Exploring Programs and Policies for Deep Energy Efficiency Opportunities

Jennifer Potter, Commissioner

Hawaii Public Utilities Commission

November 14, 2018

Hawai’i Clean Energy Initiative (HCEI)

- The US Department of Energy and State of Hawaii established a long-term partnership, referred to as the HCEI, which set a goal for Hawai’i to meet 70% of its energy needs by 2030 through clean energy, with 30% coming from energy efficiency measures, and 40% coming from locally-generated renewable sources.
- The Hawaii State Legislature passed Act 155, Session Laws of Hawaii 2009, codified under section 269-96, Hawaii Revised Statutes, which established the State’s energy efficiency goals into an Energy Efficiency Portfolio Standard (“EEPS”).
- As specified in HRS § 269- 96, the statewide EEPS goal is **4,300 gigawatt-hours (GWh) of electricity savings by 2030.**

"The Hawai'i Public Utilities Commission shall establish the Energy Efficiency Portfolio Standards that will maximize the cost effectiveness of energy efficient programs and technologies."

The Commission oversees the activities of the Public Benefit Fee Administrator (PBFA). The current Administrator is Leidos, LLC aka "Hawaii Energy"

- From PY 2009 through PY 2016 the Hawaii Energy program has saved approximately 718 GWh of energy in Hawaii (excluding Kauai). The 718 GWh represents about 68% of the economic potential available (1,049 GWh) in 2015— as estimated by the 2012 potential study.

- EE reduces electricity sales by approximately 1.5%, saving consumers approximately $625 million in the last 8 years, and an estimated $1.74 billion in lifetime savings. The annual budget for Hawaii Energy's program is ~$29 million

Market Transformation-
Keeping up with the pace of change

Is this refrigerator energy efficient?? What about controls? Enlist enough refrigerators and we have a grid resource.

- Food Management: create shop lists and see inside w/ 3 built-in cameras
- Family Connection: share calendars, photos, notes and memos
- Entertainment: stream music, videos or watch your Samsung TV

Energy Efficiency, Market Transformation and Grid Services

Energy Optimization with Behind the Meter Resources

- Programs must be customer centric strategies that can be customized to solve specific distribution system challenges & constraints.

- Offerings should be specific to a customer demographic or even electricity consumption profile within targeted areas on the distribution system or transmission system.

- Focus on electricity usage behind the meter and optimize consumption.

- Enabling technology end-uses that have technical capabilities that allow the end-use to achieve multiple DSM objectives

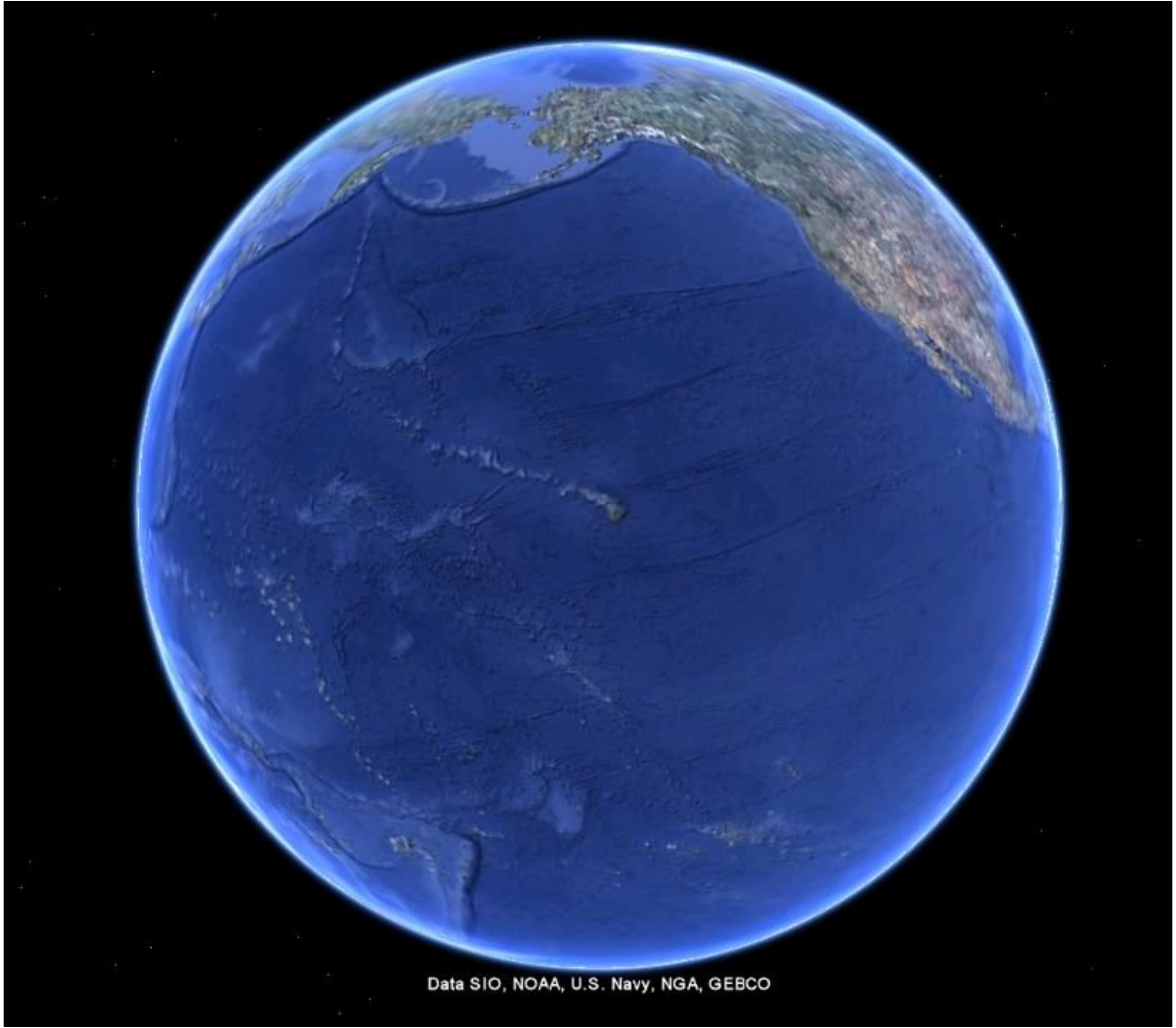
"What kind of grid services do we need?" Focus EE on grid services

- Distribution System Services: Capacity, frequency and voltage regulation, harmonics, thermal capacity overload
- Bulk Power System Services: System resiliency, baseload/conventional generation, overgeneration of renewable energy
- Overvoltage at primary and secondary transformers

- **What can we do on the DEMAND SIDE to assist in building a reliable, resilient, and clean grid?**

Non-Wires Alternatives

An electricity grid investment or project that uses **non-traditional transmission and distribution (T&D) solutions**, such as distributed generation (DG), energy storage, **energy efficiency (EE)**, demand response (DR), and grid software and controls, to defer or replace the need for specific equipment upgrades, such as T&D lines or transformers, by **reducing load at a substation or circuit level.**


Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Thank you!

Jennifer Potter

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Energy Efficiency in New York

Raghu Sudhakara

Energy Efficiency and Demand Management
Consolidated Edison

November 14, 2018

Power Sector Transformation

Regulatory (State, Federal and Local), Consumer and Technology Changes are creating new opportunities and challenges

Major Drivers

- New York Policy Shifts
  - Reforming the Energy Vision "REV"^
  - Energy Efficiency Target by 2025
  - Clean Energy Standard (50x30)
- Consumer Preference Shifts
  - Manage Energy Usage
  - Solar Panels
  - Smart Technologies (E.g. Thermostats)
- Technology Shifts
  - Solar technology costs
  - Wind Energy Technology and Costs
  - Storage Technology and Costs

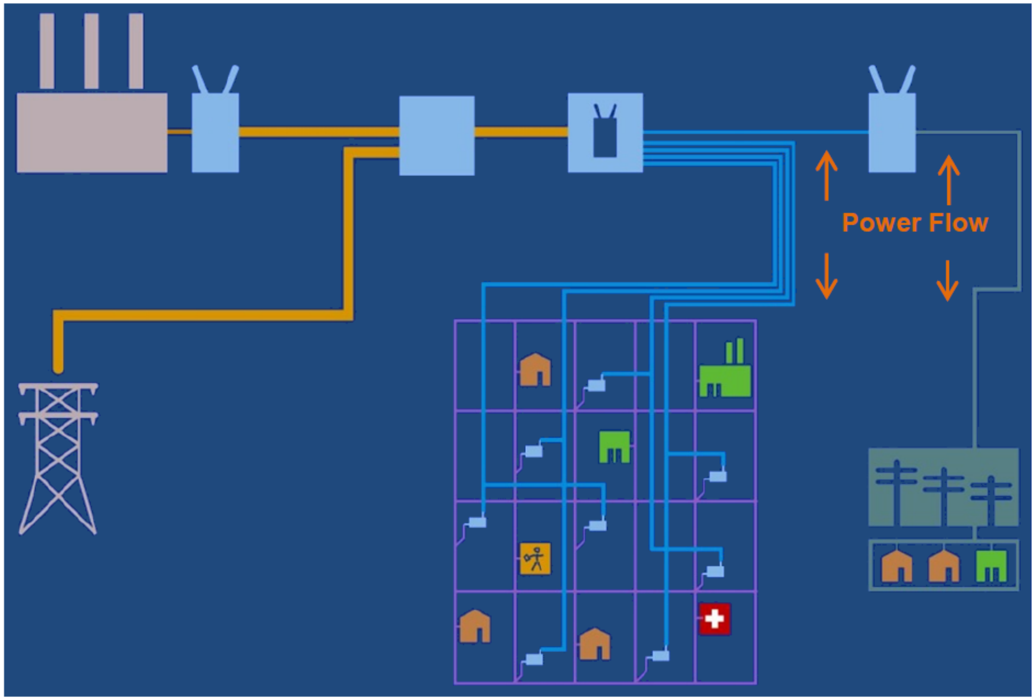
Major Consequences

- New York Policy Shifts
  - Increased amount of DERs, NWS, NPS*
  - Rapid growth of Energy Efficiency
  - Development of new REC market
- Consumer Preference Shifts
  - Communications
  - Incentives and tariffs
  - Consumption behaviors
- Technology Shifts
  - Grid and vertical compatibility
  - Parity and integration (Transmission)
  - Shaping demand but permitting hurdles

^ Reforming the Energy Vision (New York Regulatory Proceeding)
** Distributed Energy Resources, Non-wires Solutions, Non-pipeline solutions*

The Main Theme of REV is Integration

- **Integrate individual resources**
- **Integrate resource portfolios**
- **Integrate market**



Current Energy Efficiency

Existing and Authorized Initiatives

- Utilities delivering significant energy efficiency
  - ETIP^: Electric and gas territory-wide
  - Additional efficiency through rate cases
- NYSERDA* focused on statewide initiatives
  - Clean Energy Fund: $5 billion over 10 years
  - More than 50% towards market development
- Partnerships between NYSERDA and utilities

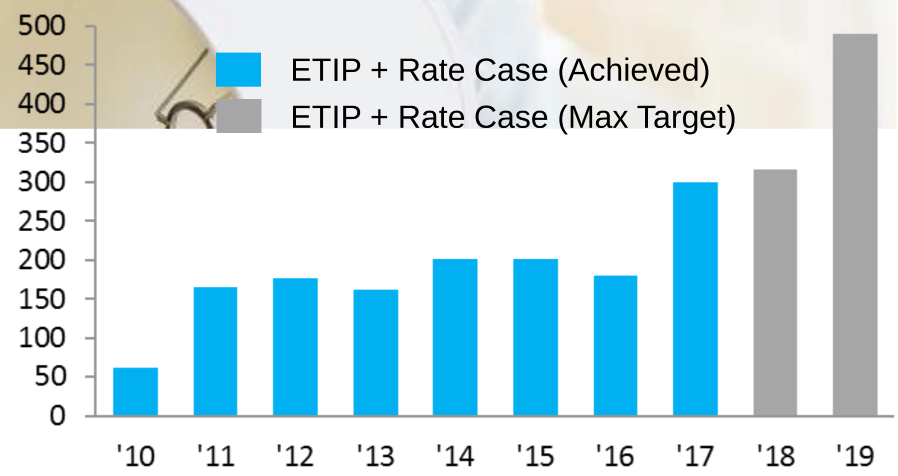
^ Energy Efficiency Transition Implementation Plan
** New York State Energy Research and Development Authority*



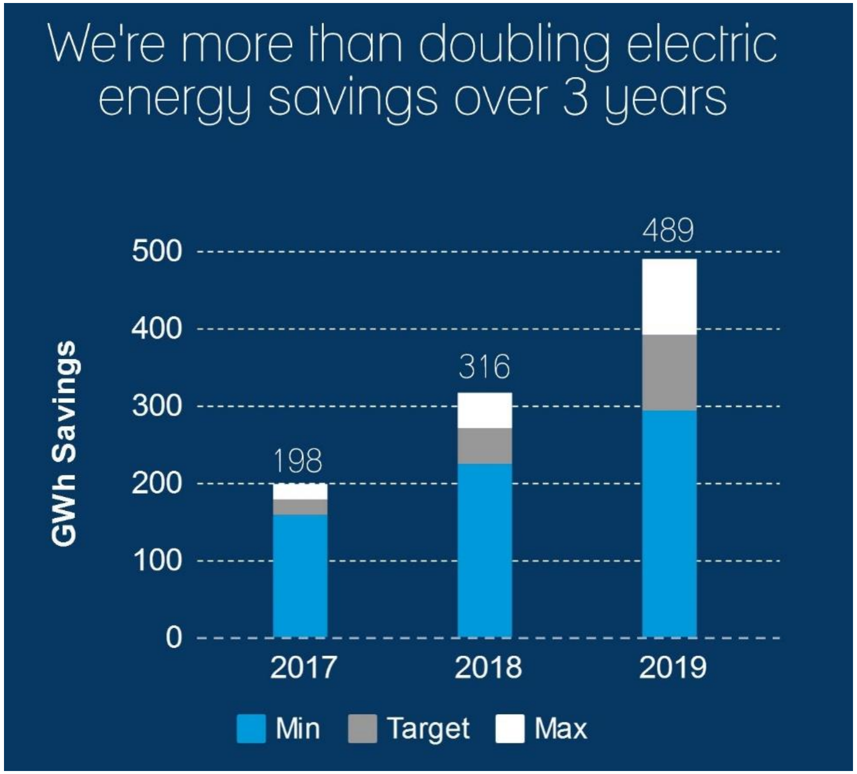
Energy Efficiency reaching more customers

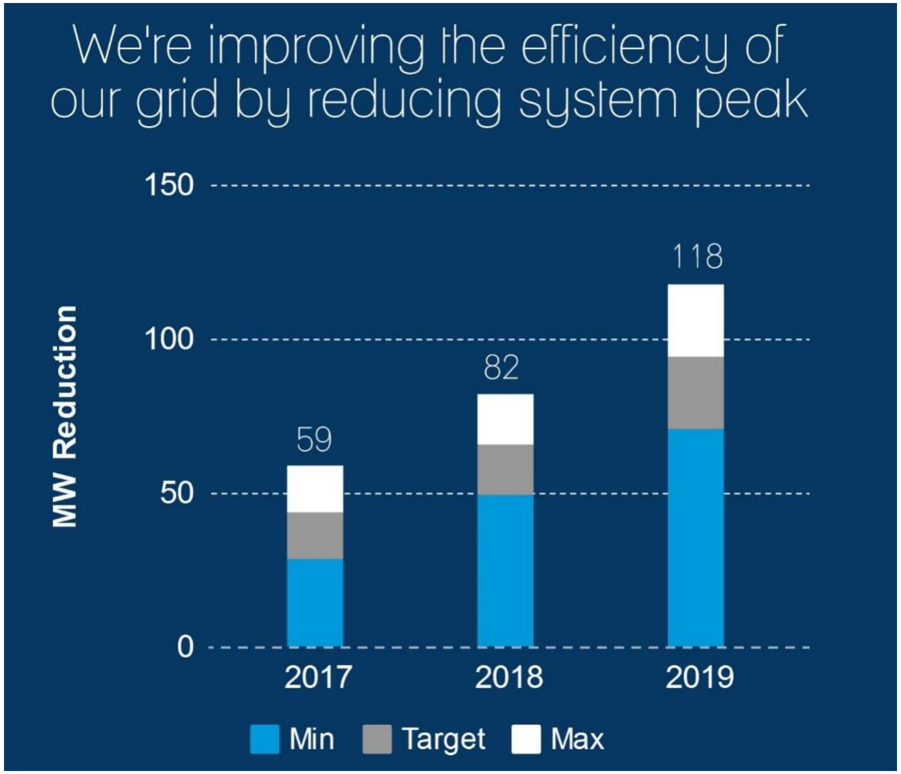
Innovation and Efficiency for All

- Goal to create a seamless customer experience, strong customer relationships
- Reach all customer segments and transform markets, e.g. Smart Kids, Upstream
- Higher savings (deep efficiency) are needed to reach more, achieve more



Ramping Up Efficiency and Demand Relief





2017 Electric EE: 300 GWh

2017 Electric Demand: 61 MW

Earnings Adjustment Mechanisms

Align Policy Goals with Utility Interest

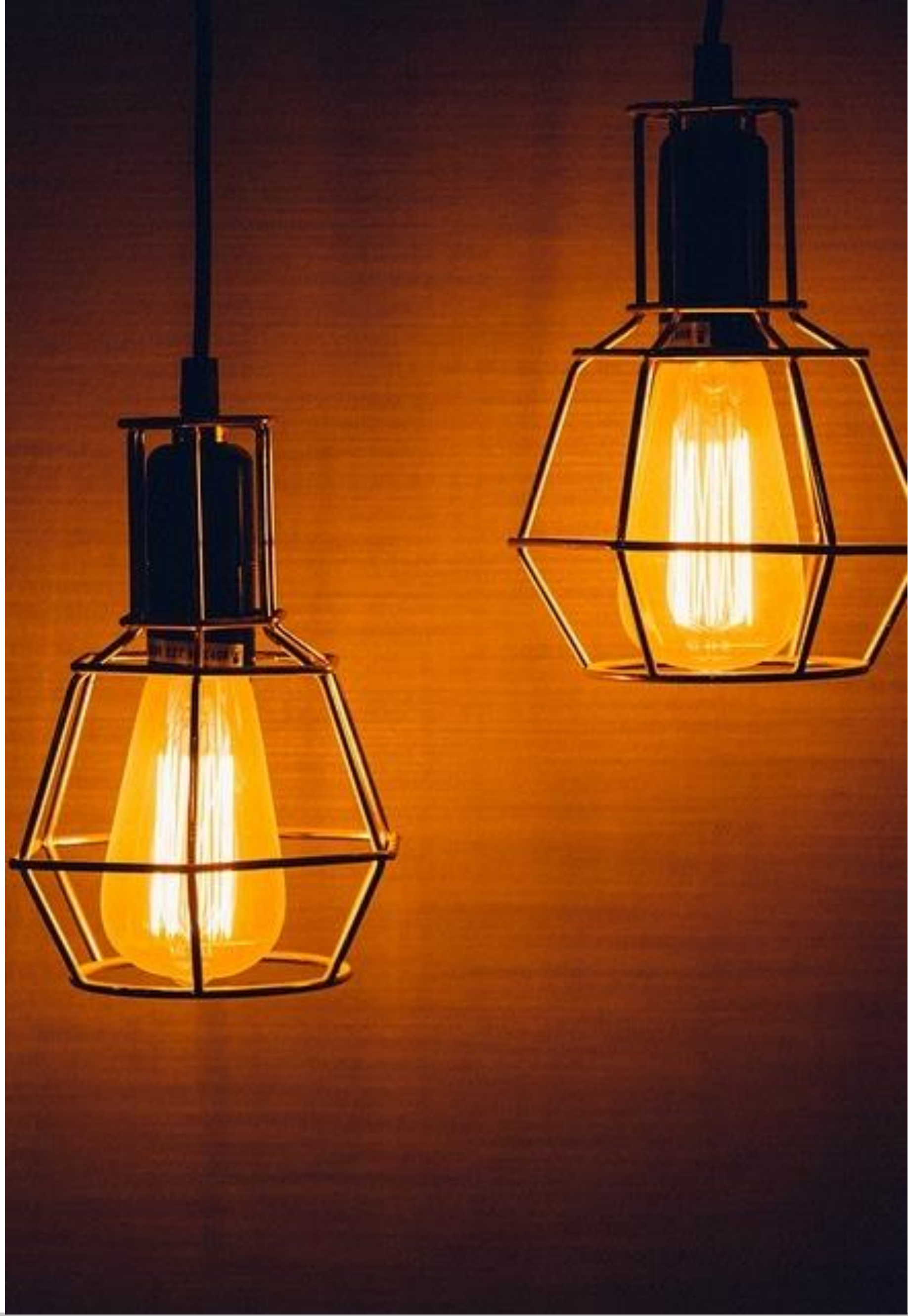
- Expand electric and gas efficiency savings
- Reduce electric and gas peak demand
- Support distributed energy resources
- Reduce greenhouse gas emissions

Focus on Key Metrics

- Utility efforts that influence outcomes

Incentivize Real Achievement

- Meaningful incentives to drive achievement



New Energy Efficiency

State Policy Objectives

- Vision outlined in “New Efficiency: New York”
  - 185 tBTU savings by 2025
  - Three percent of electric utility sales by 2025
  - 20% incremental funds for LMI customers
  - Cost-effective, territory-wide and locational

- Actions needed to execute
  - Ramp efficiency fast to achieve targets
  - Consider investment need, bill impacts
  - Align utility business with state policy goals



Energy Efficiency Portfolio Development

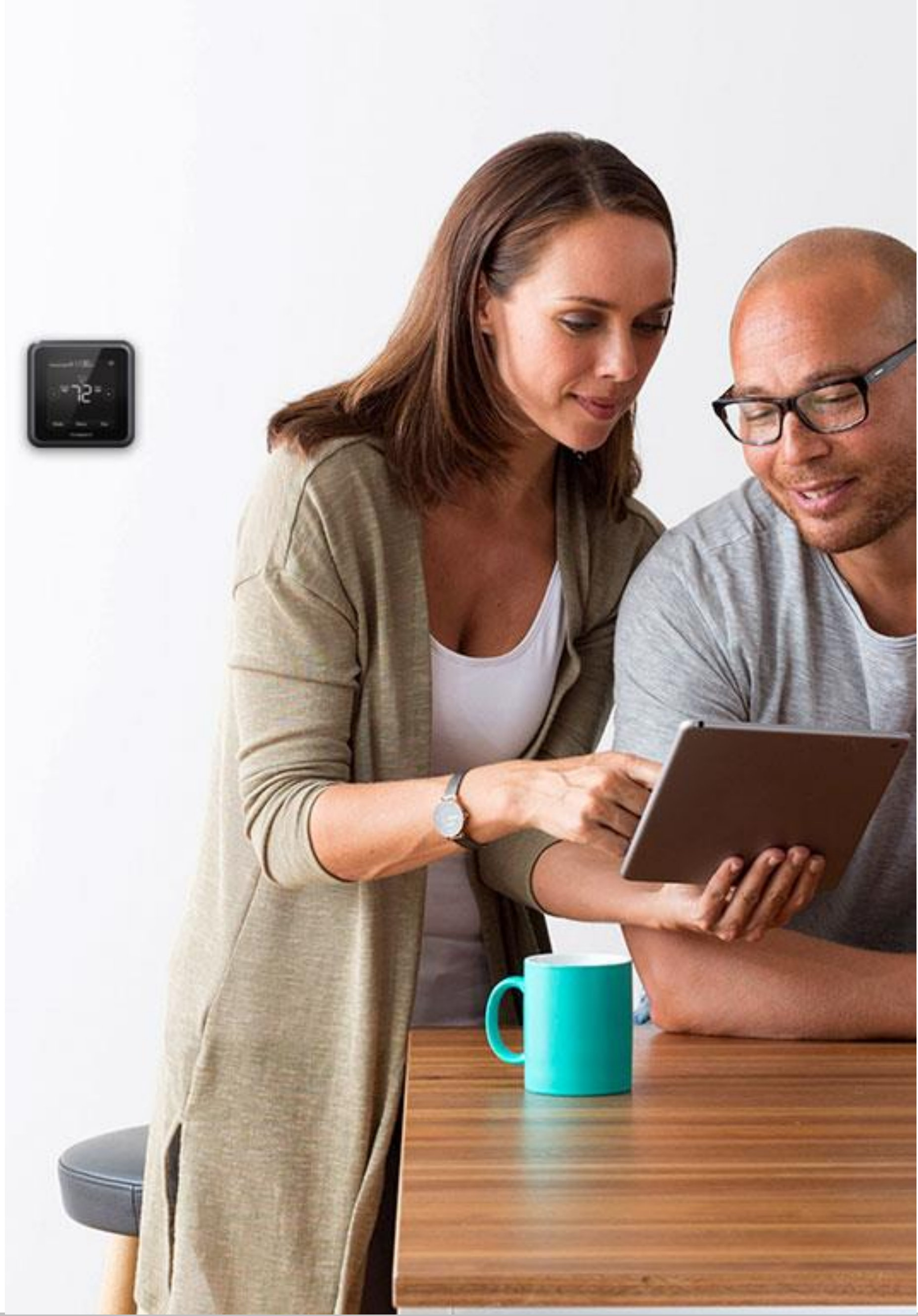
Building Blocks to Achievement

- Alignment of interests for fast ramp-up, smooth bill impact, and integration into utility core business
- Performance incentives (EAMs) drive cost-effective overachievement
- Stability to aid investments and planning over multiple years
- Flexibility to allow multiple paths to achievement of targets
- Consistent baseline methodologies to estimate savings achievements

Energy Efficiency Portfolio Development

Balancing Competing Considerations

- Managing unit costs ($/kWh & $/Dth)
- Achieving deeper savings beyond lighting
- 20 percent of incremental funding to LMI
- Aggressive ramp rates to achieve targets
- Lighting baseline change impacts



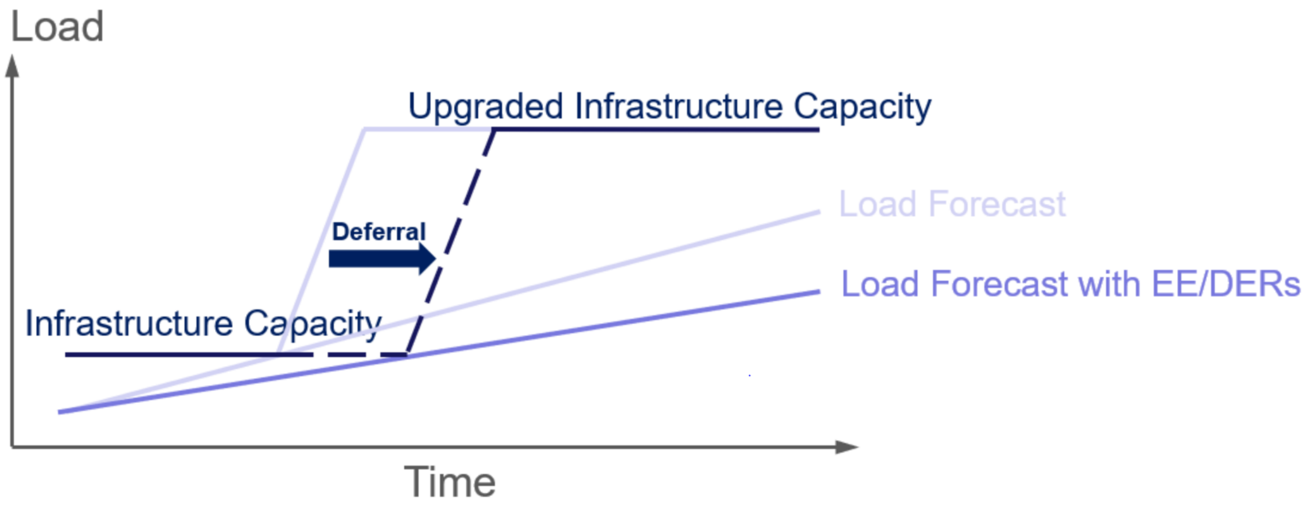
Non-Wires Solutions

- The Non-Wires Solutions program has grown and operational experience has increased
- With added experience, gained new insights on the way the framework is working
- Learning about assembling portfolios and optimal methods to implement them
- Cost-effective with sharing of net benefits

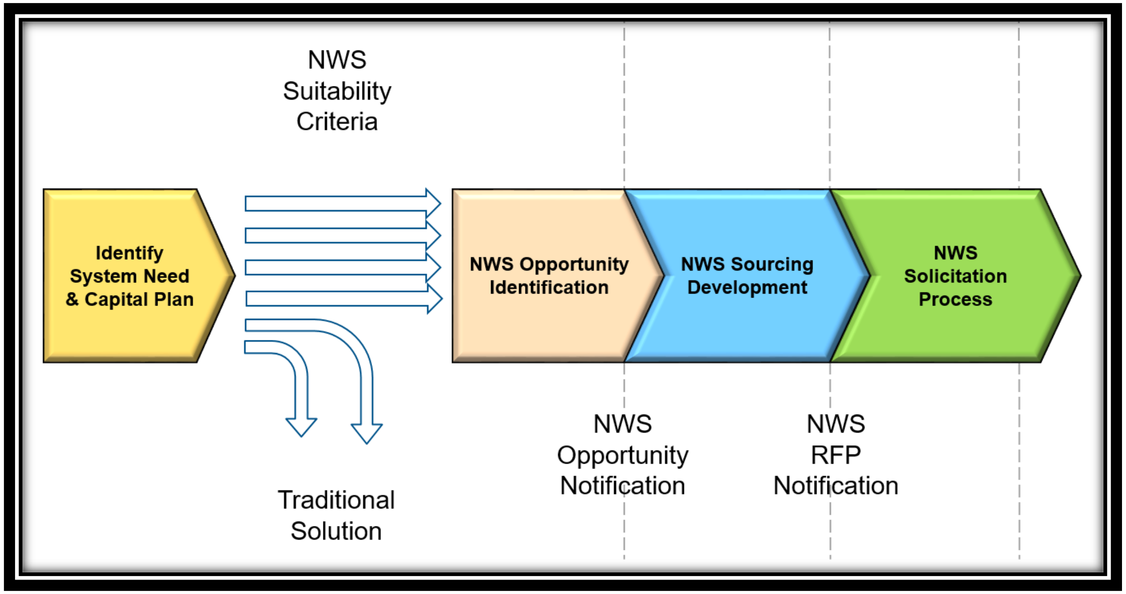


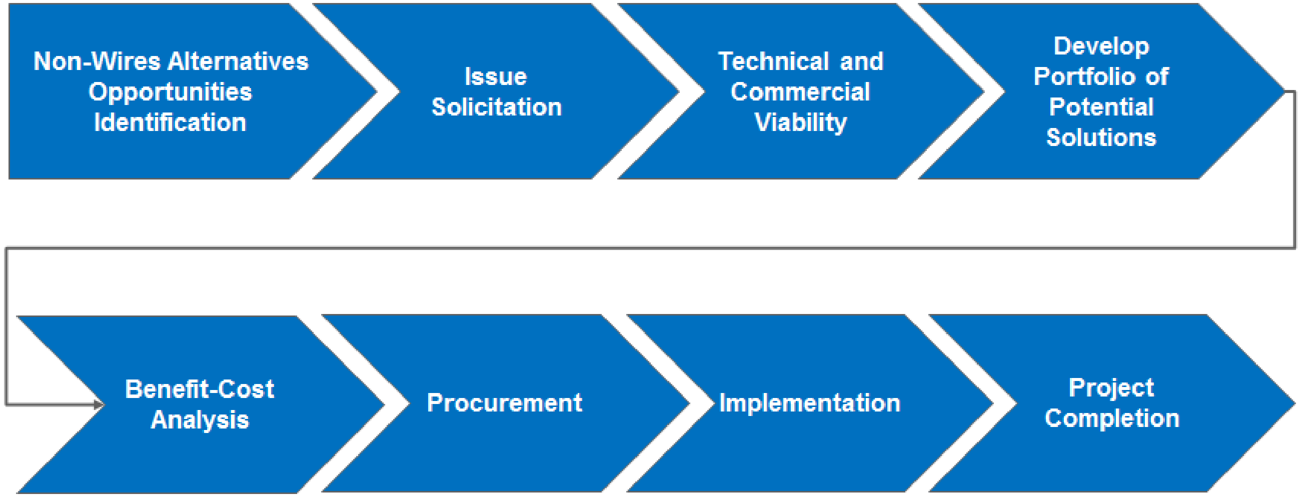
Non-Wires Solutions: Approach

- Lower forecasted load through targeted Energy Efficiency (EE) and Distributed Energy Resources (DER) to enable deferral of upgrade



Non-Wires Solutions: Process





Deferral of ~$1 billion in traditional solutions

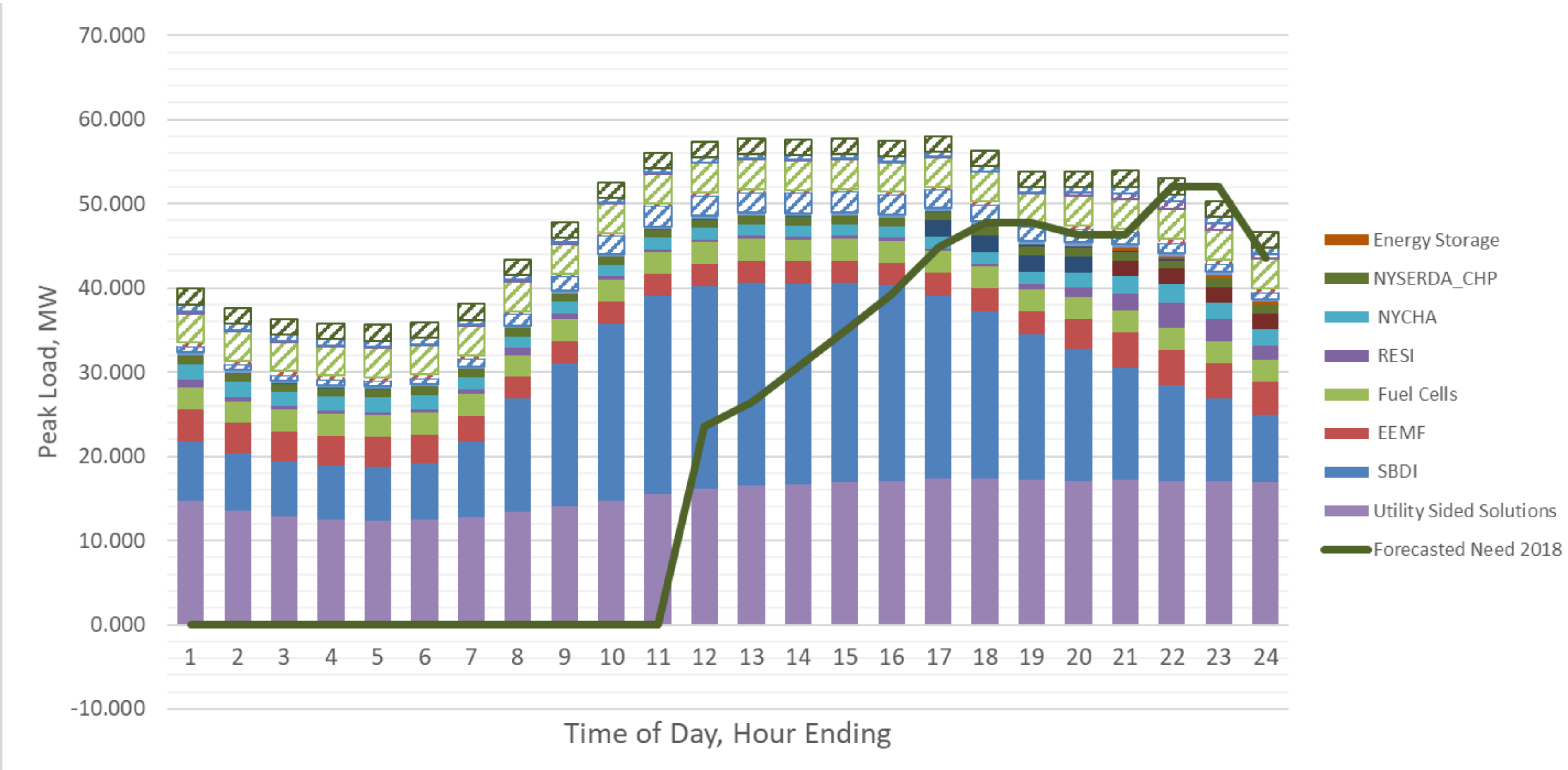
BQDM Program

- Strong peak growth in 3 networks in Brooklyn-Queens would require ~$1 billion in capital upgrades.
- Instead, Con Edison used under $200 million to enable deferral.
  - Customer side (41 MW, $150 million)
  - Utility side (11 MW, $50 million)
- Utility expenditures treated as 10-year capital assets with regulated return, with performance incentive on ROE.
- BQDM extension in 2017 permits continuation of the program beyond 2019 for additional deferral.

BQDM Geography

CUSTOMER, UTILITY SIDE SOLUTIONS PORTFOLIO

Sample Portfolio Approach



Non-Financial Risk Impacts to NWS

Risks → Resources↓	Customer Acquisition	Electric Inter-connection	Gas Inter-connection	City Planning or Buildings Department	Fire Department New York	Budgetary Cycle and/or Lead Time
CHP	Medium	Medium	Medium	Medium	Medium	High
Fuel Cells	High	Medium	Medium	High	Medium	Medium
Demand Response	High	Medium	Medium	Medium	High*	Medium
Battery	High	Medium	N/A	High	High	High
Thermal Storage	High	Medium	N/A	Medium	Low	High
Solar	High	Medium	N/A	Low	Low	Medium
Small Business EE	Medium	N/A	N/A	Low	N/A	Medium
Residential EE	High	N/A	N/A	Low	N/A	High
Public Entity EE	Low	N/A	N/A	Low	N/A	High
Commercial EE	Medium	N/A	N/A	Low	N/A	Medium

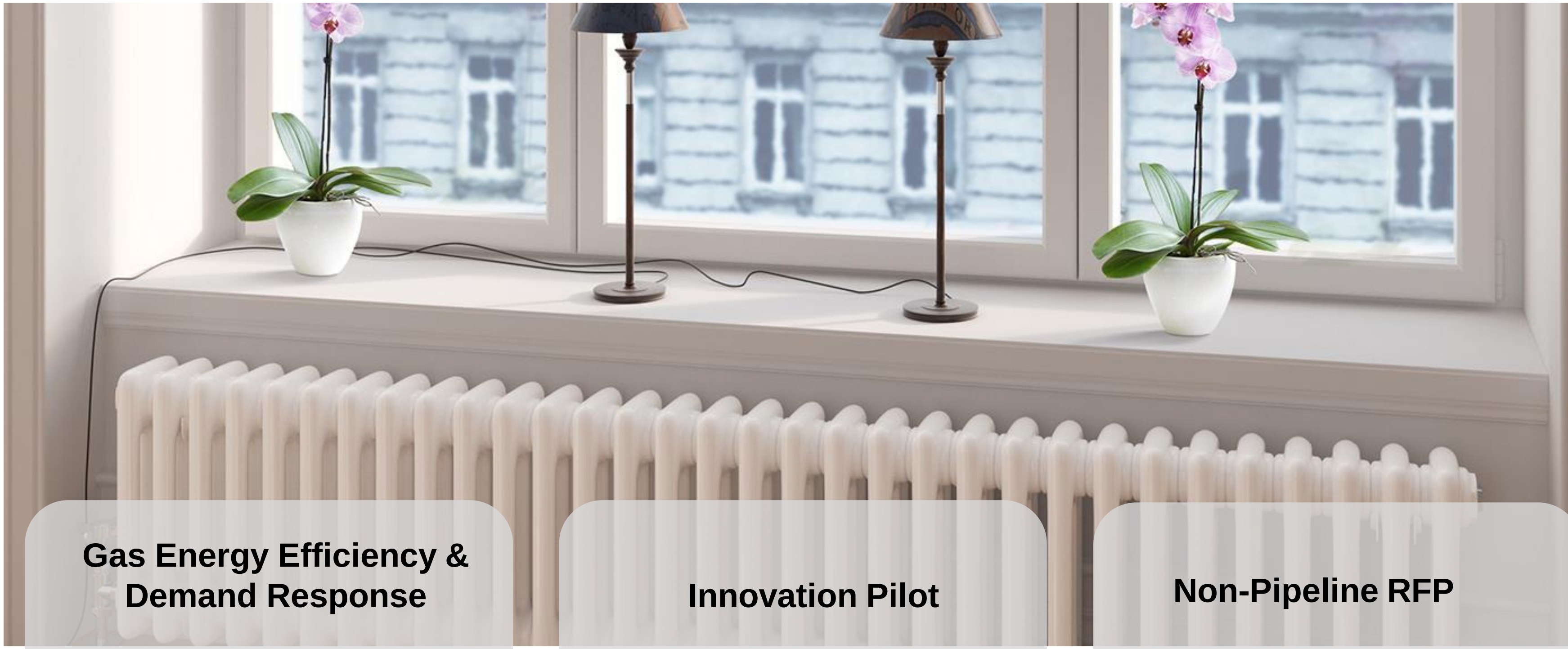
NWS for System Needs

Non-Wires Solutions

	Market Solicitation	Current Status	Next Steps
BQDM Program (Original)	Completed	Implementation	See BQDM Extension
Columbus Circle	RFP Closed	Implementation	Contract Negotiations
Water Street / Williamsburg Feeder	RFP Closed	Portfolio Development	Portfolio Development
Plymouth Street	RFP Closed	Portfolio Development	Portfolio Development
West 42nd Street	RFP Closed	Team Scoring	Portfolio Development
Flushing Project	RFP Closed	Team Scoring	Portfolio Development
BQDM Extension	Submission Closed	Procurement	Procurement Process
Hudson Feeder Project	RFP Closed	Not Feasible	Implement traditional

New potential projects to be released next quarter
www.coned.com/nonwires

Smart Solutions for Natural Gas Customers



Gas Energy Efficiency & Demand Response

- EE: Double 2017 goals
- DR: Pilot for peak day relief
- DR: Currently available for winter 2018-19

Innovation Pilot

- Business model innovations to accelerate clean heating
- RFI issued June 18 and awaiting approval

Non-Pipeline RFP

- September 2018 – Filed a portfolio for authorization
- Filing seeks budget approval for NPS portfolio

Questions?

Energy Efficiency in Massachusetts and Other States

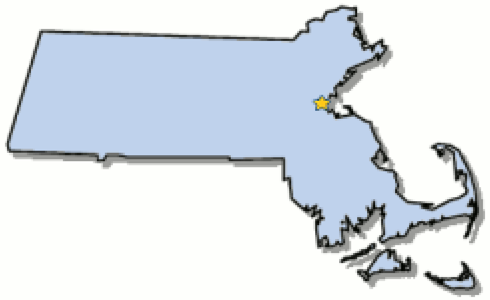
Jeff Schlegel, Independent Consultant

Hawaii Symposium on Exploring Programs and Policies for Deep Energy Efficiency Opportunities

November 14, 2018

(Comments are my own)

Massachusetts: #1 in EE



- In 2017, Massachusetts EE programs achieved electric savings of 3.18% of retail sales and gas savings of 1.20% of sales
- 2019-2021 Plan proposes 2.7% electric savings and 1.25% gas savings
- Customer focused – opportunities for all customer segments
- New plan pivots to address additional objectives and opportunities
- Multiple-goal framework includes EE energy savings, strategic electrification and heat pumps, summer and winter demand efforts, active demand management, behind-the-meter energy storage, increased focus on underserved customer segments, and greater attention to benefits (e.g., T&D impacts, carbon emissions, NEIs)
- ***Achieving high savings and benefits by going deeper and broader***

MA ENERGY EFFICIENCY ADVISORY COUNCIL

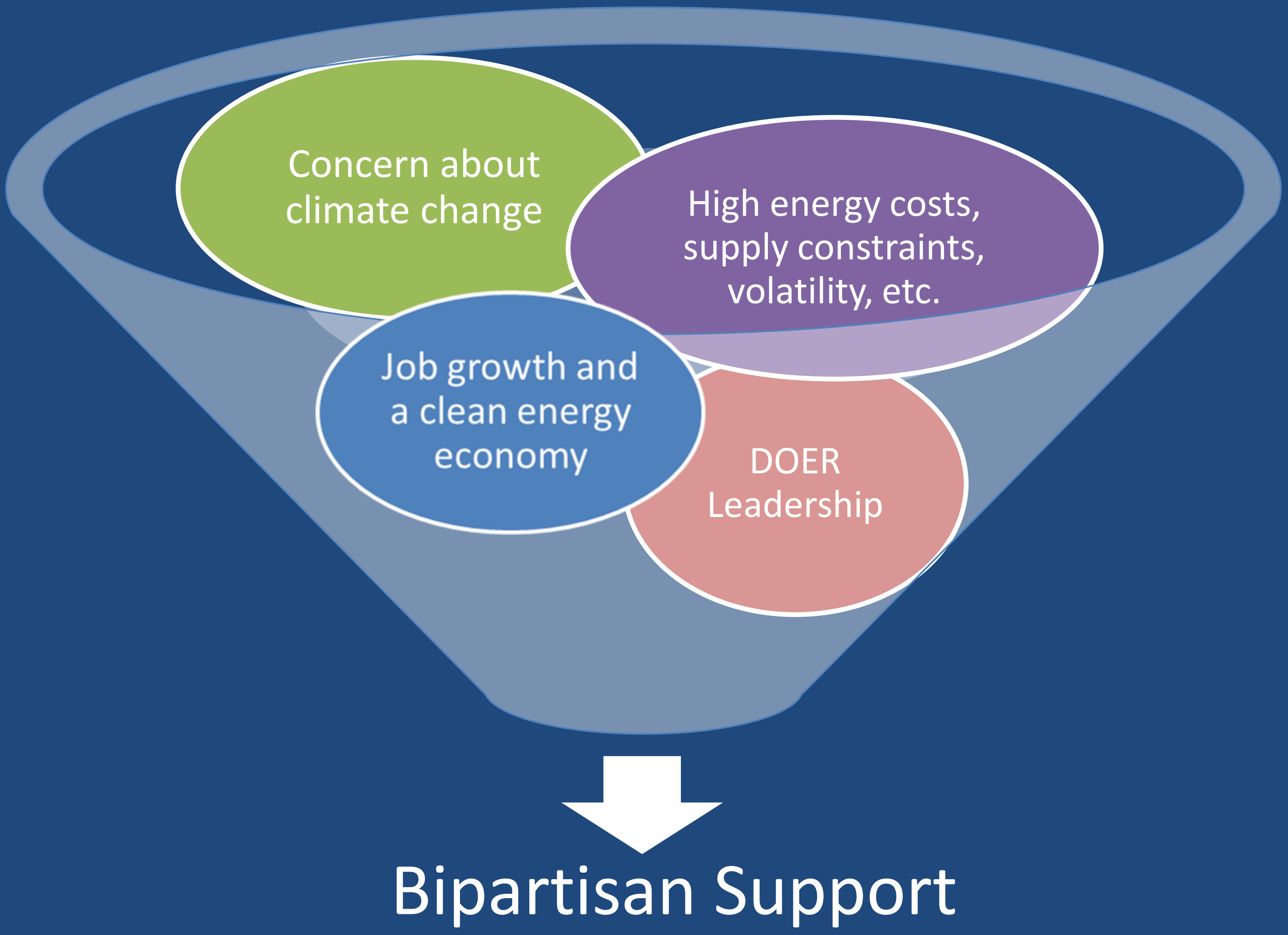
MA Legislative and Policy Framework

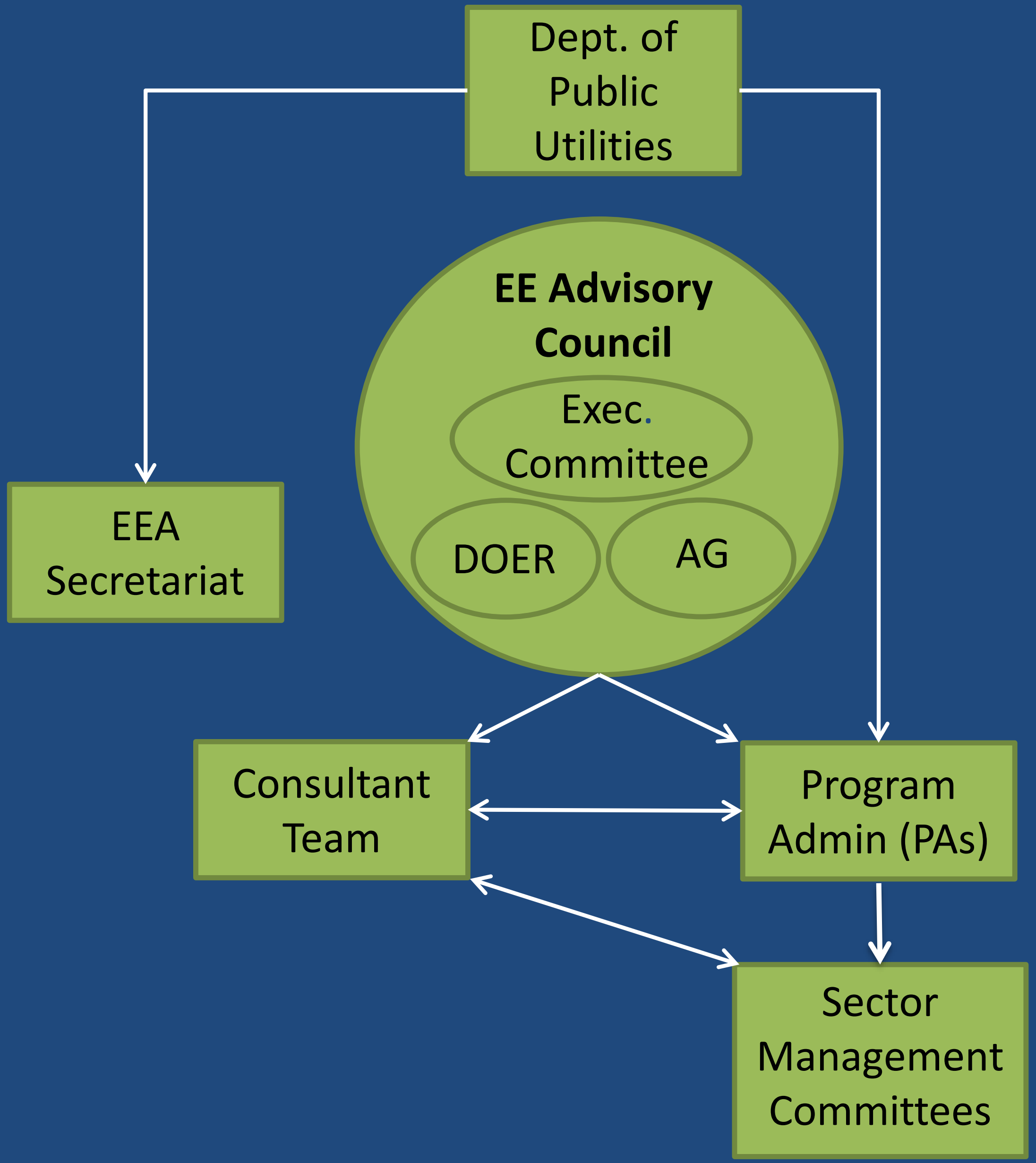
- **Green Communities Act (2008)**
  - PAs jointly prepare electric and gas efficiency plans every 3 yrs
  - Must acquire **all cost-effective** EE and demand resources
  - Fully integrated electric and gas plans; also fuel oil and propane
  - 10% (electric) or 20% (gas) of budget to low income programs
  - Created the Energy Efficiency Advisory Council (EEAC)

- Global Warming Solutions Act (2008)
- Clean Energy and Climate Plan
- Green Jobs Act
- 2018 Bill – Electrification, More Focus on Demand

Political Context

MA ENERGY EFFICIENCY ADVISORY COUNCIL

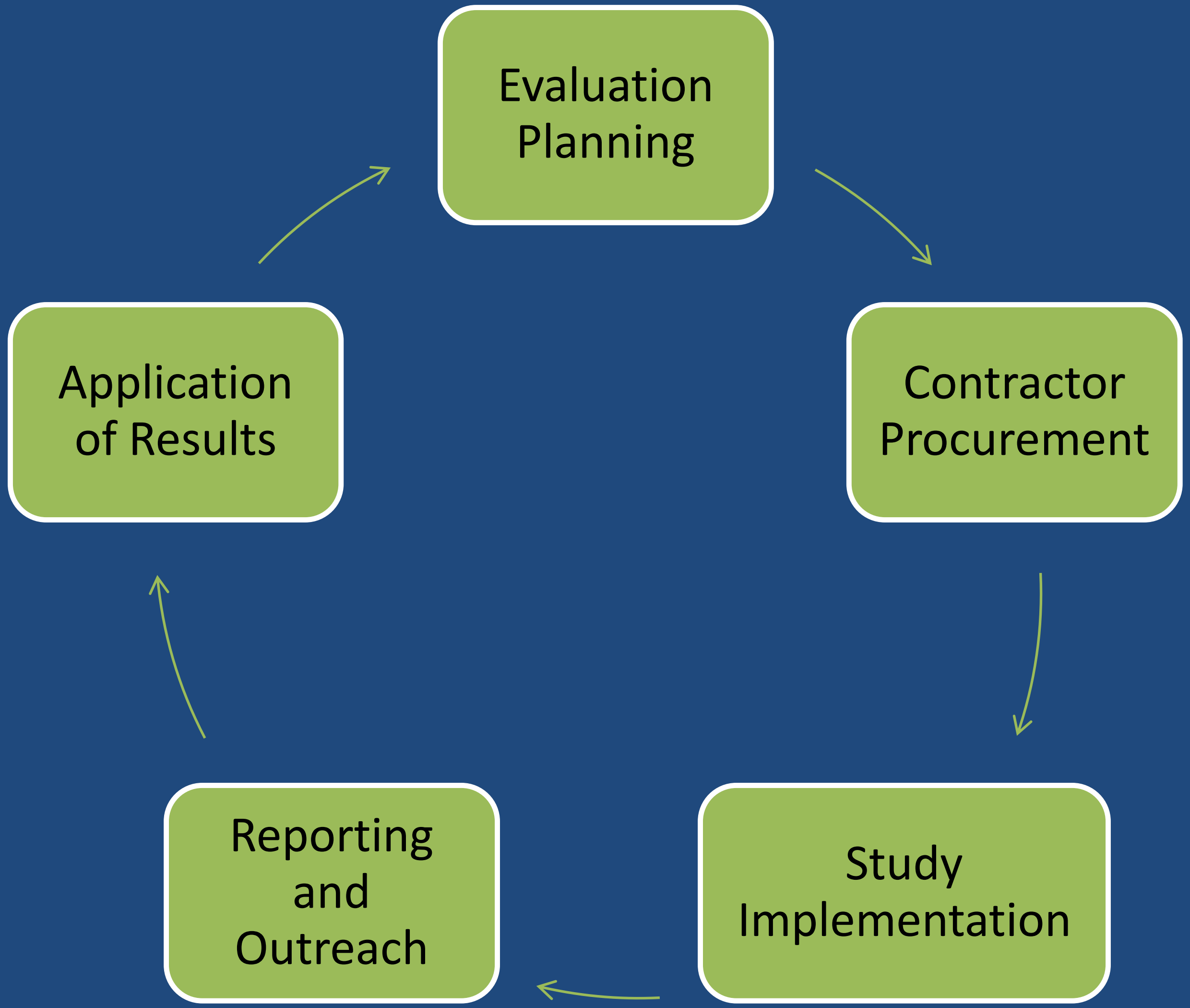




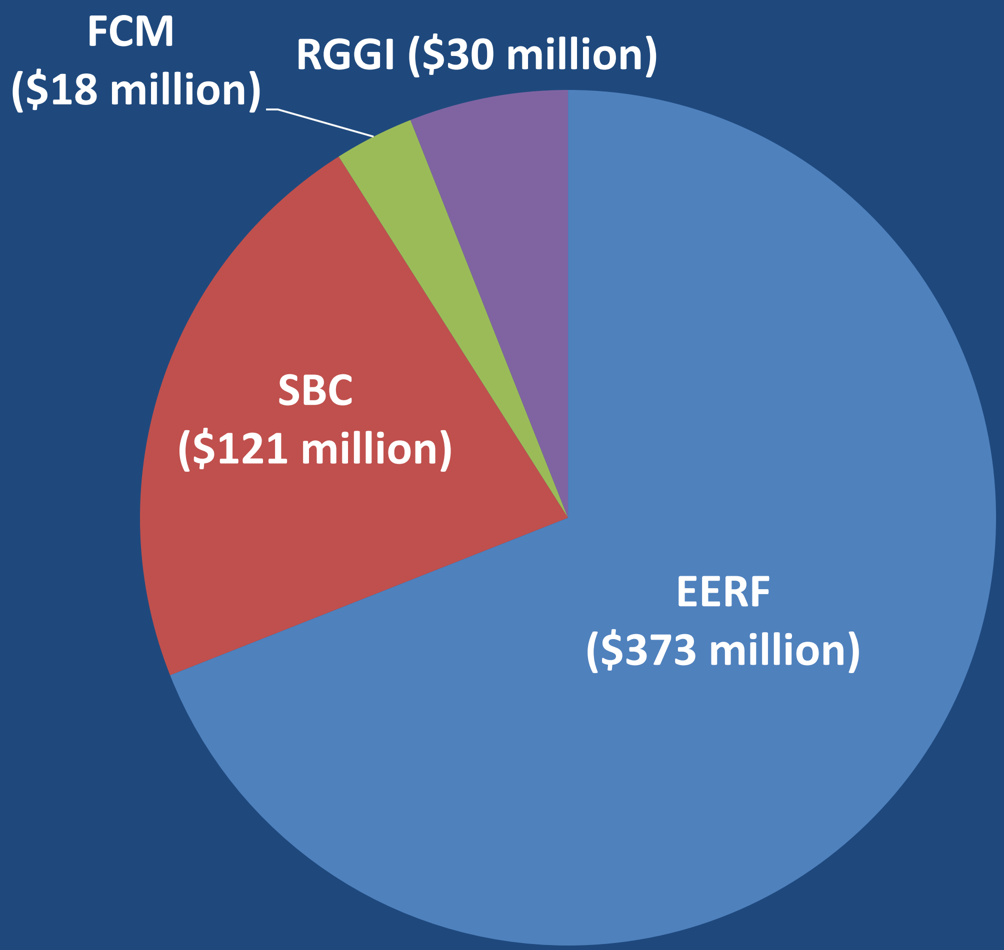
Key Structures, Roles, and Responsibilities

EM&V Feedback Loop

- **EM&V Framework est. in 2009**
- Overseen by Council's Consultant Team
- Collaborative effort with PAs and Council



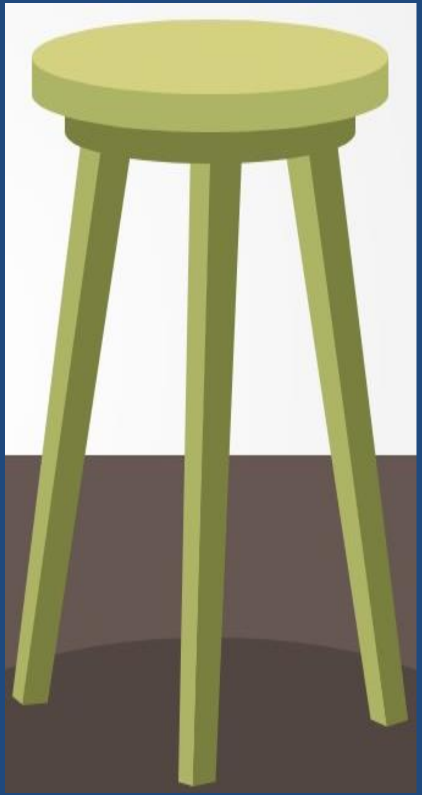
Electric Funding from Several Sources



- EERF=Energy Efficiency Reconciliation Factor
- SBC=System Benefit Charge
- FCM=Forward Capacity Market
- RGGI=Regional GHG Initiative

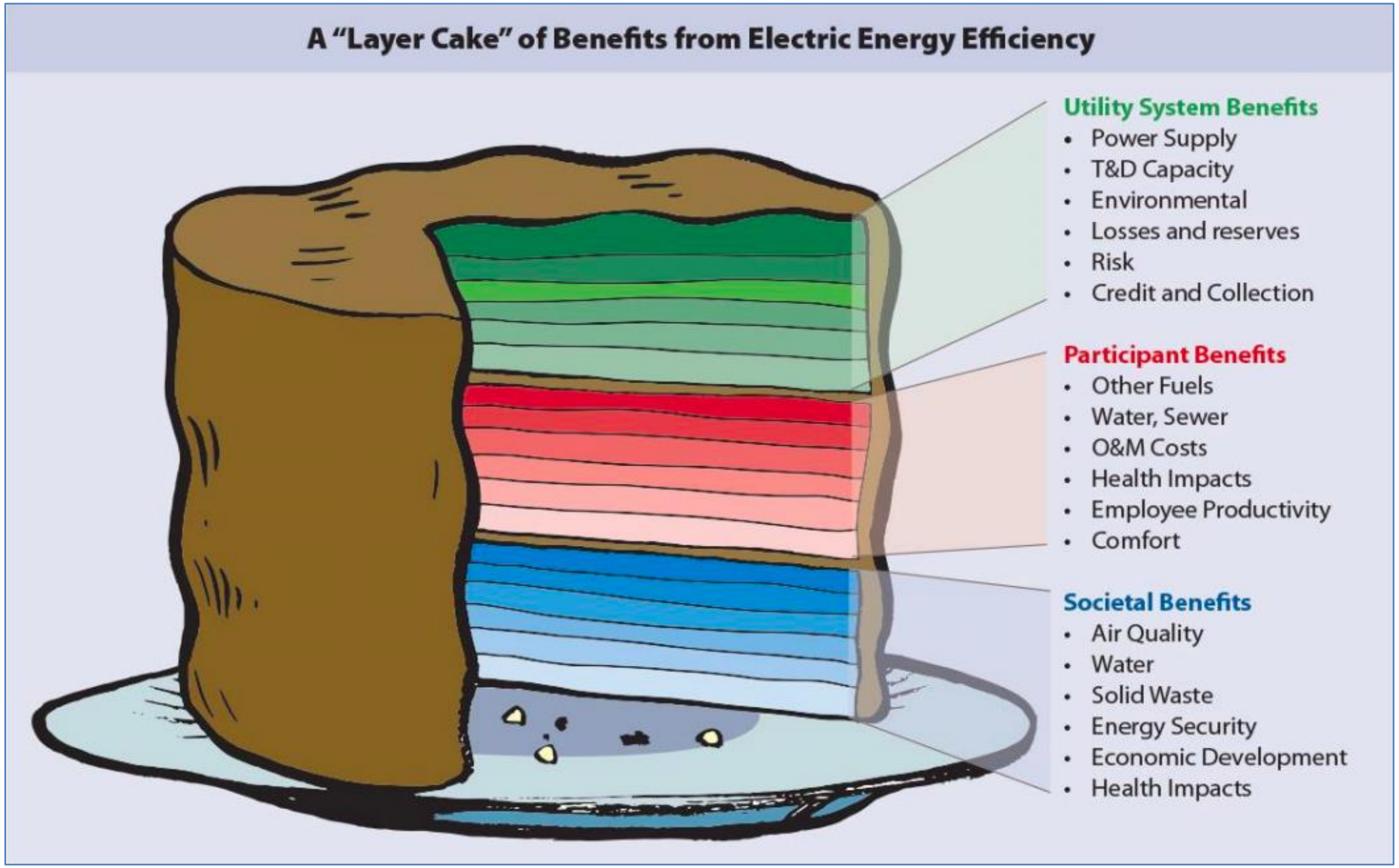
MA Performance Incentives

MA ENERGY EFFICIENCY ADVISORY COUNCIL



- **Performance incentives are crucial for MA PAs (have been in place since 1991)**
- **Total Performance Incentive** = **Savings Component** (total benefits) + **Value Component** (net benefits)
- Payout rates set by dividing total incentive pool by benefit amount for each component
- Incentive pool allocated for PAs, sectors, and programs based on benefits contribution
- PAs begin earning incentive at 75% of planned benefits (threshold), up to 125%

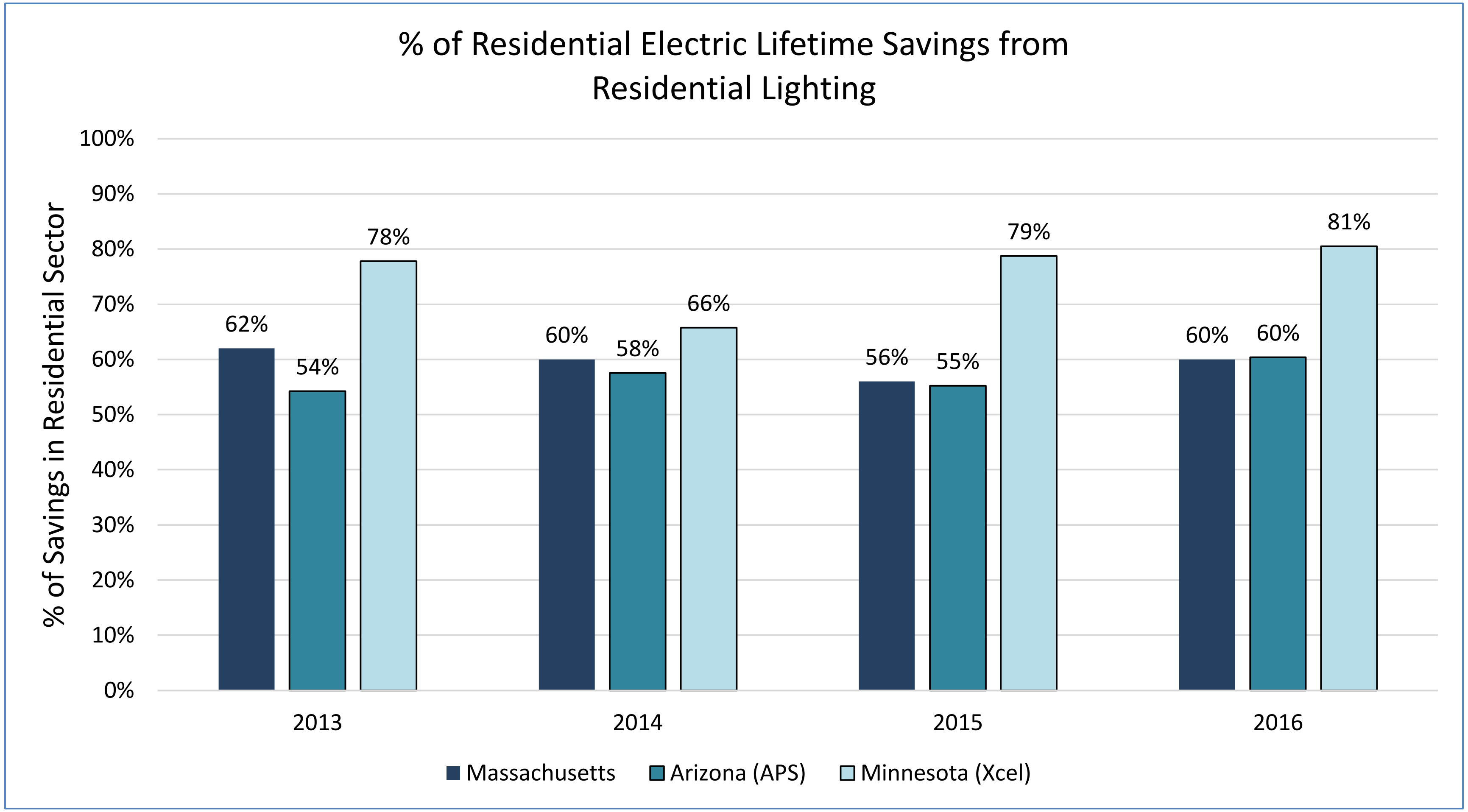
Addressing the integrated benefits of EE (vs. markets, which are often single-issue)



Source: Regulatory Assistance Project, "A Layer Cake of Benefits: Recognizing the Full Value of Energy Efficiency," 2013.

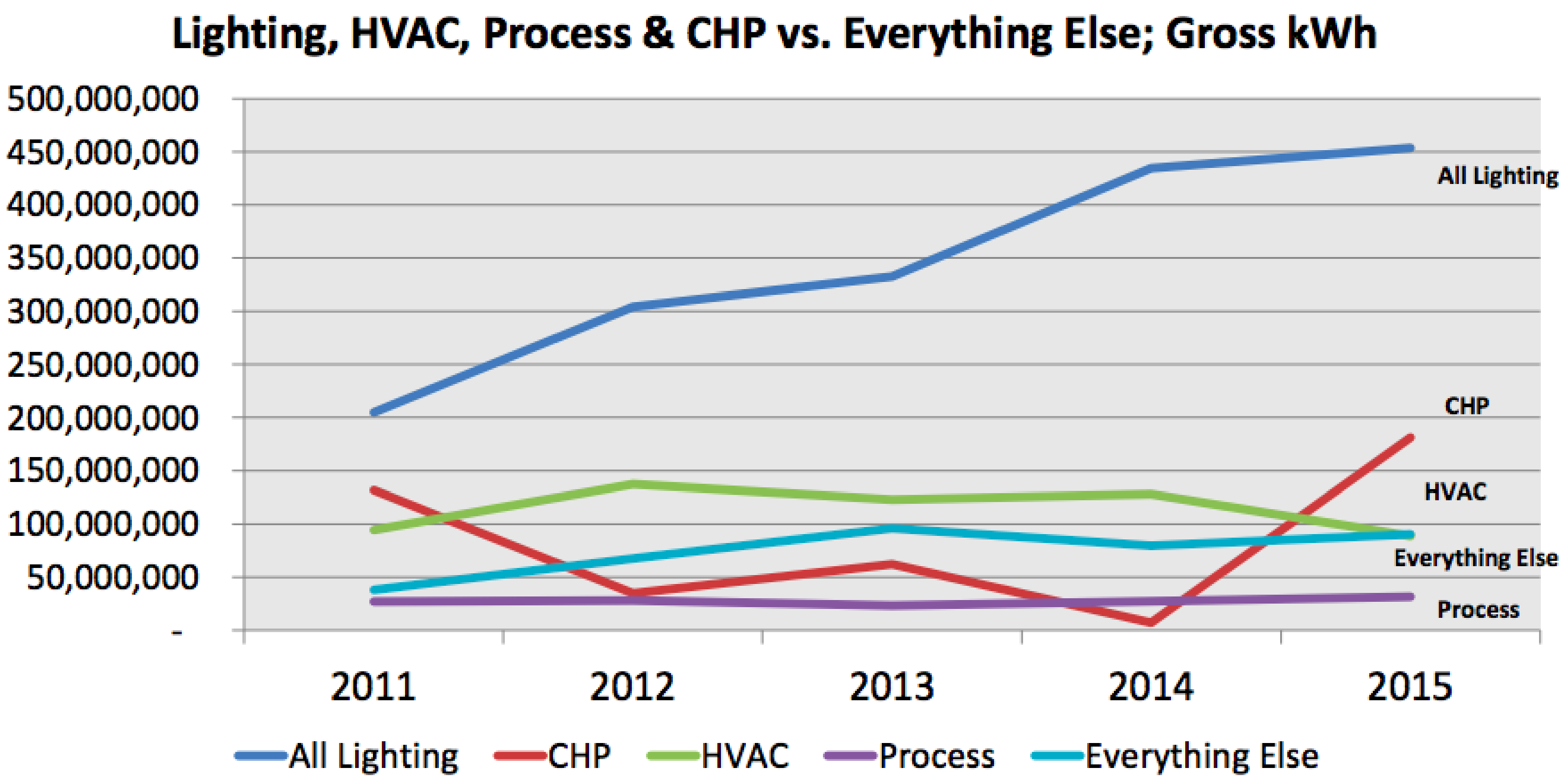
Policy drivers, market changes, and evolving strategic directions for program design

Lighting has been a major contributor to program lifetime savings in many states



Source: Arizona Public Service (APS) Company Annual Demand Side Management Reports, 2013-2016; Xcel Energy Status Report & Associated Compliance Filings Minnesota Electric and Natural Gas Conservation Improvement Program, 2013-2016; Massachusetts Energy Efficiency Advisory Council, “New Approaches in the Face of Rising Baselines and Other Trends: Challenges and Innovative Options,” Sept. 21, 2017.

The importance of lighting to C&I programs



Source: Optimal Energy analysis for Massachusetts Energy Efficiency Advisory Council, C&I Workshops

Society and system will still receive savings from LED lighting; Res. savings just won’t be “claimable” by programs

- Evolution of the market means that businesses and residents will continue to reap the savings and benefits of energy efficient lighting – which is a success story.
- However, federal standards and market developments (which impact net-to-gross ratios) mean utilities will not be able to claim as much *program* savings from lighting (especially for Residential programs beginning in 2020-2021).

There will still be lighting opportunities in programs – program-claimable savings

- Residential:
  1. Hard-to-reach customers and market segments
  2. High lumen and specialty products
  3. Lighting opportunities in the near-term (to ~2020)
  4. Early replacement of lighting
- C&I
  1. Better lighting products and systems still needed
  2. Solid state lighting opportunities, especially with the integration of controls and DR capabilities – network lighting
- How to guard against a premature exit from the markets/technologies while avoiding unnecessary support for already transformed markets/technologies

One challenge for residential programs: on-site program delivery approaches

- Program delivery approaches will also be impacted.
- Will programs pencil out for cost-effectiveness?
- Will programs remain a viable business opportunity for contractors?

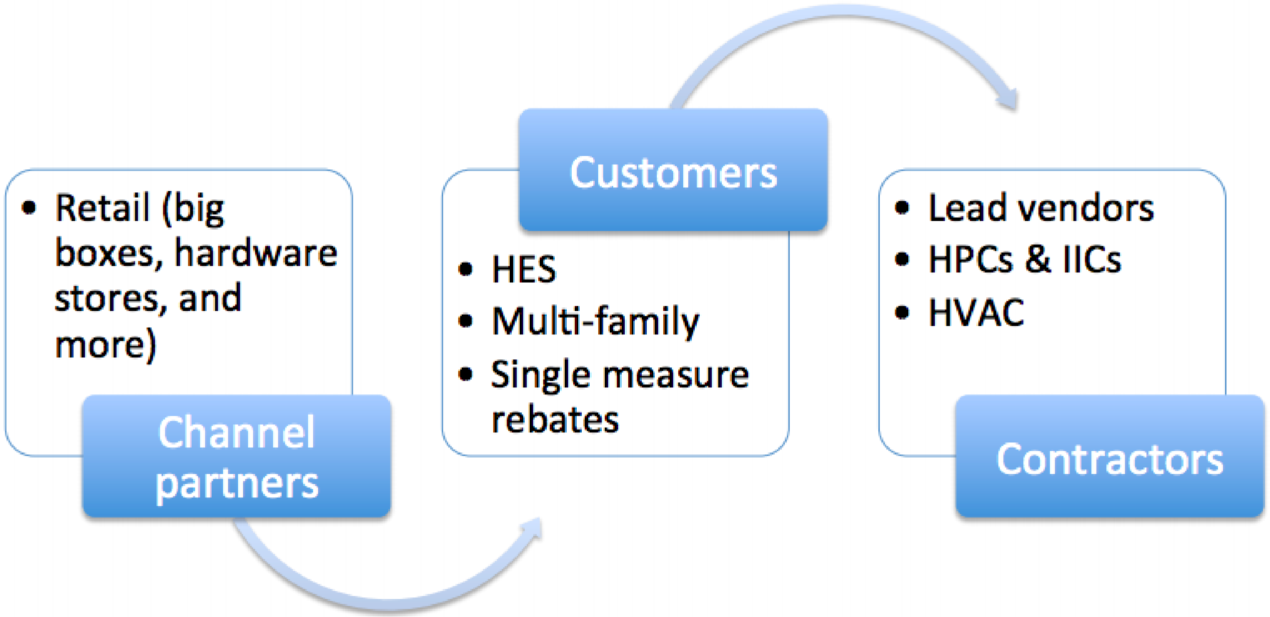


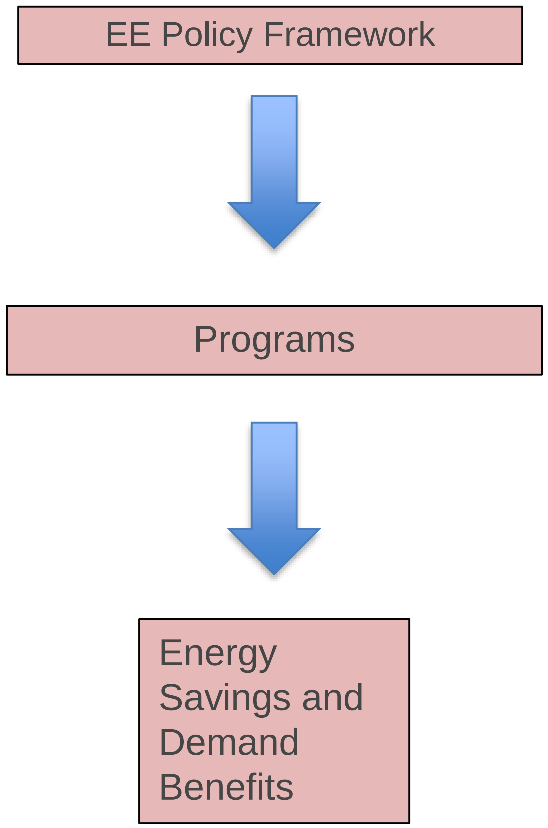
Image Source: Massachusetts Energy Efficiency Advisory Council

New approaches: new measures and strategies

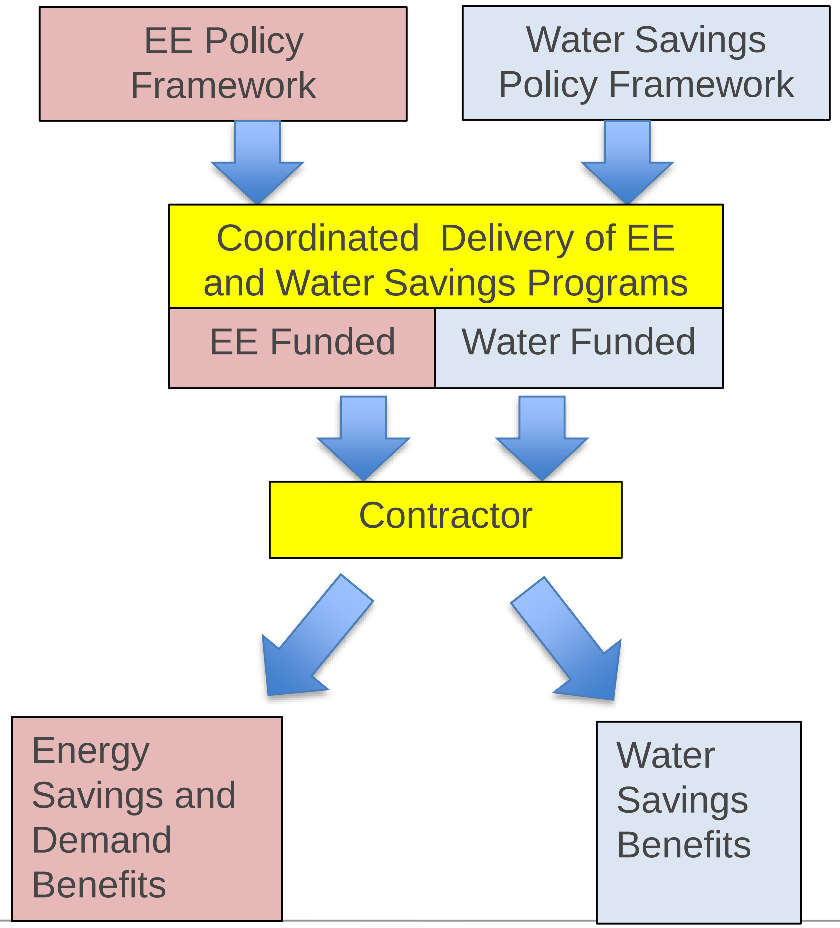
- Co-delivery
  1. Electric & natural gas integrated programs (fuel oil, propane)
  2. Water efficiency
  3. Health services
  4. Resiliency
  5. Rate education
- Fuel switching/electrification
- Active demand management, new measures, grid services
- Energy storage (BTM)
- Electric vehicles co-delivery
- Solar PV co-delivery
- Utility support of codes & standards adoption, implementation
- New objectives and funding sources (i.e. health insurance/services)
- New approaches for evaluating cost effectiveness

EE Programs vs. Co-Delivered and Co-Funded

EE Programs



Co-Delivery and Co-Funded



Key C&I Program Design Themes

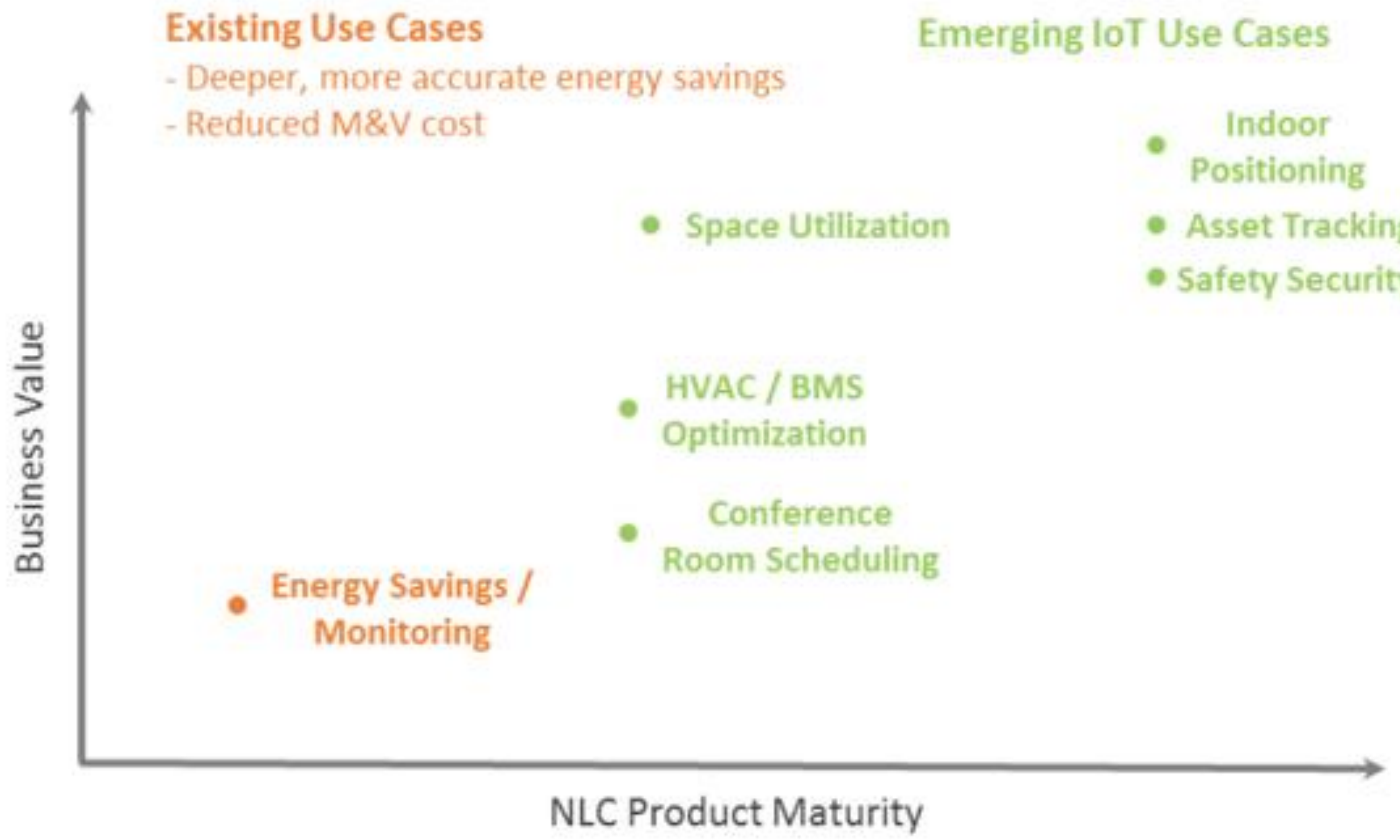
- Conducting granular market segmentation research to aid in the development of effective market-segmented and comprehensive approaches to service delivery – *customer focused*.
- Offering packaged marketing and tailored comprehensive solutions that meet the energy needs of the individual customer or market segment and provide additional benefits – *tailored solutions*.
- Developing a C&I Advanced Lighting Strategy that uses connected lighting systems, advanced lighting controls, and emerging LED technologies as a ubiquitous platform for advanced services and analytics – *harnessing and leveraging technology and automation*.
- Enhancing the role of the utilities as informational conduits for any C&I customer or market segment interested in pursuing energy efficiency, renewables, and sustainability projects – *engagement and information*.

CT: Advanced C&I Lighting Strategy

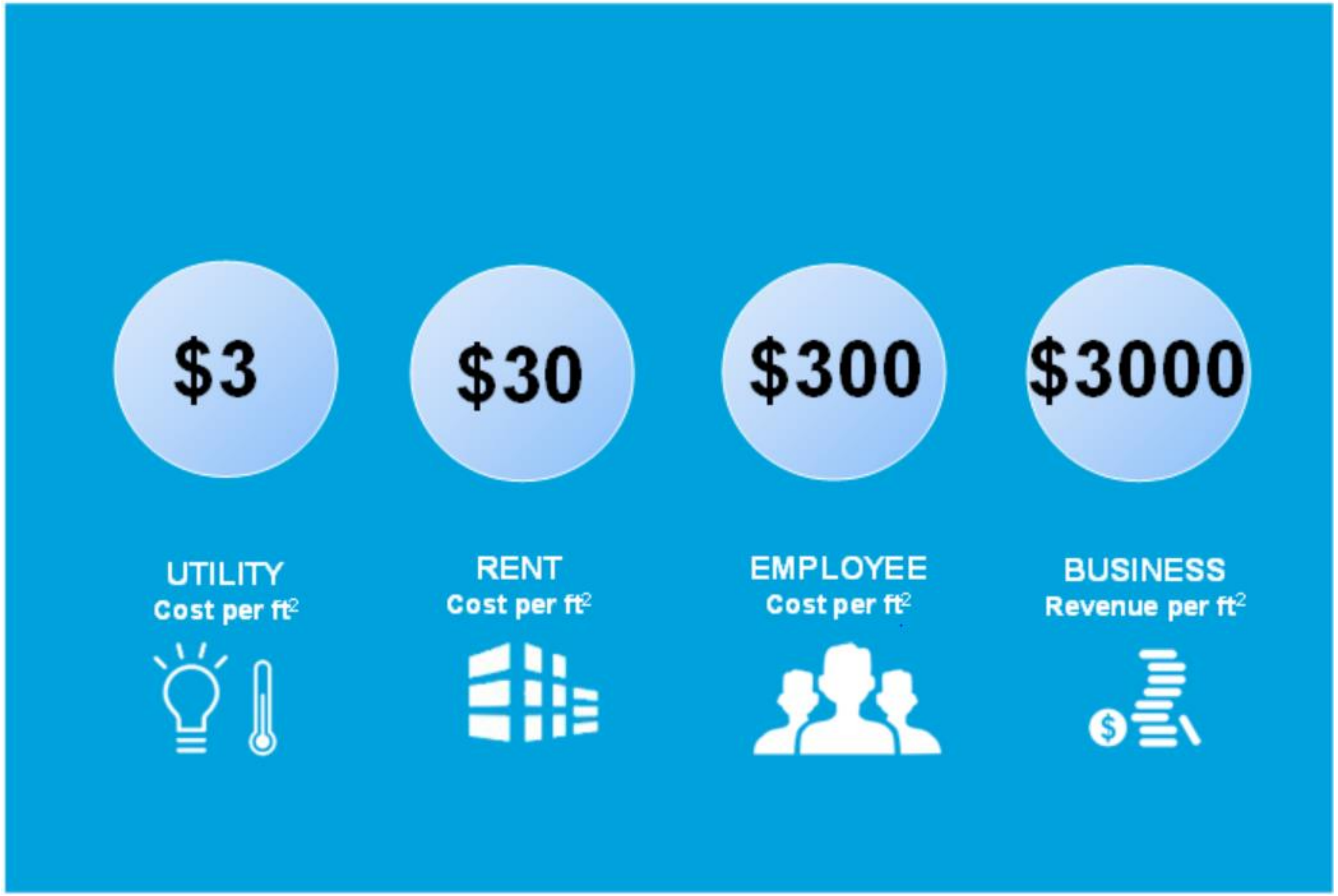
- Advanced lighting controls involve the use of multiple strategies (occupancy, tuning, daylight dimming)
- A Design Lights Consortium study has found an average 47% savings from advanced controls
  1. Savings vary by customer type (assembly 23%, office 62%, warehouse 82%, etc)
- Strategy: tiered incentives, lighting designer assistance, workforce training

Networked Lighting Controls – Customer Value

- Networked controls provide customer value beyond just lighting (*and also grid services beyond energy savings*)



What motivates customers & action?
Where is the value?



Source: Alex Do, Acutity Brands; presentation at Design Lights Consortium Stakeholder Meeting, July 2017
(Several people have used the 3/30/300 analysis previously)

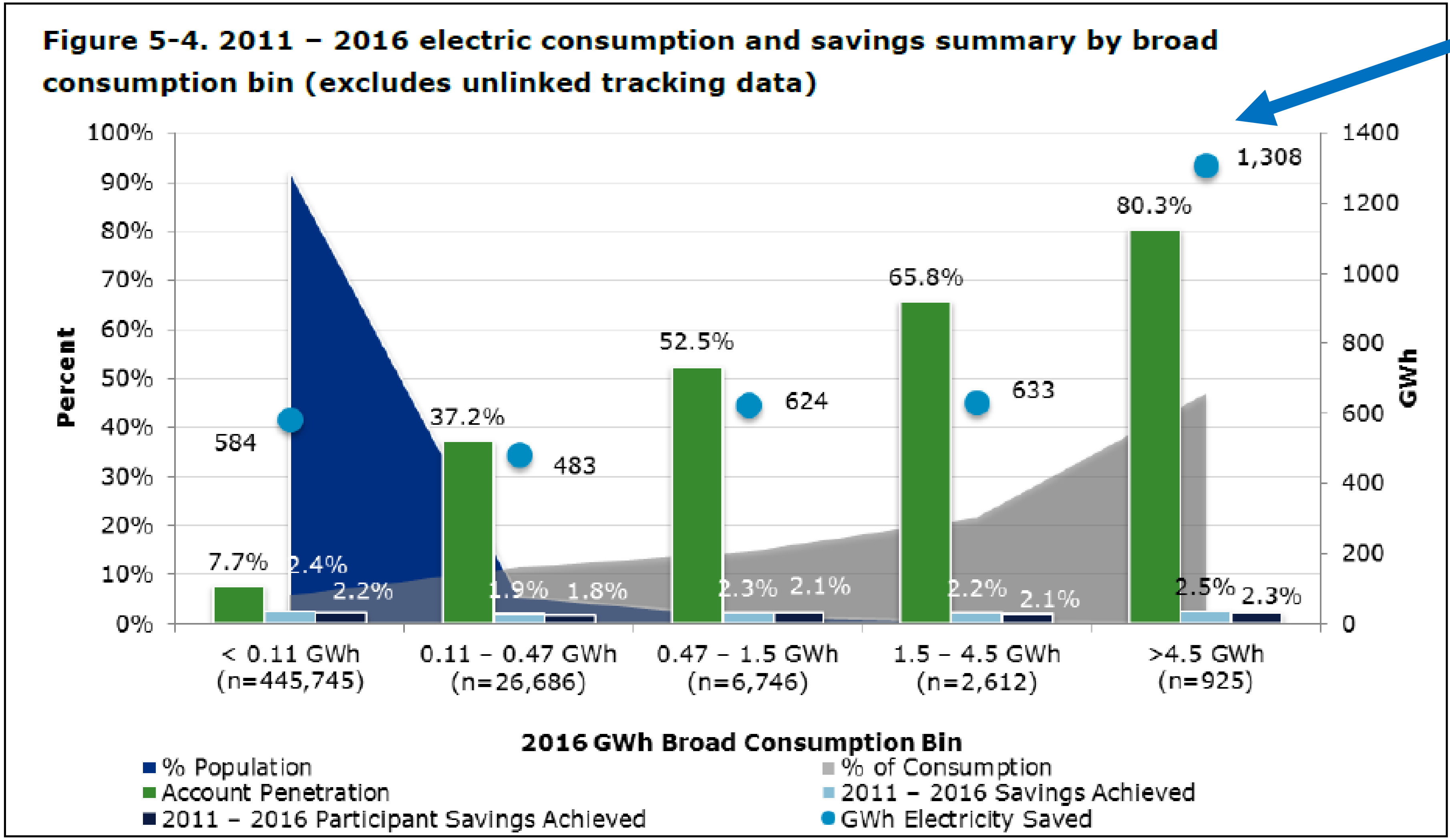
Value Propositions

Bringing Commercial Real Estate into the Internet of Things.

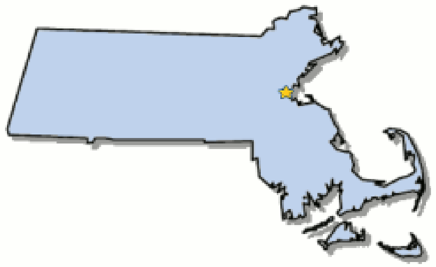
Demand management and grid services

Source: Carol Jones, Enlighted; presentation at Design Lights Consortium Stakeholder Meeting, July 2017, added to by Jeff Schlegel

Massachusetts Large Customers Deliver



Largest 925 customers (0.2% of C&I customers), who use 48% of C&I electricity, accounted for 1,308 GWh of savings in 2011-2016 – 36% of the total C&I savings



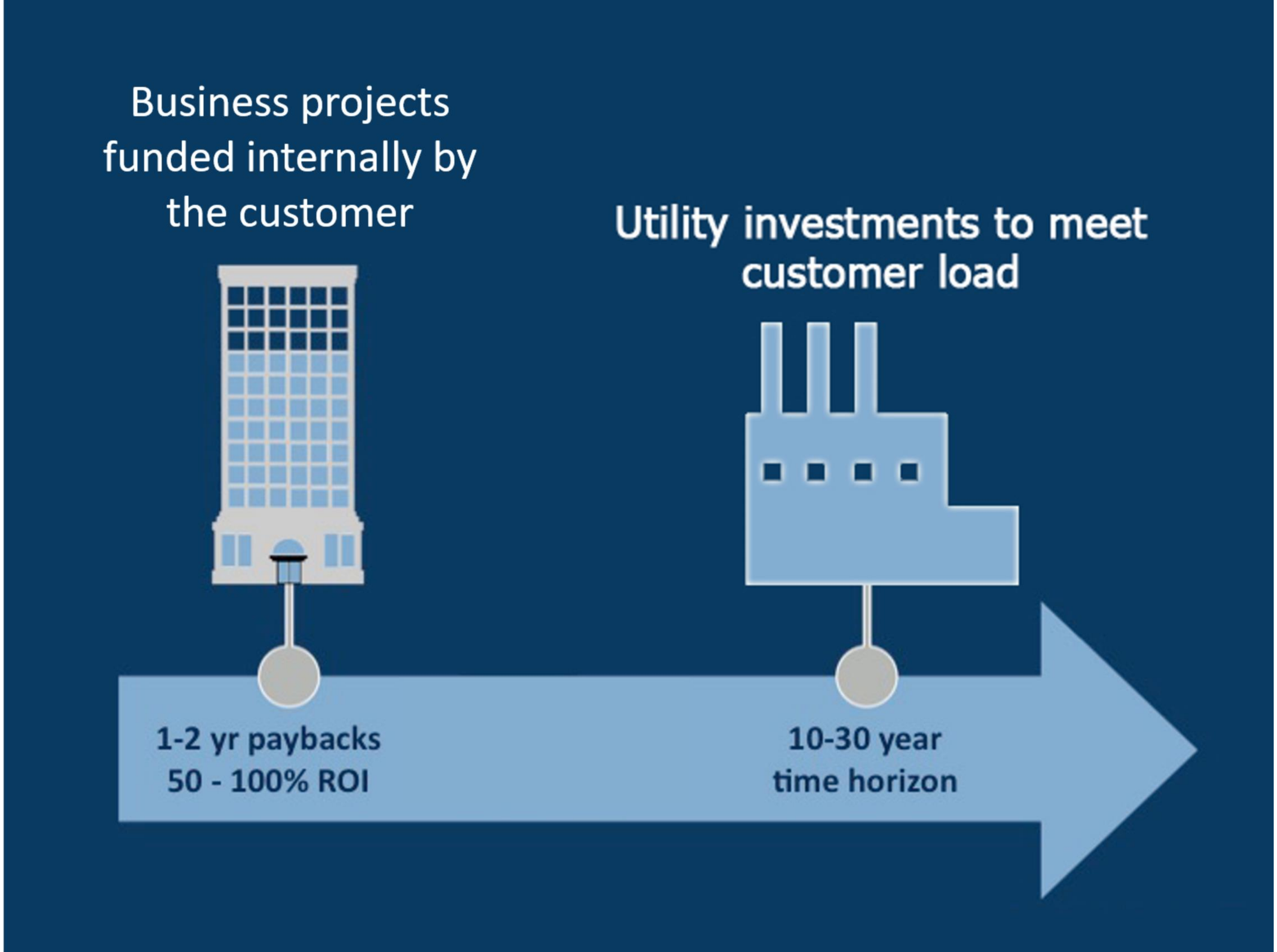
MA Comprehensive Commercial and Industrial Customer Profile Report, March 2018, http://ma-eeac.org

Connecticut Business CSP/SEM

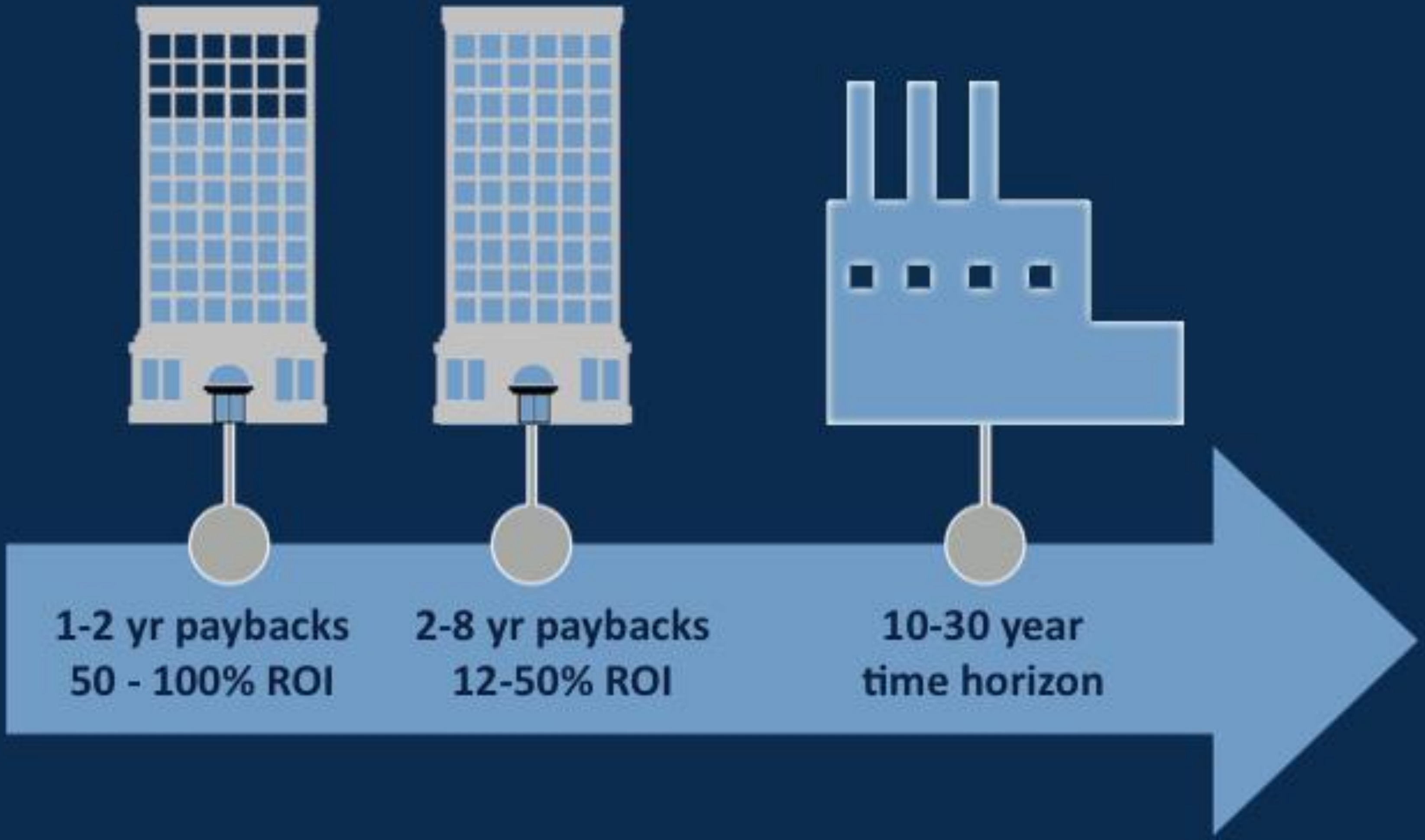
- Program offering for large customers in Connecticut – the Customized Solutions Partnership (CSP) with Strategic Energy Management (SEM)

Multi-year agreement (MOU) and targets	Strategic Energy Management (SEM)	Encourage early retirement of equipment
Facility-wide boundary and scope	Savings from capital, operations, and behavior measures	ISO 50001 and DOE 50001 Ready

- ***Large businesses in Connecticut (and elsewhere) want and need a program that is going to meet their needs – customer centric.***


Business projects funded internally by the customer
Utility investments to meet customer load
1-2 yr paybacks
50 - 100% ROI
10-30 year
time horizon

Business projects co-funded by the customer & ratepayers



Credit: Schlegel & Associates

Small business programs

- Small businesses need services and programs tailored to their needs
- Turnkey, one-stop, full spectrum of services
- The most effective small business programs have:
  - Vendor outreach and delivery
  - Simple and easy for customer to participate
  - Information, recommendations, financing and installation – seamless
  - No cash out of pocket
  - Low or no-interest financing
  - Many (but not all) projects with positive cash flow from day one

Increased focus on active demand management (ADM), delivered through integrated EE and ADM(DR) services

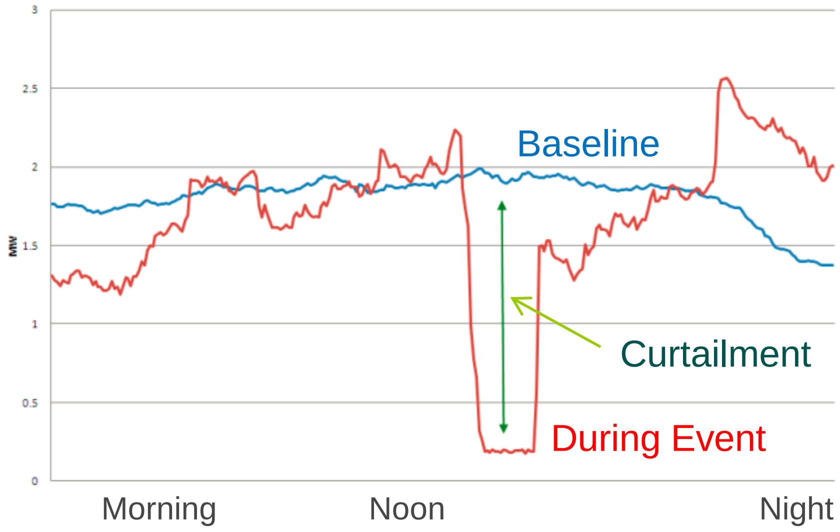
- Active Demand Management (ADM) refers to the dynamic management of end-use customers' energy demand using information, incentives, and technology. ADM products and services, which in recent years have been enabled by advances in technology and automation, can include, among other things:
  - Direct load control
  - Traditional and "new" demand response (DR, Auto DR)
  - Behind the meter (BTM) battery storage
  - Thermal storage
- ADM can be used for load shedding (peak demand reduction) and also for load shifting and grid services

Massachusetts Demand Demonstrations

- National Grid DR Demonstration Offering in 2016-2018 Plan
  - Residential demonstration with a target of 2.6 MW of peak demand reduction
  - C&I demonstration with a target of 41 MW of peak demand reduction

<u>Commercial and Industrial Customers</u>

“Performance Based” – Customer Incentive of about $35 per kW per Year



<u>Residential and Small Commercial Customers</u>

“Pay for Connected Device” – Customer Incentive of about $30 per Thermostat per Year

Supported devices so far

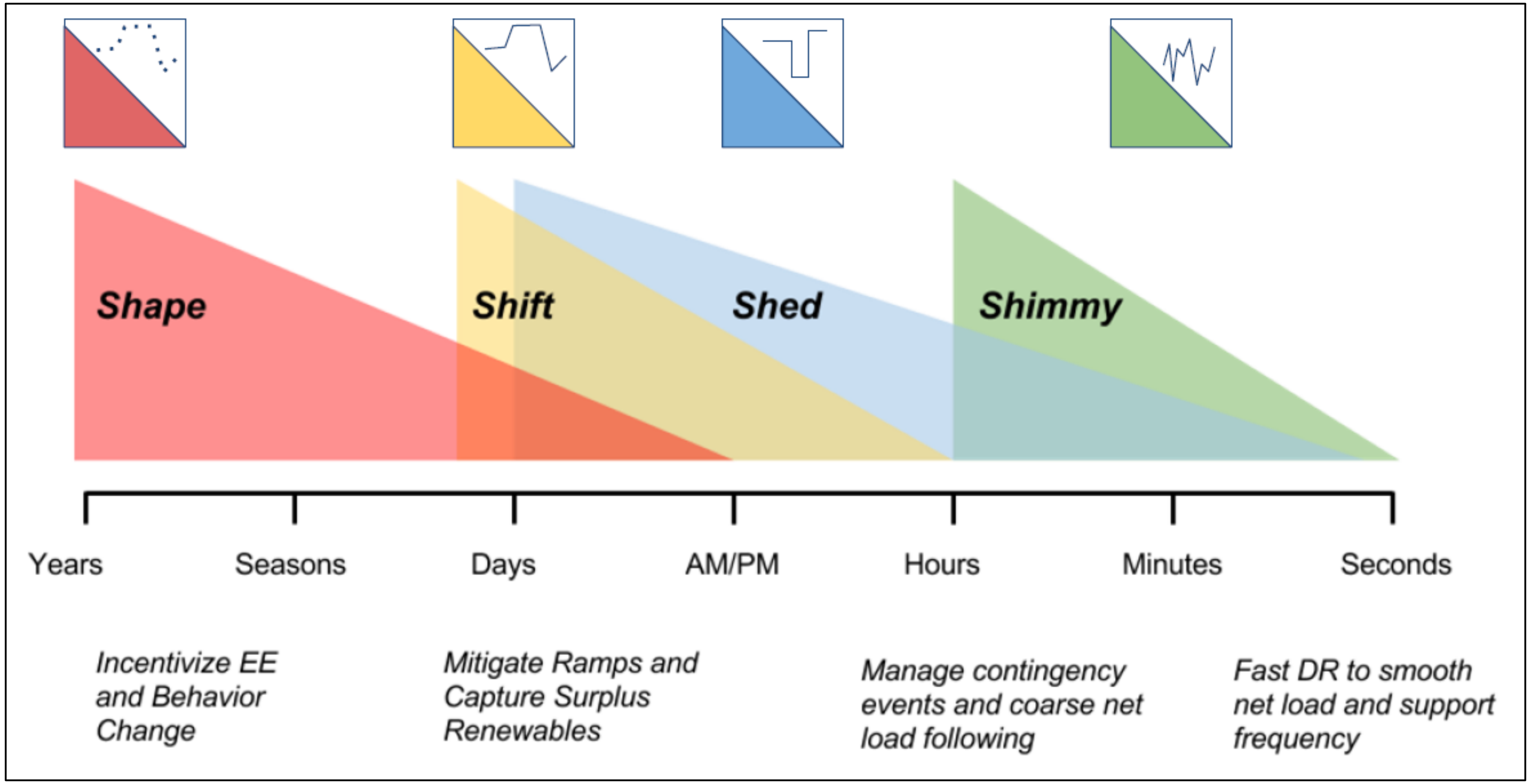
Honeywell

ecobee

Nest

How can ADM be used, for which objectives, and what values?

ADM Service Types Across Timescales and Objectives to Meet Grid Needs



Source: 2025 California Demand Response Potential Study, LBL, May 2017

Two Priority Examples for ADM and Integrated EE/DR

- Software and controls
  - LED lighting with integrated controls as an energy efficiency measure, plus enabling technology for ADM
  - Tune light levels to maximize productivity and provide active demand management and grid services
  - Massachusetts' lighting load could be automatically dimmed by ~10% to reduce loads when needed/valuable
- Automation and agreements with customers
  - NV Energy engaged customers via thermostats for HVAC
  - In 2017, NV Energy had over 60 DR direct load control "events" (for 2-hours each event), many not at peak (e.g., for ramping)
  - Not much customer override due to automation

Future Direction and Trends in Utility Customer-funded Energy Efficiency Programs

Charles Goldman

Electricity Markets and Policy Group

Lawrence Berkeley National Laboratory

Symposium on Existing Programs and Policies for Deep Energy Efficiency Opportunities

November 14, 2018

This presentation was supported by the U.S. Department of Energy's Office of Electricity, Transmission Permitting and Technical Assistance Division, under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

Overview of Presentation

- Greater, deeper energy efficiency
  - What do we mean? Why is it important?
- Recent findings on cost performance of electricity efficiency programs
- Future trends and directions in electricity efficiency programs
  - Time-varying value of efficiency
  - Efficiency as a grid resource
- Potential implications for efficiency in Hawaii

Greater, Deeper Energy Efficiency

Deep Energy Efficiency: Overview

- Building Level
  - A **deep energy retrofit** is a whole-building analysis and construction process that uses "integrative design" to achieve much larger energy savings than conventional energy retrofits. Deep energy retrofits can be applied to both residential and non-residential buildings; typically results in savings of 30 (50)% or more, perhaps spread over several years
- Program perspective
  - “Depth” – Deeper savings per facility
  - “Breadth” – Greater market penetration; increasing participation rates

https://en.wikipedia.org/wiki/Deep_energy_retrofit

Deep Energy Efficiency: Overview

- Resource Characteristics
  - Efficiency measures can be described in terms of the decision event for their adoption
    - Retrofits – efficiency measures that can be adopted any time
    - “Lost opportunity” measures – adoption decision occurs only when new building is constructed or an appliance or piece of equipment is purchased for a new installation or to replace burned out equipment
    - Programs that target “lost opportunity” measures may be high priorities, particularly if EE budgets are limited
- Policy perspective – Why is “deeper EE” important?
  - Reduce dependence on fossil fuels & Affordability
  - Climate change: EE as cornerstone of strategy to reduce carbon emissions

Energy Efficiency: Policy Drivers

Key Policy Drivers	States Where Applicable to Electricity Efficiency Programs
Energy efficiency resource standard	AZ, CA, CO, HI, IL, MD, MI, MN, NJ, NM, NV, NY, OH, PA, TX, VA, VT, WI
Energy efficiency eligibility under state renewable portfolio standards	MI, NC, NV, OH
Voluntary savings target	IA, IN, MN, MO, UT
Statutory requirement that utilities acquire all cost-effective energy efficiency	CA, CT, MA, ME, NH, OR, RI, VT, WA
System/public benefit charge	CA, CT, DC, HI, MA, MT, NH, NJ, NY, OH, OR, RI
Regional Greenhouse Gas Initiative	CT, DE, ME, MD, MA, NH, NY, RI, VT, NJ, PA*
Integrated resource plan	28 states (primarily in the West and South)
Demand-side management plan, multi-year energy efficiency budget or both	46 states
Utility business model (e.g., decoupling, lost revenue adjustment, shareholder incentives for performance)	27 states

* *New Jersey and Pennsylvania have decided to join RGGI, which will provide some revenues for program administrators in the future.*

Recent Findings on Cost Performance of Electricity Efficiency programs

LBNL Cost of Saving Electricity Project: Data and Analytical Approach

Approach

- Collect & analyze reported annual energy efficiency (EE) program data

LBNL DSM Program Database

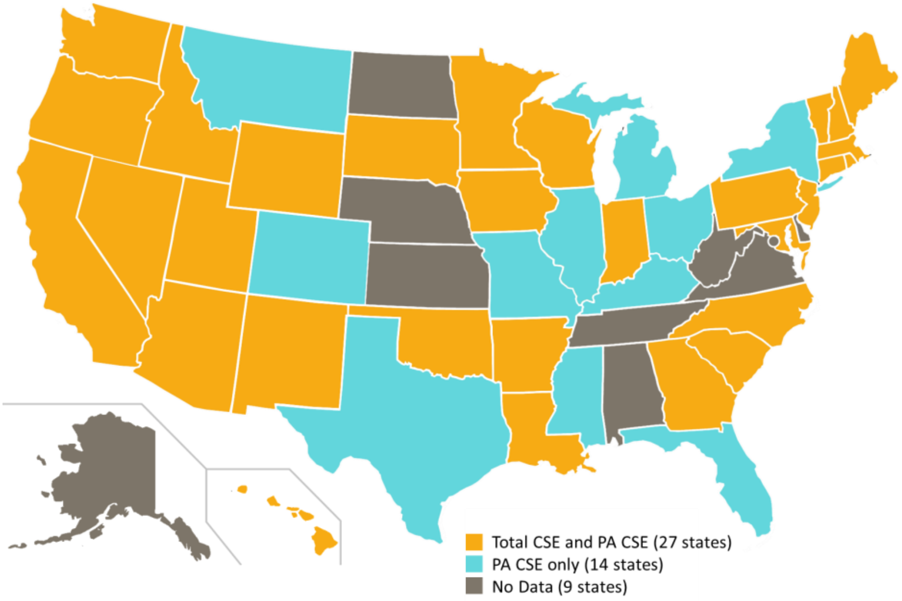
- Program Administrator CSE: 116 electricity EE administrators in 41 states
  - N = 8,790 program years (2009-2015)
- Total Cost of Saved Electricity: 67 administrators in 27 states
  - N = 4,590 program years

Data Collected

- Annual & lifetime savings
- Budgets & expenditure details
- Measure lifetimes for programs
- Participation

Standardization Is Critical

- A common DSM lexicon and program typology
- LBNL program reporting tools for:
  - Investor-owned utilities
  - Public power utilities



Definitions: PA and Total Cost of Saving Electricity

Levelized Program Administrator Cost of Saving Electricity (PA CSE)	The cost to the *program administrator* for achieving electricity savings over the economic lifetime of the actions taken, discounted back to when the costs were paid and the actions occurred

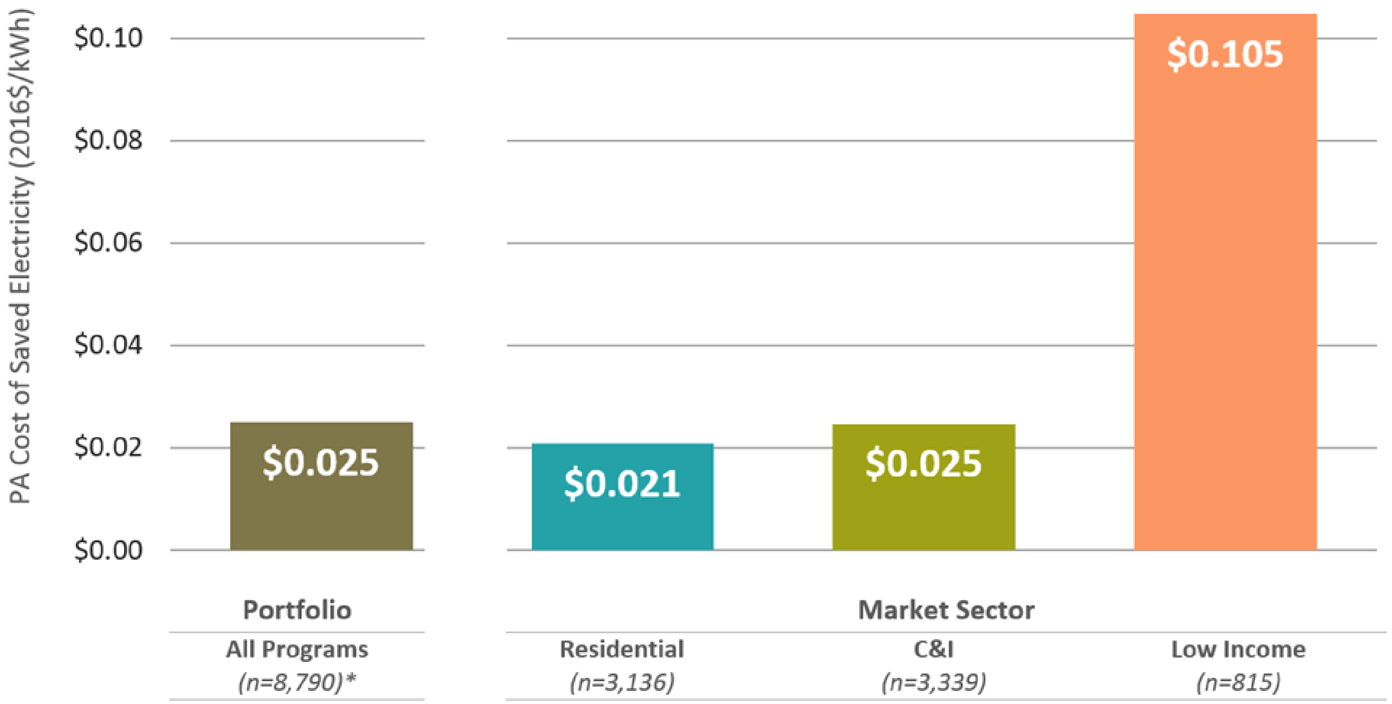
Levelized PA CSE for EE programs calculated using the following assumptions and inputs:

- 6% discount rate (real)
- Estimated program average measure lifetime
- Total program cost, including incentives (2016$)
- Gross annual kWh saved

Levelized Total Cost of Saving Electricity (Total CSE)	The costs incurred by program administrators and participants for achieving electricity savings over the economic lifetime of the actions taken, discounted back to when the costs were paid. Participant costs are net of any incentives paid by the program.

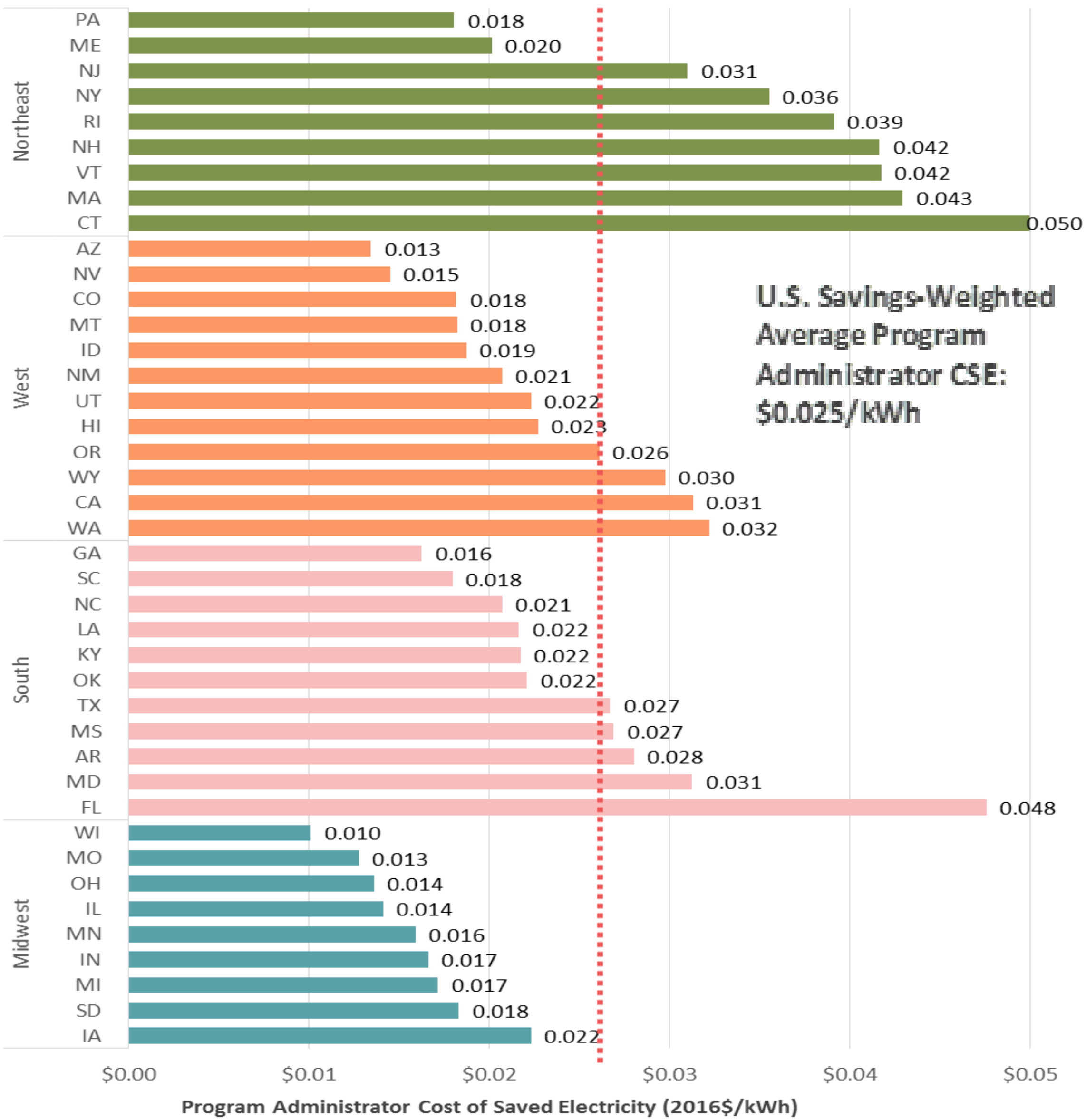
Program Administrator Cost of Saving Electricity: National Results (2009-2015)

- U.S. savings-weighted average PA CSE for all programs: $0.025/kWh (2009-2015)
- PA CSE for residential programs: $0.021/kWh, influenced strongly by lighting rebate programs
- PA CSE for C&I programs: $0.025/kWh
- PA CSE for low-income programs: $0.105/kWh (account for 2% of savings, 9% of spending)



*Portfolio sample size includes planning and other support programs that do not directly generate savings. Source: LBNL Database

Program Administrator Cost of Saving Electricity: State-level Results (2009-2015)



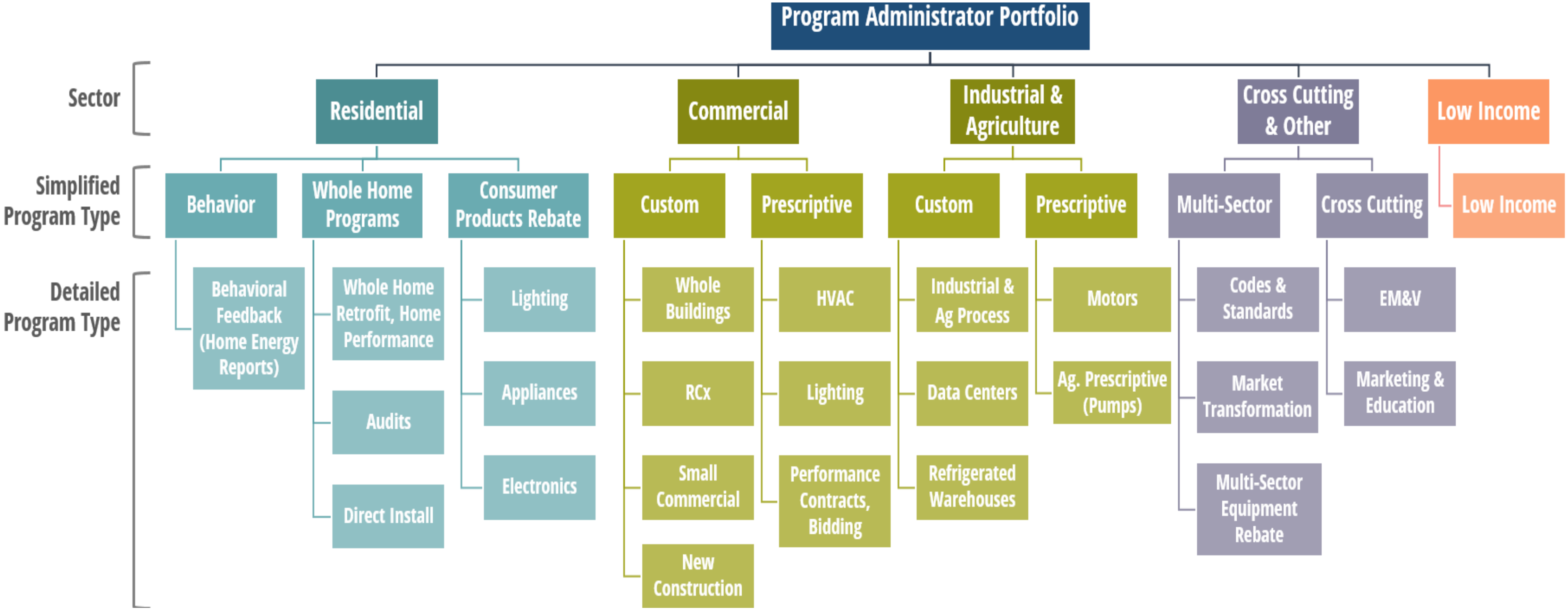
- 17 states with a PA CSE of ≤$0.02/kWh, concentrated in the Midwest, South and Intermountain West
- PA CSE greater than $0.04/kWh in five states. Four of these states (CT, VT, MA, and NH), in the Northeast, have relatively high electricity prices, extensive history with EE and strong policy commitments.

Program Administrator Cost of Saving Electricity: State-level Results

- 2015 electricity savings expressed as % of 2015 retail sales
- PA CSE values tend to be higher in states that achieve more aggressive savings levels. 23 states reported annual electricity savings ≥1% of retail sales
- Nine states in NE and West >1.5% savings
- Four states with >2% savings (ME, VT, RI, MA)

LBNL Efficiency Program Typology

- Characterizes programs by market sector, technologies and delivery approaches
  - Reflects range of reporting detail and enables multiple levels of analysis
- Six sectors, 27 simplified programs and >60 detailed program types

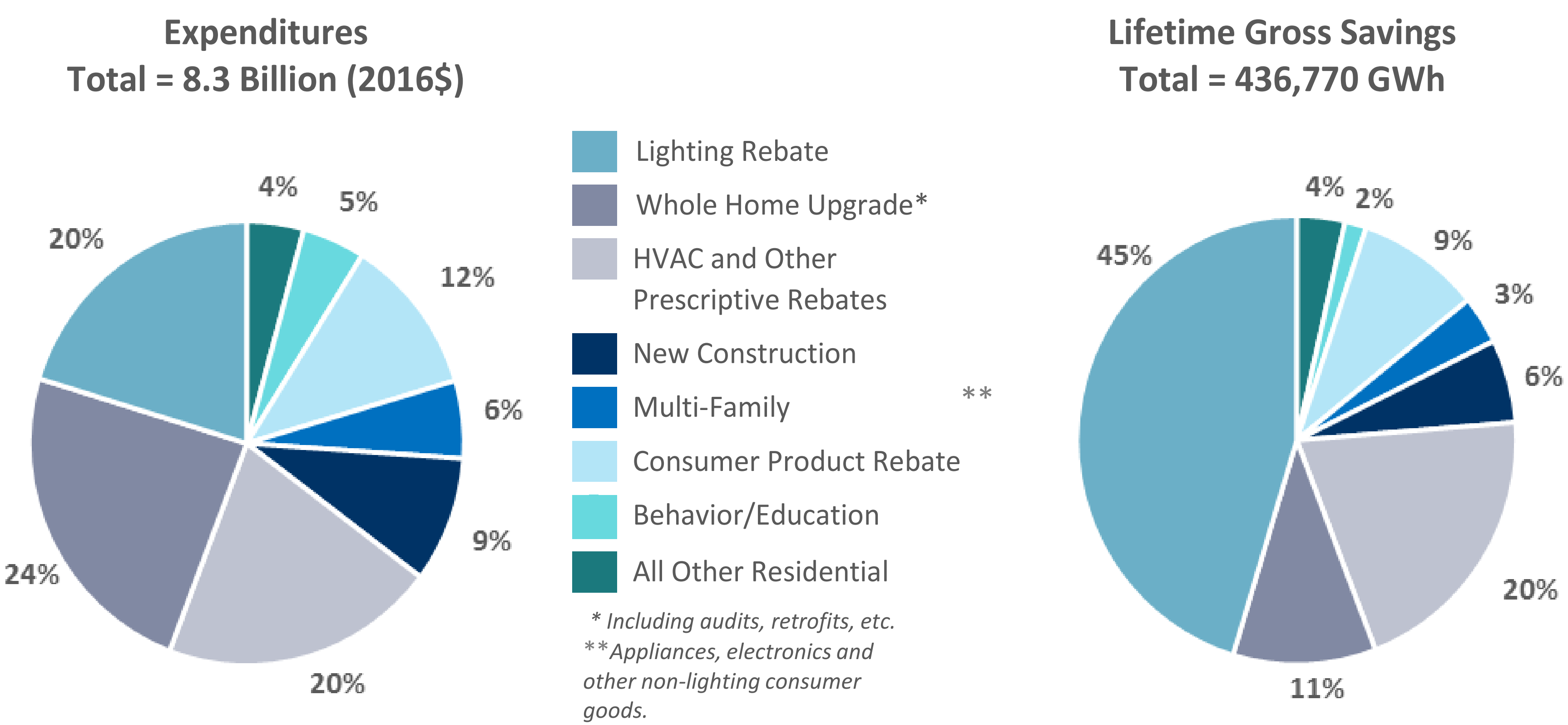


See LBNL brief, *Energy Efficiency Program Typology and Data Metrics: Enabling Multi-State Analyses Through the Use of Common Terminology*

**Figure is illustrative. Not all program types are depicted.*

Residential Program Spending and Lifetime Savings

- $8.3B in residential program spending from 2009 to 2015 in LBNL database
- Whole-home upgrades and prescriptive rebates together account for 44% of spending and 31% of lifetime savings
- Lighting rebate programs account for 20% of spending and 45% of lifetime savings

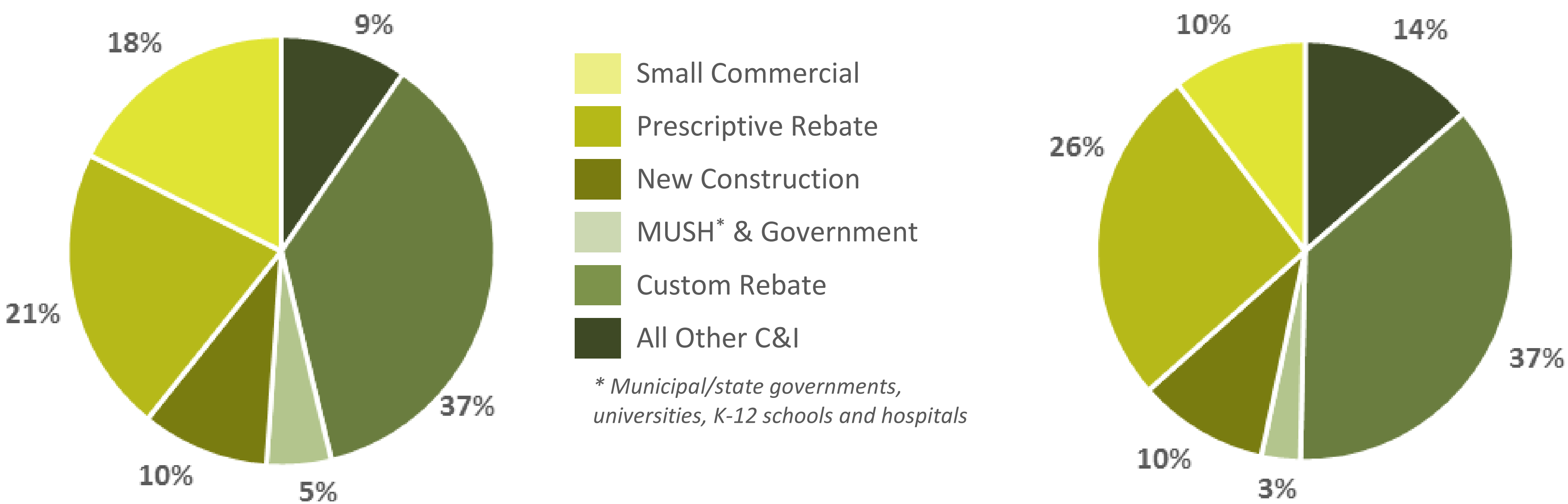


C&I Program Spending and Lifetime Savings

- $13.4B in C&I program spending from 2009 to 2015 in LBNL database
- Custom rebate, prescriptive rebate, and small commercial programs account for about 3/4 of spending and lifetime savings

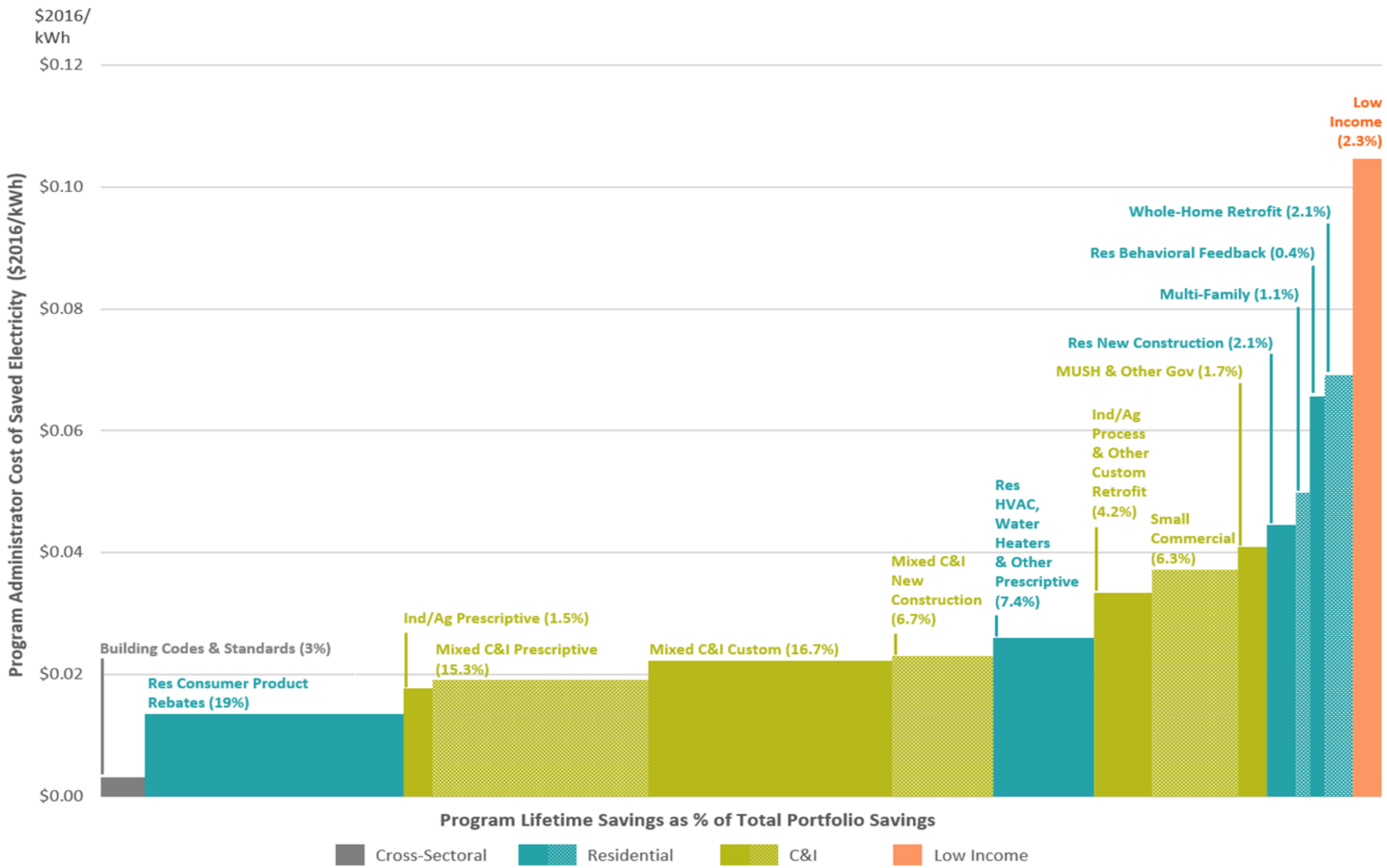
Expenditures
Total = 13.4 Billion (2016$)

Lifetime Gross Savings
Total = 836,241 GWh



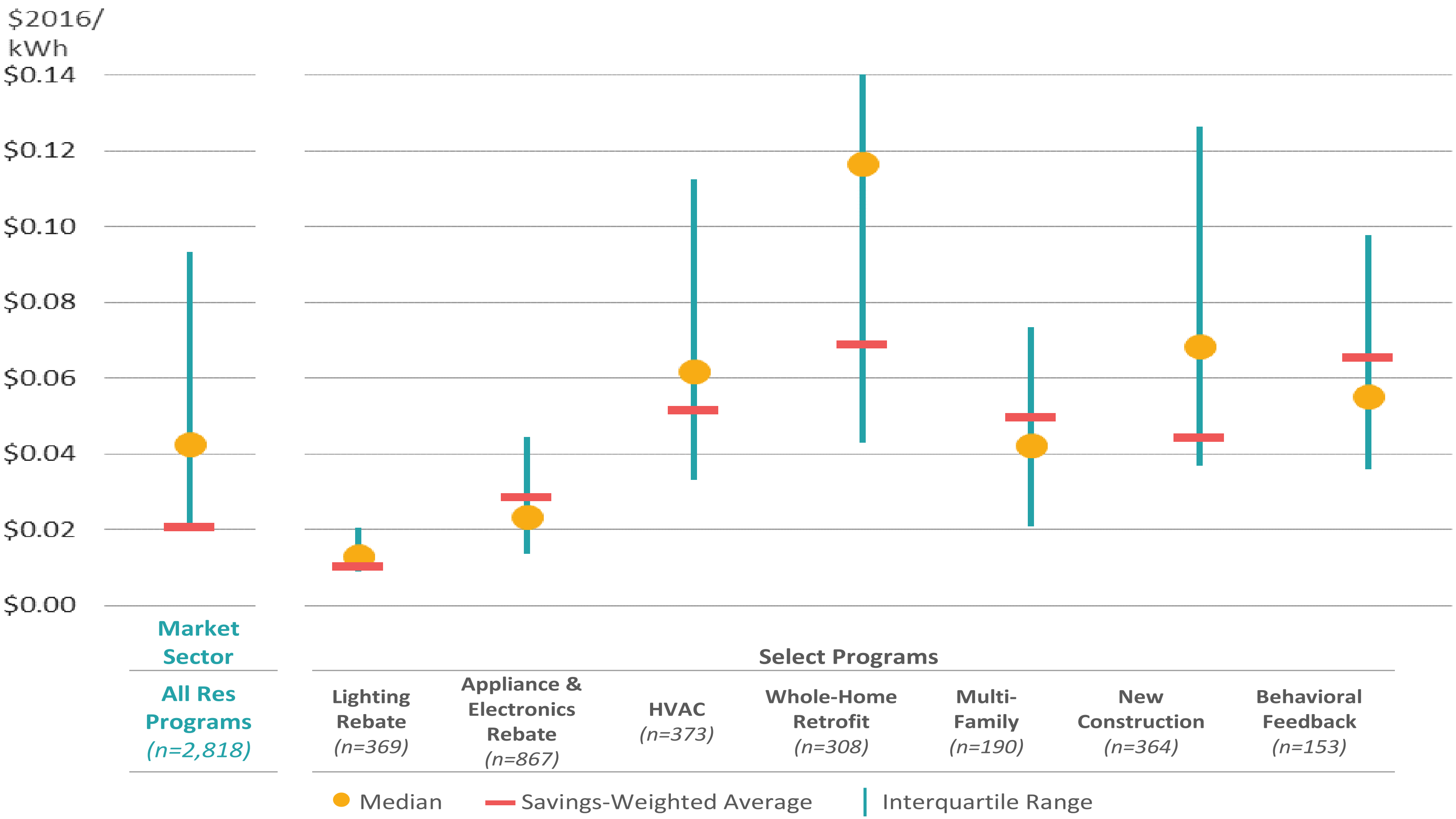
Program Administrator Cost of Saving Electricity: Program Savings Cost Curve

- Programs ordered by actual cost performance on x-axis; width scaled to represent lifetime savings
- Reinforces program analysis: Residential programs (blue) are least (and most) expensive; C&I programs (green) are key contributors to overall EE portfolio



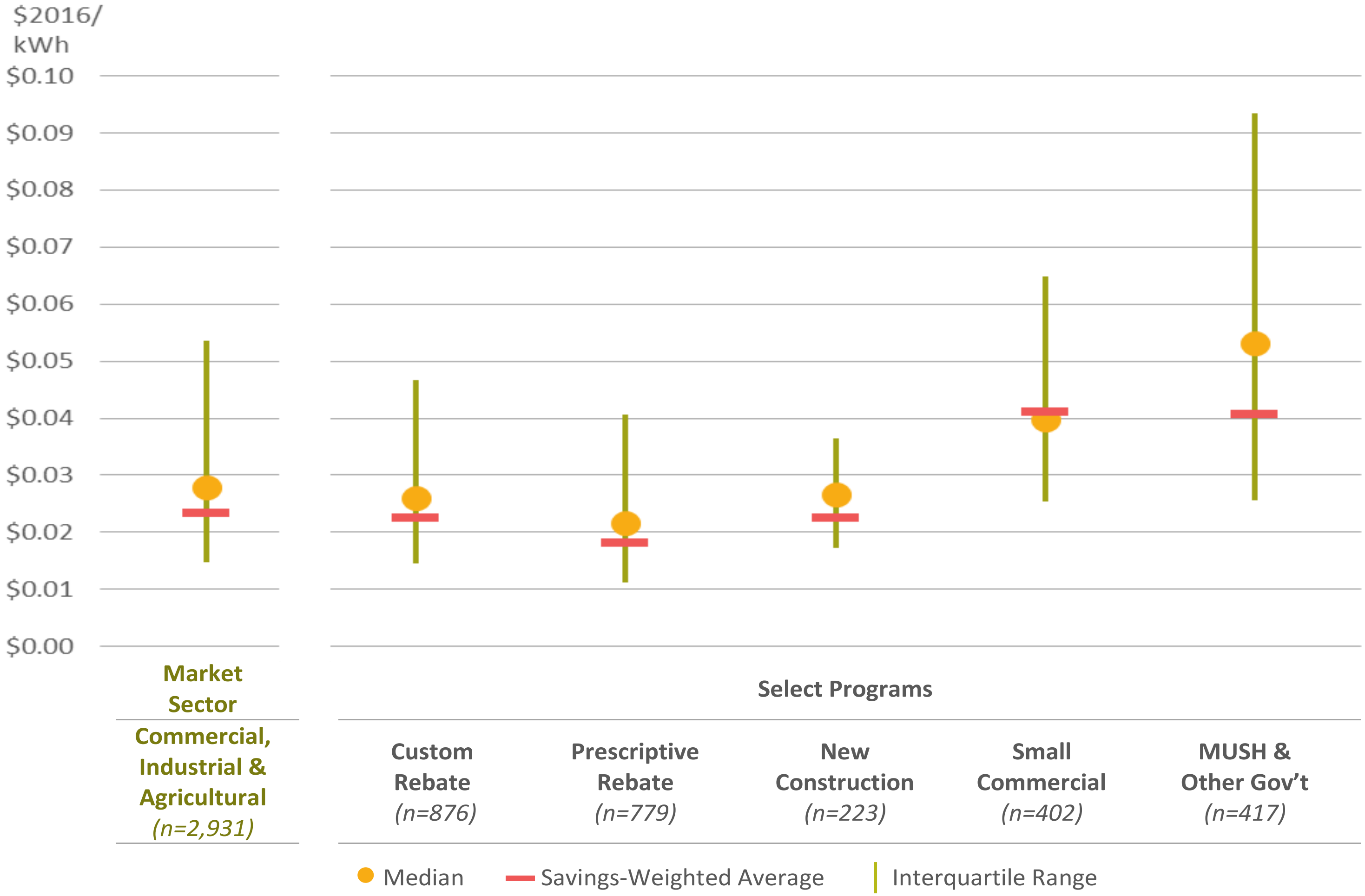
Program Administrator Cost of Saving Electricity: Median Values and Ranges for Residential Programs

- Median PA CSE for residential sector: $0.042/kWh
- Low variability in PA CSE for lighting vs. other programs (HVAC, whole home retrofit, new construction) where variability in CSE values is greater — reflects diversity in program design and mix of measures



Program Administrator Cost of Saving Electricity: C&I Program Medians and Ranges

- Low variability in PA CSE among major C&I programs with ~3/4 of sector savings
- Medians close to weighted averages suggests that most C&I programs perform similarly for large and small program administrators.



Future of Utility Customer-funded Efficiency Programs

Future of Efficiency: Approach

- State-by-state projections of electricity efficiency program spending and savings (kWh) to 2030
  - Based on detailed review of state policy drivers (e.g., EERS, all cost-effective EE statutes, DSM plans and IRPs, utility business model changes that support EE) and performance of program administrators
- Captures the efforts and prospects of all electric utilities (IOUs, munis, coops) and other ratepayer-funded program administrators
- Three scenarios—low, medium and high—designed to capture alternative pathways for evolution of EE programs
  - Policy implementation and efficacy (e.g., performance of administrators)
  - Broader policy and market drivers and constraints
  - State-specific scenarios informed by ~50 interviews with PUC staff, program administrators and EE experts
  - None of the scenarios is intended to capture wholesale shifts in federal policies

Modeling Future Spending and Savings

Historical 2013–2016

- **Actual EE spending, savings data**
  - Sources: LBNL DSM Program Database, EIA 861, and PA filings

Policy e.g., 2017–2024

- **Current, planned & projected EE spending and savings**
  - Sources: DSM plans, PUC orders, statutes (EERS, SBC, all cost-effective EE mandates, spending minimums, lost-revenue recovery, performance incentives), IRP plans

Post-Policy e.g., 2025–2030

- **Forecast spending and savings**
  - Extrapolation from historical performance, IRP plans
  - Interviews and Expert judgment
  - Regional "best practices" (high case)

- Historical – collect information on actual program spending and savings to establish an initial relationship between costs and first-year savings
- Policy period – duration varies by state; project future savings and spending driven by explicit state policies or plans
- Post-policy period – Policy commitments are less firm or have ended; rely on interviews, expert judgment , and regional best practices to define a range of savings targets for each state

Key Scenario Assumptions: West

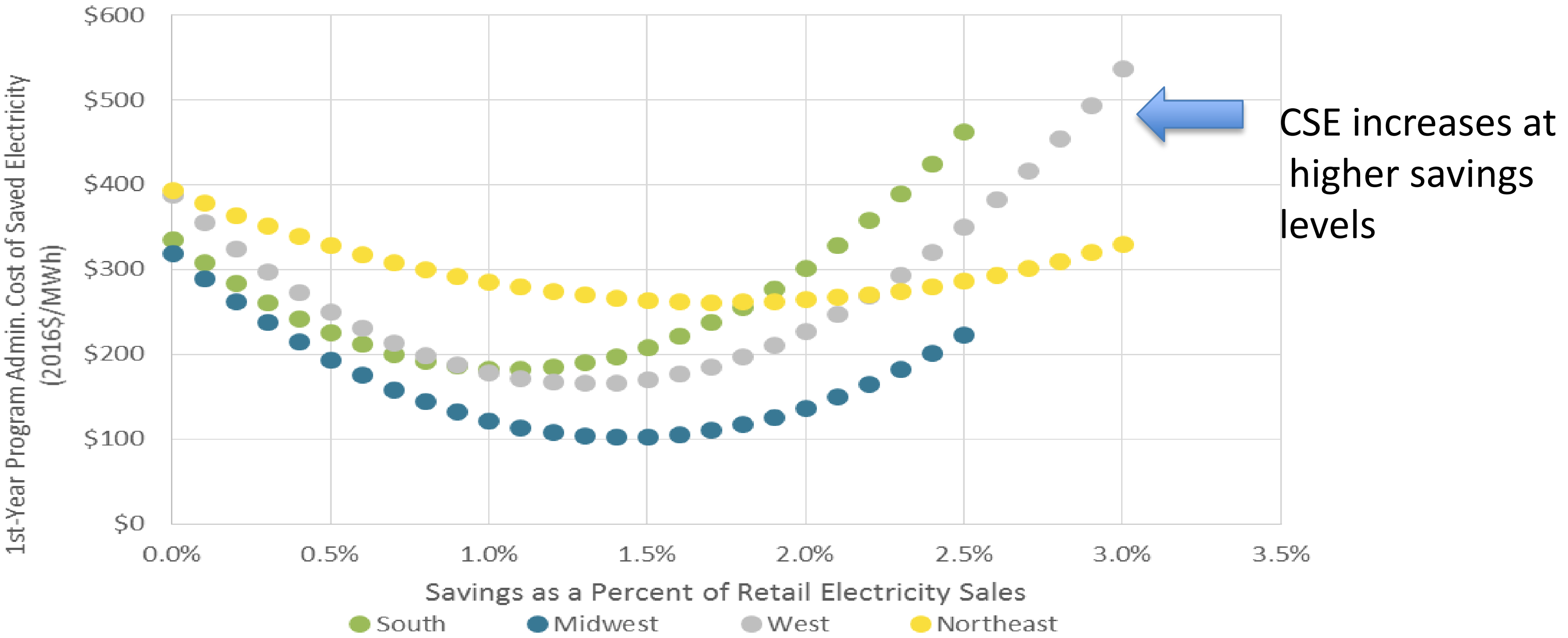
Region	Scenario	Assumptions for Selected States
West	Low	• California – Assume difficulties in IOU transition to 3rd-party program managers, but savings recover somewhat after 2020. POUs reduce their efforts(0.9%). • Washington – Assume IOU savings targets decrease from current levels (1.1% in 2018 to 0.5% in 2030) due to low wholesale prices which erode cost-effectiveness and impact of appliance standards. • Arizona – IOUs fall short of EERS; savings after 2020 fall to IRP level; Salt River Project savings decline slightly.
	Medium	• California – Extensive policy support for efficiency with savings targets based on potential studies and aggressive state policies; assume IOUs meet current targets (1.7%), which decrease somewhat over time (1.4% in 2030); low-income savings decline somewhat. POUs meet targets (1.1% in 2030). • Washington – All-cost effective efficiency statute and Northwest Power and Conservation Council estimates efficiency potential. Assume IOUs maintain aggressive savings levels through mid-2020s (1.8% in 2025), but savings decline in later years primarily due to impact of appliance efficiency standards (0.6% in 2030). • Arizona – EERS sunsets in 2020; after that, assume IOUs savings decrease from current levels for IOUs (1.7% in 2017 to 1.0% in 2030).
	High	• California – Assume IOU savings rise to higher tier of achievable market potential (1.7% in 2030); low-income savings sustained. POUs meet targets. • Washington – Assume IOUs and POUs achieve savings that are close to achievable potential (2% in 2025), but savings decline in later years due primarily to impact of efficiency standards. • Arizona – Assume EERS requirements remain largely in place with IOU savings at 1.5% in 2030; Salt River Project maintains current savings (2.0%).

Hawaii: Policy Context and Scenarios

- EERS: Reduce electricity consumption by 4300 GWh by 2030, enough to power every home on Oahu, Maui, Molokai, Lanai, and Hawaii for 2 years;
- Most recent potential study shows economic potential about 45% above savings target
- HECO has decoupling; Hawaii Energy is eligible for performance incentive
- EE funded through a public benefits fee

Scenario	Description
Low	• Assume Hawaii Energy has difficulty maintaining low EE costs and meeting mandated savings targets cost-effectively • Assume savings decline to 1.2% by 2030
Medium	• Assume Hawaii Energy sustains current levels of savings to 2030 • Assume savings remain at 1.6% of retail sales by 2030
High	• Assume Hawaii Energy continues achieving EE targets to 2020; then savings goals increase over time, closer to identified economic potential (savings rise to 1.8% of sales in 2030)

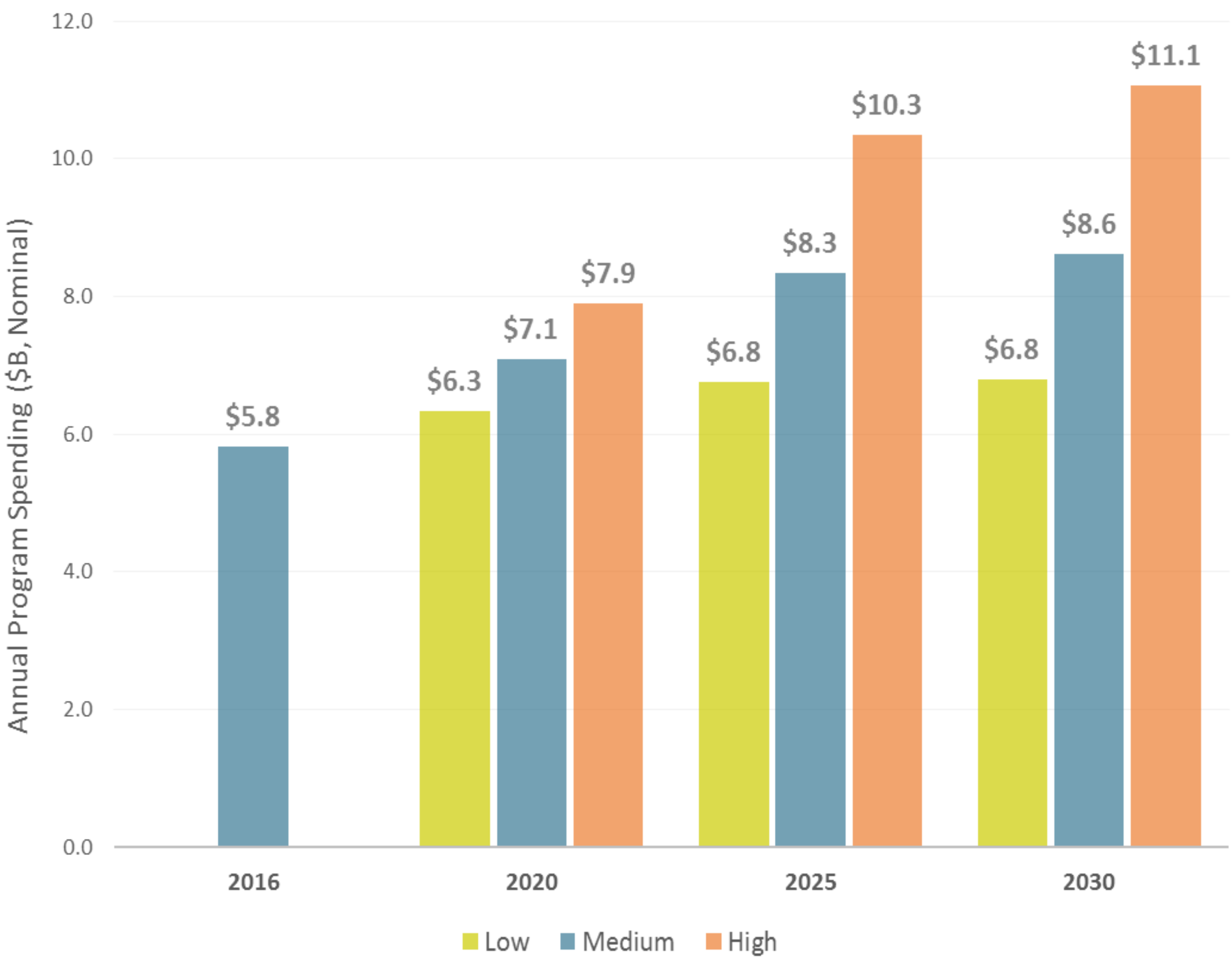
Regional Cost of Saving Electricity Curves for Investor-owned Utilities



Source: LBNL DSM Program database, Cost of Saved Energy Project

- Regression analysis results by census region for first year cost of savings vs. first-year savings as a % of retail sales based on data for 115 program administrators between 2009-2015
- We used historic state-specific cost of saved electricity values and then applied the regional cost of savings function slope to estimate spending in future years given projected savings level

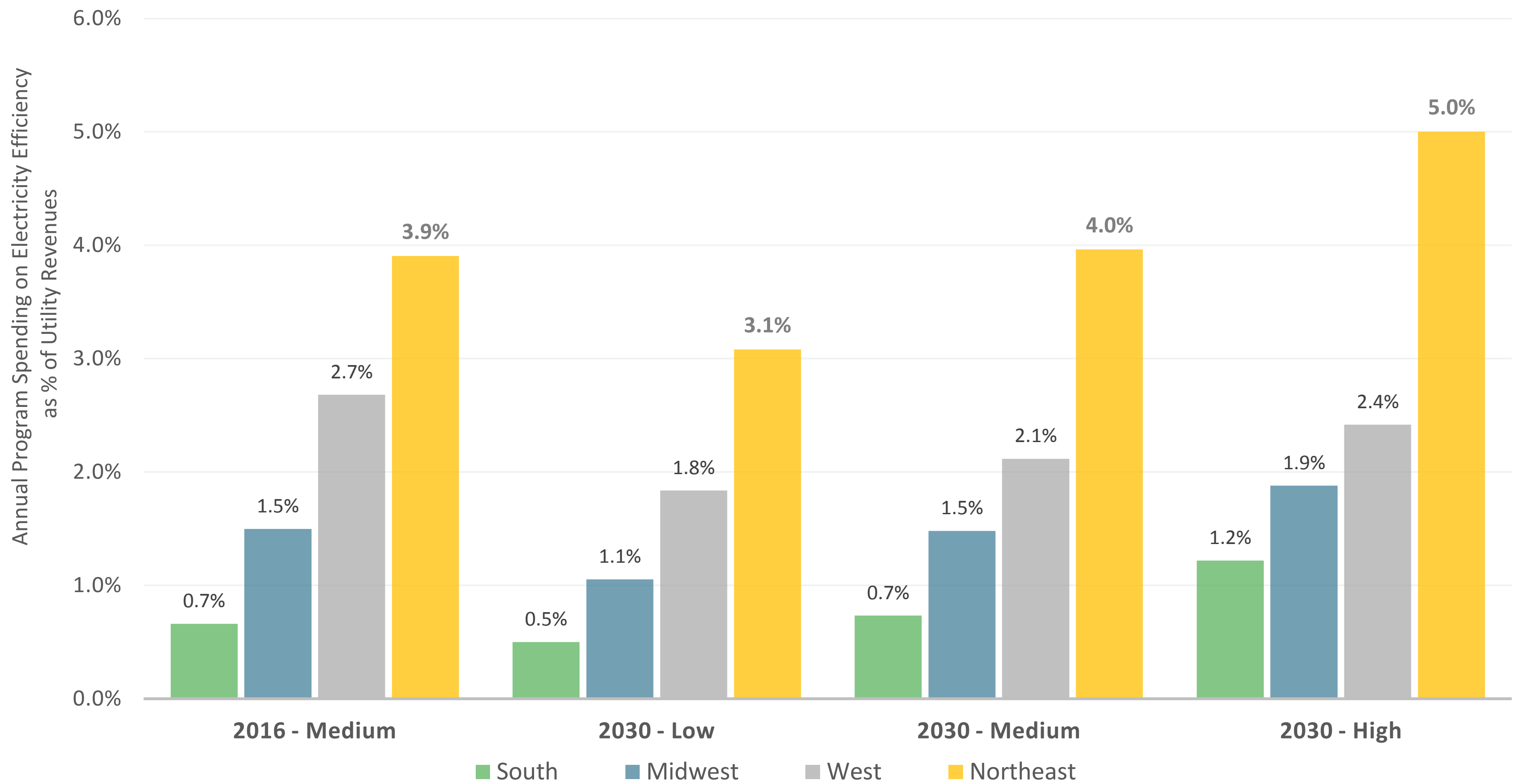
Electricity Efficiency Program Spending: U.S.



Projected electricity efficiency program spending to 2030 under three scenarios

- **Medium case**: Spending projected to increase to $8.6B by 2030
  - 3-4% annual growth to 2025 but slows to <1% in 2025-2030 period
- **Low case**: Flat spending to 2030 ($6.8B)
- **High case:** $11.1 billion in 2030 (90% higher than 2016)
  - Driven primarily by the potential of the South and prospects for stronger spending in large states
- Total market activity leveraged by utility efficiency program increases ($13-22 billion per year by 2030 in three scenarios vs. $11.6B in 2016)

Program Spending as % of Retail Electric Utility Revenues



- EE spending represents a higher share of retail revenues in the Northeast compared to other three regions (3.1%-5% vs. 0.5%-2.4% in 2030) because utilities only provide distribution service
- South lags well behind West and Midwest in relative spending levels in all three scenarios
- **Hawaii EE spending is ~1.4% of utility revenues**

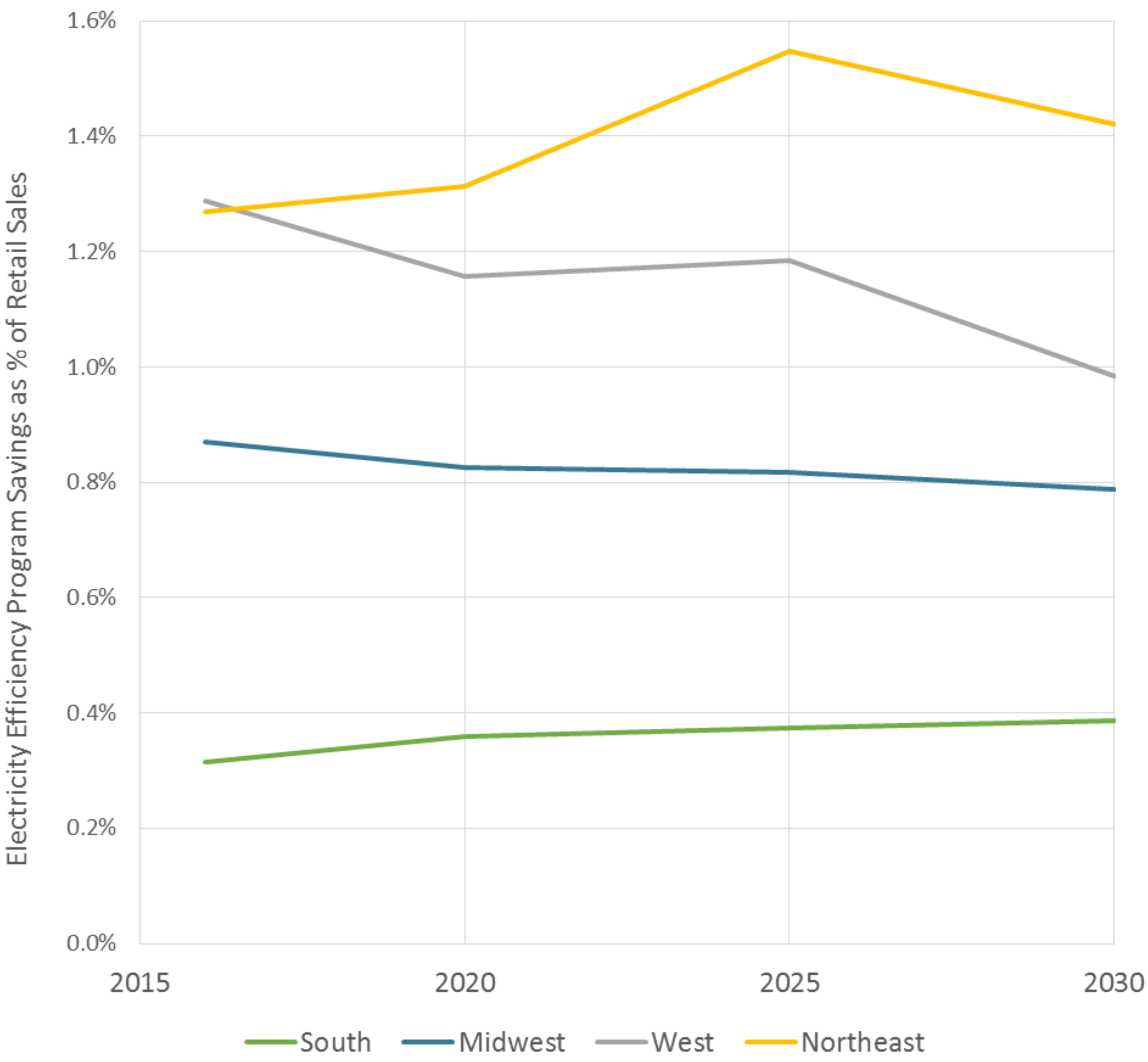
Electricity Efficiency Program Savings: National

- Efficiency programs funded by utility customers saved 27.5 TWh in 2016, equal to 0.73% of retail sales
- **Medium case:** Annual savings increases modestly to 28 TWh in 2030
- **High case:** Annual savings increases to 38 TWh/year in 2030 (38% higher than in 2016)
- **Low case:** Annual savings decreases to 20.3 TWh in 2030

Current and projected annual incremental electricity savings (TWh)

	Annual Electricity Savings (TWh)			
Scenario	**2016**	**2020**	**2025**	**2030**
Low		23.6	22.5	20.3
Medium	27.5	27.8	29.6	28.0
High		31.7	38.9	38.0

Electricity Program Savings by Region: Medium Scenario



- **Northeast and West**: Saving as % of retail sales have similar trajectory; steeper decline for the West from 2025-2030
  - Some Northeast states (NY, NJ) have adopted new, aggressive savings targets
  - Many Western and NE states have not addressed the sunsets of their current policies or are impacted by standards or market transformation in later years
- **South** has lowest savings levels but steady, shallow increase to 2030
- **Midwest:** Steady decrease to 2030

Energy Efficiency Program Policies and Implementation Issues

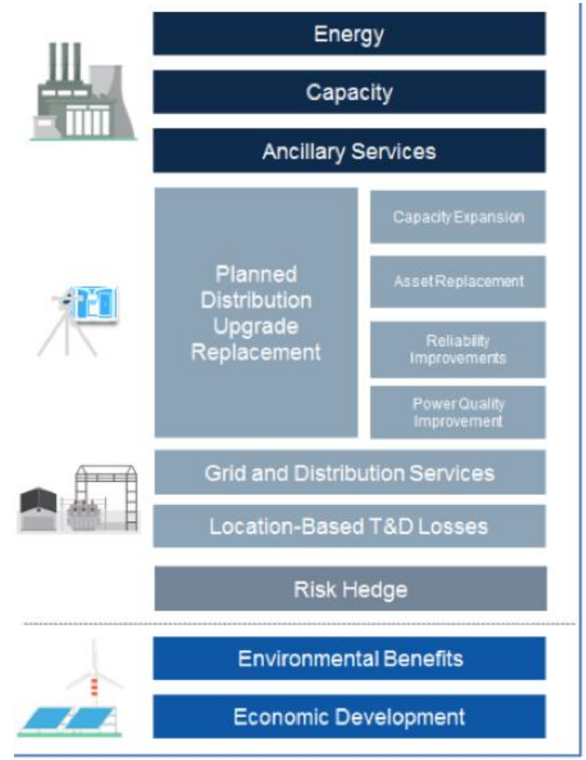
- Program portfolios will need to evolve to continue to capture cost-effective electricity savings
  - Residential – new technical opportunities to offset lighting
  - C&I – programs focused more on small and mid-size customers if states adopt opt-out policies
  - Achieving deeper savings – In states with stringent EE goals, programs will need to achieve deeper savings, broader reach in terms of market penetration and targeting under-served markets and design new, innovative programs
    - Changing value proposition for EE: time-varying and locational value
    - Strategic energy management and behavior-based programs
    - Competitive procurements to meet distribution system needs: bundles of demand-side services
    - Integrated delivery of electric and gas efficiency programs
    - Leverage state/local govt. programs and combine financing (e.g. PACE) with technical assistance

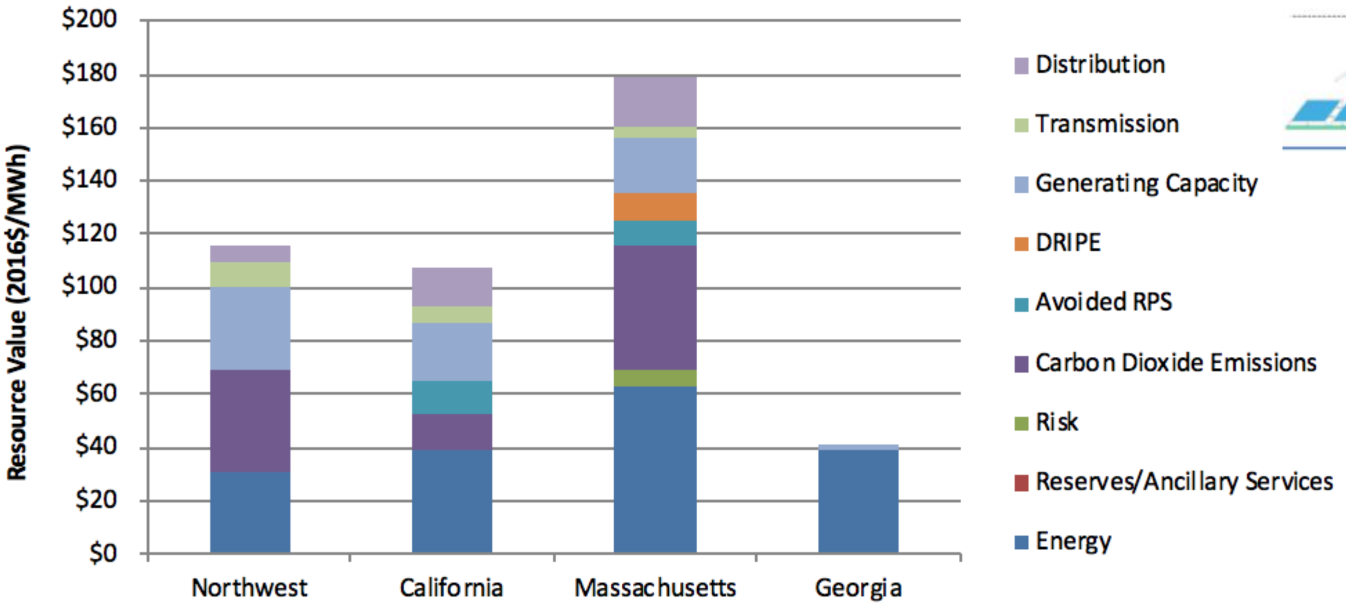
Evolution of energy efficiency: Changing grid needs, technological changes, and policies/programs

Reducing energy use anytime

Locational value of efficiency

Time-varying value of efficiency





Market and Policy Context

- A changing economy and shifting policy objectives complicate forecasting of future electricity loads
  - EIA load growth forecast is very low compared to past (0.59%/year to 2030 vs. 1.3%/year since 1990)
  - Energy intensity decreasing in all economic cycles due to structural changes in economy, fuel economy improvements and success in implementing complementary efficiency policies
  - Beneficial electrification (e.g., adoption of electric vehicles, heat pumps and selected industrial applications) may increase electricity sales over the longer term (to 2050)
- Cost of electricity supply options has declined
  - Declining costs for gas-fired and renewable generation technologies and low gas prices translate into lower avoided costs (and reduced EE program benefits); program administrators face ongoing challenges in designing cost-effective EE portfolio
  - Evolving generation mix and resource needs of utilities is changing the value proposition that efficiency resources face
    - IMPLICATION: Greater focus on time-varying value of EE resources,
    - More emphasis on controllable loads, and more interest in bundling of demand-side options to provide grid services

Market and Policy Context (cont.)

- Electricity savings from complementary strategies such as equipment standards and building codes will increasingly impact utility efficiency programs
  - Many states have adopted more stringent building codes while federal and state governments have adopted new or updated standards for appliances and equipment.
  - Standards raise the baseline against which savings from utility customer-funded programs are measured;
  - For last decade, estimated annual savings from electricity efficiency programs were roughly comparable to annual savings from standards
  - For 2017-2030 period, standards that take effect during next 5 years may produce significantly higher savings
  - IMPLICATION: standards influence size of remaining achievable potential and the mix of technologies targeted by voluntary programs
  - IMPLICATION: Increasing savings from standards means that it will be more challenging for program administrators of utility customer-funded programs to obtain cost-effective savings, particularly in later years of our study period

Market and Policy Context (cont.)

- Market transformation: Energy efficiency products and services
  - Some/many end users are investing in higher efficiency products and services on their own because of technological innovation (e.g., declining costs, higher quality products)
  - Example: General service lamp (mainly screw-type light bulbs known as A-line lamps) market is changing rapidly
  - National Electrical Manufacturers Association (NEMA) reports that shipments of LEDs accounted for 36% of A-line lamp sales in 2017 compared to <1% in 2011. Share of CFLs decreased to 8.4% in 2017.
  - Implications for future residential efficiency programs
    - At present, 45% of lifetime savings come from residential lighting programs
    - CFL and LED will become the new savings “baseline”
    - Program administrators will have to look for additional technical opportunities for saving electricity to offset reliance on lighting programs

Future of Efficiency Study: Conclusion

- Portfolio of efficiency programs in each state is likely to evolve significantly over the time horizon of this study
- Emerging challenges:
  - Increased impact of complementary strategies (e.g., standards)
  - Decreasing costs of supply-side resource options
  - Adapting the value proposition for energy efficiency to reflect changing utility system needs (e.g., integrating variable generation, time-varying value of efficiency, offsetting local distribution system investments)

  Institutional framework for energy efficiency

  - Program success depends on customer acceptance and adoption; stakeholder input on program design is crucial
  - Need for measurement and verification of savings
- Degree to which program administrators and state regulators address these challenges is likely to heavily influence the longer term pathway for efficiency programs

Time-varying value of Efficiency

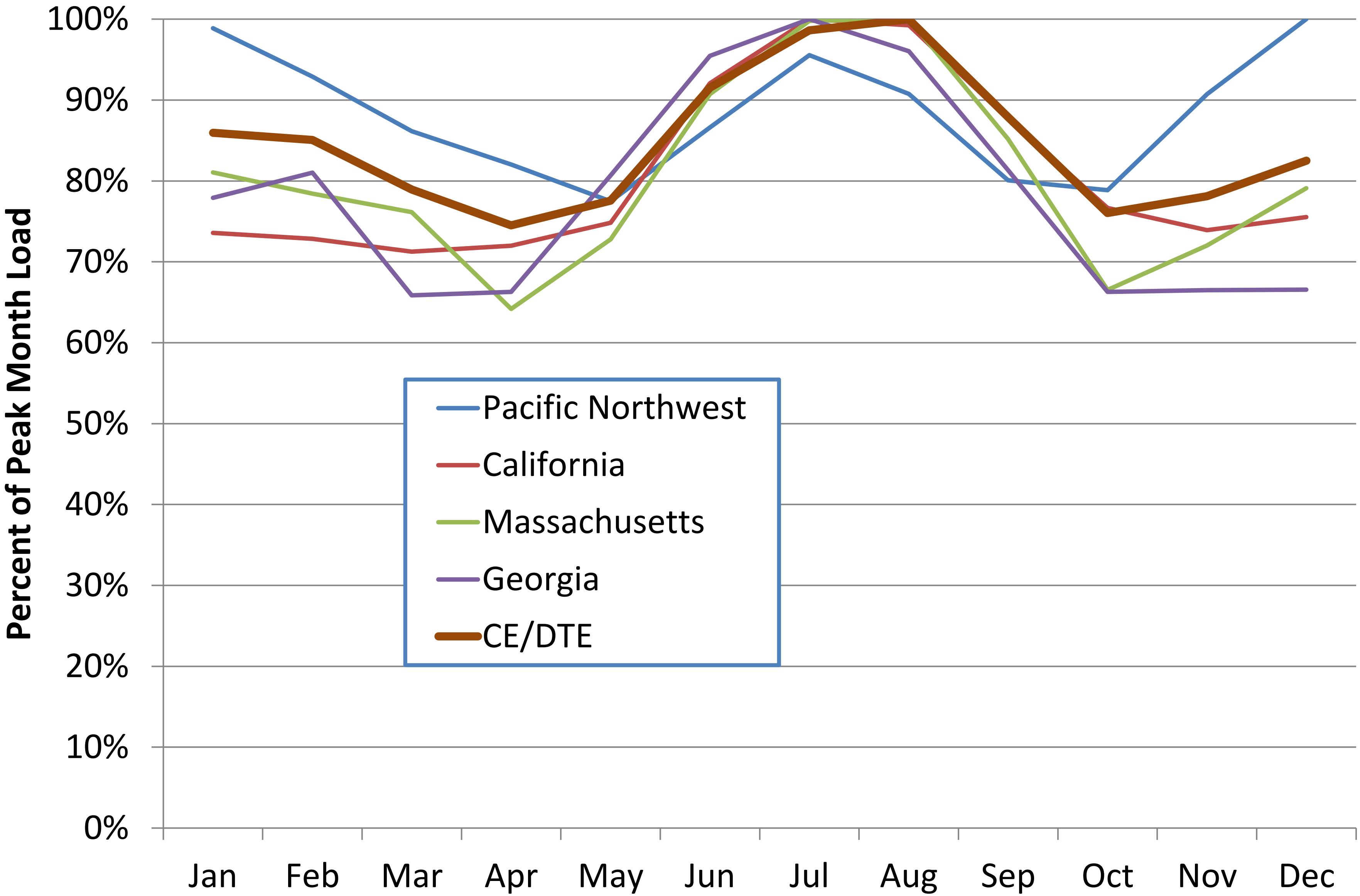
Approach

- Use publicly available avoided costs and end-use load shapes from state or regional sources.
- Document time-varying energy and demand impacts of 5 measures in 5 locations:

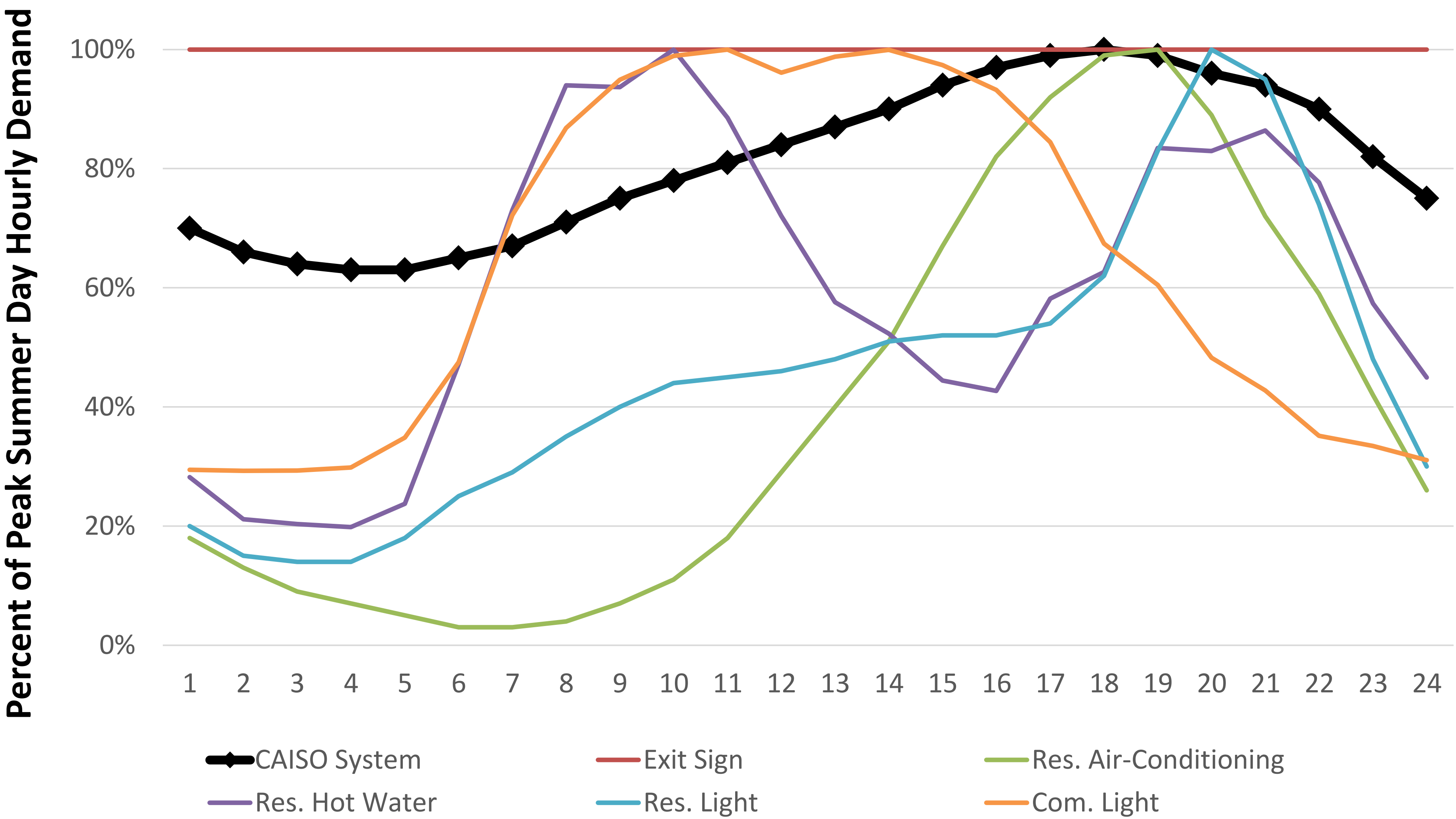
Measures	*State/Region*
Exit sign (flat load shape)	Pacific Northwest
Commercial lighting	California
Residential lighting	Massachusetts
Residential water heater	Georgia
Residential air conditioning	Michigan

1. Apply hourly avoided costs to each measure load shape to calculate the time-varying value of measure,

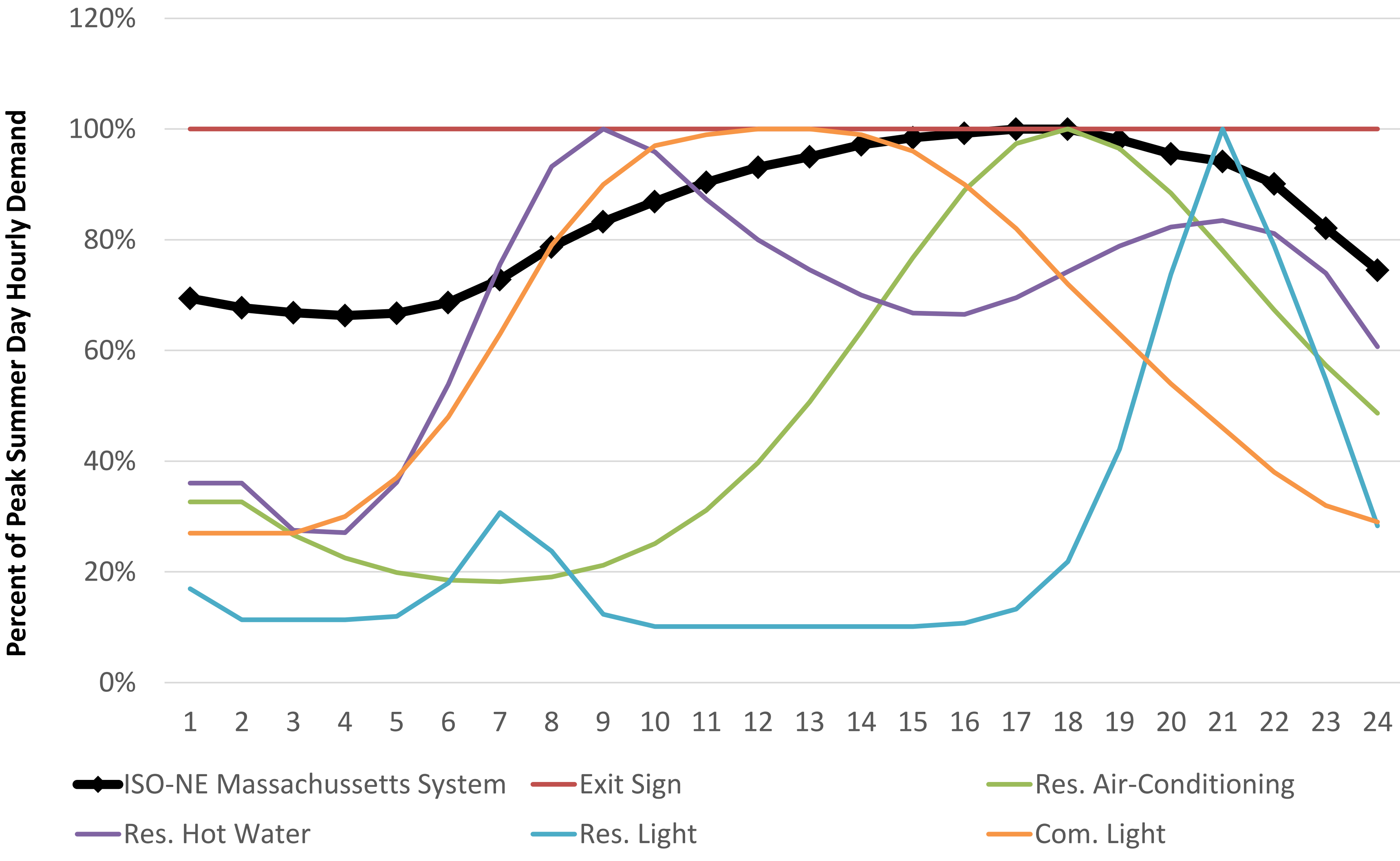
Annual System Load Shapes



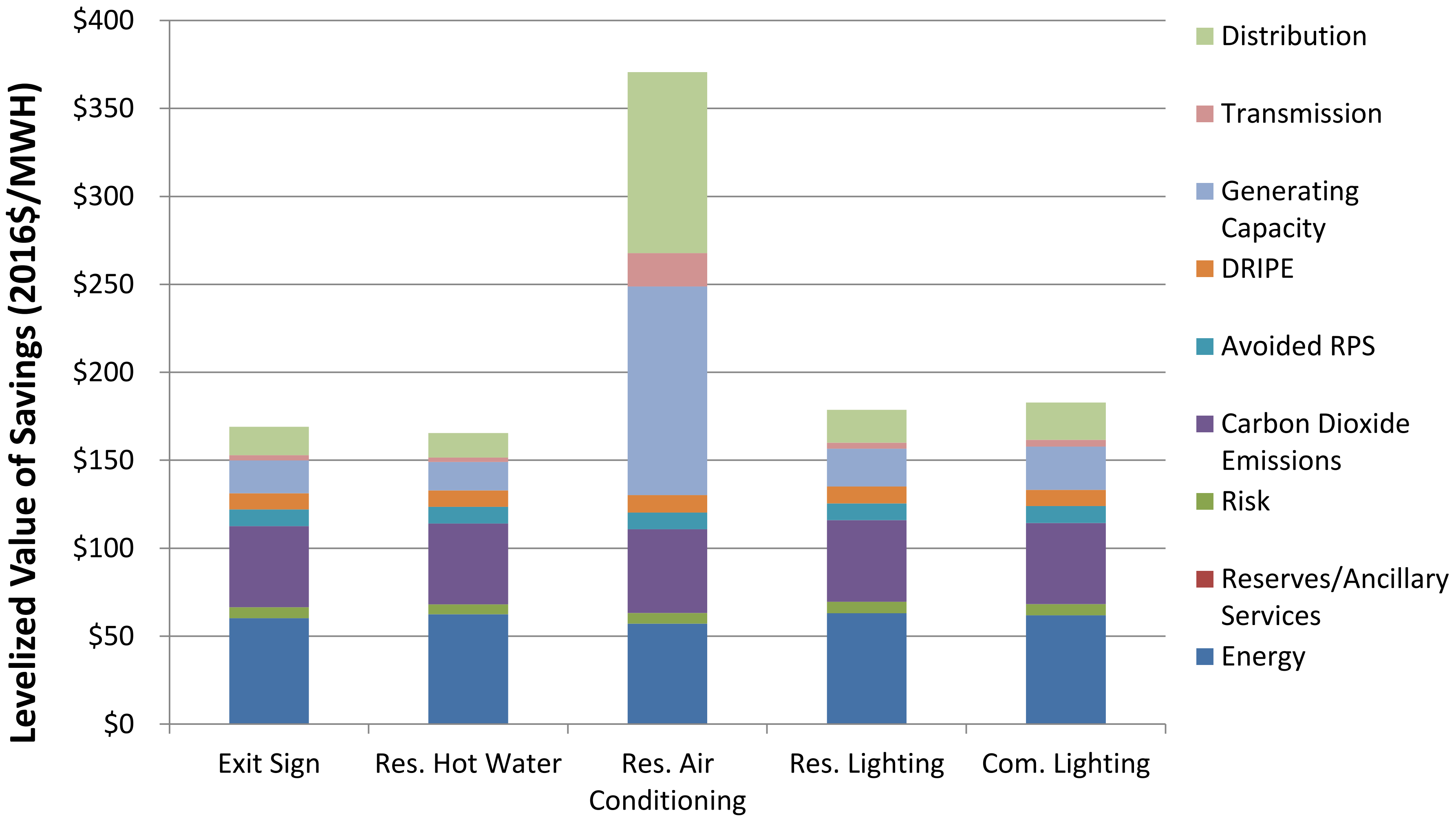
California System Shape and End-Use Load Shapes



Massachusetts System Shape and End-Use Load Shapes

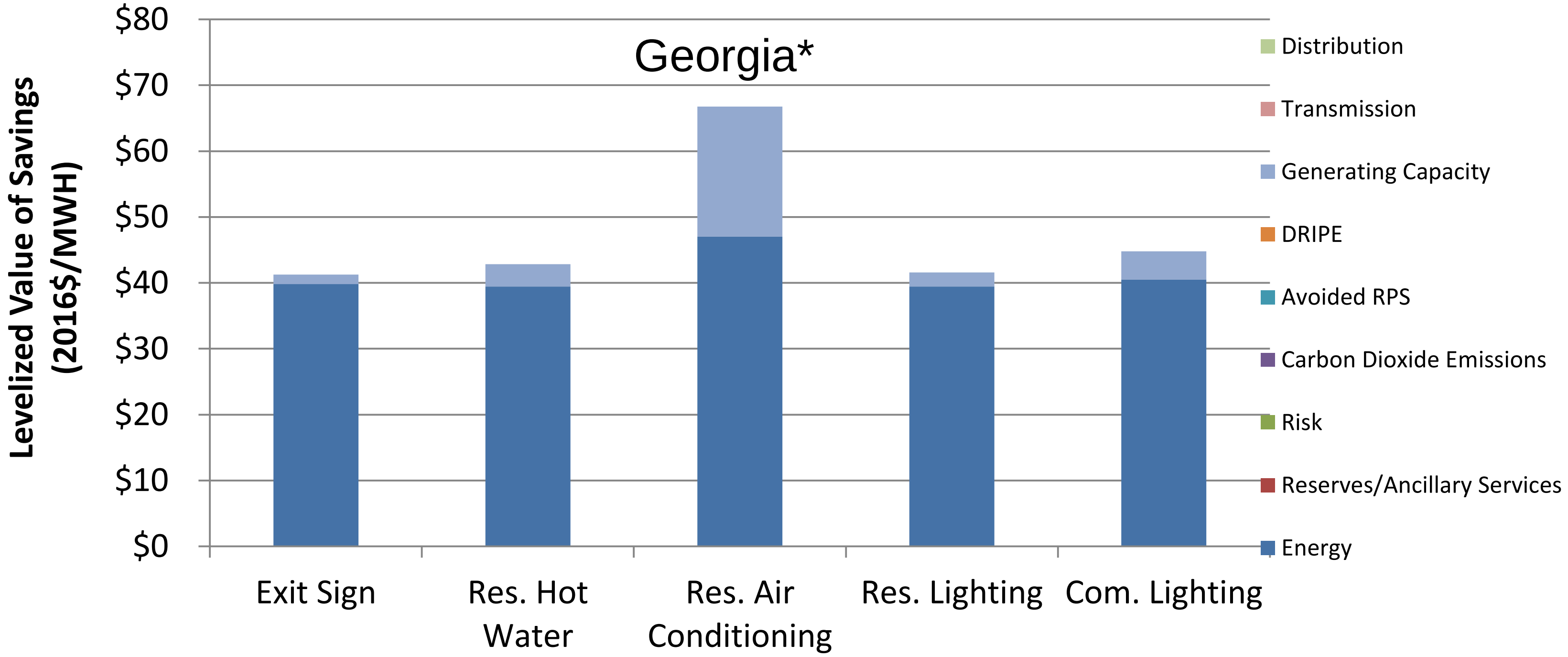


Massachusetts Time-Varying Value by Load Shape



Why All Avoided Cost Values Matter

- The time-varying value of energy efficiency measures varies across the locations studied because of physical and operational characteristics of the utility system, the time periods that savings occur and differences in the value and components of avoided cost considered.
- Publicly available components of electric system costs avoided through energy efficiency are not uniform across states and utilities. Inclusion or exclusion of these components and differences in their value affect estimates of the time-varying value of efficiency.

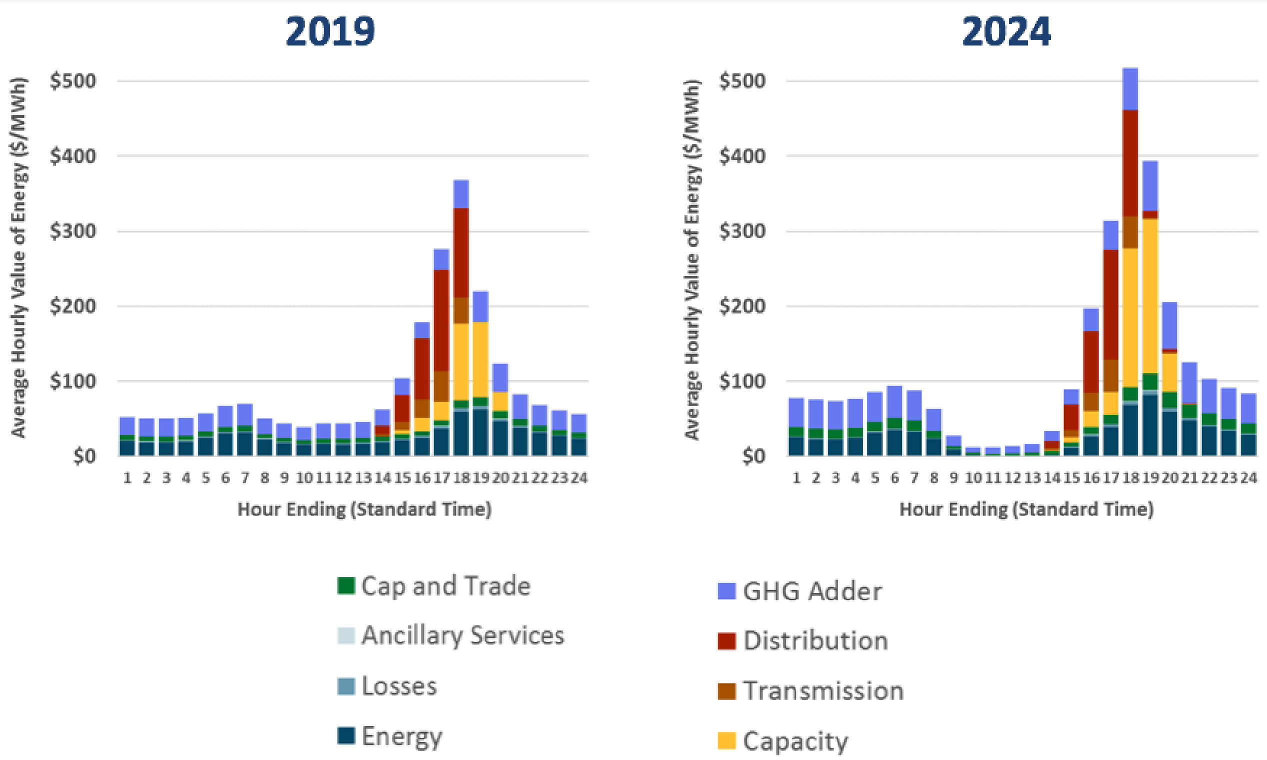


*** In Georgia, where publicly available data did not include avoided transmission and distribution system values, the time-varying value of efficiency appears much lower for all measures evaluated. Avoided transmission and distribution costs are included in Georgia Power's energy efficiency planning, but are not a part of the publicly available PURPA avoided cost filing and therefore are not included here.**

Why Changing *System* Shapes Matter (1)

- The increased use of distributed energy resources and the addition of major new electricity-consuming end-uses are anticipated to significantly alter the load shape of many utility systems in the future.
- Data used to estimate the impact of energy efficiency measures on electric system peak demands will need to be updated periodically to accurately reflect the value of savings as system load shapes change.

Components of Electric Avoided Cost for climate zone 4 in 2019 and 2024



Time-varying Efficiency: Conclusion

- The time-varying value of efficiency measures varies across the locations studied because of physical and operational characteristics of utility systems, the time periods that measure savings occur, and differences in the value and components of avoided costs considered.
- Some of the largest capacity benefits from efficiency are derived from the deferral of distribution system infrastructure upgrades, although the deferred cost of infrastructure upgrades exhibited the greatest range in avoided cost value
- The increased use of distributed energy resources (PV, storage, EV) are anticipated to significantly alter the load shape of many utility systems in the future
- Publicly available data on end-use load and energy savings shapes are limited, concentrated regionally, and should be expanded
- LBNL found, the total value of energy savings increased significantly — 6-13 percent in California, 13-28 percent in Massachusetts, and 32-52 percent in the Pacific Northwest- in states that included avoided cost values for reduced carbon dioxide emissions

Potential Implications for Efficiency in Hawaii

Implications for Hawaii: Discussion

- Cost of saving electricity likely to increase in future to achieve comparable savings levels
  - Evolving program mix (impact of standards & market transformation) and Hawaii EE policy priorities (e.g., AGILE, under-served populations)
  - But Hawaii's EE spending as % of utility revenues is modest (1.4% compared to other leading states
- Policy drivers (and constraints)
  - "All cost-effective EE" vs. EERS (annual vs. cumulative savings target)
  - Updated Hawaii EE potential study will provide important insights

    -- What does the "EE cost curve" look like for Hawaii (compared to supply-side options & retail rates)?
  - B/C tests (societal perspective)
  - Constraints or caps on Public Benefits Fee

Implications for Hawaii: Discussion

- Evolving value proposition for EE in Hawaii
  - Time-varying value of Efficiency
  - EE as a Grid Resource & connection to Distribution System Planning
  - Synergies and increased coordination
    - Complementary EE strategies (e.g. codes/standards & programs, ESCOs/finance & programs)
    - Integrated Demand-side Management
  - Does this impact our thinking about "Deeper Efficiency"?
- Aligning performance metrics for program administrator(s) with policy goals & priorities