are in the appendix, slide 77.



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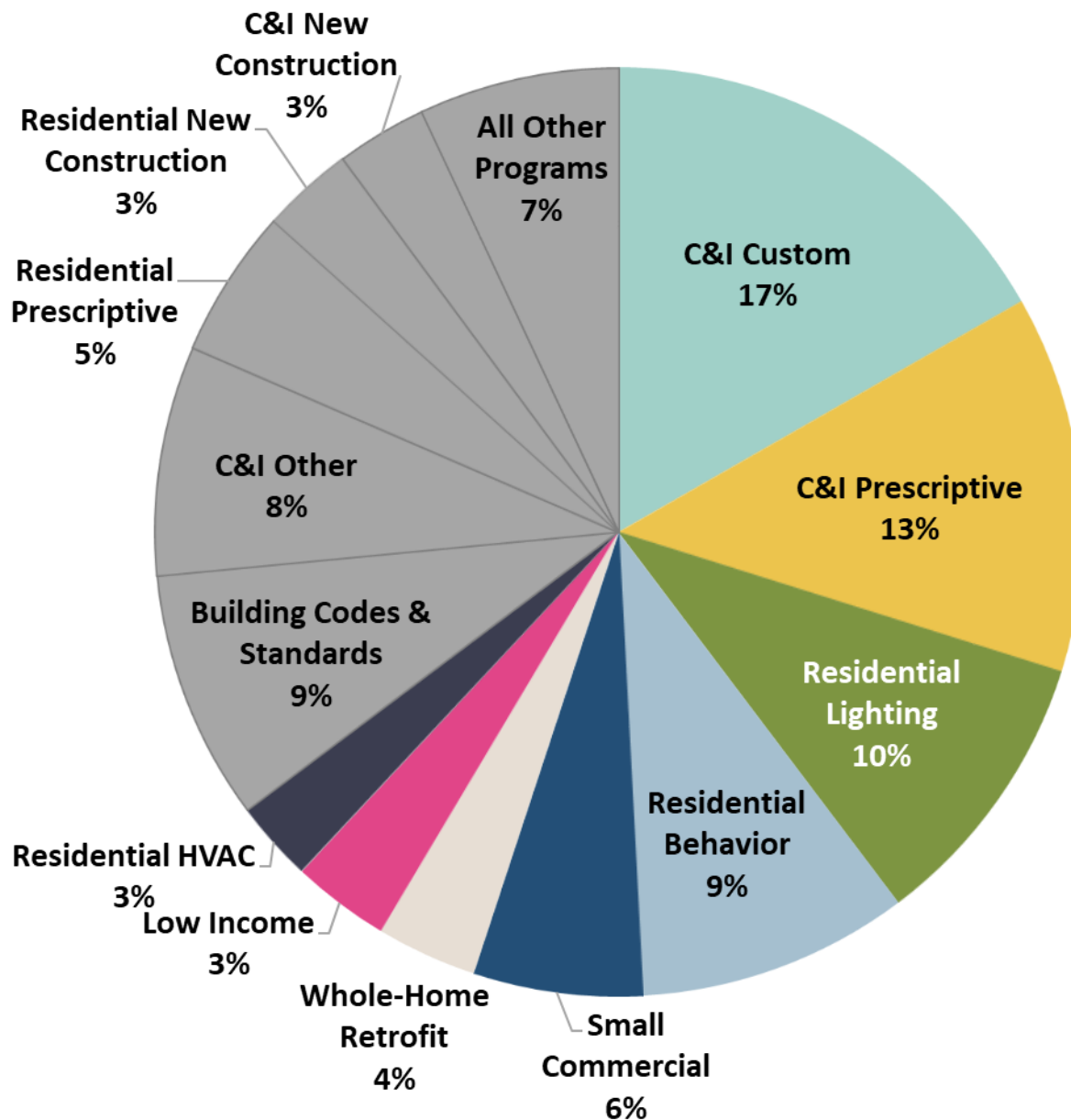


U.S. DEPARTMENT OF
ENERGY

Results: Program Level Peak Demand Impacts



Peak Demand Savings by Program Type for 15 States



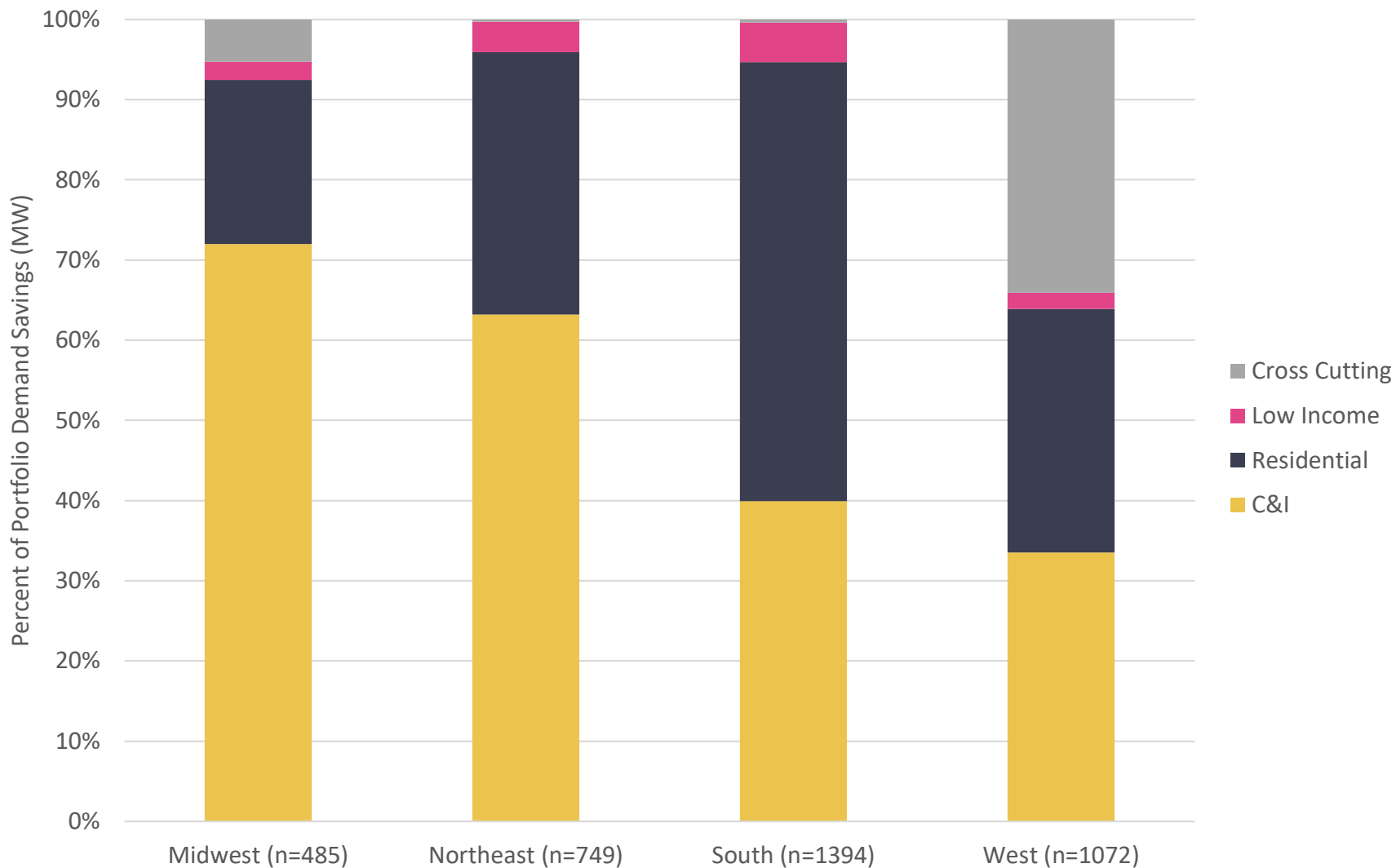
- Programs we focused on in our study (in color) represent 68% of peak demand savings for our 52-program administrator sample during the study period (2014-2018)

Peak Demand Savings by Program Type for 15 States

Notes for slide 32

- This slide shows the share of peak demand savings for various types of programs studied in the 15 states between 2014 and 2018. The area of the pie chart that is in color represents the programs we focus on for in this study, which accounts for 68% of peak demand savings for the 52 utilities in our study between 2014 and 2018.
- Our sample for this study includes 52 utilities and more than 6,878 program years of data. Approximately 3,713 of the program records (or program years) include peak demand impacts. Data fields for each program year include the program name, spending information (e.g., actual expenditures), peak demand savings, and annual and lifetime gross and net energy savings, where available. Spending on electricity efficiency programs in the 15 states represents about 66% to 80% of national spending during the 2014-2018 period.
- All programs with peak demand savings above 3% are shown except for C&I: Other category, which represents 8% of peak demand savings.
- In the prior analysis, program savings were 42% of peak demand reductions and did not include residential behavioral programs.

Peak Demand Savings Vary by Sector and Region



Peak Demand Savings Vary by Sector and Region

Notes for slide 34

- To understand if peak demand savings vary by region, we divided program savings into four sectors—Residential, Commercial, Low Income, and Cross Cutting—and geographic regions. Peak demand savings were added for all program years from 2014 to 2018. We calculated the percentage of the peak demand savings by sector for each region's portfolio.
- This figure shows how each sector—Residential, Commercial, Low Income, and Cross Cutting—contributes to overall peak demand reductions by region. C&I provides the majority of savings in both the Midwest (72%) and Northeast (63%), but in the South, the Residential is the majority (55%). This difference in overall demand reductions may reflect program design as opposed to differences in which sectors contribute to load.
- The West has the lowest share of peak demand savings from C&I and largest contribution from Cross Cutting programs. The growth of codes and standards programs in California and Arizona lead to Cross Cutting providing a large share of peak demand savings. Peak demand savings in other states indicate that cross cutting programs generally provides a smaller share of peak demand savings ($\leq 5\%$).
- Codes and standards savings do accrue to residential and commercial customers, but our current program typology does not differentiate the sectoral impact.

State-level Program Analysis

- To better understand what programs are reducing peak demand the most, we combined demand savings by program across the study period for each state as follows:

Demand reductions for a specific program type for all PAs in the state for all years of the study period

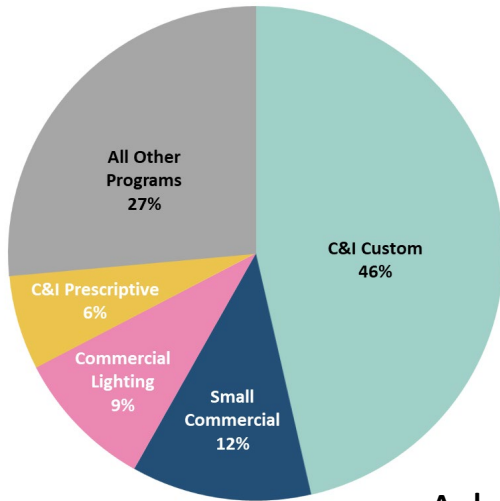
All demand reductions for all PAs in the state for all years of the study period

- The results indicate that program types producing large peak demand reductions as a percentage of portfolio demand reductions vary by state.
- Most programs do not reduce peak demand by a large percentage of total portfolio impacts.
 - ▣ For this dataset, the average value is 2.1%, the median is 0.6% and the mode is 0.4%.
- Residential behavioral and custom C&I programs produced the most peak demand reductions in eight of the states included in our study.
- Residential lighting programs account for more than 10% of demand savings in eight states, and commercial lighting programs account for more than 10% of demand savings in six states.

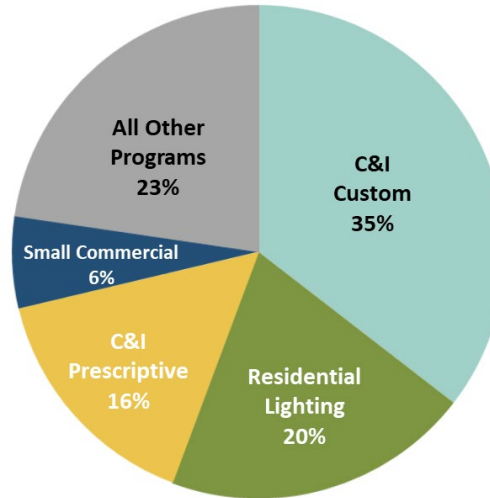
Custom C&I Programs Produced the Largest Peak Demand Savings in Many States Studied

Peak Demand Impact by Program Type as Percentage of Portfolio, All Years

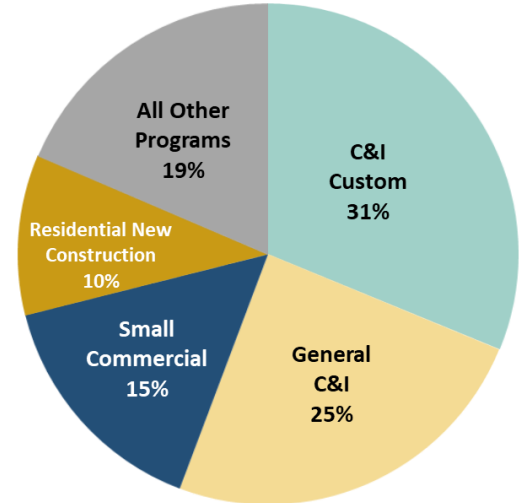
Illinois



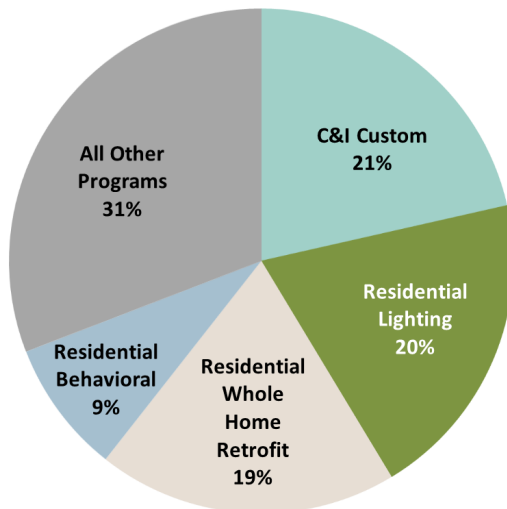
Michigan



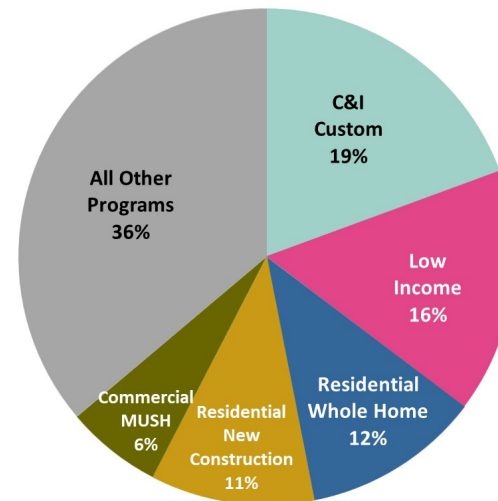
New York



Arkansas



Texas

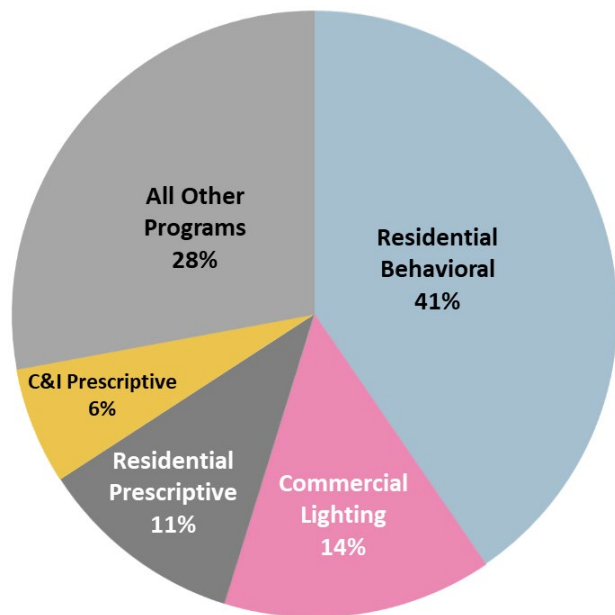


MUSH – Municipal, universities, state, hospitals

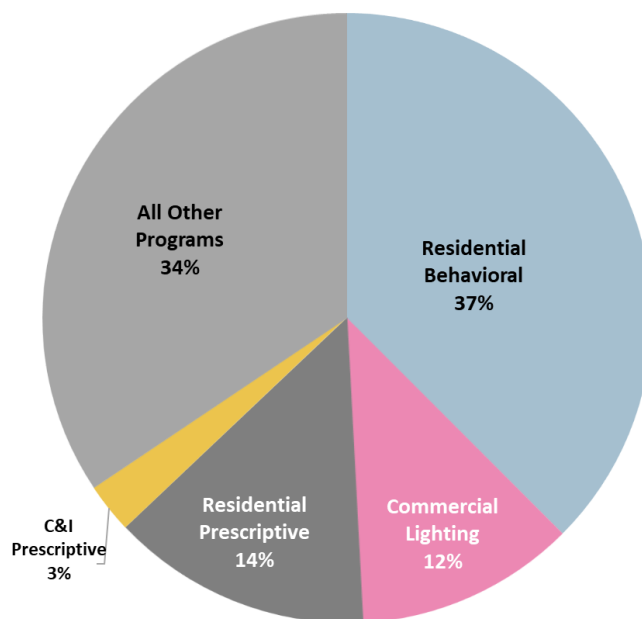
Residential Behavioral Programs Produced the Most Peak Demand Savings in Three States Studied

Peak Demand Impact by Program Type as Percentage of Portfolio, All Years

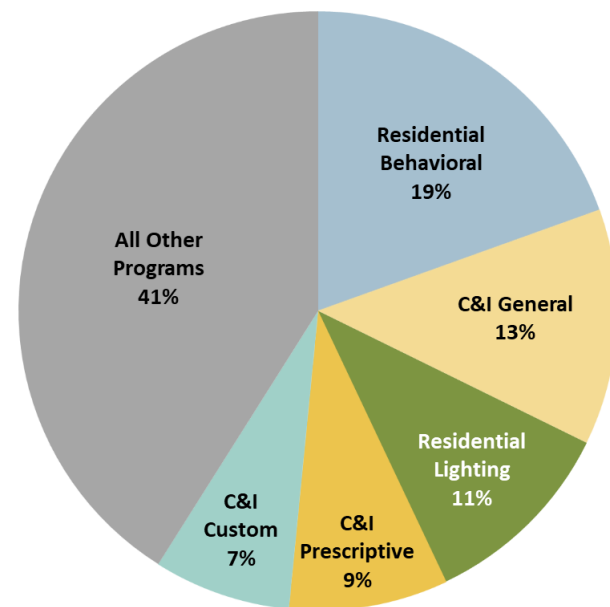
North Carolina



South Carolina



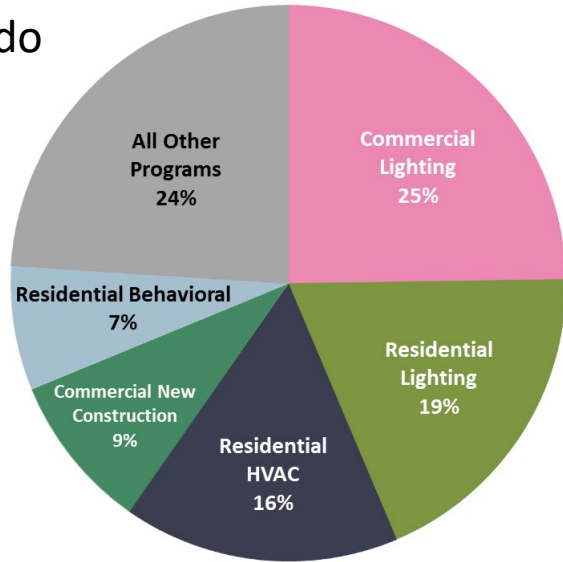
Pennsylvania



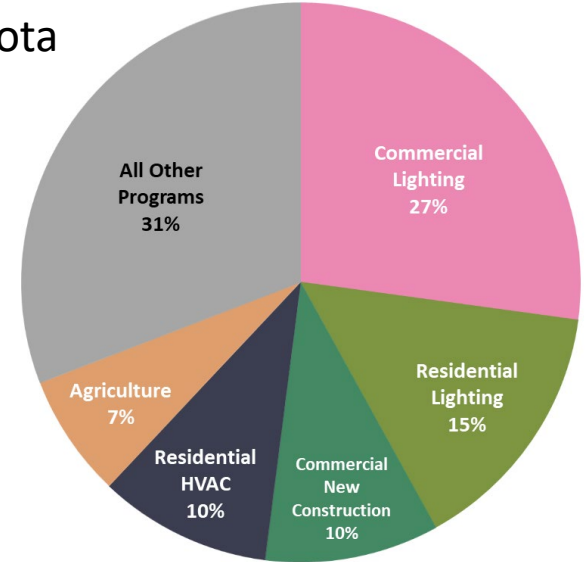
Commercial and Residential Lighting are Significant Drivers of Peak Demand Savings

Peak Demand Impact by Program Type as Percentage of Portfolio, All Years

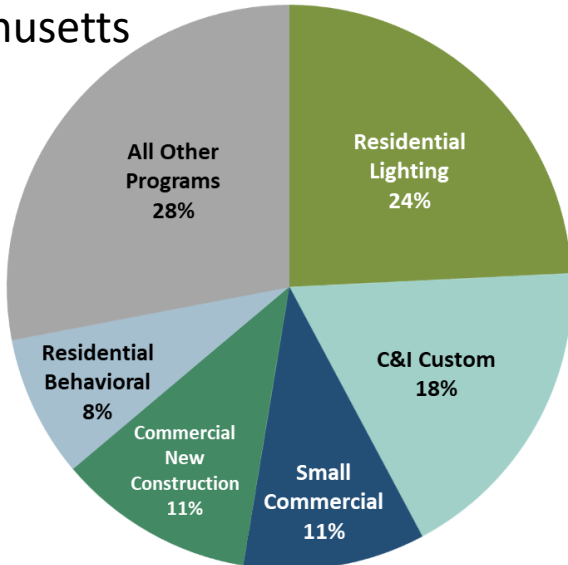
Colorado



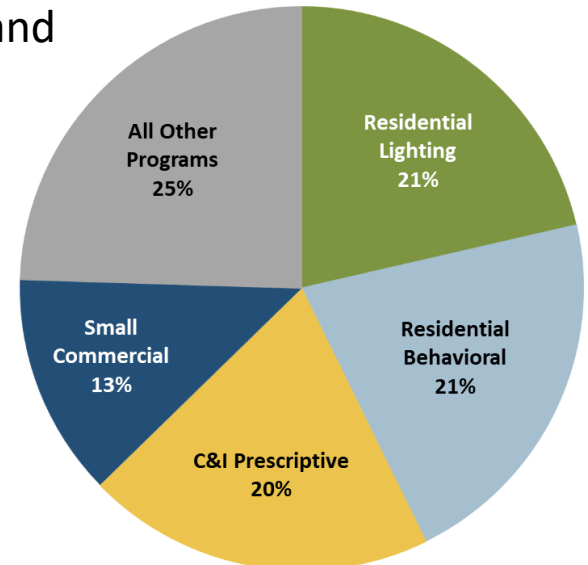
Minnesota



Massachusetts

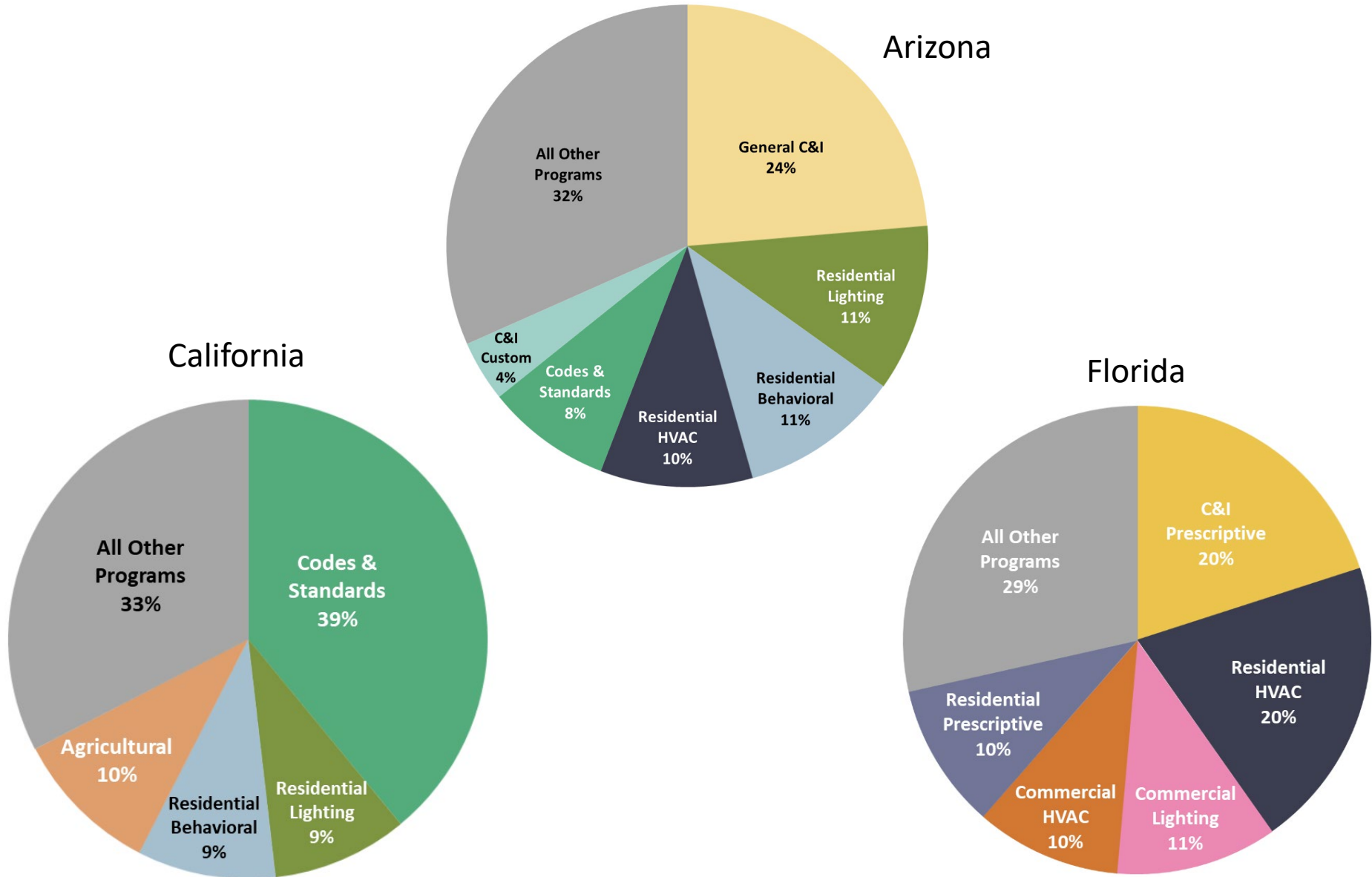


Maryland



In a Few States, Some Programs Achieved Notably Higher Peak Demand Savings than in Other States

Peak Demand Impact by Program Type as Percentage of Portfolio, All Years





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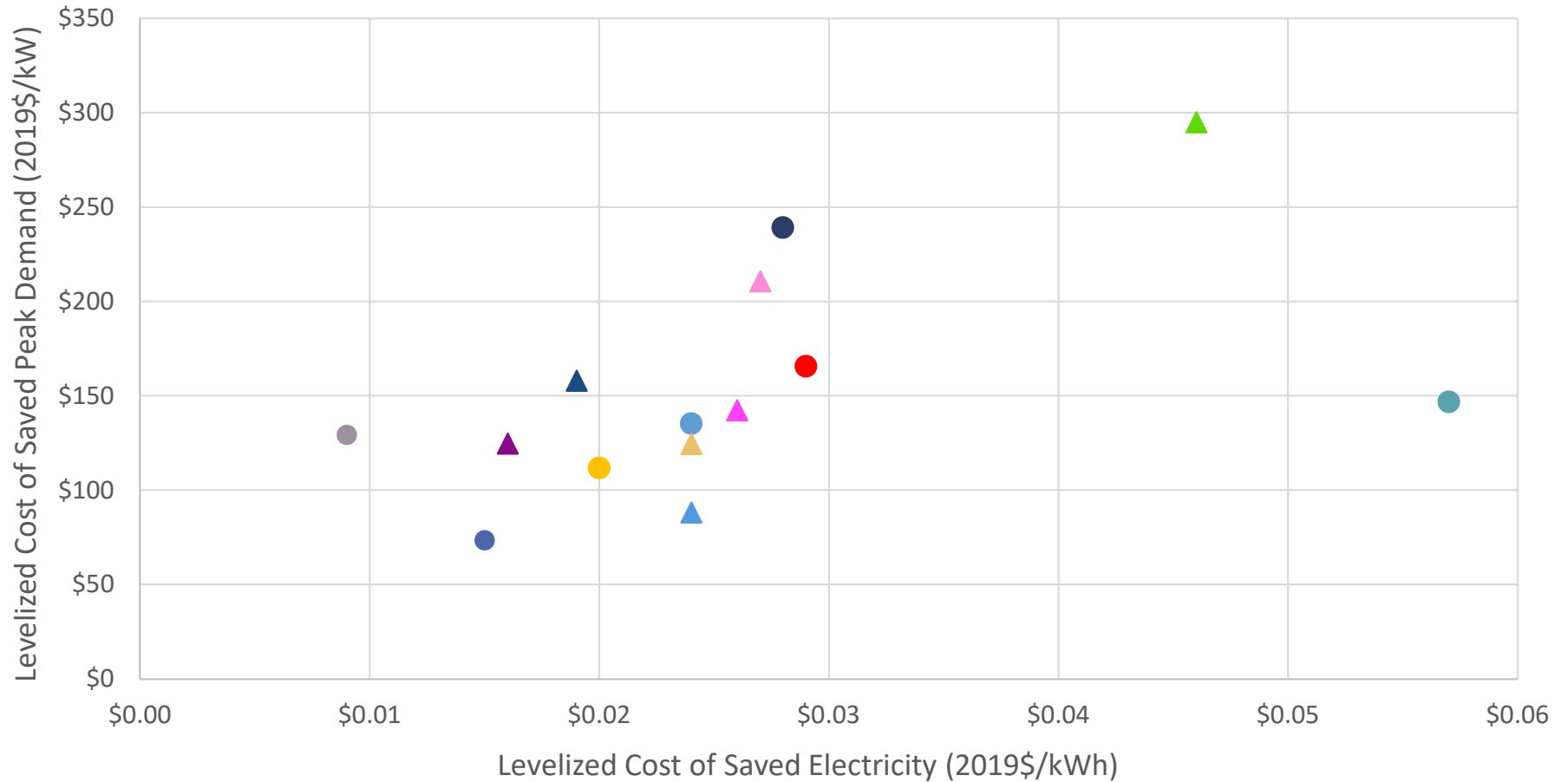


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Results: CSPD and CSE by State, Market Sector and for Select Programs



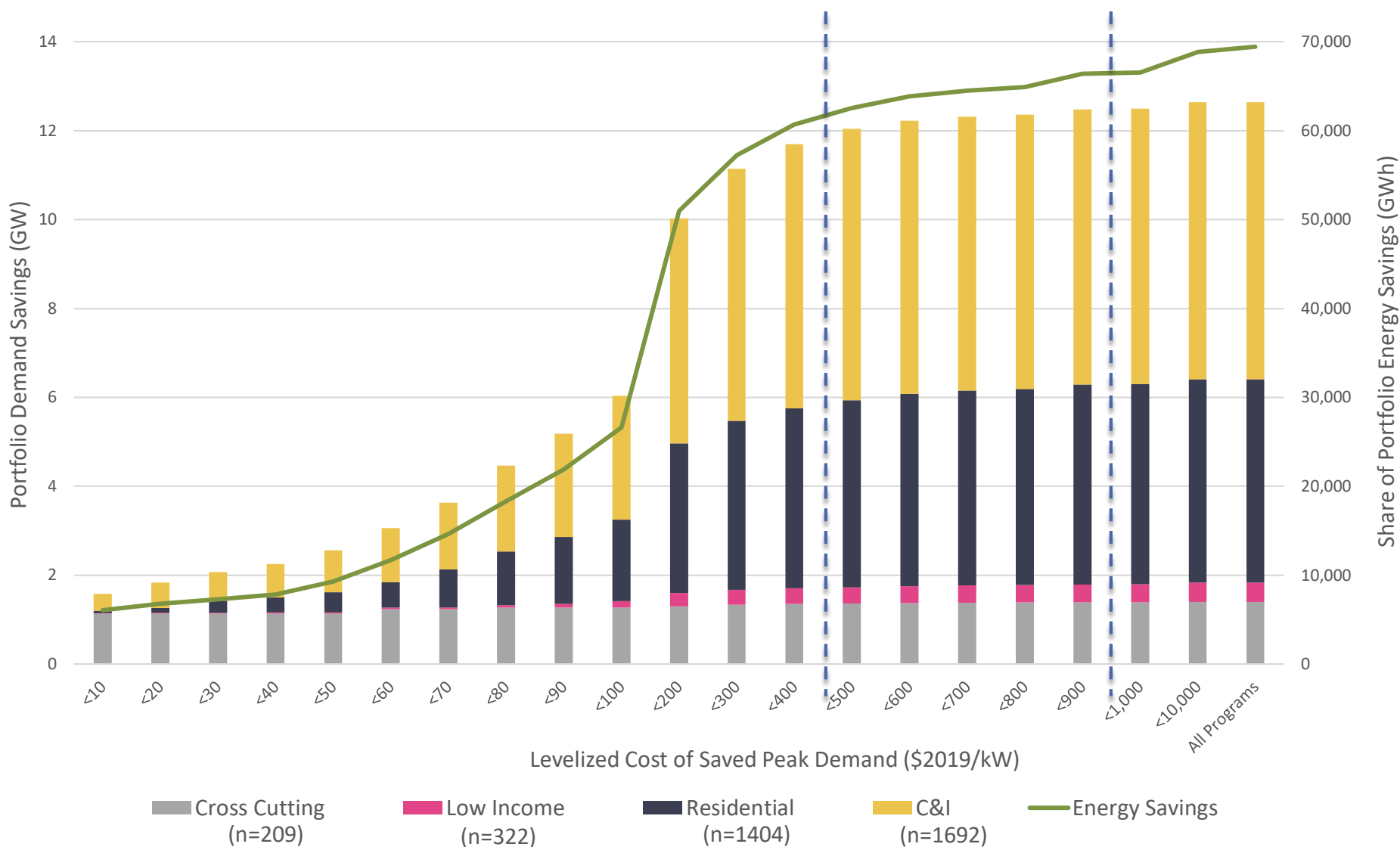
Levelized CSPD and CSE, by State



- Arizona
- Arkansas
- California
- Colorado
- Florida
- Illinois
- Maryland
- ▲ Massachusetts
- ▲ Michigan
- ▲ New York
- ▲ North Carolina
- ▲ Pennsylvania
- ▲ South Carolina
- ▲ Texas

- This chart shows the relationship between the CSE and CSPD. Each data point on the chart represents the levelized CSE or CSPD for a state during the study period.
- The levelized CSE and CSPD generally have a linear relationship, but some states are exceptions. Florida, for example, has a low CSPD relative to its CSE, possibly due to a program administrator focus on peak demand savings. C&I prescriptive programs generate the most peak demand savings in Florida. Duke Energy Florida administers the C&I prescriptive program that produces the most peak demand savings. The program provides incentives for non-residential HVAC efficiency measures.
- Arizona has the lowest CSPD of all states, but second to Illinois in terms of CSE. Almost 75% of the peak demand reductions for the state during the study period are from four Arizona Public Service programs: Large Existing Facilities (37% of total demand reductions); Consumer Products (14%); Conservation Behavior (13%) and codes (11%).

Distribution of Peak Demand and Energy Savings, by Levelized CSPD Bin and Market Sector



Distribution of Peak Demand and Energy Savings, by Levelized CSPD Bin and Market Sector

Notes for slide 44

- This chart shows the cumulative peak demand and energy savings over the study period, segmented by CSPD cost bin and market sector.
- Individual program years from 2014 to 2018 are sorted into levelized CSPD bins by sector: cross cutting, low income, residential, and C&I. For each bin, the total cumulative portfolio demand savings is plotted on the primary y-axis (i.e., program years with levelized CSPD equal or lesser than the value on the x-axis are included). The cumulative energy savings for all sectors is plotted on the secondary y-axis. The x-axis is the levelized cost of saved peak demand. The primary y-axis shows the peak demand savings and the secondary y-axis shows the energy savings associated with each cost bin.
- About half of all program demand savings are available at a CSPD of less than \$100/kW, and three-quarters of all demand savings are available at a CSPD of less than \$200/kW. Residential consumer products, C&I custom and C&I prescriptive programs all have a CSPD below \$175/kW. Collectively the three programs contribute more than 40% of the portfolio demand savings for the period studied.
- Codes and standards programs have both the highest and lowest CSPD. Low cost cross-cutting programs are code and standards programs from California and Arizona. High cost cross-cutting programs are marketing, education and outreach and market transformation programs.
- The comparison of demand and energy savings have a similar distribution of achieved savings in relation to levelized CSPD. From \$100/kW-\$200/kW, peak demand achieves 31.6% of savings while energy achieves 35.1% of savings. The largest increase in energy savings occurs from \$100/kW-\$200/kW compared to other ranges. The largest increase in energy savings are also achieved from \$100/kW-\$200/kW for most sectors.
- The majority of cross cutting programs fall in the \$0/kW-\$10/kW. This is largely driven by codes and standards programs in California and Arizona.
- A table of values for the distribution curve shown is provided in slide 86.

CSPD and CSE for Select Programs

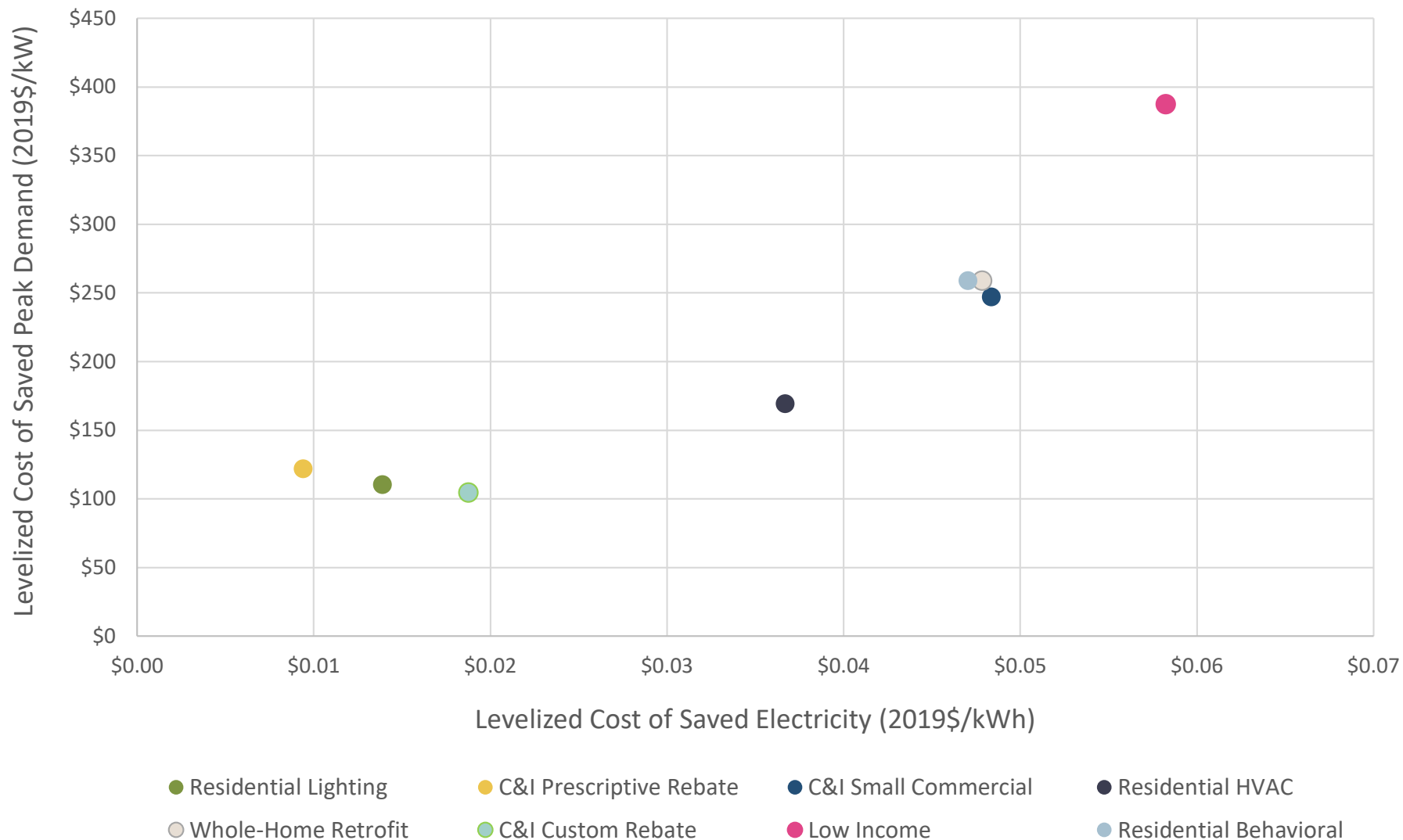
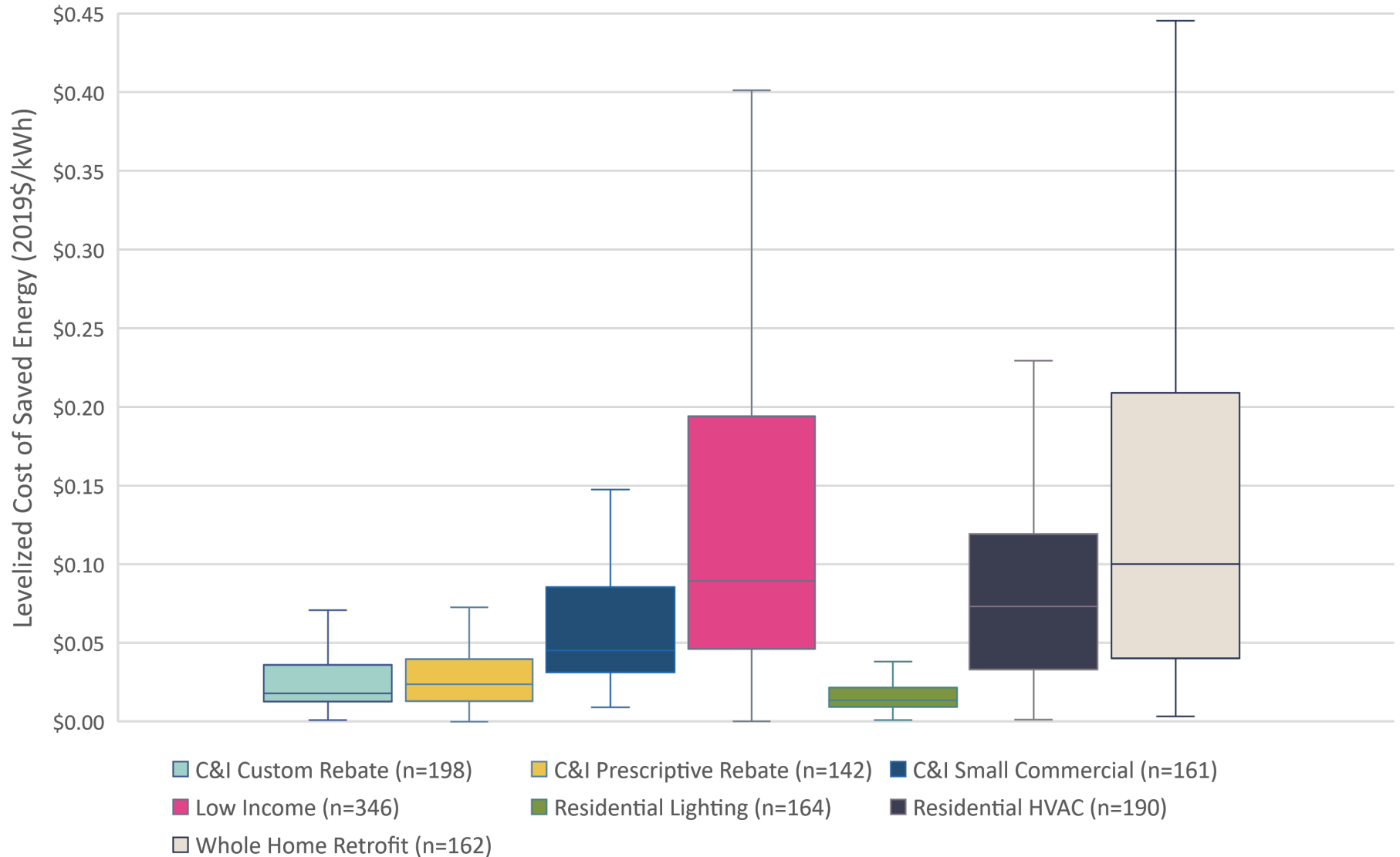


Chart data is available in a table format in the appendix, slide 78 and 79.

- Slide 46 shows the relationship between the levelized CSE and CSPD for selected program types. Each data point on the chart represents the levelized CSE or CSPD for a program during the study period.
- Residential lighting has the lowest CSE and CSPD of the residential programs. Of the C&I programs studied, C&I prescriptive has the lowest CSE and C&I custom has the lowest CSPD. Low income programs are costlier for both energy and demand savings.
- These values are not averages of individual programs, but the levelized cost of all programs within a program type. Large programs, therefore, can weight CSEs and CSPDs high or low. On slide 48 and 50, we look at the range of the levelized costs within each program type. Low income programs are the most expensive program for both energy and demand savings.

Median Value and Interquartile Range for Levelized CSE for Select Efficiency Programs



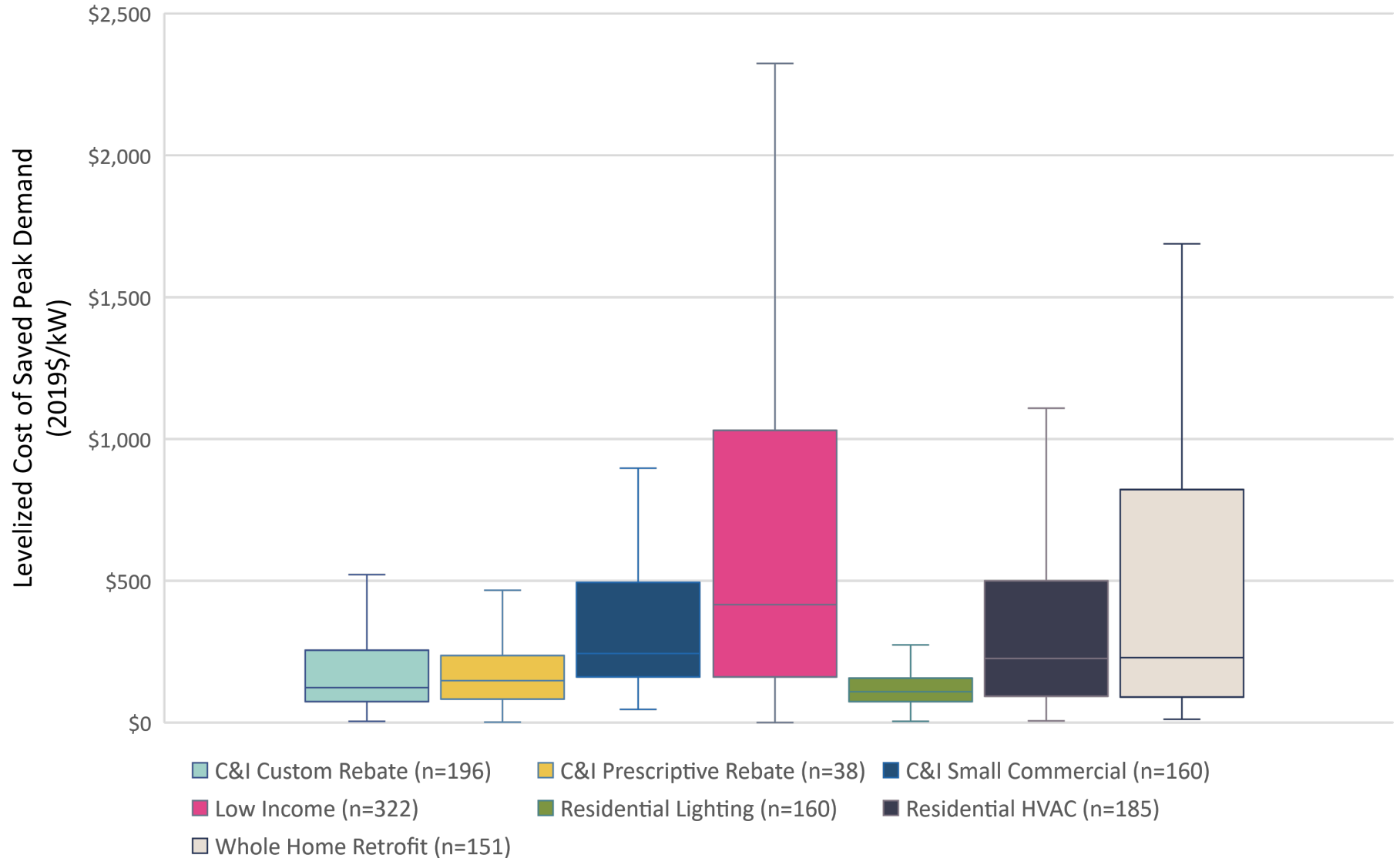
Annual data for each program and year is in the appendix, slide 80.

- We selected seven programs and examined the changes in the average and median levelized CSE over time in each of these programs (2014-2018). For each program, we show the range of values for levelized CSE (slide 48) and CSPD (slide 50).

- The bottom, midline, and top of boxes represent 25th, 50th, and 75th percentile CSE. Sample size (n) is number of program years.
 - ▣ The interquartile range (IQR) is the difference between the 75th and 25th percentiles values.
 - ▣ Top hat is largest value less than the 75th percentile plus 1.5*IQR.
 - ▣ Bottom hat is smallest value greater than 25th percentile minus 1.5*IQR.

- Examining the changes in the median levelized CSE over time per program, we found little variation. However, there is variation within and between program types, with the greatest variation in low income 25th and 75th percentile (\$0.05/kWh - \$0.19/kWh) and residential whole home retrofits (\$0.04/kWh - \$0.21/kWh). In contrast, lighting programs have the lowest median levelized CSE (\$0.013/kWh) and display the least variation (<\$0.01/kWh - \$0.02/kWh) between the 25th and 75th percentile.

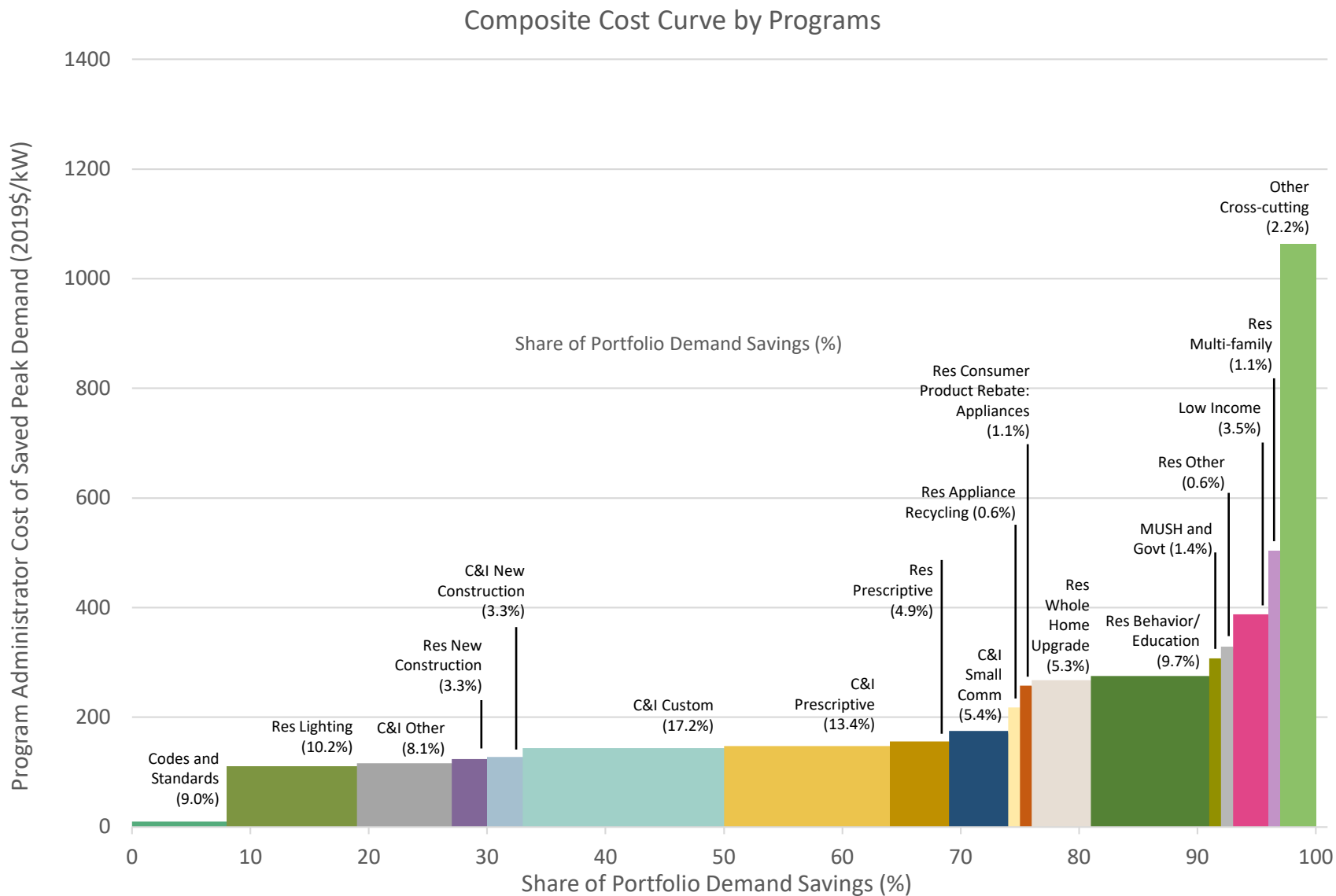
Median Value and Interquartile Range for Levelized CSPD for Select Efficiency Programs



Annual data for each program and year is in the appendix, slide 82.

- We find that the trends in levelized CSPD align with the levelized CSE trends. The CSPD varies across and within program types. Low income programs have the highest median CSPD (\$415/kW) and displays the greatest program variation. Residential lighting programs have lowest median (\$106/kW) and least variable CSPD.
- Each data point in the box plot is a single program year between 2014 and 2018.
- The bottom, midline, and top of boxes represent 25th, 50th, and 75th percentile CSE.
 - The interquartile range (IQR) is the difference between the 75th and 25th percentiles values.
 - Top hat is largest value less than the 75th percentile plus 1.5*IQR.
 - Bottom hat is smallest value greater than 25th percentile minus 1.5*IQR. Dots are data points that are outside the range set by the hats.
- Some levelized CSPD values are well above the box plot, as indicated by the data points in the plot. We can think of them as outliers, in so far as they are so different from the rest of the programs, but they do reflect real data reported by utilities.

Program Cost for Cost of Saving Peak Demand



A chart showing more programs detail is in the appendix, slide 84.

Program Cost for Cost of Saving Peak Demand

Notes for slide 52

- Slide 52 is a levelized CSPD cost curve. The x-axis is the peak demand savings as a percentage of portfolio savings, by program, over the course of the study period. The y-axis is the CSPD. Programs with portfolio peak demand savings above 3% are labeled. The levelized cost of peak demand was calculated by grouping individual programs together and calculating a weighted program category lifetime.
- We observe that codes and standards programs have both the highest and lowest CSPD. Low cost cross-cutting programs are code and standards programs from California and Arizona, see slide 28 for more detail. Residential and commercial new construction both have lower CSPDs and modest contributions to the portfolio savings. Mixed C&I programs have the second lowest CSPD and have a wide variety of measures included in the programs. Residential consumer products, C&I custom and C&I prescriptive programs all have a CSPD below \$175/kW. Collectively the three programs contribute more than 40% of the portfolio demand savings for the period studied. High cost cross-cutting programs are marketing, education and outreach and market transformation programs.
- The median levelized CSPD value of residential programs is higher than C&I (\$254.95/kW and \$174.60/kW), but more peak demand savings are achieved for residential than C&I (656 MW and 407 MW). A cost curve with more detailed program categories is available in the appendix, on slide 84.



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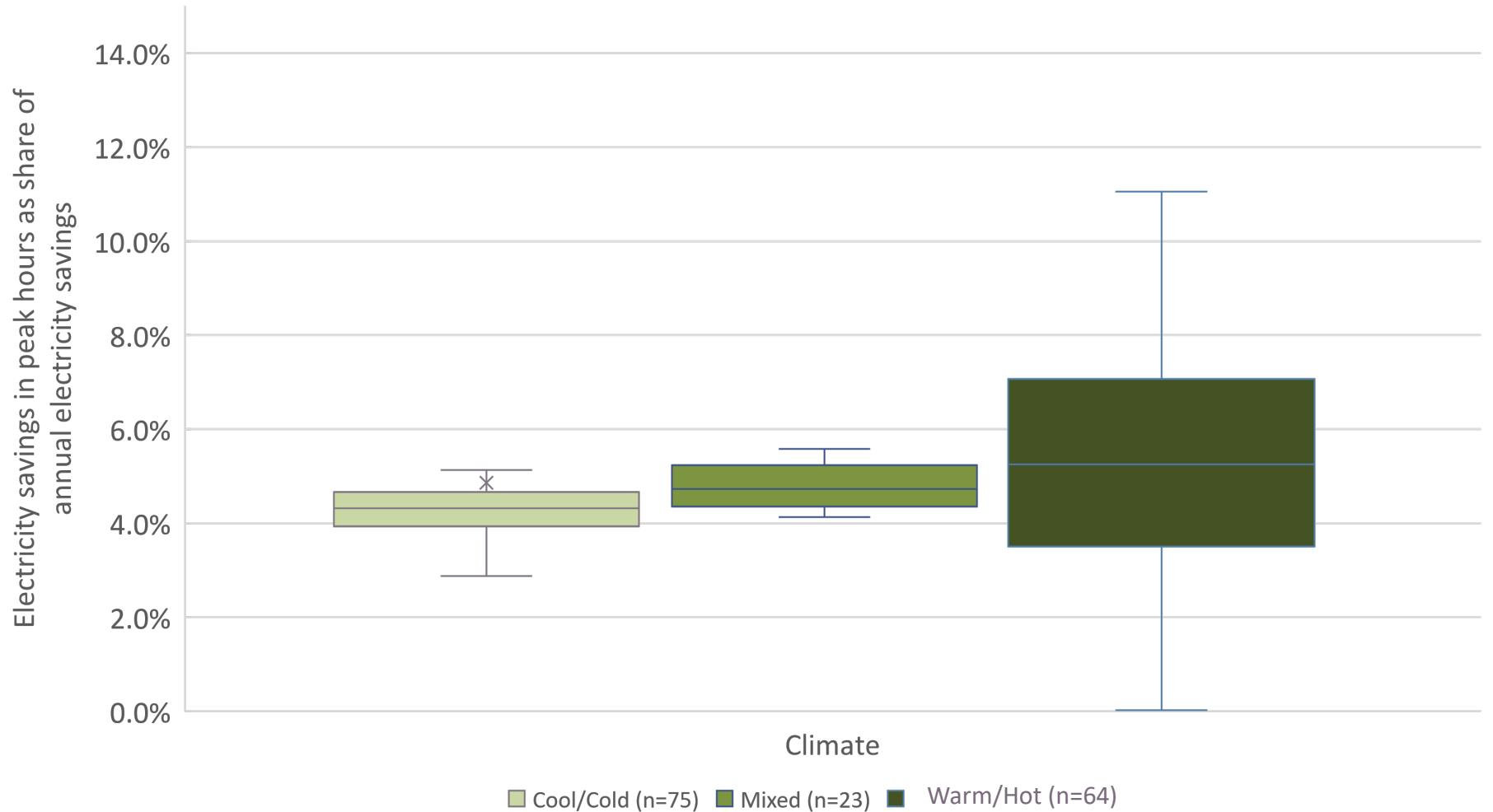
Results: CSPD Using a Standard Peak Period



CSPD Standard Peak Sensitivity

- We conducted a sensitivity analysis using a standard peak demand period and explored trends in program CSPD.
- This analysis builds on our 2019 report where we explored factors that may account for some of the observed variation in efficiency program first-year CSPD values and tested our hypothesis that programs with weather-dependent measures tend to have a lower first-year CSPD in more extreme climates. We also investigated and compiled information on each program administrator or state's definition of peak demand and peak period, such as months and peak period hours, and found variation but a general trend towards summer afternoons and early evenings. Our objective was to identify if there is a relationship between CSPD and the duration and number of hours in the peak period. In our 2019 report, we could not determine the extent to which differences in peak demand savings per program dollar invested are due to climate severity or methods used to estimate peak demand savings, given limited transparency, limitations in reporting practices, and inconsistency in methods used to define and estimate peak demand savings.
- As we did in our 2019 report, we collected information on cooling and heating degree days in nine climate zones as defined by ASHRAE and classified our program administrators into climate zones based on their service territory (Figure 2-1 and Table B - 4) (ASHRAE 2017; Briggs, Lucas and Taylor 2003). In this study we aggregated the climate zones together into three groupings – cool/cold, mixed, and warm/hot – to create larger sample sizes.
- The variation in peak periods makes comparisons across states and PAs difficult, so in this analysis we created a standard peak period that we defined as weekday hours from 2-6 PM in June through September, which totals to 340 hours per year. We calculated the percentage of annual electricity savings that occur in this peak period for different program types and climate zones, which we show in slides 56, 58, 60 and 62. Note the savings vary by program type, so the Y-axis (share of annual savings in peak period) differs by figure.

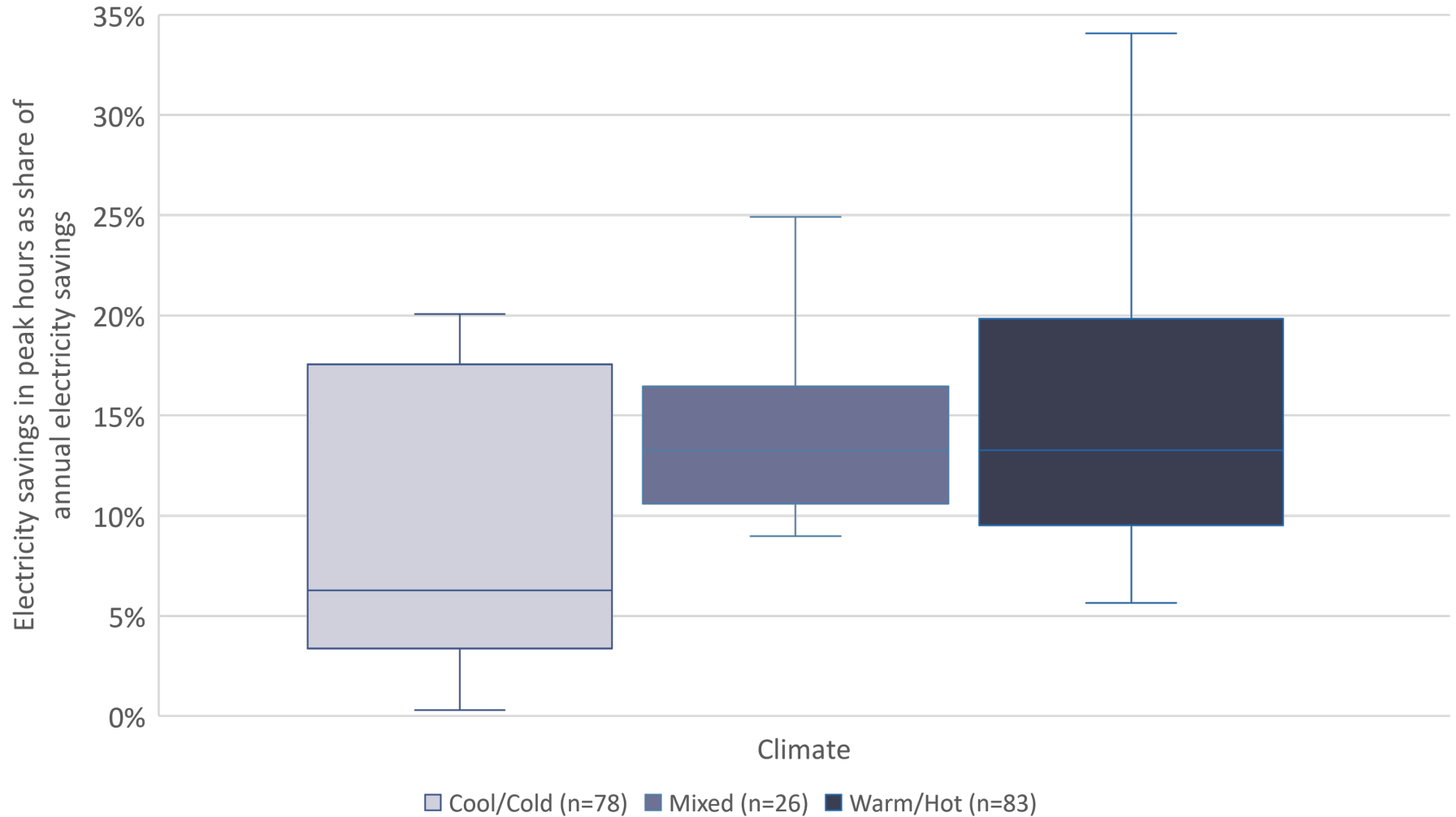
Residential Lighting Programs: Ratio of Peak to Annual Electricity Savings *Using Standard Peak Period*



Climate zone source: [ASHRAE 2017](#).

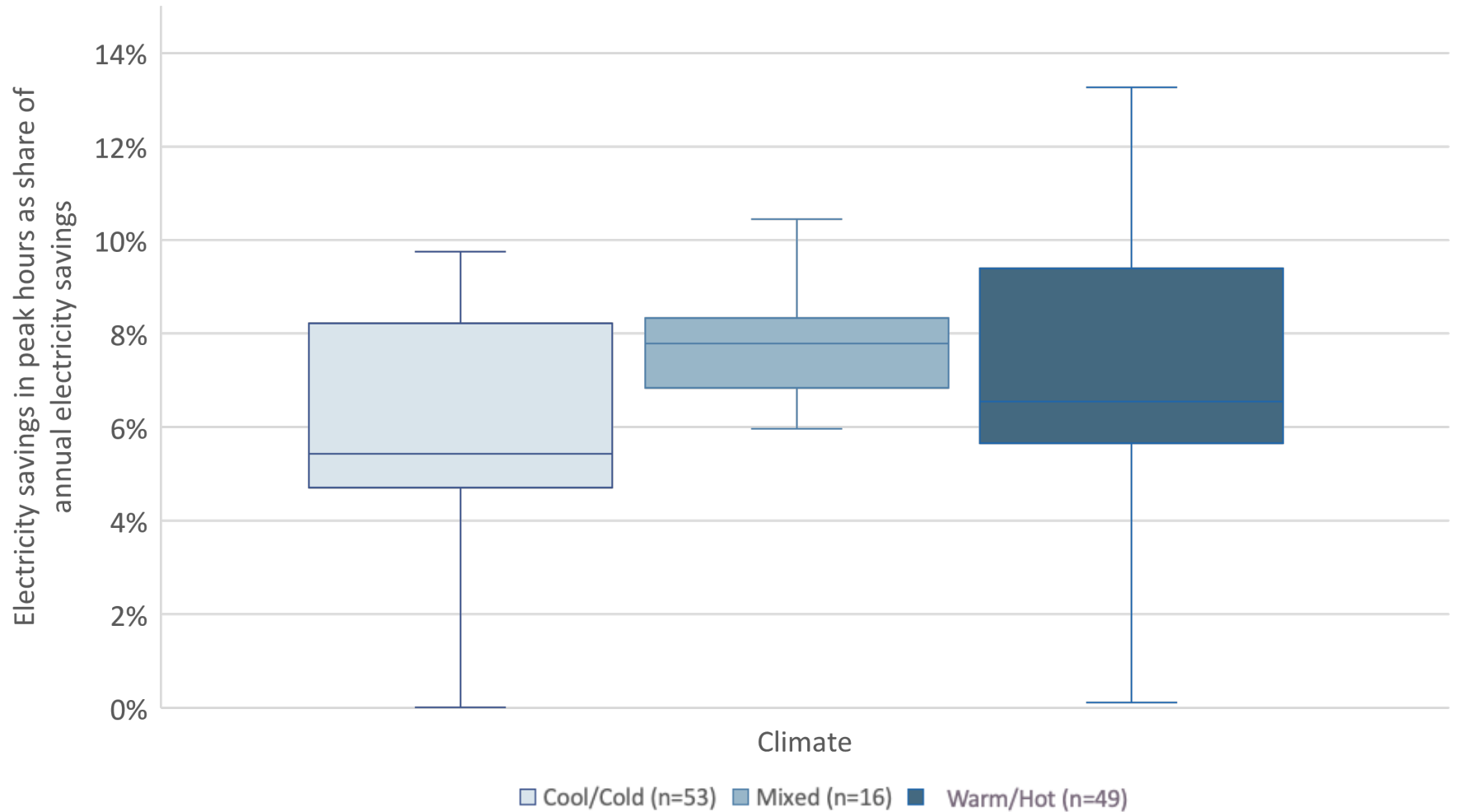
- The peak savings we collect from utilities filings correspond to utility or grid operator-defined definitions of a peak period. These periods cover different hours and different months, depending on the utility's grid characteristics. We developed a metric to understand how concentrated program savings were within peak periods since peak demand values alone do not indicate this.
- The ratio of peak to annual electricity savings measures the share of annual energy savings that occur in peak periods. Due to the disparate definitions of peak period, this metric required a standard set of hours and months. We chose weekday hours from 2-6 PM in June through September, which totals to 340 hours per year. For residential lighting, the median value for peak period share of annual electricity savings ranges from 4 to 6 percent for residential lighting programs in the three climate zones. The interquartile range values for the share of peak period savings compared to annual electricity savings are relatively tightly clustered around the median value for all three climate zones. This may be because assumptions regarding residential lighting hours of operation and savings from compact fluorescent lamps (in earlier years) and light-emitting diode lamps are relatively consistent across utilities. Residential lighting programs display modest variation in concentration of peak savings across climates, with greater variation in warmer climates.

Residential HVAC Programs: Ratio of Peak to Annual Electricity Savings *Using Standard Peak Period*



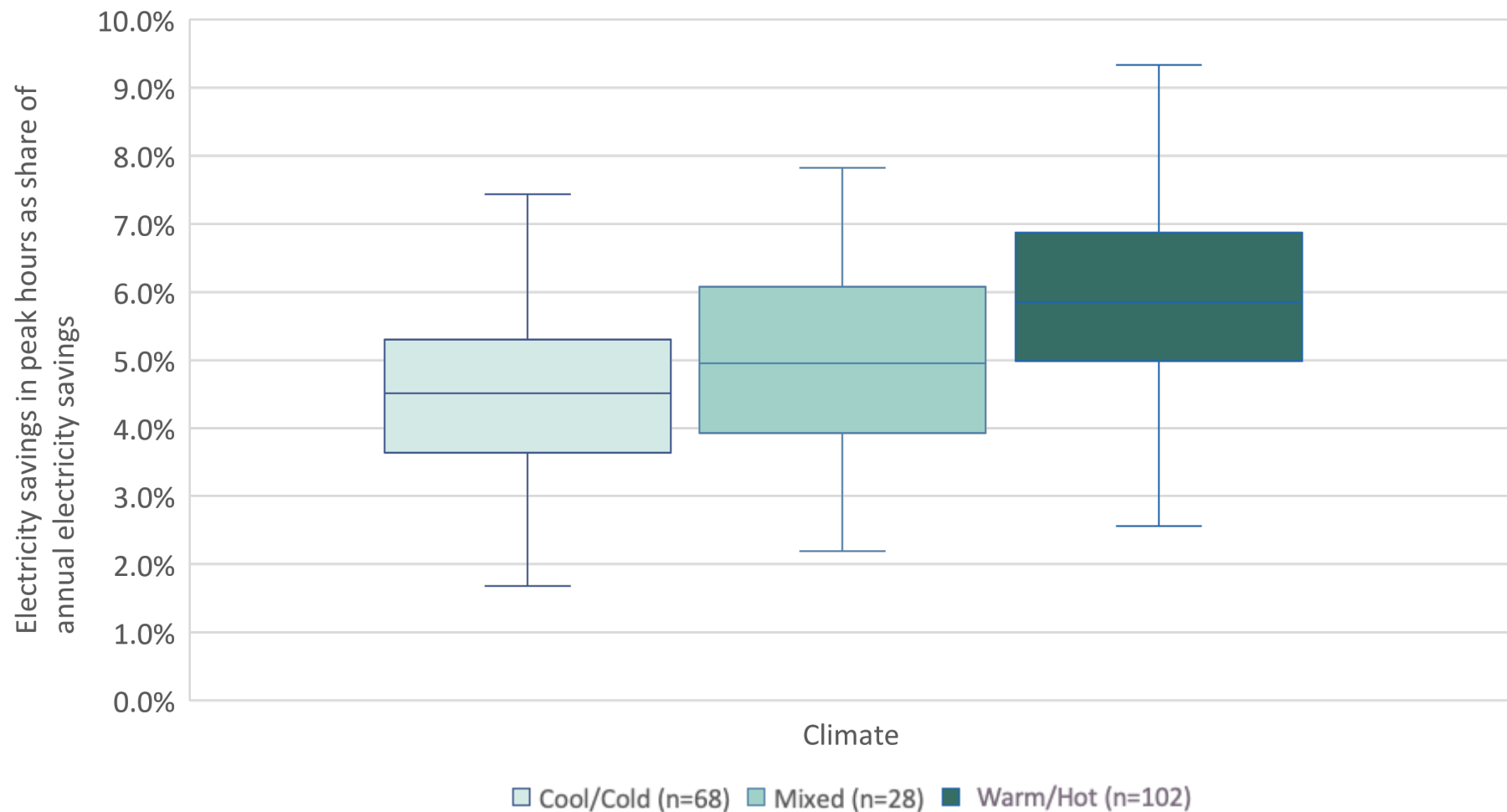
- The median values for peak period share of annual electricity savings ranges between 6 and 15 percent for residential HVAC programs in the three climate zones. We also observe that the interquartile range values for the peak period share of annual electricity savings vary by a factor of three within a climate zone (e.g., 11 to 27 percent in warm/hot climates). Not surprisingly, this illustrates the point that residential HVAC programs potentially offer a greater share of their annual electricity savings during summer peak periods; particularly programs in warm/hot climates.
- High peak share values in cold climates are all from Colorado. Values may reflect differences in utility estimate of peak demand savings.

Residential Behavioral Programs: Ratio of Peak to Annual Electricity Savings *Using Standard Peak Period*



- We find that residential behavioral programs can provide substantial energy savings in peak periods and are somewhat climate sensitive, with median savings higher in the warm/hot climate than in the cool/cold climate. Note that the mixed climate sample is quite small here, which makes it less useful as a comparator to the other climates.
- The behavioral program savings are not as high as those from HVAC programs, but they are higher than those from lighting programs.
- At the high end, behavioral programs can provide peak period savings comparable to HVAC programs. At the 75th percentile in the warm/hot climate, behavioral programs are just below 10%, but there are programs where we observe upwards of 15% of savings occurring in peak periods.

C&I Custom Programs: Ratio of Peak to Annual Electricity Savings *Using Standard Peak Period*



- C&I custom programs tend to serve larger customers and provide a range of measures, so we would expect its peak share of energy to reflect the combination of multiple measures that may or may not have savings concentrated in peak periods. C&I custom programs do display some climate sensitivity but not as much as residential HVAC programs. Median peak savings as a share of annual energy savings increase from about 4.5% in cool/cold climates to about 6% in warm/hot climates.



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Opportunities to Improve and Standardize Peak Demand Reporting



Program Characteristics and Metrics (1)

- Berkeley Lab established a typology for energy efficiency programs in [2013](#).
 - ▣ A common categorization of program types and definitions of metrics that define program characteristics and performance are necessary to compare efficiency program data across states and better understand trends in sector and program level savings.
 - ▣ The Consortium for Energy Efficiency and some states use this typology.
- We identified two key concerns when collecting peak demand savings data for energy efficiency programs.
 - ▣ Peak demand periods are often not defined.
 - The peak period definition can be challenging to locate in efficiency program documentation. The relationship between the energy efficiency peak period and the electricity system peak is rarely discussed. (See [CPUC 2018](#) for an example of the peak period being linked to resource adequacy.)
 - ▣ Data are not reported in a consistent manner.
 - Some utilities do not report peak demand savings for all or some of their energy efficiency programs, often without explaining why.
 - Some utilities report summer or winter peak demand or both; others do not specify a season.
- We created a typology for utilities and other energy efficiency PAs to better understand peak demand reductions from energy efficiency programs, including key characteristics and metrics for defining peak demand savings.

Program Characteristics and Metrics (2)

- Clear documentation and reporting of the following five program characteristics will improve comparisons of peak demand reductions from efficiency programs across utilities and geographic regions.

1. Program impacts

- *What approach is used to estimate or measure peak demand savings (e.g., engineering/deemed, metered)? If applicable, what is the source of the estimate? How frequently are peak demand savings estimates updated?*

■ Metrics

- Peak period definition (for both summer and winter, if applicable) used to determine program impacts, and whether the impacts are the average over the period or the peak during the period.
 - Peak period start hour
 - Peak period end hour
 - Peak period start month
 - Peak period end month
- Gross peak demand savings
 - Summer kW
 - Winter kW

- This information will help PAs and electricity system planners understand the robustness of the reported peak demand impacts.

Program Characteristics and Metrics (3)

2. Contribution to resource adequacy and meeting infrastructure needs

- *Do efficiency peak period definition(s) align with other system planning peak definitions (e.g., ISO/RTO, distribution system peak)?*
- *Are peak demand impacts reported in energy efficiency documentation used in electricity system planning processes such as integrated resource planning and distribution system planning?*
- Metric – Document peak demand impacts, using a clear and consistent definition, in all relevant electricity system planning processes.
- This information will help PAs and system planners understand how the reported impacts contribute to resource adequacy of the bulk power system and distribution system infrastructure needs.

3. Contribution to state energy or utility/PA goal

- *Do peak demand reductions from efficiency programs contribute to state energy goals or program administrator performance incentives (e.g., energy efficiency resource standards, peak demand reductions, air pollutant emissions reductions)?*
- Metric – Identify contribution, in capacity (kW) or air pollutant emissions reductions (e.g., tons, ppm), toward achieving state or utility energy, capacity or emissions reduction goals.
- This information provides important context for program impacts.

Program Characteristics and Metrics (4)

4. Motivation

- *What is the driver for the energy efficiency program (e.g., reduce peak demand or reduce energy savings, meet all cost-effective requirement, reduce air pollutant emissions)?*
- Metric - Stated driver for the program or portfolio in state law or PUC order, or stated goal of the program in a planning process.
- This information will help PAs understand if programs designed to reduce peak demand are achieving their goal.

5. Demand Flexibility

- *How can technologies included in an energy efficiency program provide dispatchable savings to contribute to demand flexibility as utility system peak periods shift over time?*
- Metric – Document technologies included in the program that provide demand flexibility in PA reporting.
- This information will help identify the cost and value of efficiency programs that provide demand flexibility.

Example of Standardized Peak Demand Reporting: Acme Electric Company Residential Lighting Program

Key Characteristic	Description	Metric
Program impacts	Engineering calculations are used to determine the peak demand reductions. The coincidence factor is derived from a lighting meter study for the utility in 2016. The next evaluation, measurement and verification update for this program is in Q4 2020. Savings are calculated as the average reduction during the peak period.	The utility only measures summer peak savings. <ul style="list-style-type: none"> • Peak period start hour: 2 p.m. • Peak period end hour: 6 p.m. • Peak period start month: June 1 • Peak period end month: September 30 • Program savings in CY19 were 25 MW
Contribution to resource adequacy and meeting infrastructure needs	<ul style="list-style-type: none"> • Program savings align with the ISO's passive demand resource performance period. • The peak demand reductions reported are not used in the utility's distribution system planning because the utility's distribution system peak does not align with the ISO's system peak. • Peak demand reductions from efficiency are estimated on an ad hoc basis in distribution system planning. See docket XX-XXXX. 	
Contribution to state energy or utility/PA goal	<p>The utility does not have a capacity reduction goal. The energy savings associated with the efficiency programs contribute to the utility's energy reduction goal and associated performance incentive. The Commission recently approved use of active demand measures in the energy efficiency program and a demand reduction goal and associated performance incentive is the subject of ongoing discussion.</p> <p>Peak demand reductions from energy efficiency programs contribute to the state's Clean Energy Standard. Efficiency produces a 0.01 ton per kWh saved emissions reduction.</p>	
Motivation	The residential lighting program was established in 2004 to help residential consumers reduce their electricity bill. The program did not explicitly seek to produce peak demand reductions. The demand reductions associated with the program are included in the cost-benefit analysis of the program.	
Demand Flexibility	The residential lighting program measures include dimmable bulbs but not controls at this time. The multi-family, small commercial and prescriptive commercial lighting programs all contain occupancy sensor measures and lighting control measures.	



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Potential Future Analysis



Potential Future Analysis

- *Reporting template and guidance documents.* Build on Berkeley Lab tools for data collection and reporting on efficiency program costs and savings (Rybka et al. 2015) to provide templates for states, utilities, and other program administrators to improve reporting on peak demand savings and costs. In particular, we could collaborate with state PUCs, investor-owned and public power utilities, and stakeholders to develop guidance for consistent methods to define peak periods and calculate and report peak demand savings.
- *Broaden data collection to include demand response programs.* Expand CSPD data collection to include utility demand response data for one region (e.g., MISO). To better understand the full picture of demand response savings this research would also identify the ISO/RTO demand response offerings and, if available, collect program cost and impact information. This research would explore the ability to aggregate demand response program data from utilities and ISO/RTOs for comparison and quantify the CSPD for both program types if possible.
- *Bigger and more diverse sample.* Collect and analyze data on peak demand savings for efficiency programs from additional states to *provide broader geographic* representation, larger sample size, more diversity and greater confidence in results. Additional data collection could focus on PAs with winter peaking systems. Our analysis thus far has focused on the cost of saving peak demand for summer peaking utilities.
- *Additional program specific analysis.* Focus program specific analysis on programs that have many measures but produce significant peak demand reductions (e.g., C&I custom, C&I general) to better understand what measures or end-uses are driving reductions. A case study approach could be used for a subset of PAs.



Natalie Mims Frick

nfrick@lbl.gov

510-486-7584

Visit our website at: <http://emp.lbl.gov/>

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Appendix

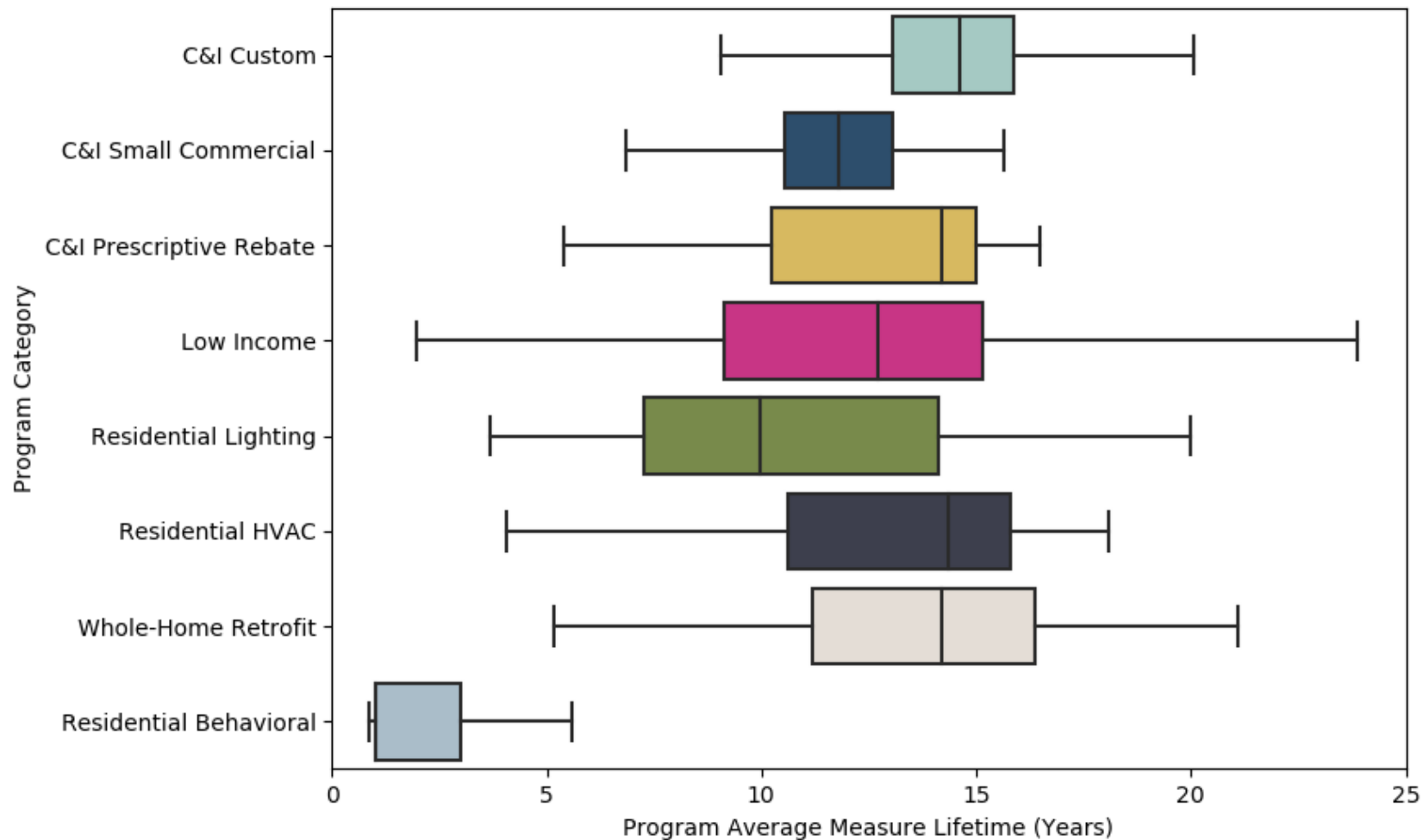


2019 Study Results: Cost of Saving Peak Demand and Cost of Saving Electricity, by State

State	First-Year Savings-Weighted PA CSPD (2017\$/kW)	Savings-Weighted PA CSE (2017\$/kWh)
Arizona	568	0.013
Illinois	646	0.020
Texas	732	0.021
Colorado	963	0.020
Arkansas	1,208	0.030
California	1,555	0.036
Maryland	1,651	0.036
New York	1,836	0.025
Massachusetts	2,353	0.039
All Nine States (average)	1,483	0.029

- The savings-weighted PA CSE during the study period averages \$0.029/kilowatt-hour (kWh) and varies by a factor of three (\$0.013/kWh to \$0.039/kWh) across the nine states. The first-year savings-weighted PA CSPD averages \$1,483/kilowatt (kW) and varies more than four-fold (\$568/kW to \$2,353/kW). Comparing the range in values for these two metrics illustrates that program costs are the primary driver of differences in the first-year PA CSPD across states, although the level of peak demand savings (per program dollar invested) appears to have some impact as well.

Measure Lifetimes



Organizations Interviewed

- Arizona Public Service (AZ)
- Commonwealth Edison (IL)
- Guidehouse (IL)
- Nexant (FL and Southeast)
- Massachusetts Department of Energy Resources (MA)
- Minnesota Department of Commerce (MN)
- Michigan Public Service Commission (MI)

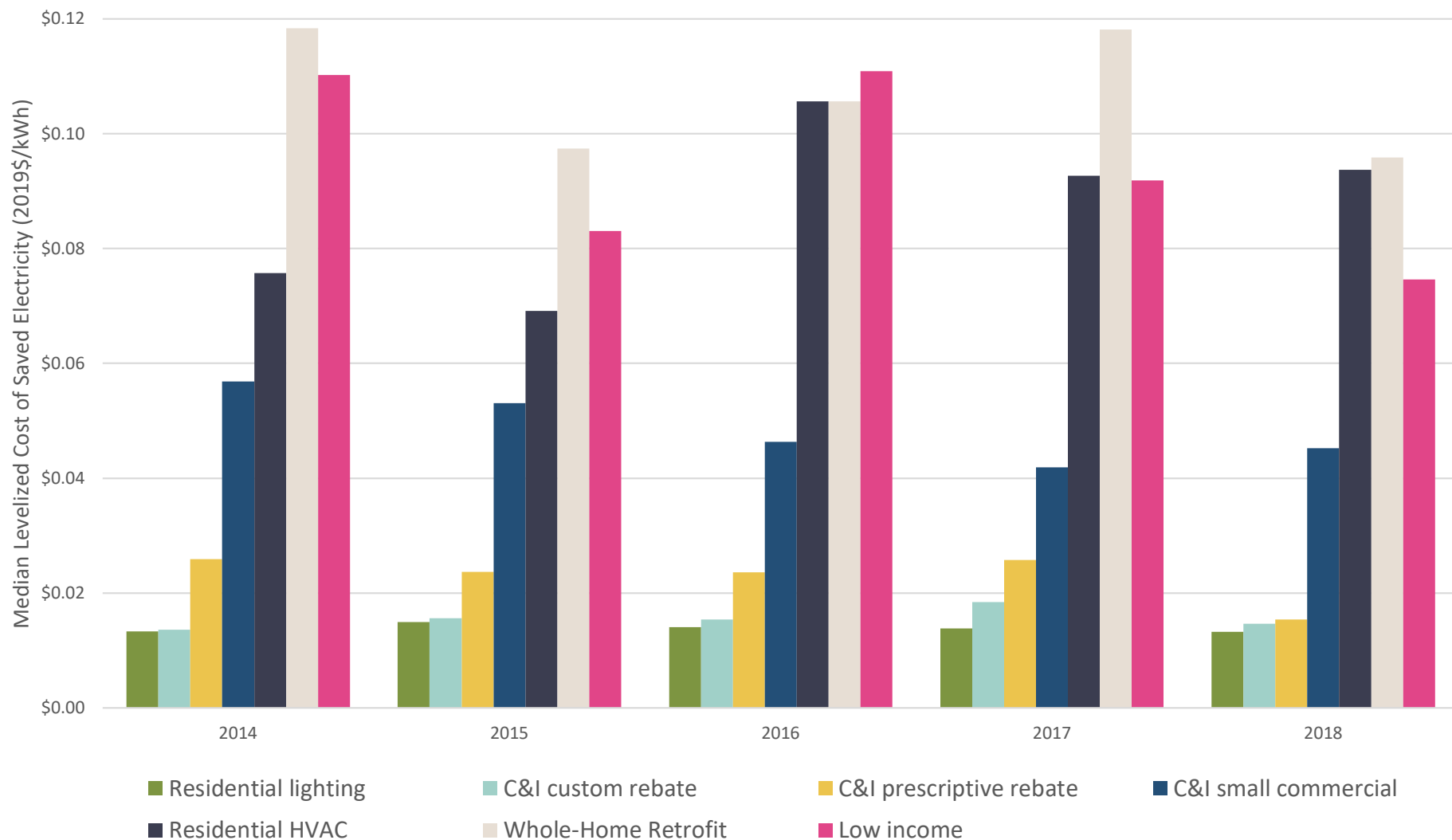
2020 Study Results: Cost of Saving Peak Demand and Cost of Saving Electricity, for Select Programs

Program Type	Average CSPD (2019\$/kW)	Median CSPD (2019\$/kW)	Average CSE (2019\$/kWh)	Median CSE (2019\$/kWh)
Residential Lighting	111.0	107.7	0.014	0.013
C&I Prescriptive Rebate	122.1	147.2	0.009	0.024
Small Commercial	246.1	243.1	0.048	0.045
Residential HVAC	169.7	226.1	0.037	0.071
Whole-Home Retrofit	259.0	229.1	0.048	0.100
C&I Custom Rebate	104.5	123.6	0.019	0.018
Low Income	387.6	415.0	0.058	0.089
Residential Behavioral	254.4	226.3	0.047	0.042

2020 Study Results: Cost of Saving Peak Demand and Cost of Saving Electricity, for Select Programs

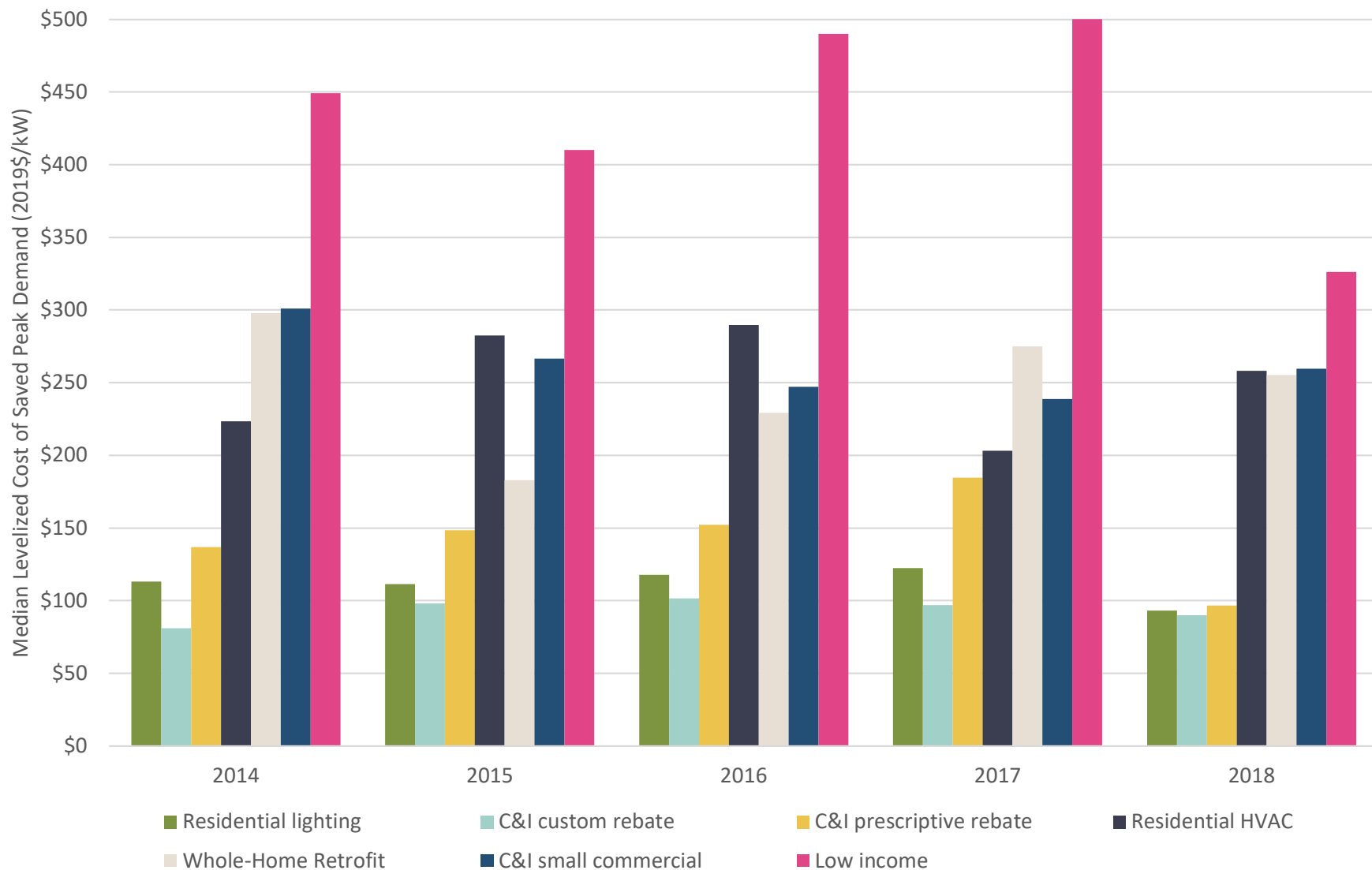
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Median Levelized CSE for Select Efficiency Programs



- This figure shows the median levelized CSE for select program types in each year between 2014 and 2018.
- As shown on slide 48, programs can differ in their typical CSE. We find a mix of time trends, with the median levelized CSE for some program types increasing and for others decreasing. We see the largest overall reductions in median CSE for C&I prescriptive rebate (41%) and low income programs (32%). The median CSE for C&I small commercial and residential whole home retrofits declined 20% and 19% respectively. We found the least variation in residential lighting, whose median levelized CSE declined by 0.5%.
- The median levelized CSE for residential HVAC and C&I custom, in contrast to the rest of the programs, increased by 24% and 8% between 2014 and 2018 respectively. Within these overall decreases or increases in median levelized costs, we find some year-to-year variation. For example, the C&I small commercial median levelized CSE decreases from 2014 to 2017 before increasing from 2017 to 2018.

Median Levelized CSPD for Select Efficiency Programs

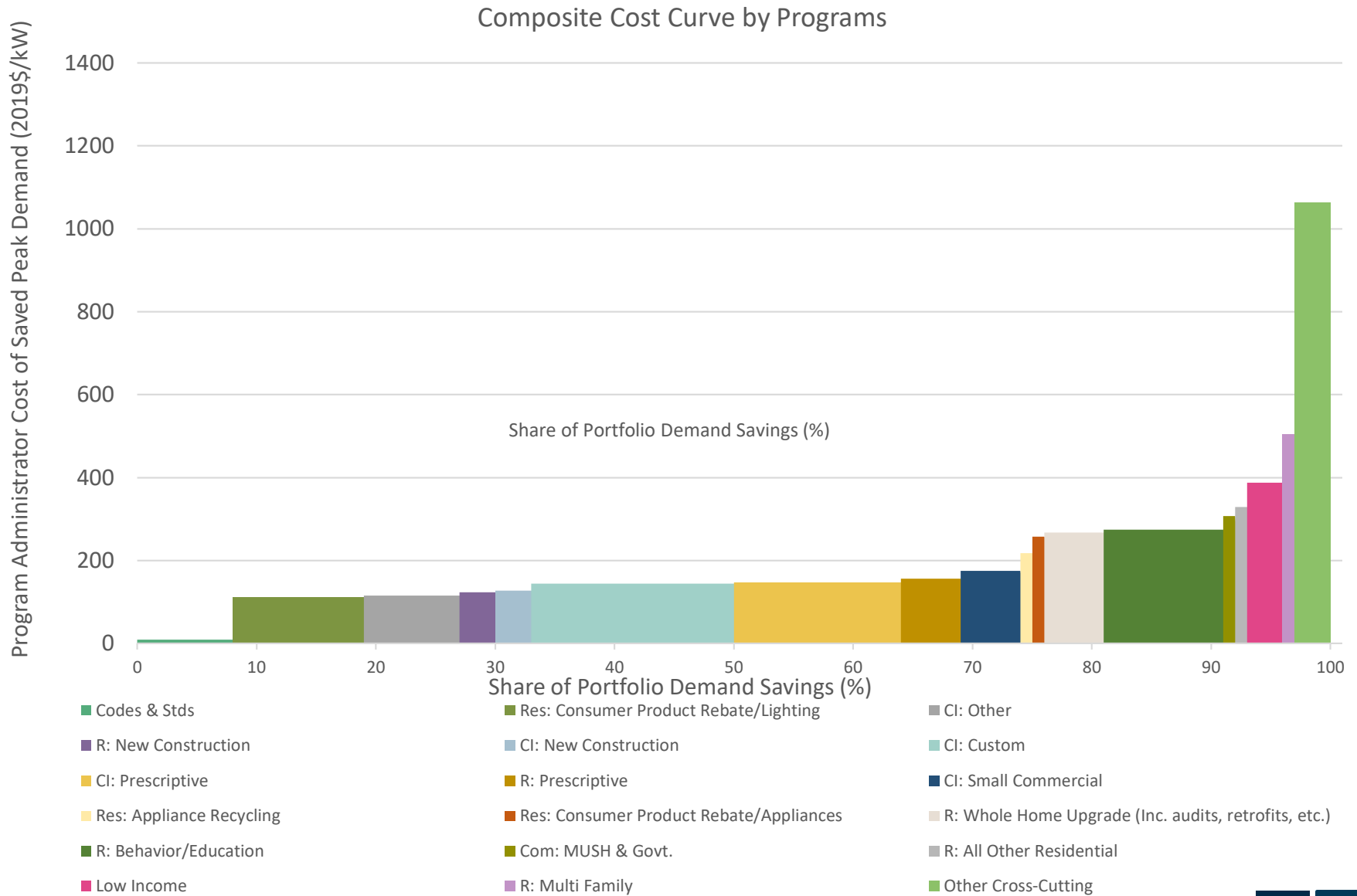


Median Levelized CSPD for Select Efficiency Programs

Notes for slide 82

- Here we look at the median levelized CSPD for select program types from 2014 to 2018.
- The trends generally align with what we show on slide 50 for the median levelized CSPD. From 2014-2018, the median levelized costs decrease overall for low income (27%), C&I prescriptive rebate (29%), residential lighting (18%), whole home retrofit (14%), and C&I small commercial (14%). For residential HVAC and C&I custom rebate, we find the median levelized CSPD increases by 16% and 11% between 2014 and 2018. The size of the changes, both increases and decreases, are smaller than what we observed for the median levelized CSE.
- We note that in between 2014 and 2018, the median levelized CSPD for a program may exhibit variation from year-to-year. For example, the median levelized CSPD for C&I Small Commercial programs, for example, decreases in each year except in 2017. Other examples include:
 - Low-income has a 63% CSPD decline between 2017 (\$494/kW) and 2018 (\$304/kW)
 - Whole home retrofit has a 63% CSPD decline between 2014 (\$298/kW) and 2015 (\$183/kW)
 - Residential lighting 22% CSPD decline between 2016 (\$112/kW) and 2018 (\$92/kW)
 - C&I small commercial had a 25% CSPD decline between 2014 (\$328/kW) and 2017 (\$262/kW)
 - C&I custom had a 41% increase between 2014 (\$79/kW) and 2016 (\$110/kW).

Detailed Program Cost Curve for Cost of Saving Peak Demand



Detailed Program Cost Curve for Cost of Saving Peak Demand

Notes for slide 84

- This slide shows a more detailed cost curve than the one shown on slide 52, where certain program categories have been separated. For example, program categories such as C&I: New Construction and C&I: Prescriptive are separated into respective commercial and industrial/agricultural categories.
 - ▣ Levelized CSPD by program category shows less distribution than levelized CSPD by individual program years:
 - ▣ Cross cutting program categories represent both lowest and highest groups
 - ▣ The median levelized CSPD value of residential programs is higher than C&I, but more peak demand savings are achieved for residential

Data for Distribution of Peak Demand Savings by Levelized CSPD and Market Sector

Levelized Cost of Saved Peak Demand (\$2019/kW)	Cross Cutting			Low Income			Residential			C&I		
	Count of Programs	Demand Savings (MW)	Energy Savings (GWh)	Count of Programs	Demand Savings (MW)	Energy Savings (GWh)	Count of Programs	Demand Savings (MW)	Energy Savings (GWh)	Count of Programs	Demand Savings (MW)	Energy Savings (GWh)
<10	24	1131	5540	3	17	17	9	53	106	23	377	413
<20	26	1133	5544	4	17	17	26	114	270	66	569	935
<30	29	1135	5549	6	17	19	44	270	590	99	644	1145
<40	30	1138	5563	10	22	26	64	337	863	133	755	1394
<50	31	1138	5563	13	24	27	105	452	1273	181	950	2401
<60	34	1236	5857	14	35	43	139	577	1898	231	1209	3869
<70	34	1236	5857	17	38	49	188	857	3242	273	1501	5493
<80	38	1267	5895	25	57	79	223	1206	4675	357	1936	7679
<90	38	1267	5895	31	85	106	287	1508	5940	433	2321	9960
<100	39	1269	5906	48	145	206	334	1831	7587	503	2794	12896
<200	70	1296	6003	98	300	586	659	3364	16941	950	5071	27456
<300	93	1335	6164	132	333	700	875	3805	19052	1147	5670	31338
<400	120	1351	6275	157	352	825	1003	4047	20264	1260	5946	33307
<500	140	1365	6386	174	362	870	1086	4210	21050	1339	6107	34258
<600	156	1375	6455	191	378	1007	1146	4329	21839	1397	6145	34553
<700	166	1381	6507	207	390	1110	1175	4381	22187	1434	6162	34692
<800	174	1386	6541	216	395	1192	1201	4410	22409	1464	6171	34785
<900	178	1388	6564	233	399	1224	1238	4499	23025	1483	6195	35602
<1,000	184	1392	6595	239	401	1233	1265	4509	23079	1500	6198	35623
<10,000	207	1395	6631	321	436	1582	1394	4571	23750	1672	6242	36904
All Programs	209	1395	6631	322	436	1582	1404	4572	24130	1692	6242	37090

Notes for slide 86

- Slide 86 provides additional detail for chart shown on slide 44. The table shows how individual program years from 2014 to 2018 are sorted into Levelized Cost of Saved Peak Demand bins by sector. Each bin shows the count of programs, peak demand savings, and energy savings per sector.