Cape Light Compact 2019-2021 Potential Study

Antje Flanders
Vice President

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Contributors:

Opinion Dynamics Corporation

Jake Millette, Principal Consultant
Jayden Wilson, Senior Consultant
John Tortorella, Consultant

Dunsky Energy Consulting

Martin Poirier, Senior Research Lead
Francois Boulanger, Senior Research Lead
Jeff Turner, Consultant
Brent Langille, Senior Analyst
Karine Cazorla, Analyst

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Executive Summary

This report summarizes the methodology and results of the *2017 Cape Light Compact Potential Study*, conducted by Opinion Dynamics Corporation and Dunsky Energy Consulting. This study is an update of the *2014 Penetration, Potential, and Program Opportunities Study* (hereafter referred to as the "2014 Potential Study") conducted by the Opinion Dynamics team in 2014/15.[1]

The goal of this new study was to determine the remaining achievable potential from electric energy efficiency and demand response (DR) measures among residential, low income, and commercial and industrial (C&I) customers for the three-year period 2019-2021 and to inform CLC's program planning efforts. The outputs of this study satisfy the requirements of the Massachusetts Department of Public Utilities ("DPU") that each Program Administrator "conduct a service territory-specific energy efficiency potential study every three years."[2]

The results presented in this report are based on several data sources, including statewide data collection efforts, data collected by the Opinion Dynamics team for the 2014 Potential Study, and secondary data.

We estimate CLC's total achievable energy efficiency and DR potential for the three-year period from 2019-2021 to be 156,697 annual MWh and 83 MW. Achievable potential represents 49% of economic potential and 36% of technical potential. On average, over the three-year period, achievable energy savings represents 2.78% of CLC annual forecasted sales (as forecasted by Eversource[3]). These savings would cost CLC ratepayers $201.1 million (incentive and non-incentive program costs), an average of $67 million per year or $1.28 per annual kWh.[4] The total cost (including the participants' net cost) amounts to $219.2 million (in 2018 dollars) for the three-year period.

All of the 2019-2021 proposed investments are cost-effective, with a portfolio-wide Total Resource Cost (TRC) ratio of 3.8 at the measure level and of 2.7 at the sector level.

Table ES-1 summarizes results for the three-year period 2019-2021, overall and by sector.

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[1] Opinion Dynamics. 2015. Cape Light Compact 2014 Penetration, Potential and Program Opportunity Study. July 20, 2015.

[2] MA DPU. D.P.U. 15-160 through D.P.U. 15-169 (p.25). January 28, 2016.

[3] The forecast has been adjusted for energy efficiency gains prior to the study's period.

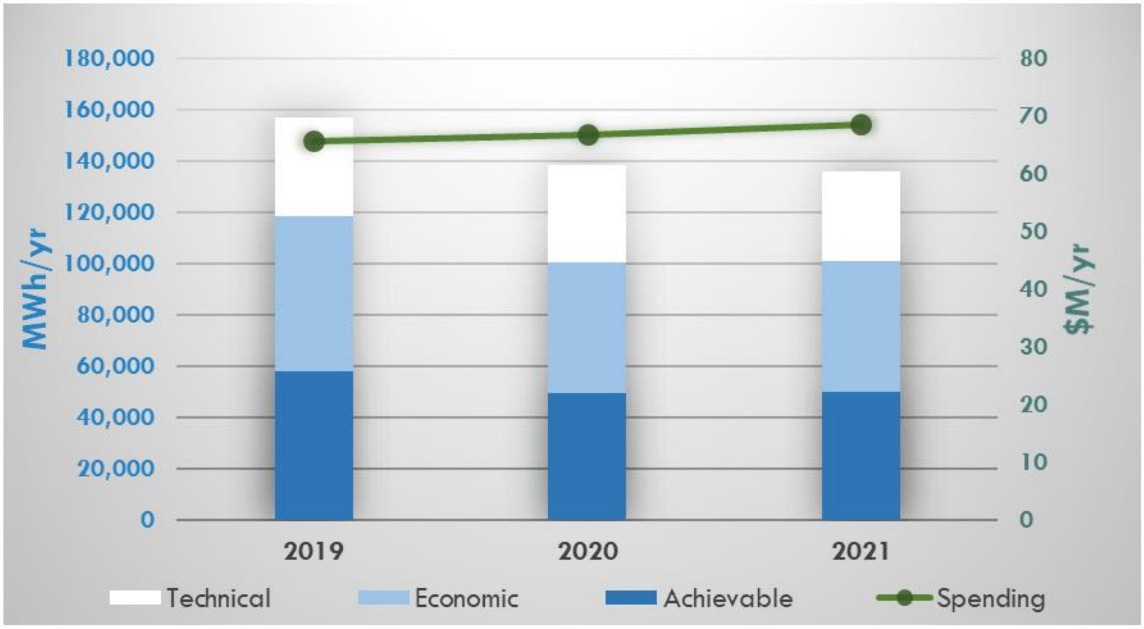
[4] This compares to a projected average cost of $0.724/kWh during the 2016-2018 Three Year Plan Cycle and $0.895 per annual kWh estimated for 2016-2021 in the 2014 Potential Study. The higher cost per kWh is the result of inclusion of DR measures and programs in this study, which contribute to cost and do not have significant energy savings.

Table ES-1. Key Potential Results – 2019-2021

	All Sectors		Residential		Low Income		C&I	
Potential (Total)	**MWh**	**MW**	**MWh**	**MW**	**MWh**	**MW**	**MWh**	**MW**
Technical	431,323	351	266,636	196	17,797	12	146,890	143
Economic	319,981	329	173,821	177	12,589	10	133,572	142
Achievable	156,697	83	93,571	53	8,404	4	54,722	25
Potential (Annual)	**MWh**	**MW**	**MWh**	**MW**	**MWh**	**MW**	**MWh**	**MW**
Technical	143,774	116.9	88,879	65.5	5,932	3.9	48,963	47.5
Economic	106,660	109.8	57,940	59.0	4,196	3.5	44,524	47.3
Achievable	52,232	27.7	31,190	17.8	2,801	1.5	18,241	8.4
Annual Achievable as % of Sales	2.78%		2.94%		4.44%		2.43%	
Cost								
Total (millions)	$219.2		$163.4		$16.9		$38.9	
CLC (millions)	$201.1		$152.3		$14.7		$34.1	
CLC Cost/kWh	$1.28		$1.63		$1.75		$0.62	
Cost-Effectiveness								
Total Resource Cost Test (Sector level)	2.7		2.2		4.0		4.1	
Total Resource Cost Test (Measure level)	3.8		3.1		4.7		6.8	

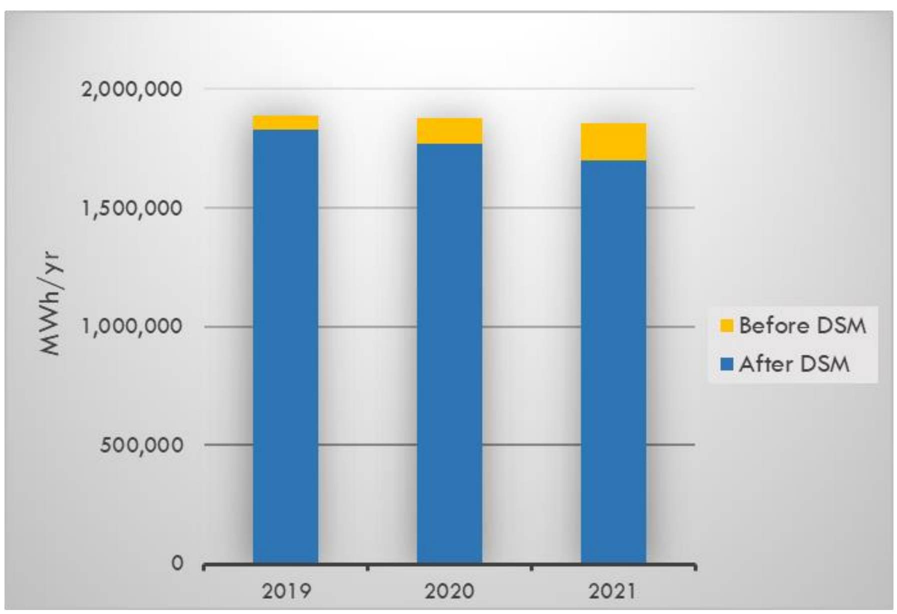
Figure ES-1 presents annual savings (in MWh) for the three types of potential – technical, economic, and achievable – as well as annual spending required to meet the achievable potential. The MWh savings are net of measures removed from the potential because they reached the end of their useful life (or dual baseline measures yielding lower savings upon reaching second-stage savings).

Figure ES-1. Annual Savings and Spending



Eversource forecasts slightly declining energy sales, before energy efficiency (EE) efforts[5], over the three-year period, with total 2021 sales of 1,859,049 MWh compared to 1,890,051 MWh in 2019. With EE efforts at the level of the achievable potential, energy sales would decline faster, with 2021 sales amounting to 1,702,352 MWh, a drop of 10% from pre-DSM 2019 sales (Figure ES-2).

Figure ES-2. Impact of Achievable Potential on Annual Sales



[5] The forecast has been adjusted with achieved and planned savings from the 2018-2020 period to create a more appropriate baseline for the 2019-2021 period.

This potential study includes potential from demand response (DR) efforts. DR potential and costs are generally included in results throughout the report, unless noted otherwise, as they are an integral part of the overall estimated potential. DR measures contribute 42 MW of demand savings during the three-year period, or 51% of the demand savings potential. The remaining demand savings come from energy efficiency measures with coincident peak savings.

1. Introduction

Cape Light Compact contracted with the Opinion Dynamics team to update the 2014 Penetration, Potential, and Program Opportunities Study (hereafter referred to as the "2014 Potential Study")[6] of its residential, low income, and commercial and industrial (C&I) sectors. The goal of this research was to determine the remaining achievable potential from electric measures for the three-year period 2019 – 2021 and to inform program planning efforts. The outputs of this study satisfy the requirements of the Massachusetts Department of Public Utilities ("DPU") that each Program Administrator "conduct a service territory-specific energy efficiency potential study every three years."[7]

This document presents the methodology for this study, baseline penetration and saturation estimates, and electric energy efficiency and demand response potential estimates. The remainder of this document is organized as follows:

- **Section 2: Methodology.** This section presents information about our approaches to developing penetration and saturation inputs, adoption assumptions, and potential modeling. It also defines key terms and concepts used throughout this report.
- **Section 3: Summary of Baseline Results.** This section presents key penetration and saturation data developed as inputs to the potential model.
- **Section 4: Overall Potential Results.** This section shows potential results for CLC's service territory, including estimates of technical, economic, and achievable potential for 2019 – 2021. Results are presented by sector, segment, and end-use.
- **Section 5: Residential Potential Results.** This section shows potential results for the residential sector.
- **Section 6: Low Income Potential Results.** This section shows potential results for the low income sector.
- **Section 7: Commercial & Industrial Potential Results.** This section shows potential results for the C&I sector.
- **Section 8: Demand Response Potential.** This section shows the contribution of demand response (DR) measures to total 2019-2021 demand potential.

[6] Opinion Dynamics. 2015. Cape Light Compact 2014 Penetration, Potential and Program Opportunity Study. July 20, 2015.

[7] MA DPU. D.P.U. 15-160 through D.P.U. 15-169 (p.25). January 28, 2016.

2. Methodology

Key activities in support of the 2017 Potential Study included updates to the 2014 energy efficiency potential model, incorporation of new DR measures, and development of model inputs, based on secondary data. Below is a non-exhaustive list of the main activities for this study (details are presented in the following sections):

- General update of measure assumptions based on Massachusetts' Technical Reference Manual, evaluation reports, and other sources
- Adjustment of measure costs
- Adjustment of lighting savings, cost, measure life, and adjustment factors to reflect latest market data and assumptions related to EISA reulations
- Addition of several new energy efficiency measures; removal of a few others
- Addition of demand response measures
- Adjustment of market assumptions to reflect latest market and penetration/saturation data
- Update of detailed program-level costs (with fixed and variable components)
- Review of baseline assumption following code and standard changes

Although several of these activities may have resulted in substantial changes of the achievable potential compared to the previous study, we believe that the addition and removal of measures, and the adjustments to lighting measure assumptions, are the key drivers of results.

It should be noted that the scope of this study did not include consideration of on-bill financing as a strategy to increase uptake of energy efficiency and DR measures among residential and commercial customers. CLC is currently not able to offer on-bill financing to its commercial customers. However, a near final study conducted by DNV-GL (*Draft Final Report Commercial and Industrial 2011-2016 Mid-size Customer Assessment*; forthcoming) encourages PAs to consider providing on-bill financing for a greater number of projects.

2.1 Potential Modeling

2.1.1 General Methodology

Description of Model

We developed a CLC-specific potential model that estimates the electric energy and demand savings potential in CLC's service territory. The model embeds CLC-specific inputs with respect to measure characteristics, equipment penetration and saturation, and measure adoption assumptions. We developed a flexible potential model structure that can produce the outputs and level of disaggregation specified by CLC – at the sector level (C&I, residential, and low income) and for key C&I market segments – and that allows for future modification of key model parameters by CLC staff to test different scenarios during the program planning process.

The scope of the study included development of three levels of potential: technical potential, economic potential, and achievable potential. They are defined as follows:

- **Technical Potential**: For each market,[8] the measure procuring the most energy savings per unit is selected. The technical potential is defined as the electricity savings from these measures multiplied by the theoretical maximum number of units per year.
- **Economic Potential**: For each market, the cost-effective measure procuring the most energy savings per unit is selected. The economic potential is defined as the electricity savings from these measures multiplied by the theoretical maximum number of units per year.
- **Achievable Potential**: The achievable potential is defined as the electricity savings from cost-effective measures adjusted by several factors to represent the potential that could be achieved through ambitious and comprehensive programs/initiatives.

Key concepts used in the estimation of potential are briefly described below.

- **Inputs**: The model requires several inputs at the measure level (e.g., energy and capacity savings, costs, effective useful life, net-to-gross factors, load profile, etc.), as well as other inputs such as avoided costs, rates, electricity forecasts,[9] markets, and initiatives.[10]
- **Units per Year (theoretical maximum)**: Using inputs and calculations such as market size and growth, measure type, and natural replacement rates of existing equipment, the maximum number of units that could be replaced or installed per year is calculated.
- **Cost-Effectiveness**: The model calculates two types of cost-effectiveness ratios. Both tests can be calculated at the measure, initiative, segment, sector, and portfolio level.[11]
  - The **Total Resource Cost test (TRC)** is used to screen measures for the economic and achievable potentials. A positive TRC result (net present value higher than zero or cost-benefit ratio higher than one) indicates that the energy efficiency measure (or initiative) will produce reductions in energy and demand costs, as well as non-

[8] We use the words “market” or “market size” to describe the number of baseline equipment or buildings in a given segment that capture the opportunity for specific energy efficiency or DR measures. For example, the number of sockets with incandescent bulbs in the non-seasonal residential sector would be an example of a “market” for LEDs.

[9] The forecast has been adjusted for energy efficiency gains prior to the study’s period.

[10] Initiatives are sub-components of programs that target specific opportunities. For instance, the Residential New Construction, Residential Multi-Family Retrofit, and Residential Behavior/Feedback initiatives are all part of the Residential Whole House Program.

[11] Program costs (general administration, marketing, evaluation, etc.) are included in the budgets. Those costs do not impact measure selection because screening is conducted at the measure level.

energy benefits, that are greater than the costs of implementing that measure (or initiative).

  - The **Participant Cost Test (PCT)** is an input for measure adoption rates. A positive PCT result means that the participant of an energy efficiency initiative will receive benefits – including energy and demand bill savings and non-energy benefits – that are higher than net costs (i.e., the cost of the measure minus incentives received by the participant).

- Base Adoption Rate: The base adoption rate for determining the achievable potential is calculated using the cost-effectiveness of measures from the participants' point of view and levels of market barriers.

- Competing Measures: At the achievable potential level, multiple cost-effective measures can compete with each other for the same market. In that case, each measure is attributed a share of the overall market, based on its base adoption rate compared to other measures. An example would be two different heat pump efficiency levels competing in the same market segment. If both are cost-effective, both will be included in the achievable potential (each with a share of the market based on their respective cost-effectiveness and barrier levels).

- Cumulative Annual Savings: Cumulative savings are calculated for each potential type and each year, using incremental savings potentials. Savings from individual measures are removed from the cumulative savings at the end of the measure life. For instance, a measure installed in Year 1 and with a measure life of two years would be removed from the cumulative potential starting in Year 3.

- Aggregate Results and Reporting: Measure-level energy and capacity savings, costs, and benefits are aggregated and can be displayed by sector, segment, end-use, measure-type, or initiative. Costs are reported from both the program administrator's and the service territory's perspectives. The program administrator's costs do not include the participants' share of costs (i.e., costs that are not covered by incentives), nor do they include any adjustments for early retirement measures.

The following sections present more detailed descriptions of the modeling methodology. It should be noted that the rest of the methodology discussion focuses on the achievable potential as it is the study's primary focus.

Sectors and Segments

The model reflects three different sectors: residential, low income, and C&I. In addition, the C&I sector is divided into 12 segments (see Table 2-1). Measure inputs are differentiated by sector and segment (e.g., lighting savings vary by commercial segment according to reported hours of use and seasonality adjustments). Results are reported at both the sector and segment levels.

Table 2-1. Sector and Segment Definition for Potential Model

Sector	Segment
Residential	Not Low Income (Non-Seasonal and Seasonal)
Low Income	Low Income
C&I	Small Retail
	Office
	Restaurant
	Government or Education
	Lodging/Hospitality
	Health Services
	Multifamily or Rental Housing
	Grocery, Convenience or Large Retail
	Other Commercial
	Industrial, Automotive, Warehouse/Distribution

End-Uses

The model includes 12 different end-uses, listed in Table 2-2 below (with examples of associated measures).

Table 2-2. End-Uses Included in Potential Model

End-Use	Examples of Measures
Lighting	LED light bulbs, lighting controls, efficient linear lighting
HVAC (Heating, Ventilation, Air Conditioning)	Thermostats, heat pumps, air conditioning units
Motors	Pool pumps, process motors
Refrigeration	Commercial refrigeration, vending machine misers
Food Services	Ovens, dish washers, fryers
Hot Water	Heat pump water heaters, low flow showerheads, spray rinse valves
Appliances	Residential refrigerators and freezers, clothes dryers
Products	Smart strips, air cleaners, dehumidifiers, set top boxes
Behavior	Feedback, opt-In behavioral, basic educational measures
Envelope	Insulation, air sealing, efficient windows
CHP (Combined Heat and Power)	Combined heat and power
Other	Retro-commissioning, advanced energy analytics, smart electric vehicle supply equipment (EVSE)

Measures

The measures included in the 2017 potential model are based on the measures included in the 2014 Potential Study, but were updated to exclude measures no longer relevant (e.g., CFLs) and to include new measures. In particular, the model now includes DR measures, which were not part of the 2014 study.

Table 2-3 lists the new measures added to the 2017 potential model.

Table 2-3. New Measures Included in 2017 Potential Model

Energy Efficiency Measures	DR Measures
Residential / Low Income	
Programmable Thermostats for oil, gas and propane heated homes (with fan/cooling electric savings) Wi-Fi Thermostats Clothes Washers Dehumidifier ECM Circulator Pumps Freezers Ductless MiniSplit QIV Down Size of Cooling Equipment Ceiling Fans Set Top Boxes Drain Water Heat Recovery Windows	Wi-Fi Thermostats Three-Element Water Heater Thermal Energy Storage Electric Storage Window AC DR Water Heater DR Smart EVSE Pool Pump DR Appliances DR (Refrigerator, Clothes Dryer, Clothes Washer)
C&I	
Drain Water Heat Recovery	WiFi Thermostats Thermal Energy Storage Water Heater DR Refrigeration DR Lighting Controls DR

The following measure categories were outside the scope of this study:

- Fuel Switching
- Renewables
- Gas-saving measures that are covered by other PAs' natural gas initiatives, which may also have an electric impact.

Calculation of Achievable Potential

Achievable potential is based on the electricity savings from cost-effective measures, the theoretical maximum number of units per year, the base adoption rates, market share adjustments for competing measures, and other adjustments such as market applicability factors[12] and uptake factors.

Adoption Curves of Energy Efficiency Measures

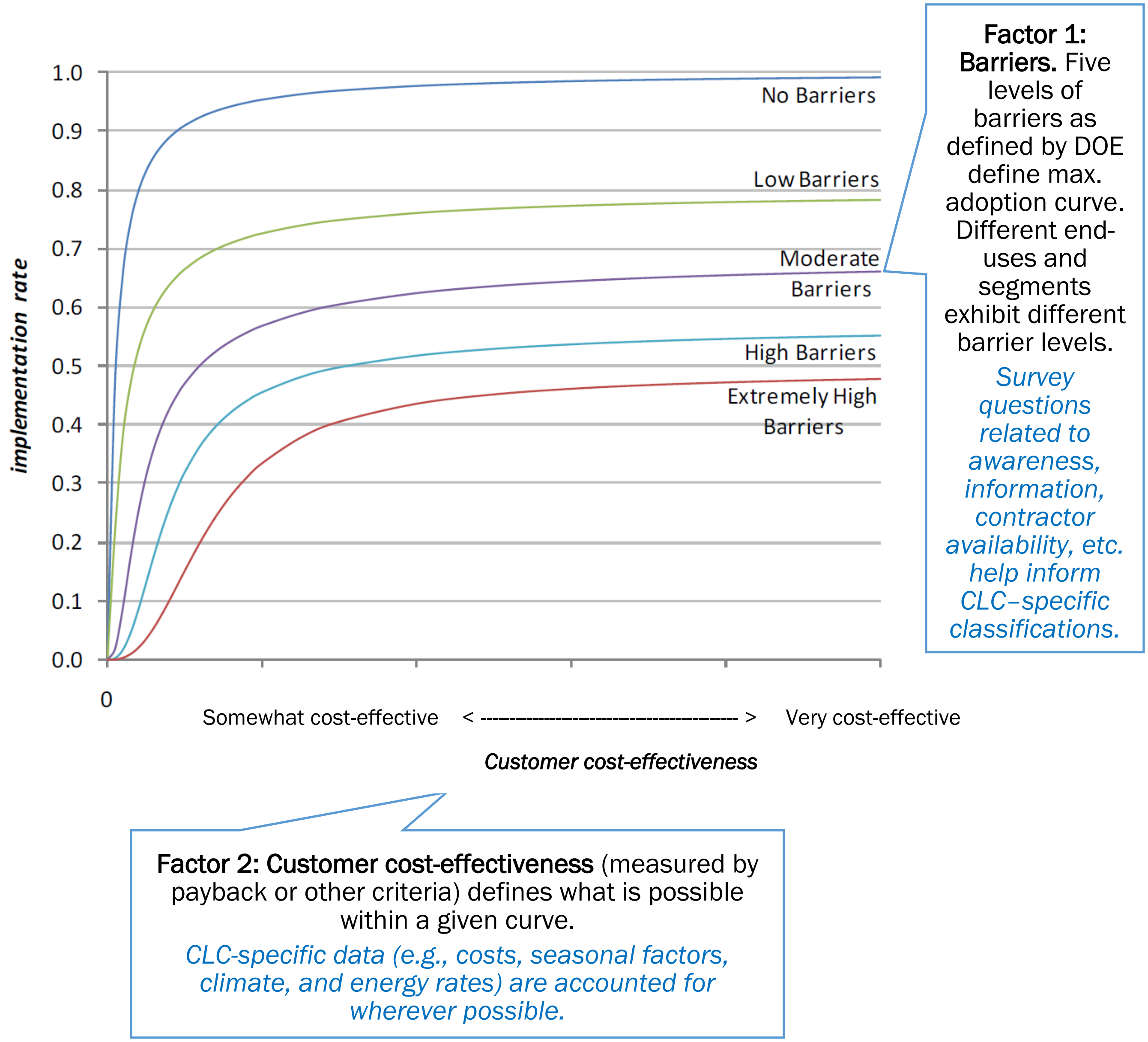
For energy efficiency measures, we used adoption curves based on the Department of Energy (DOE) adoption model, to determine the base adoption rate for each measure, by segment.[13] These curves provide a formula for relating customer cost-effectiveness to adoption rates, given different levels of market barriers. The DOE model is grounded in a qualitative assessment of market barriers and the calculation of a cost-benefit ratio to estimate the maximum achievable market penetration for energy efficient products. Based on this approach, measure cost-effectiveness and perceived barriers are the two primary factors affecting adoption rates. In our model, both market barriers and the cost-effectiveness ratios encompass several CLC-specific inputs (see also Table 2-4, later in this section).

Figure 2-1 presents a schematic view of adoption curves.

[12] Market applicability factors adjust the potential of some measures to account for specific technical barriers that prevent the application of that measure in a share of the potential market.

[13] DOE uses this model in several regulatory impact analyses. An example can be found in http://www.regulations.gov/contentStreamer?objectId=090000648106c003&disposition=attachment&contentType=pdf, section 17-A.4.

Figure 2-1. US DOE Adoption Curves



The main steps for determining the adoption rate for each measure/segment are:

1. Selection of a curve, based on barriers level and benefit-cost criteria. Both barrier levels and the benefit-cost criteria (net present value versus simple payback period) were determined using results from the 2014 customer surveys.[14]

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[14] The 2014 surveys were aimed at individuals who make decisions about purchasing new energy-using equipment in their home or business. The surveys collected information on barriers to energy efficiency and participation in CLC programs, the role of incentives in adopting energy efficient technologies, as well as program awareness and past program participation. To reflect changes in the market over the past three years, we reviewed and adjusted several measure assumptions, with a special focus on lighting. E.g., to reflect quickly

2. Calculation of customer cost-effectiveness, using the model's inputs, including measure characteristics (costs, savings, measure life, etc.), energy rates, and the incentive levels offered by modeled initiatives. Incentives are calculated as a pencentage of incremental costs, based on existing initiative incentive levels.
3. Calculation of the adoption rate, based on the selected curve and the cost-effectiveness value.

The DOE model assumes that participants make their decisions based on a benefit-cost ratio calculated using discounted values. While this may be true for more sophisticated customers (large institutional and C&I customers), many customers use much simpler decision criteria, including the payback period. This has implications on the choice of measures by the model, since the payback period ignores the value of money over time as well as any impacts after the break-even point has been reached. Thus, using the payback period, short-term benefits are favored over long-term benefits, creating a bias in favor of measures with a short effective useful life.[15]

To determine which cost-benefit criteria should be used for this study, the 2014 customer surveys gathered information on the criteria actually used by C&I customers. Based on survey responses, we used the PCT ratio for the C&I sector (we did not observe clear differences by C&I segment). For the residential and low income sectors, we assumed that a simple payback period is used. As a result, for the residential and low income sectors, we converted the DOE adoption curves to equivalent curves reflecting payback periods, based on discounted values. We assumed an average effective useful life of 15 years and used CLC's discount rate.

Adoption Curves of DR Measures

The DOE adoption curves are difficult to apply to DR measures for various reasons related to the details of conducting cost-effectiveness analysis. Typically, DR will provide little or no bill savings to customers unless a customer is on a time-of-use (TOU) rate or a rate that includes a demand charge; however, participating customers will get an annual incentive from the program, in addition to all incremental costs being paid for by the program. This implies that the cost-effectiveness ratio would be infinite, thus placing participation levels at the highest point on a given DOE curve. However, this ignores the lack of bill savings and the hassle of participating in DR programs from the participant point of view. We indeed found that the application of DOE curves to DR measures would result in participation levels much higher than what is observed in real programs.

For these reasons, we looked to the 2025 DR Potential Study conducted by Lawrence Berkeley National Laboratory (LBNL) for the state of California.[16] This study included the development of a "Propensity Score Model" that estimates the propensity or predisposition of customers to

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evolving LED market shares, we reduced lighting market barriers to "low", except for the low income sector where we kept barriers as "moderate."

[15] Let's suppose a 3-year simple payback criteria is used by a customer. This means that a measure has to pay for itself within this 3-year period, regardless of its useful life. A measure with a payback of 4 years and a useful life of 20 years would be very cost-effective using a PCT ratio (with a cost-effectiveness ratio of approximately 3.5) but would be rejected using a simple payback criterion. On the other hand, a measure that is barely cost-effective (PCT ratio of 1) but has a very short useful life would be included.

[16] http://www.cpuc.ca.gov/General.aspx?id=10622.

participate in DR programs. The model incorporates information from empirical studies about the impact of various factors on program participation, including incentive levels, marketing tactics, and whether or not participation requires installation of additional equipment. The model is calibrated to reflect actual enrollment rates in mature programs.

For the purposes of determining the maximum achievable potential, we applied LBNL's model assuming the most aggressive marketing scenario. Resulting participation rates for typical incentive levels are in the range of 20%-30% for residential programs, and 10-15% for C&I programs.

Chained Measures

Chained measures are measures that are installed in combination with one another. Chained measures require an adjustment in savings because the total savings of these measures is less than the sum of the savings of each individual measure. For example, if a customer installs a heat pump water heater as well as low flow showerheads and faucet aerators, the savings from the low flow showerheads and faucet aerators are smaller than if they were installed in a home with a less efficient water heater (less energy is lost for the same amount of wasted water). The adjustment to the chained measures' savings are calculated based on the different measures in the chain and entered for each individual measure.

CLC-Specific Adjustments

A key aspect of this study was to incorporate CLC-specific factors that differentiate CLC from the rest of Massachusetts.

The most important adjustment to measure inputs in this study was to account for seasonality. More than 30% of residential customers, as well as many C&I customers (especially in the restaurant and lodging/hospitality segments), show reduced occupancy or hours of operation, especially during the winter. Some customers even shut down completely during that period. Reduced activity is also observed during the spring and autumn seasons. For this study, we adjusted energy savings, peak savings, and load shapes to account for seasonality using data from the surveys and onsite visits conducted for the 2014 Potential Study. The seasonality adjustment factors were calculated for each major end-use, taking into account the requirement to maintain a minimum temperature in buildings to prevent freezing conditions. Reduced savings due to seasonality impact cost-effectiveness of measures, thus screening out some measures for specific segments and reducing adoption rates of remaining measures for segments with a strong seasonal profile.[17]

We also considered several other CLC-specific characteristics, such as business types and size, building stock, milder climate, and measure cost when developing the model's inputs. The characteristics of the low-income sector and of multifamily households on CLC's territory, for example, have been considered and integrated in our measure and market assumptions.

Regarding DR measures, CLC's service territory includes a large number of homes that do not have an internet connection, especially among seasonal homes, creating an additional barrier

[17] In addition to the savings adjustment, we also increased market barriers for the opt-in behavioral measure for residential customers with a strong seasonal profile. Because this measure is more demanding, we expect that customers with secondary homes, presumably on leisure time, would show less interest.

to participation, because most DR measures rely on internet-based communications to relay DR event signals. The model applies a market applicability factor to limit the participation for DR measures based on estimated penetration of internet connectivity for seasonal, non-seasonal, and low-income homes.

Table 2-4 (next page) summarizes CLC-specific factors that were considered and how they were addressed in the model.

Table 2-4. CLC-Specific Factors Considered in Potential Model

Factors Considered	Model addresses this through...					Notes
	Baseline Equipm. / Usage	Barriers	Costs	Savings	Other	
Residential						
<u>Seasonality</u> A sizable proportion of the population and housing stock is seasonal, which means (a) they may use less energy compared to similarly-sized non-seasonal houses, (b) the savings they could get from a measure may be less, (c) the payback period may be longer, (d) they may have a different set of priorities for home improvements, or (e) CLC may have more limited time period and channels to intervene/promote programs.	✔	✔		✔		Seasonal and non-seasonal are treated as separate segments in the model (but grouped together for reporting purposes), with separate annual usage assumptions (based on actual data and the 2014 surveys) and measure characterization (from the 2014 baseline study). We also adjusted savings for measures affected by seasonality, to reflect factors such as lower HOU. Our 2014 survey didn't find significant differences in barrier levels between seasonal and non-seasonal customers, so we did not adjust barriers with the only exception being opt-in behavioral, as this measure requires much more involvement than the other measures.
<u>Age of population</u> The CLC customer base is older than statewide average. This may result in a lower likelihood to invest in EE (ROI calculus is off, fixed income, etc).		✔				Any lower likelihood to adopt EE measures as a result of age was captured in the 2014 barrier survey and is therefore reflected in the adoption curves.

Factors Considered	Model addresses this through... Baseline Equipm. / Usage	Barriers	Costs	Savings	Other	Notes
Building stock CLC believes that stock is newer than the rest of the state. That means that pre-weatherization barriers may be low (e.g., knob and tube wiring), and there may be many 1- or 2-story homes that are relatively easy to insulate and work on. Additionally, many 3-season homes are converted to 4 season homes, which presents lots of opportunity. However, this means that the required upgrades are significant, and it's possible that customers would rather renovate the kitchen or bath than spend the incremental dollars for high efficiency.	✔	✔				The model uses CLC-specific information on insulation and barrier levels (based on data collection for the 2014 Potential Study)
Commercial & Industrial						
Seasonal business cycles Cash flow for some business owners is concentrated in a few months of the year. Seasonable businesses have a smaller window of opportunity to complete EE retrofits. CLC has a narrow window to approach them to discuss the programs and EE retrofits that are available to them. Seasonality also affects savings - for businesses that are closed during the winter and much of the spring and fall, the payback period may be longer.		✔		✔		The model uses a weighted average of barrier levels by segment (including both seasonal and non-seasonal customers). We also adjusted savings to account for reduced hours of operation and/or shutdowns during the off-peak seasons.

Factors Considered	Model addresses this through...					Notes
	Baseline Equipm. / Usage	Barriers	Costs	Savings	Other	
Business types CLC's non-residential customer base is dominated by small businesses, with very few large commercial or industrial customers. Business owners whose income is tied to tourism may be more reluctant to spend on EE in the off season because they have a hard time forecasting how business will be next season.		✔				Since barriers levels are determined for each market segment, and modeling is performed at the segment level, the overall potential model results appropriately represent barriers for CLC's mix of businesses.
Business size For many segments, commercial businesses are generally smaller than businesses in the rest of MA.	✔			✔		Each segment's average and total annual consumption is reflected in the measure characterization, which reflects any difference in equipment penetration/saturation (and equipment size, where relevant) related to small business size.
Building stock Many commercial operations are in structures originally built as residential, creating significant issues with measure applicability. CLC, along with the statewide programs in general, has limited commercial measure offerings for these building types (though residential measures are offered).	✔				✔	We moved customers who are clearly "residential commercial" (as identified by CLC) into the residential study. Still, there is a fair number of small, house-like structures in other segments. The characteristics of these businesses are reflected in the measure characterization and baseline equipment.

Factors Considered	Model addresses this through...					Notes
	Baseline Equipm. / Usage	Barriers	Costs	Savings	Other	
All Sectors						
Climate The climate is milder on the Cape and Vineyard relative to the rest of the state, so weather-dependent measures may have lower savings (and a longer payback)				✔		Savings have been adjusted using Cape Cod weather normals where relevant.
Connectivity In the absence of dedicated utility-owned communications infrastructure (e.g. AMI), most DR measures rely on internet-based communications to relay DR event signals. CLC's service territory includes a large number of homes that do not have an internet connection, especially among seasonal homes, creating an additional barrier to participation.		✔				The model applies a market applicability factor to limit the participation for DR measures based on estimated penetration of internet connectivity for seasonal, non-seasonal, and low-income homes.

Model Calibration

Model calibration ensures that the overall estimated consumption levels determined by the model are in line with utility electricity forecasts. For this study, because of the amount and quality of primary data, model calibration is not as critical as for other potential studies that must rely on secondary sources to make broad assumptions on equipment saturation and building characteristics. The comprehensive primary data on penetration, saturation, and characteristics of equipment and buildings in each sector and segment greatly reduces the chance of underestimating or overestimating the load forecast because the modeled baseline does not fit the actual baseline and real consumption.

In the residential and low income sectors, we used annual energy consumption levels by equipment type – obtained through regression analyses of actual electric accounts as well as secondary sources – to ensure that our overall estimated consumption matches the electricity forecast for these sectors.

In the C&I sector, this approach would be too onerous due to the complexity and diversity of equipment and buildings. As both the potential markets and the baseline equipment were well defined due to extensive primary research, those elements were not deemed critical. We therefore used indirect approaches, including verification of lighting densities and average floor area, to validate our primary data.

2.1.2 Inputs and Assumptions

Measure Characterization

For existing measures, we reviewed measure assumptions (savings estimates or algorithms, cost, effective useful life, etc.) and assessed if they adequately reflect CLC's service territory and customer base.

We based savings assumptions on the Massachusetts Technical Reference Manual (TRM),[18] where possible. For measures with algorithm-based or custom savings, we used primary data and engineering algorithms, historical program data, or program impact evaluations to derive the required inputs to calculate the savings. We also used evaluation results and participation data to validate measure assumptions.

Savings include impacts from other fuels (oil, gas, propane). These other fuels savings or added consumption do not directly affect electric potential results (no "kWh-equivalent" savings/reductions were used) but are considered when calculating measure cost-effectiveness and may positively or negatively impact measure screening and adoption rates.

As discussed above, we made adjustments to savings for residential customers and C&I segments with high seasonality profiles. These adjustments were made for each major end-use, based on 2014 survey and site visit occupancy results and operational profiles during unoccupied periods use. For the C&I sector, this was supplemented with a billing analysis, to identify the proportion of businesses within a segment with seasonal consumption patterns. We derived seasonal adjustments from those results for winter peak and off-peak as well as

[18] 2016-2018 Program Years – Plan Version (October 2015): http://ma-eeac.org/wordpress/wp-content/uploads/2016-2018-Plan-1.pdf

summer peak and off-peak consumption. Overall energy and peak savings were adjusted accordingly.

We used CLC-specific incremental costs wherever those costs were available.[19]

Non-energy impacts (often referred to as "externalities"), as quantified in the Massachusetts' TRM,[20] are monetized in the potential model. Because they directly affect the cost-benefit ratio results, there is no need to adjust market barriers to account for non-energy impacts.

Measure Types

The model uses four types of measures: replacement on burnout (ROB), early retirement (ER), addition (ADD), and new construction/installation (NEW). Each of these measure types requires a different approach for determining the maximum yearly units available for potential calculations, as detailed in Table 2-5.

Table 2-5. Types of Measures Used in Potential Model

Measure Type	Description	Market Base	Yearly Units Calculation
Replace On Burnout (ROB)	Existing units are replaced by efficient units after they fail *Example: Replacing incandescent bulbs with LEDs*	Existing Units	Market/Measure Life *The Measure Life is set at a minimum of 6 years. Alternate Measure Life can be used to calculate yearly units if baseline units have a different Measure Life than efficient units.*
Early Replacement (ER)	Existing units are replaced by efficient units before burnout *Example: Early replacement of functional but inefficient refrigerators*	Existing Units -- Old	Market (old units)/6 *The market is defined as the number of old units, not the total number of units (e.g., old refrigerators that could be retired early, not all existing refrigerators).*
Addition (ADD)	An EE measure is applied to existing equipment or structures *Example: Adding controls to existing lighting systems, adding insulation to existing buildings*	Existing Units	Market/6
NEW	Measures not related to existing equipment *Example: new construction, installing a new heat pump (<u>not</u> replacing an existing heat pump)*	Custom	Market *Market base is measure-specific and defined as new units per year.*

[19] For measures where only statewide cost assumptions were available, we made no CLC-specific adjustments. We explored differences between statewide and CLC costs during our 2014 Potential Study but did not find evidence of materially higher CLC costs.

[20] Non-energy impacts are values that are estimated after the measures have been implemented, and as such may not represent exactly what consumers perceive as non-energy impacts at the time of investment decision-making. Our analyses using the potential model indicate, however, that non-energy impacts have a very small effect on results, meaning that this effect would not have a significant impact on potential results.

Early Retirement

Early retirement refers to efficiency measures (and program strategies) that seek to replace functional equipment before the end of its useful life. Refrigerator replacement is a common measure that falls into this category, but early retirement can also apply to other equipment including other appliances, HVAC systems, and lighting.

In addition to the yearly unit calculations explained above, the first cost for early retirements is adjusted to reflect true economic costs. This adjustment is required because early retirements defer the need for new capital investment in the future. Assuming, for example, that there is an initial investment to buy a refrigerator in year 1 and this refrigerator would have been replaced anyway in year 5, the future investment that would have taken place in year 5 is now pushed forward in the future because the new fridge will last 15 years (instead of 5 years for the old fridge). Because the value of money decreases with time, there is an economic benefit in deferring future investments.[21]

We use the following formula to adjust costs for early retirements, which calculates the difference between the discounted values of two streams of investments:

$$PV = (C - incr)\left\{1 + \frac{1}{(1+dr)^{ml} - 1}\right\}\left\{1 - \frac{1}{(1+dr)^{erp}}\right\} + incr$$

<u>Where:</u>

PV = present value of initial cost and deferred future costs

C = initial capital cost

incr = Incremental cost (cost of efficient vs baseline unit)

dr = discount rate

ml = measure life of new unit

erp = early replacement period (remaining effective useful life of old unit)

Savings for early replacement measures are determined using a dual baseline approach. During the initial “early retirement” period, the energy consumption of the new, efficient unit is compared to the old, retired unit to calculate savings. After the initial period, the new efficient unit is compared to a new “baseline” unit with standard efficiency.

Economic Parameters

The potential model incorporates several key economic parameters:

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[21] Note that because of this adjustment, the economic cost used by the model might be lower than the incentive in some cases.

- The **cost-effectiveness** framework used in this study follows the Department's directive in Energy Efficiency Guidelines (D.P.U. 08-50-A), as well as the benefit-cost model used internally by CLC. Before building the 2014 potential model, we ensured that our core calculations replicated the results of CLC's model.
- **Avoided costs** in this study reflect the latest available information from the 2018 study by the Avoided-Energy-Supply-Component (AESC) Study Group.
- **Electricity rates**, used for participant cost-effectiveness calculations, are based on energy and capacity avoided costs for the wholesale portion, and on marginal retail rates for the retail portion. We assumed that the retail portion would grow at the same rate as the energy portion in the long term, reflecting pressures on the grid from renewable energy and aggressive EE targets. For non-electric fuel types (gas, oil, and propane), we used the avoided costs as a proxy of future fuel prices.
- We used a **real discount rate** of 0.46%.

Baseline Potential Markets

Markets are largely determined by data on equipment and building characteristics collected in several recent statewide studies as well as the surveys and site visits conducted in support of 2014 Potential Study. We used this information to quantify baseline equipment and building components to which energy efficient measures can be applied. (See Sections 2.2 and 2.3.)

For new equipment (heat pumps that do not replace existing heat pumps, room air cleaners, dehumidifiers, etc.), we estimated the number of annual units based of penetration and saturation data, comparing 2014 vs 2017 data.

Assumptions about new construction markets are from the 2014 Potential Study. Because the growth rates and new construction potentials are very small, updating those assumptions was not deemed critical as it would have a neglible effect on overall potenial estimates.

2.2 Baseline Inputs for the Residential and Low Income Sectors

The 2017 CLC Potential Study relied on penetration and saturation data based on two recent statewide primary data collection efforts. Lighting data was developed from the most recent Massachusetts statewide lighting market assessment conducted by the NMR Group.[22] Non-lighting penetration and saturation data were developed from the Massachusetts Residential Baseline Study conducted by Navigant Consulting.[23] Because we relied on existing data, the resulting residential and low income baseline inputs to the potential model are limited by the original studies' methodologies and sample sizes.

[22] NMR Group Inc. 2016-17 NMR Lighting Market Assessment Consumer Survey and On-site Saturation Study, April 7, 2017.

[23] Navigant Consulting: Data Files for the Massachusetts Residential Baseline Study, July 16, 2017.

2.2.1 Lighting Measures

The NMR study included primary data collection between October 2016 and November 2016, consisting of a telephone/web survey of 601 Massachusetts households and 465 onsite visits.

Key outputs of the NMR study, used for the CLC potential study, include:

- Statewide penetration rates for LEDs, CFLs, incandescents, and halogens;
- Average number of sockets per household, by residential and low income households; and
- Socket saturation rates for LEDs, CFLs, incandescents/halogens, and linear fluorescents/other, by residential and low income households.

The NMR study was a statewide study and did not provide results by program administrator. In addition, not all results are presented separately for the residential and low income sectors. Based on these limitations, we developed the following inputs for the potential study:

- **Lighting penetration:** We used statewide lighting penetration results for LEDs, CFLs, incandescents, and halogens, as presented in the NMR report. Penetration results for linear fluorescents and "other" types of light bulbs were not available. Penetration results were only available for all residential customers and were not available separately for low income customers.
- **Lighting saturation:** The NMR report presents socket saturations (i.e., the percentage of all sockets occupied by a specific type of light bulb), rather than saturation rates as defined for the potential study (i.e., the average number of a type of light bulb that exists among all customers). We calculated saturation rates for the potential study by multiplying the bulb type's share among all bulbs by the average number of sockets in a home. We developed these saturation rates for LEDs, CFLs, incandescents/halogens, and linear fluorescents/other, for all residential customers and for low income households. Similar to the penetration results, saturation results are statewide results, rather than CLC-specific.

In addition to results from the NMR study, we adjusted savings, incremental costs, and applicable market assumptions for LEDs, using the following data sources:

- The 2016-2018 Massachusetts TRM[24]
- Cadmus, February 2016. LED Incremental Cost Study[25]
- The 2016 Residential Lighting Market Adoption Model Spreadsheet

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[24] Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2016-2018 Program Years – Plan Version, October 2015

[25] LED Incremental Cost Study Overall FINAL Report, Prepared for the Electric and Gas Program Administrators of Massachusetts Part of the Residential Evaluation Program Area, February 2016. Cadmus, Navigant Consulting, NMR Group, Tetra Tech, DNV-GL.

With these updated assumptions, annual LED quantities (and resulting saturation) produced by our model more closely align with historical and expected market trends.

2.2.2 Non-Lighting Measures

To develop baseline penetration and saturation estimates for non-lighting measures, we used primary data collected for the recent Massachusetts Residential Baseline Study led by Navigant Consulting. This study included an online survey with 6,673 residential customers across Massachusetts as well as 300 onsite visits. The online survey collected penetration and saturation information for a variety of energy-using equipment as well as some measure characteristics. The onsite visits were used to verify and adjust the results of the online survey and to collect additional measure characteristics (those that customers cannot easily self-report). The onsite visits also included metering of a small number of end-uses.

The study developed a stratified sample of the population of Massachusetts residential accounts. The stratification was based on occupancy type, previous program participation, building type, heating fuel, and income. Proportional quotas were also employed to maintain representativeness across electric PAs, gas PAs, and language spoken at home. Based on this stratification scheme, Navigant completed 656 online surveys and 10 onsite visits with CLC customers.

The data files delivered by Navigant included survey data, weights, and onsite visit adjustment factors, but also contained CLC-specific equipment penetration and saturation rates. These rates were developed using statewide weights (based on education level and language) for the “bins” summarized in Table 2-6 below.

Table 2-6. Bin Variable Definitions for Massachusetts Residential Baseline Study

Bin Variable	Definition
Occupancy Type	Whether the occupant is the owner or a renter.
Building Type	Single Family Detached: single family homes, including mobile homes and trailers.
	Single Family Attached: apartment/condo in a 2-4 unit building, townhouse, row house, or duplex.
	Multi-family: apartment/condo in a 5+ unit building.
Program Participation	Whether the occupant has previously participated in the Mass Save program.
Language	Whether or not English is the primary language spoken in the home.
Income	Whether the household is low income, defined as < $30,000 for a household of 1, < $50,000 for a household of 2-4, and < $75,000 for a household of 5+.
Age	Age, split into <30, 30-59, and 60+.
Education Level	Whether or not the respondent attained a college degree.
Heating Fuel	Home heating fuel: gas heat only, gas plus electric, oil heat only, oil plus electric, other heat (propane/wood) only, other plus electric, shared heat (whole building), shared plus electric, all electric, all other.

Source: Navigant Consulting: Data Files for the Massachusetts Residential Baseline Study (July 16, 2017)

We analyzed the survey data collected in the Massachusetts Residential Baseline Study and recalculated penetration and saturation rates, replicating Navigant’s approach of applying weights and onsite adjustment factors, but using CLC-specific weights (rather than the statewide weights used to develop the results included in the data files).

To develop CLC-specific weights, we first estimated the percentage of CLC households by education level (college degree vs. no college degree) and language (English is primary language vs. English is not primary language), based on Public Use Microdata Area (PUMA) data at the subarea level. Because the PUMA subareas do not align perfectly with CLC's territory, we utilized the current American Community Survey (ACS) census block group definitions to determine the share of each PUMA subarea that is part of CLC's territory.

We then developed weights by dividing the population percentage of each education-language stratum by the stratum's survey percentage (see Table 2-7).

Table 2-7. CLC-Specific Post-Stratification Weights

Education Level	Language	Population Proportion	Survey Completes	Survey Proportion	Weight
College Degree	English Is Primary Language	0.52	445	0.68	0.77
College Degree	English Not Primary Language	0.02	11	0.02	1.48
No College Degree	English Is Primary Language	0.42	192	0.29	1.43
No College Degree	English Not Primary Language	0.04	8	0.01	3.16

Source: 2015 American Community Survey (ACS) and Public Use Microdata Sample (PUMS) data; Navigant Consulting: Data Files for the Massachusetts Residential Baseline Study (July 16, 2017)

Using the CLC-specific post-stratification weights as well as Navigant's statewide onsite adjustment factors, we then generated the residential and low income penetration and saturation rates using a two-step process.

- Since some model inputs benefit from additional granularity, we first developed penetration and saturation values—separately for the residential and the low income sectors—for the three building types defined by the Navigant study: single family attached, single family detached, and multifamily.
- We calculated sector-level results as the weighted average of the building type-level results, based on the proportion of each building type in CLC's service territory (developed from the 2015 American Community Survey).

2.3 Baseline Inputs for the Commercial & Industrial Sector

To develop estimates of C&I baseline penetration, saturation, and measure characteristics of CLC customers, we relied on primary data collected for the 2014 Potential Study. We also leveraged data from the recent Massachusetts C&I Market Characterization Study led by DNV GL. Even though the Market Characterization Study was conducted more recently, we primarily relied on the 2014 Potential Study estimates because its sample was designed to provide rigorous results for CLC's C&I customers whereas the Market Characterization Study focused on the statewide electric market with limited CLC sample points.

Both data sources are discussed in more detail below.

2014 CLC Potential Study

The primary data collection activities for the 2014 Potential Study included a telephone survey with 448 CLC C&I customers and on-site visits at 150 businesses within CLC's service territory. The telephone survey gathered high level penetration information on electricity-using equipment and information on barriers to energy efficiency and participation in CLC programs. The site visits collected more detailed information about electricity-using equipment, including penetration, saturation, efficiency, and end-use specific information such as wattage, cooling capacity, and horsepower. We used the combined data from these two data collection efforts to characterize penetration and saturation of energy efficiency equipment in the C&I sector and estimate potential.

The 2014 Potential Study contains a detailed description of the methodology and results of the primary data collection activities for the C&I sector.

Massachusetts C&I Market Characterization Study

The Massachusetts C&I Market Characterization Study conducted site visits with 800 C&I facilities across Massachusetts (60 of which were within CLC's service territory) between August 2014 and December 2015. The DNV GL team developed a stratified random sample of the statewide population of C&I accounts based on business type and consumption. While the sample was geographically representative of electric customers across Massachusetts, it was not directly based on electric program administrator (PA) service territories.[26]

The site visits collected detailed information about major energy-using equipment, including lighting, heating and cooling equipment, hot water equipment, refrigeration, energy management systems, motors and drives, and on-site generation equipment. We relied on only a portion of this data to update the 2014 CLC Potential Study baseline results. In particular, we summarized the DNV GL site visit data related to exit signs, central air handler units, kitchen hoods, and Energy Management Systems (EMS).

[26] Because DNV GL did not stratify their sample by Program Administrator, we could not use the weights developed in the C&I Market Characterization Study and had to develop new weights specific to CLC and the business segments under study.

3. Summary of Baseline Results

A key input into the potential model is the penetration and saturation of major electricity-using equipment in homes and businesses. These two concepts are defined as follows:

- **Penetration:** A percentage representing the proportion of customers that have one or more of a particular piece of equipment. It is calculated by dividing the number of customers with one or more of a piece of equipment by the total number of customers responding to that question. For example, the penetration rate of window/room air conditioners is 36% for residential customers (meaning that 36% of all residential households had at least one window/room air conditioner) compared to 26% for low income customers.

- **Saturation:** A number representing how many of a particular piece of equipment exist, on average, among all customers. It is calculated by dividing the total number of a particular piece of equipment by the total number of customers responding to that question (regardless of whether they reported having the equipment or not). This ratio is at least equal to, but generally higher than the corresponding penetration of the equipment, because some customers will have more than one of the equipment. For example, the saturation rate of window/room air conditioners in residential homes was 0.85, compared to 1.09 in low income homes.

The following tables summarize key penetration and saturation results for the residential and low income sectors and for the C&I sector, respectively. The complete baseline results are provided in separate spreadsheets.

Table 3-1 presents residential and low income equipment penetration and saturation estimates, based on data collected in the 2017 Lighting Market Assessment (lighting measures) and the 2017 Massachusetts Residential Baseline Study (non-lighting measures).

Table 3-1. 2017 Residential and Low Income Equipment Penetration and Saturation Results

Appliance/Equipment	Penetration		Saturation	
	Res	Low Income	Res	Low Income
Lighting				
Incandescent	95%		28.14	14.82
Halogen	67%			
CFL	95%		18.09	13.65
LED	61%		14.07	5.07
HVAC - Cooling				
Shared Central Cooling	4%	10%	0.04	0.10
Central Air Conditioner (Ducted)	36%	26%	0.42	0.30
Mini-Split Air Conditioner (Ductless)	3%	1%	0.04	0.01
Room or Window Air Conditioner	36%	55%	0.85	1.09
Other Cooling System	1%	1%	0.02	0.03

Appliance/Equipment	Penetration		Saturation	
	Res	Low Income	Res	Low Income
No Cooling System	19%	9%	0.19	0.09
HVAC - Cooling/Heating				
Central Heat Pump (Ducted)	1%	4%	0.01	0.02
Mini-Split Heat Pump (Ductless)	9%	3%	0.10	0.02
Ground Source or Geothermal Heat Pump	0%	0%	0.00	0.00
HVAC - Heating				
Shared Central Heating	5%	10%	0.05	0.10
Furnace - Natural Gas	29%	27%	0.31	0.31
Boiler - Natural Gas	32%	35%	0.29	0.36
Boiler - Fuel Oil	16%	9%	0.16	0.07
Furnace - Fuel Oil	4%	6%	0.04	0.05
Furnace - Electric	0%	0%	0.00	0.00
Electric Baseboard Heat	11%	9%	0.33	0.34
Furnace - Other Fuel Fype	2%	0%	0.02	0.00
Boiler - Other Fuel Type	2%	0%	0.03	0.00
Fireplace - Natural Gas	16%	11%	0.18	0.15
Fireplace or Heating Stove - Other Fuel Type	17%	15%	0.20	0.16
Space Heater or Plug-in Fireplace	31%	32%	0.51	0.50
Other Heating System	3%	1%	0.05	0.01
No Heating System	1%	2%	0.01	0.02
HVAC - Other				
HRV or ERV	3%	7%	0.03	0.07
Thermostat	86%	89%	2.24	1.86
Dehumidifier	59%	47%	0.67	0.51
Humidifier	15%	12%	0.20	0.15
Air Purifier/Cleaner	11%	12%	0.15	0.14
Whole House Fan	4%	7%	0.04	0.07
Ceiling Fan	51%	45%	1.30	1.07
Domestic Hot Water				
Shared Central Water Heater	5%	10%	0.05	0.10
Water Heater - Electric	14%	14%	0.14	0.14
Tankless Water Heater - Electric	1%	1%	0.01	0.01
Water Heater - Heat Pump	2%	2%	0.02	0.02
Water Heater - Natural Gas	40%	40%	0.39	0.39

Appliance/Equipment	Penetration		Saturation	
	Res	Low Income	Res	Low Income
Tankless Water Heater - Natural Gas	4%	4%	0.04	0.04
Water Heater - Fuel Oil	2%	1%	0.01	0.01
Tankless Water Heater - Fuel Oil	2%	2%	0.02	0.02
Water Heater - Propane	1%	2%	0.01	0.02
Tankless Water Heater - Propane	1%	0%	0.01	0.00
Water Heater - Solar	1%	0%	0.01	0.00
Water Heater - Indirect	27%	27%	0.27	0.26
Other Water Heater	3%	4%	0.03	0.04
Hot Water Recirculation Pump	2%	2%	0.02	0.02
Showerhead	100%	100%	1.95	1.58
Sink Faucet	100%	100%	3.71	3.10
Appliances				
Refrigerator	100%	99%	1.43	1.23
Freezer	22%	11%	0.21	0.11
Shared Washer/Dryer	3%	12%	0.03	0.12
Clothes Washer	90%	78%	0.93	0.81
Clothes Dryer - Electric	69%	58%	0.71	0.60
Clothes Dryer - Natural Gas	21%	20%	0.22	0.20
Clothes Dryer - Propane	1%	1%	0.01	0.01
Outdoor/Garage				
Pool Pump	5%	2%	0.05	0.03
Electric Vehicle Charger	4%	1%	0.04	0.01
Electronics/Misc				
TV	94%	91%	2.30	2.12
Cable/Satellite TV Box	83%	84%	1.74	1.61
Stereo or Home Entertainment Sound System	52%	45%	0.65	0.55
Desktop Computer	39%	36%	0.51	0.41
Laptop Computer	64%	64%	0.92	0.74
Computer Monitor/Display	44%	49%	0.66	0.57

Sources:

Lighting data: NMR Group Inc. 2016-17 NMR Lighting Market Assessment Consumer Survey and On-site Saturation Study, April 7, 2017

Non-lighting Data: Adapted from: Navigant Consulting: Data Files for the Massachusetts Residential Baseline Study (July 16, 2017)

Table 3-2 presents key C&I equipment penetration and saturation data used in potential modeling. The majority of the baseline information was collected in support of the 2014 Potential Study. The penetration results are based on data from either the phone survey or the on-site visits (or both), depending on the measure, while the saturation results for all measures are based on data collected as part of the site visits. Additional saturation and penetration data—based on the data collected for the DNV GL Massachusetts C&I Market Characterization Study—agumented the 2014 data.

Table 3-2. 2014 Commercial and Industrial Penetration and Saturation Results

End Use/Equipment Type	Penetration	Saturation
Lighting[a]		
All Light Fixtures	100%	113.10
Linear Fluorescent Light Fixtures	89%	39.72
T12 Linear Fluorescent Light Fixtures	54%	8.85
T10 Linear Fluorescent Light Fixtures	8%	1.11
T8 Linear Fluorescent Light Fixtures [b]	65%	28.42
T5 Linear Fluorescent Light Fixtures	4%	1.13
T5HO Linear Fluorescent Light Fixtures	2%	0.21
CFL Fixtures	70%	36.54
Incandescent Bulb Fixtures	72%	19.04
High Pressure Sodium Bulb Fixtures	14%	0.66
Mercury Vapor Bulb Fixtures	5%	0.21
Metal Halide Bulb Fixtures	23%	1.67
Halogen Bulb Fixtures	26%	2.41
LED Light Fixtures	38%	12.19
Neon (Cold Cathode) Light Fixtures	<1%	<0.01
Other Fixtures	3%	0.66
Exit Signs[†]		
Any Exit Sign	81%	4.0
Incandescent Exit SIgn	21%	0.7
CFL Exit Sign	16%	0.9
LED Exit SIgn	38%	2.0
Reflective or Paper Exit SIgn	10%	0.4
Unknown	4%	<0.1
Cooling Equipment		
Packaged Units	19%	0.32
Split Systems	40%	1.10
Window/Wall Units	35%	2.58
Chillers	<1%	0.01
Ventilation		

End Use/Equipment Type	Penetration	Saturation
Ventilation Hoods	8%	0.07
Demand Controlled Ventilation	<1%	
Process Ventilation	2%	
Motors and Compressed Air		
All Motors	20%	0.79
Overall Compressed Air	15%	
Compressors	15%	0.27
Refrigeration		
All Commercial Refrigeration	15%	
Standalone Refrigerator or Freezer	11%	1.86
Refrigerated Display Cases [c]	6%	0.11
Walk-in Coolers	10%	0.15
Walk-in Freezers	7%	0.08
Refrigeration Systems	15%	0.19
Refrigerated Vending Machines	9%	0.10
Ice Machines	9%	0.22
Electronics		
Computers (All Types)	88%	5.85
Desktops	87%	5.05
Laptops	31%	0.80
Large Printers	30%	0.51
Small Printers	80%	2.79
Televisions	53%	6.67
Cash Registers/POS Terminals	42%	0.65
Rack Mounted Servers	6%	
Cooking Equipment		
All Commercial Food Service Equipment	12%	
Electric Ovens	4%	0.26
Electric Griddles	3%	0.15
Electric Commercial Fryers	2%	0.04
Electric Food Holding Cabinets	1%	0.01
Electric Steam Cookers	<1%	<0.01
Dishwashers	8%	0.22
Water Heating		
All Electric Water Heating	47%	
Electric Resistance Water Heaters	41%	0.48

End Use/Equipment Type	Penetration	Saturation
Heat Pump Water Heaters	1%	0.01
Low Flow Showerheads [d]	0%	0.00
Faucet Aerators [d]	37%	1.65

*Denotes fewer than 30 observations
[a] Lighting combines both indoor and outdoor overhead hardwired lighting, unless specified.
[b] T8 linear fluorescent lights include T8 Plus lights.
[c] Saturation refers to linear feet, not units
[d] Includes only showerheads and aerators served by electric water heating
† Denotes estimate from the Massachusetts C&I Market Characterization Study

4. Overall Potential Results

We estimate CLC's total achievable energy efficiency potential for the three-year period from 2019-2021 to be 156,697 annual MWh and 83 MW.[27] Achievable potential represents 49% of economic potential and 36% of technical potential. On average, over the three-year period, achievable energy savings represents 2.78% of CLC annual forecasted sales (as forecasted by Eversource, and adjusted for 2016-2018 achieved and planned savings). These savings would cost CLC ratepayers $201.1 million (incentive and non-incentive program costs), an average of $67 million per year or $1.28 per annual kWh.[28] Without DR, the cost drops to $0.66 per annual kWh.The total cost (including the participants' net cost) amounts to $219.2 million (in 2018 dollars) for the three-year period.

All of the 2019-2021 proposed investments are cost-effective, with a portfolio-wide Total Resource Cost (TRC) ratio of 3.8 at the measure level and of 2.7 at the sector level.

Table 4-1 summarizes results for the three-year period 2019-2021, overall and by sector.

[27] See Section 2 for a description of update activities and key drivers that explain the differences between these achievable potential estimates and those of the previous potential study.

[28] This compares to a projected average cost of $0.724/kWh during the 2016-2018 Three Year Plan Cycle and $0.895 per annual kWh estimated in the 2014 Potential Study. The higher cost per kWh is the result of inclusion of DR measures and programs in this study, which contribute to cost and do not have significant energy savings.

Table 4-1. Key Potential Results – 2019-2021

	All Sectors		Residential		Low Income		C&I	
Potential (Total)	**MWh**	**MW**	**MWh**	**MW**	**MWh**	**MW**	**MWh**	**MW**
Technical	431,323	351	266,636	196	17,797	12	146,890	143
Economic	319,981	329	173,821	177	12,589	10	133,572	142
Achievable	156,697	83	93,571	53	8,404	4	54,722	25
Potential (Annual)	**MWh**	**MW**	**MWh**	**MW**	**MWh**	**MW**	**MWh**	**MW**
Technical	143,774	116.9	88,879	65.5	5,932	3.9	48,963	47.5
Economic	106,660	109.8	57,940	59.0	4,196	3.5	44,524	47.3
Achievable	52,232	27.7	31,190	17.8	2,801	1.5	18,241	8.4
Annual Achievable as % of Sales	2.78%		2.94%		4.44%		2.43%	
Cost								
Total (millions)	$219.2		$163.4		$16.9		$38.9	
CLC (millions)	$201.1		$152.3		$14.7		$34.1	
CLC Cost/kWh	$1.28		$1.63		$1.75		$0.62	
Cost-Effectiveness								
Total Resource Cost Test (Sector level)	2.7		2.2		4.0		4.1	
Total Resource Cost Test (Measure level)	3.8		3.1		4.7		6.8	

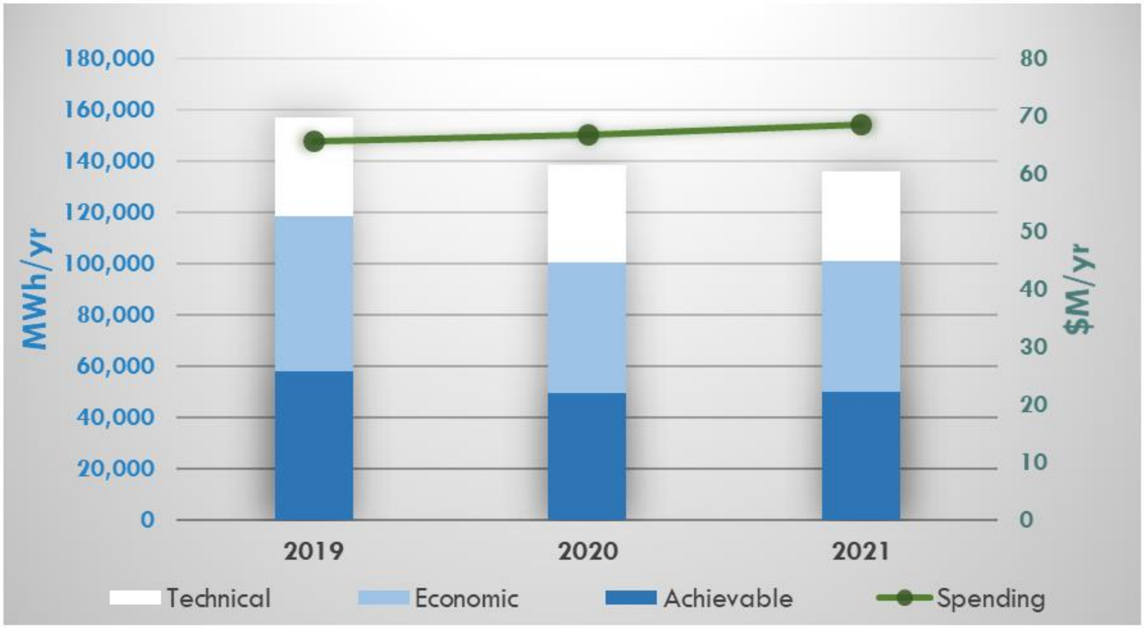
Table 4-2 details annual achievable potentials as a percentage of sales, by year and sector, for the three-year period.

Table 4-2. Achievable Potential as a Percentage of Forecasted Energy Sales – 2019 to 2021

	2019	2020	2021	2019-2021
Residential	3.40%	2.66%	2.75%	2.94%
Low Income	5.09%	4.09%	4.15%	4.44%
Commercial & Industrial	2.39%	2.43%	2.47%	2.43%
All Sectors	**3.05%**	**2.62%**	**2.68%**	**2.78%**

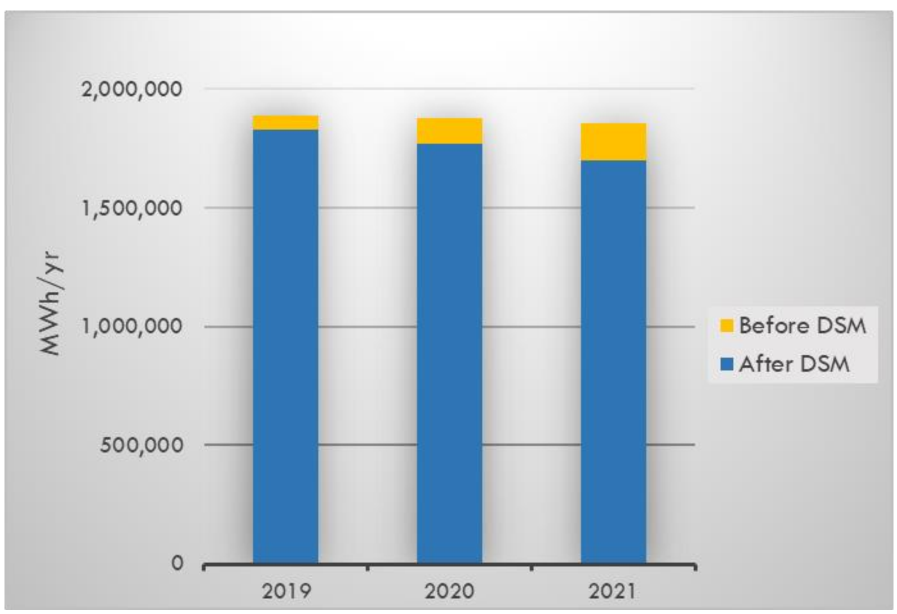
Figure 4-1 presents annual MWh savings for the three types of potential, as well as annual spending required to meet the achievable potential. The MWh savings are net of measures removed from the potential because they reached the end of their useful life (or dual baseline measures yielding lower savings upon reaching second-stage savings).

Figure 4-1. Annual Savings and Spending



Eversource forecasts slightly declining energy sales, before energy efficiency (EE) efforts,[29] over the three-year period, with total 2021 sales of 1,859,049 MWh compared to 1,890,051 MWh in 2019. With EE efforts at the level of the achievable potential, energy sales would decline faster, with 2021 sales amounting to 1,702,352 MWh, a drop of 10% from pre-DSM 2019 sales (Figure 4-2).

Figure 4-2. Impact of Achievable Potential on Annual Sales



[29] The forecast has been adjusted with achieved and planned savings from the 2018-2020 period to create a more appropriate baseline for the 2019-2021 period.

4.1 Comparison with 2014 Potential Study and 2016 Verified Results

This section compares the forecasts of the current study with the forecasts from the 2014 Potential Study and actual 2016 results. This comparison shows higher 2016 verified energy savings, compared to the potential forecasts, at lower budget and average cost. Verified 2016 demand savings fell between the two potential study forecasts (see Table 4-3).

Table 4-3. Comparison of Annual Average 2019-2021 Savings and Costs

	Current Study		2014 Study	2016 Verified
	Including DR	Excluding DR		
Incremental annual savings (MWh)	52,232	52,232	41,500	65,610
Incremental annual savings (MW)	27.7	13.7	9.5	10.0
Budget (M$)	67.0	34.5	37.7	27.3
CLC Cost $/kWh	1.28	0.66	0.91	0.42

Several factors explain the differences between the current potential forecasts and verified 2016 results, including:

- The impact of codes and standards, baseline, and technology assumptions that are evolving over time, especially, but not exclusively, for lighting, making it difficult to compare 2016 results with 2019-2021 potentials;
- The removal of saving streams from the potential at the end of measures' EUL[30] (no such adjustment is made to 2016 savings);
- Several model adjustments and CLC-specific adjustments, including cumulative effects and seasonality, that are not necessarily reflected in statewide assumptions.
- The inclusion of DR measures also greatly increases the budget without corresponding kWh savings, thus significantly increasing the unit cost ($/kWh).

Compared to the 2014 Potential Study, the current study shows an important increase in demand savings and overall budget, which is largely due to the addition of DR measures (resulting from a scope change between the two studies). When removing DR, however, results can more easily be compared to those of the previous study. The change in savings and unit cost is due, in part, to the addition of new measures as well as updated lighting assumptions (with increased adoption but a much shorter EUL due to EISA regulation). The 2019-2021 period results from the 2014 study are also more affected by measures dropping

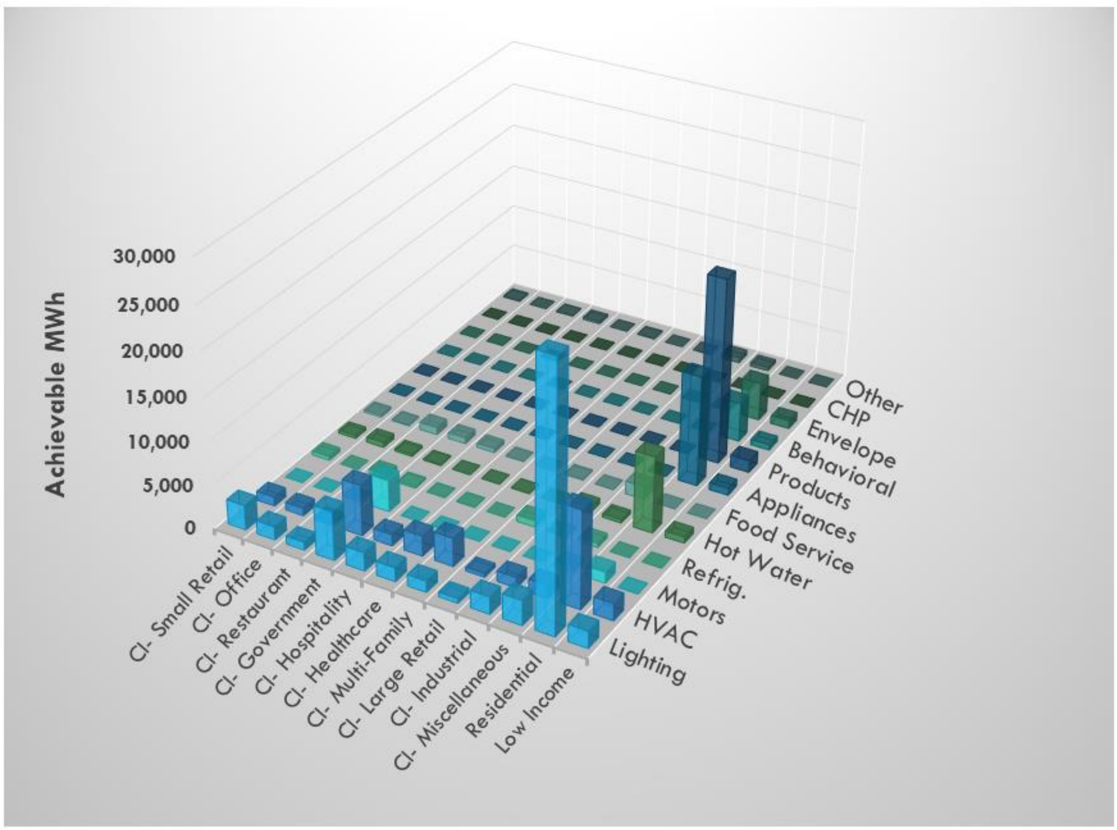
[30] To illustrate this, it is worth mentioning that 2019 achievable savings are 57,654 MWh, but because some measures have very short EULs, the annual savings drop in subsequent years, leading to an average of 52,232 MWh of yearly incremental savings over the period.

out of the potential because they reach the end of their EUL (notably by measures implemented in the 2016-2018 period).

4.2 Results by Sector and End-Use

Over half of the achievable potential comes from the residential sector (60%). The C&I sector accounts for 35% of potential and the low income sector for the remaining 5% (see Figure 4-3). The dominance of the residential sector, compared to C&I, reflects the economic structure of CLC's service territory, in which residential kWh sales comprise a higher proportion of CLC's total annual kWh sales (55%) than the statewide average (37%). The small contribution of the low income sector is in line with the sector's number of accounts and annual energy sales (3%).

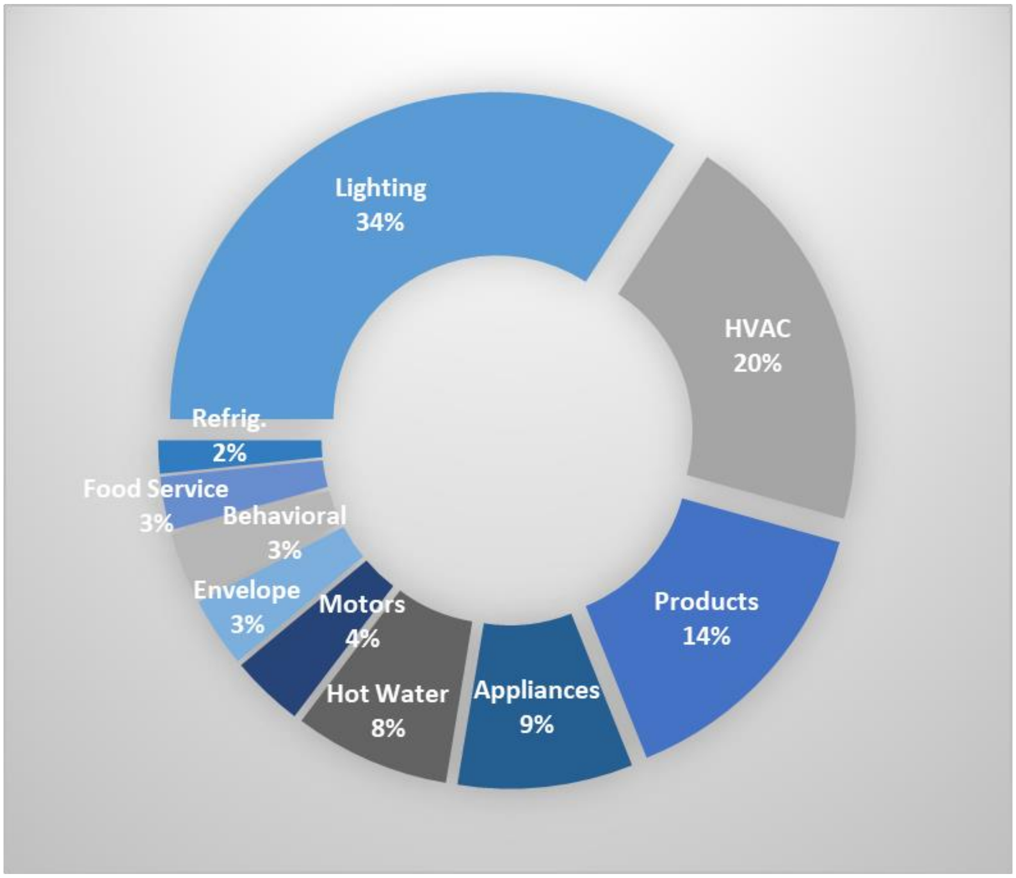
Figure 4-3. Three-Year Cumulative Achievable Potential (MWh)



The main end-use contributing to achievable potential is lighting (34%). Despite lower unit savings due to baseline adjustments—notably the Energy Independence and Security Act (EISA) lighting efficiency requirements coming into effect and its impacts on the market—lighting still achieves robust savings due to accelerating market adoption of LED bulbs. Also, because compact fluorescent lighting (CFL) have been removed from the model, they no longer compete with LEDs for incandescent replacements. The measure life of these savings is greatly reduced however, because LED lighting will become the new baseline in the near future. All saving streams end in 2025 with current assumptions, which is much shorter than the measure life of the LED bulbs themselves, and the evolving baseline has been characterized using a dual-baseline approach, with decreasing savings before 2025.

Other significant end-uses are HVAC (20%), products (14%), appliances (9%), and hot water (8%). (See Figure 4-4.)

Figure 4-4. Achievable Potential by End-Use



4.3 Top Five Measures

LED bulbs are by far the highest energy-saving measure category, contributing 40,862 MWh of savings (26% of total achievable potential) over the three-year period. LEDs no longer compete with CFLs, which have been removed from the model. This, and the lower barrier levels attributed to LEDs—a result of rapid market adoption—explain the higher savings achieved by this measure compared to the 2014 Potential Study.

Smart strips (notably Tier 2 strips that have been added to the model), HVAC controls, refrigerators, and water heaters also account for a substantial share of overall potential.

Table 4-4 summarizes the contribution to potential by the top five measure categories, by sector.

Table 4-4. 2019-2021 Savings for Top Five Measure Categories by Sector

Rank	All Sectors		Residential		Low Income		C&I	
	Measure	MWh	Measure	MWh	Measure	MWh	Measure	MWh
1	LED Bulbs	40,862	LED Bulbs	29,641	LED Bulbs	1,937	LED Bulbs	9,284
2	Smart Strip	9,238	Smart Strip	8,693	Air Conditioning	1,053	HVAC Control	8,549
3	HVAC Control	8,549	Refrigerator	7,744	Building Envelope	909	EMS	6,095
4	Refrigerator	8,176	Cable Box	5,096	Behavioral	625	Lighting Control	5,167
5	Water Heater	6,645	Water Heater	4,728	Heating System	561	Food Service	4,281

4.4 Sensitivity Analysis

We conducted a sensitivity analysis to assess uncertainty regarding the 3-year MWh savings potential, using the following ranges:

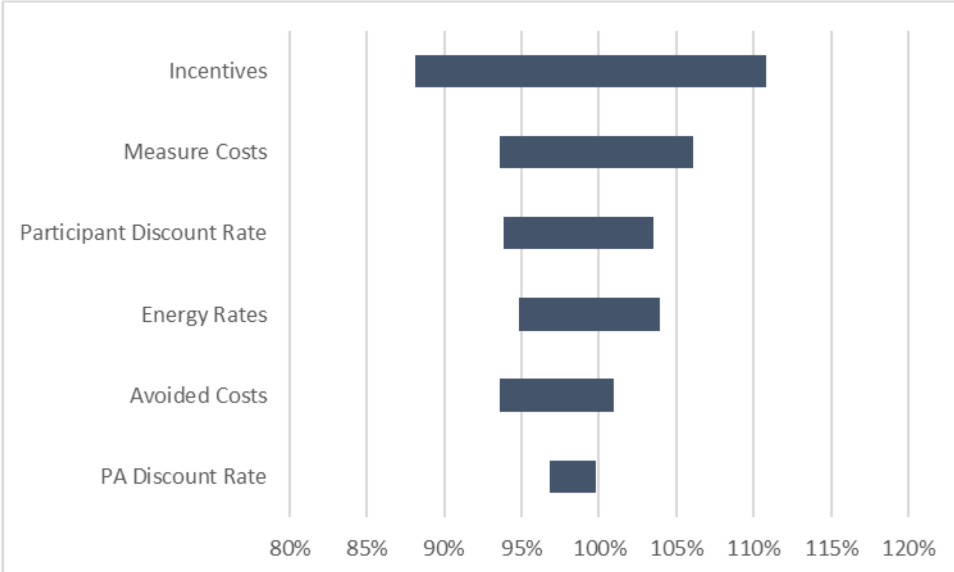
- Program administrator discount rate: 0% to 4%
- Participant discount rate: 0% to 10%
- Measure costs, incentives, energy rates, and avoided costs: -20% to +20%

Figure 4-5 presents the results of this analysis, represented as the percentage of savings under the lower and upper bounds for each factor, compared to the base scenario.

The potential model is most sensitive to changed in incentives, followed by changes in measure costs, the participant discount rate, and energy rates. It is important to note that the 2017 potential model adjusts incentives dynamically to changing measure incremental costs, which explains why the results are relatively unaffected by changing measure costs (variation of about 6% of savings for an increase or decrease of 20% of measure costs).

The potential savings appear robust, as all tested factors produce a variability of less than 20% compared to the base scenario. In all cases except for incentives, the change is far less than 10%.

Figure 4-5. 3-Year MWh Savings and Variability (Base Scenario = 100%)



4.5 Detailed Results

The following tables present additional detail on the results of the potential study, by type of potential, sector, segment, and end-use.

Table 4-5. Technical, Economic, and Achievable Potential by Year (MWh)

	2019	2020	2021	2019-2021
Cumulative Annual				
Technical	157,096	295,490	431,323	431,323
Economic	118,669	219,169	319,981	319,981
Achievable	57,654	106,788	156,697	156,697
Incremental Annual				
Technical	157,096	138,394	135,833	431,323
Economic	118,669	100,500	100,812	319,981
Achievable	57,654	49,134	49,909	156,697
Incremental as % of Sales				
Technical	8.31%	7.37%	7.31%	7.66%
Economic	6.28%	5.35%	5.42%	5.68%
Achievable	3.05%	2.62%	2.68%	2.78%

Table 4-6. Detailed Results by Sector, Segment, and End-Use (2019-2021 Cumulative Achievable Potential – MWh)

Segment	End-Use												
	Lighting	HVAC	Motors	Refrig.	Food Serv.	Hot Water	Appliances	Products	Behavior	Envelope	CHP	Other	TOTAL
CI- Subtotal	21,330	18,156	4,281	2,537	4,088	2,520	0	0	0	0	0	1,810	54,722
CI- Small Retail	*2,858*	*1,047*	*0*	*438*	*250*	*345*	*0*	*0*	*0*	*0*	*0*	*182*	*5,121*
CI- Office	*1,541*	*887*	*0*	*0*	*136*	*601*	*0*	*0*	*0*	*0*	*0*	*28*	*3,194*
CI- Restaurant	*932*	*430*	*19*	*471*	*847*	*262*	*0*	*0*	*0*	*0*	*0*	*98*	*3,059*
CI- Government	*5,600*	*5,818*	*3,649*	*196*	*669*	*131*	*0*	*0*	*0*	*0*	*0*	*282*	*16,345*
CI- Hospitality	*2,106*	*1,299*	*1*	*37*	*463*	*30*	*0*	*0*	*0*	*0*	*0*	*15*	*3,950*
CI- Healthcare	*1,601*	*2,308*	*3*	*36*	*69*	*31*	*0*	*0*	*0*	*0*	*0*	*105*	*4,153*
CI- Multifamily	*1,310*	*3,254*	*1*	*0*	*0*	*47*	*0*	*0*	*0*	*0*	*0*	*0*	*4,612*
CI- Large Retail	*556*	*416*	*0*	*757*	*163*	*45*	*0*	*0*	*0*	*0*	*0*	*75*	*2,012*
CI- Industrial	*1,985*	*1,189*	*0*	*113*	*42*	*649*	*0*	*0*	*0*	*0*	*0*	*616*	*4,595*
CI- Misc.	*2,840*	*1,508*	*608*	*489*	*1,449*	*378*	*0*	*0*	*0*	*0*	*0*	*409*	*7,681*
Residential	29,641	11,127	1,268	0	0	8,753	12,636	21,200	4,521	4,426	0	0	93,571
Low Income	1,937	1,951	47	0	0	702	796	1,401	625	945	0	0	8,404
TOTAL	52,908	31,234	5,596	2,537	4,088	11,975	13,432	22,601	5,145	5,371	0	1,810	156,697

5. Residential Potential Results

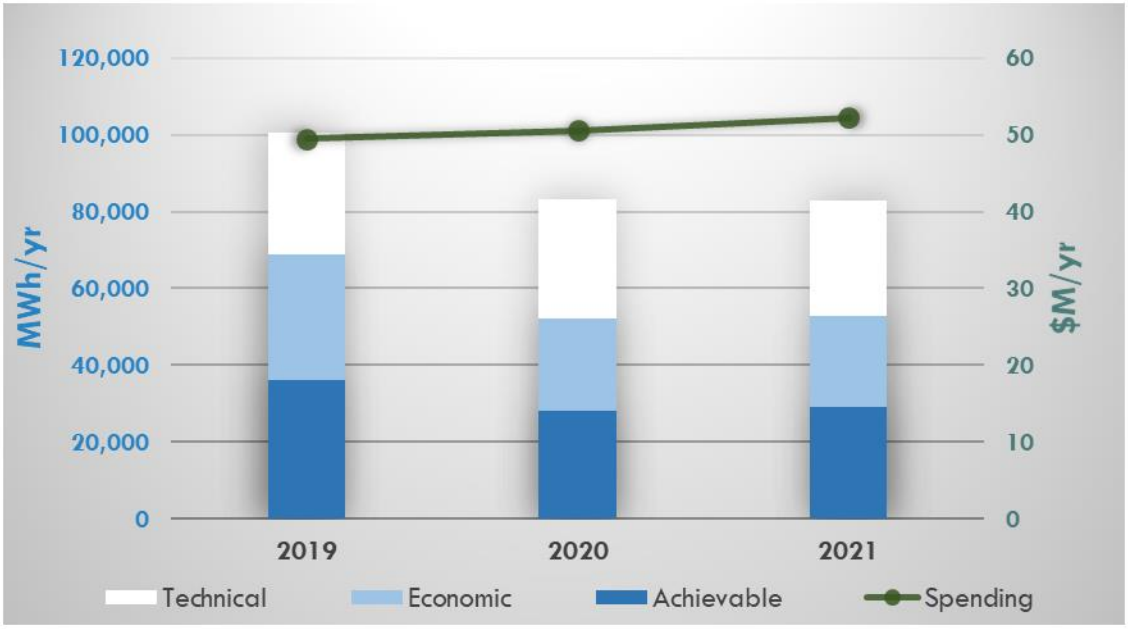
CLC's annual achievable energy efficiency potential for the residential sector is estimated at 93,571 MWh and 53 MW for the three-year period 2019-2021. Achievable potential represents 54% of economic potential and 35% of technical potential. On average, achievable energy savings amount to 2.94% of CLC annual sales to the sector. These savings would cost CLC ratepayers $152 million (incentive and non-incentive program costs), an average of $51 million per year. The total cost (including the participants' net cost) amounts to $163 million for the three-year period. These investments are cost-effective, with a Total Resource Cost (TRC) ratio of 3.1 at the measure level and of 2.2 at the sector level.

Table 5-1. Key Potential Results – Residential Sector

	2019-2021	
Potential (Total)	**MWh**	**MW**
Technical	266,636	196
Economic	173,821	177
Achievable	93,571	53
Potential (Annual)	**MWh**	**MW**
Technical	88,879	65.5
Economic	57,940	59.0
Achievable	31,190	17.8
Annual Achievable as % of Sales	2.94%	
Cost		
Total (millions)	$163.4	
CLC (millions)	$152.3	
CLC Cost/kWh	$1.63	
Cost-Effectiveness		
Total Resource Cost Test (Sector level)	2.2	
Total Resource Cost Test (Measure level)	3.1	

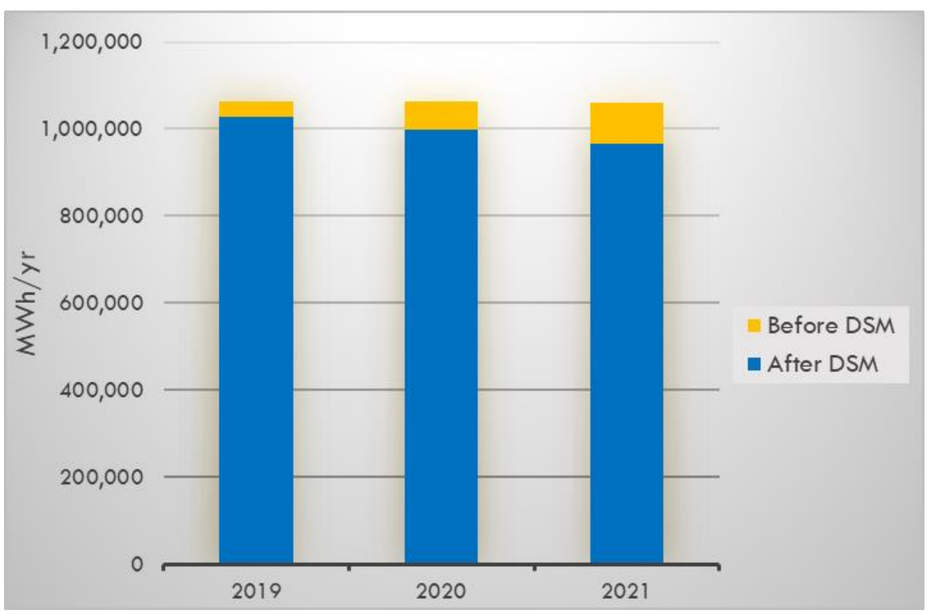
Figure 5-1 presents annual MWh savings for the three types of potential, as well as annual spending required to meet the achievable potential.

Figure 5-1. Annual Savings and Spending for Residential Sector



Eversource forecasts slightly decreasing energy sales for the residential sector, before EE efforts, over the three-year period, with total 2021 sales of 1,059,776 MWh compared to 1,062,626 in 2019. With EE efforts at the level of the achievable potential, energy sales would decline further, with 2021 sales amounting to 966,205 MWh, a drop of 9% from 2019 pre-DSM sales (Figure 5-2).

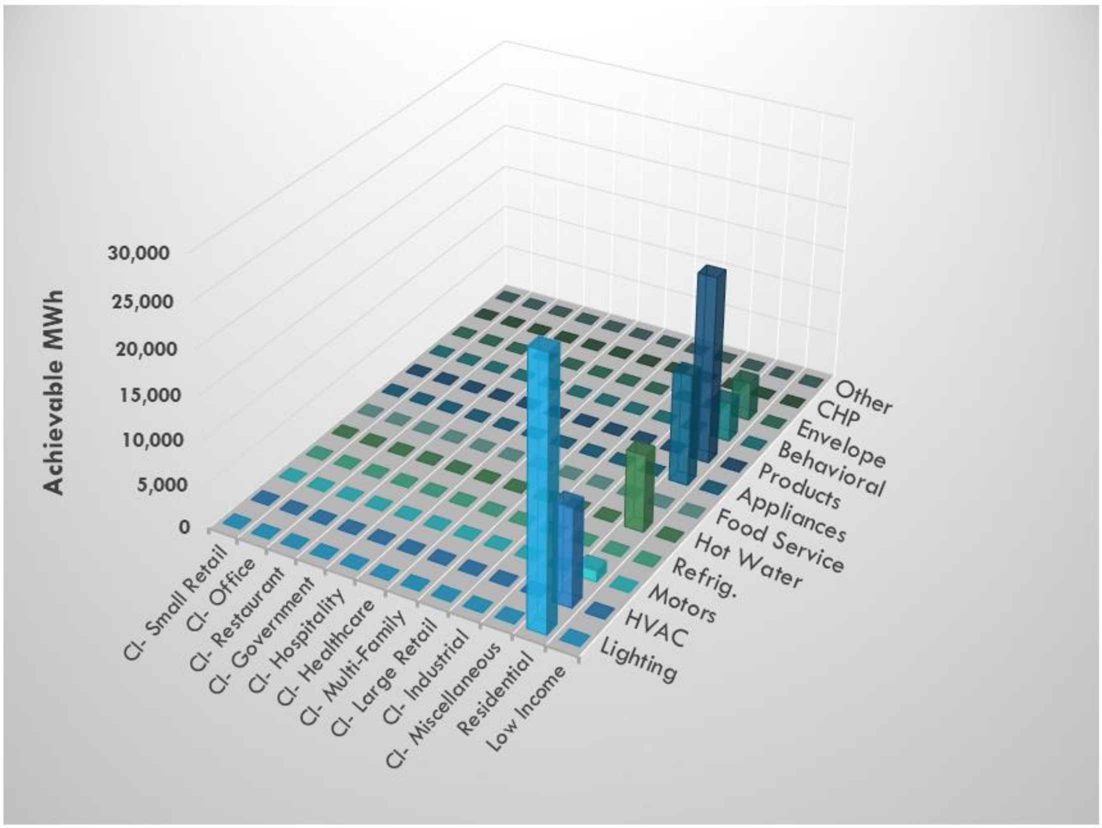
Figure 5-2. Impact of Achievable Potential on Annual MWh Residential Sales



5.1 Results by End-Use for Residential Sector

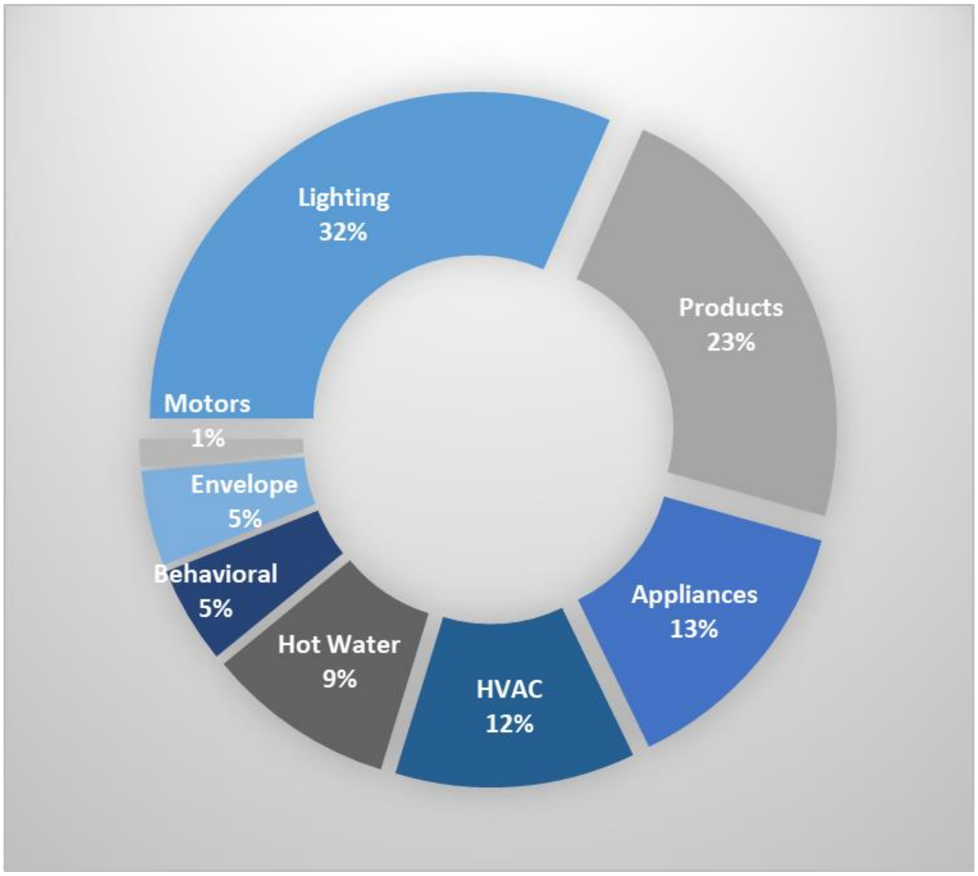
As can be seen in Figure 5-3, the main contributors to the achievable potential in the residential sector are lighting measures and the products end-use, which includes Tier 2 smart strips and several new measures.

Figure 5-3. 2019-2021 Cumulative Achievable Savings (MWh) for Residential Sector



In addition to lighting (32%) and products (23%), other significant end-uses include appliances (13%), HVAC (12%), and hot water (Figure 5-4). Compared to the 2014 Study, savings are gained mostly in the lighting, appliances and products end-uses, while envelope and motor measures have slightly lower MWh savings. While procuring higher short-term savings, lighting measures now have a much shorter EUL due to EISA regulation.

Figure 5-4. 2019-2021 Achievable Potential by End-Use for Residential Sector



5.2 Top Five Measures for the Residential Sector

The top measure category for the residential sector is the LED bulbs,[31] contributing 29,641 MWh (or 31%) to achievable potential. As indicated earlier, LEDs no longer compete with CFLs, and also benefit from accelerated adoption due to lower market barriers. Other important measures include smart strips (especially Tier 2 strips), refrigerators, heating system measures, and set-top boxes.

Table 5-2. 2019-2021 Savings for Top Five Measure Categories in the Residential Sector

Rank	Measure	MWh
1	LED Bulbs	29,641
2	Smart Strip	8,693
3	Refrigerator	7,744
4	Cable Box	5,096
5	Water Heater	4,728

[31] See Section 0 for a discussion on recent LED market trends and model assumptions.

6. Low Income Potential Results

CLC's annual achievable energy efficiency potential for the low income sector is estimated at 8,404 MWh and 4 MW for the three-year period from 2019 to 2021. Achievable potential represents 67% of economic potential and 47% of technical potential. On average, achievable energy savings amount to 4.44% of CLC annual sales to the sector. These savings would cost CLC ratepayers $15 million (incentive and non-incentive program costs), an average of $5 million per year. The total cost (including the participants' net cost) amounts to $17 million for the three-year period. These investments are cost-effective, with a Total Resource Cost (TRC) ratio of 4.7 at the measure level and of 4.0 at the sector level.[32]

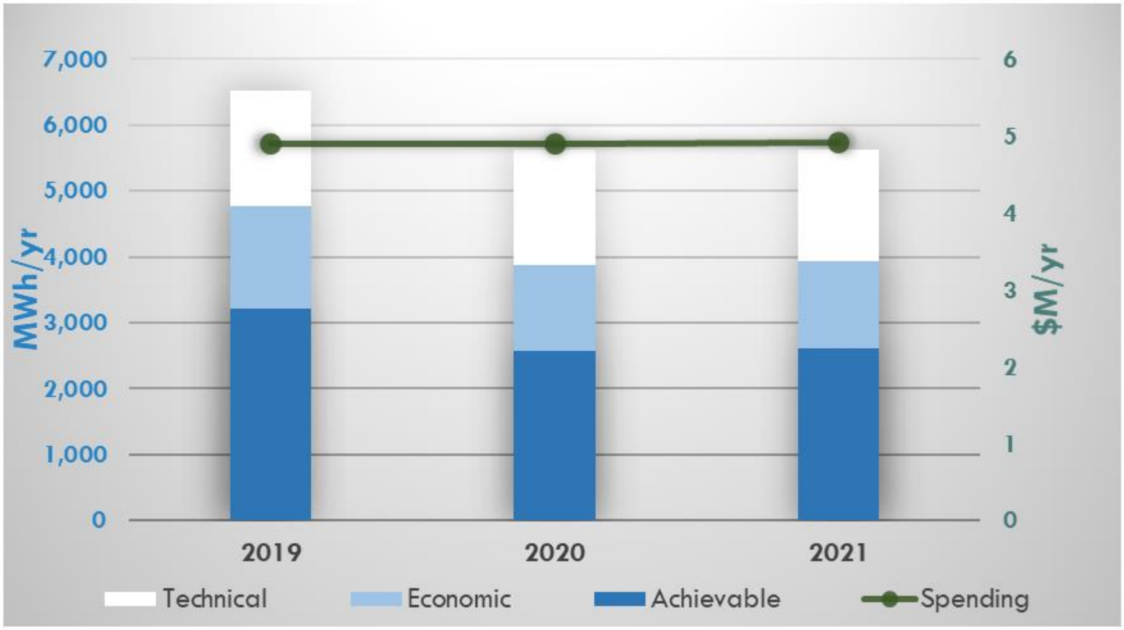
Table 6-1. Key Potential Results – Low Income Sector

	2019-2021	
Potential (Total)	**MWh**	**MW**
Technical	17,797	12
Economic	12,589	10
Achievable	8,404	4
Potential (Annual)	**MWh**	**MW**
Technical	5,932	3.9
Economic	4,196	3.5
Achievable	2,801	1.5
Annual Achievable as % of Sales	4.44%	
Cost		
Total (millions)	$16.9	
CLC (millions)	$14.7	
CLC Cost/kWh	$1.75	
Cost-Effectiveness		
Total Resource Cost Test (Sector level)	4.0	
Total Resource Cost Test (Measure level)	4.7	

Figure 6-1 presents annual MWh savings for the three types of potential, as well as annual spending required to meet the achievable potential.

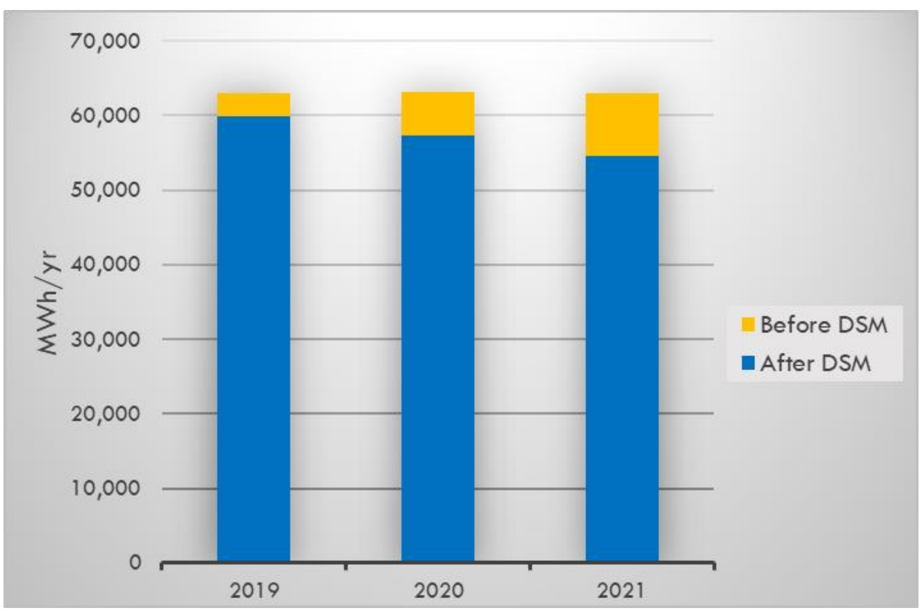
[32] Note that the budget allocation for low income programs in the potential model is not 10% of the overall CLC budget, as required by Massachusetts Statute. In order to meet the statutory 10% requirement, CLC may need to expend additional budget without corresponding savings.

Figure 6-1. Annual Savings and Spending for the Low Income Sector



Eversource forecasts slightly decreasing energy sales for the low income sector, before EE efforts, over the three-year period, with total 2021 sales of 62,903 MWh compared to 63,065 in 2019. With EE efforts at the level of the achievable potential, energy sales would decline further, with 2021 sales amounting to 54,499 MWh, a drop of nearly 14% from 2019 pre-DSM sales (Figure 6-2).

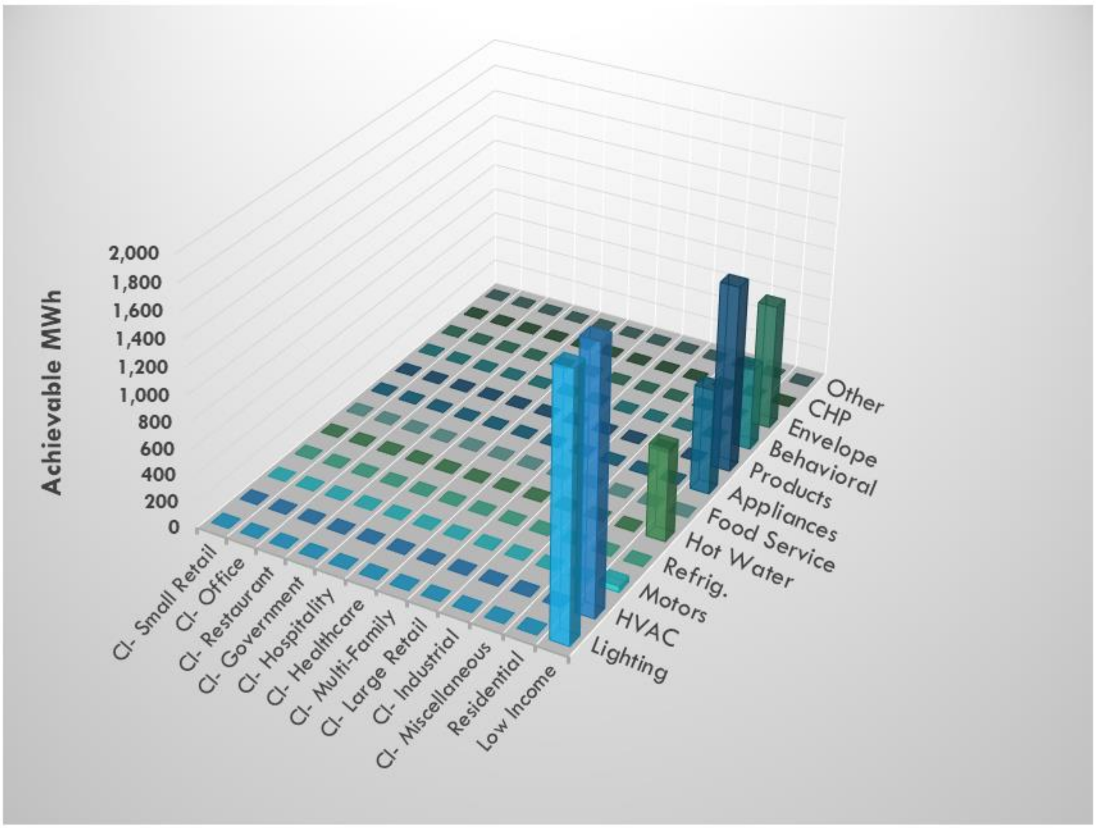
Figure 6-2. Impact of Achievable Potential on Annual Low Income MWh Sales



6.1 Results by End-Use for Low Income Sector

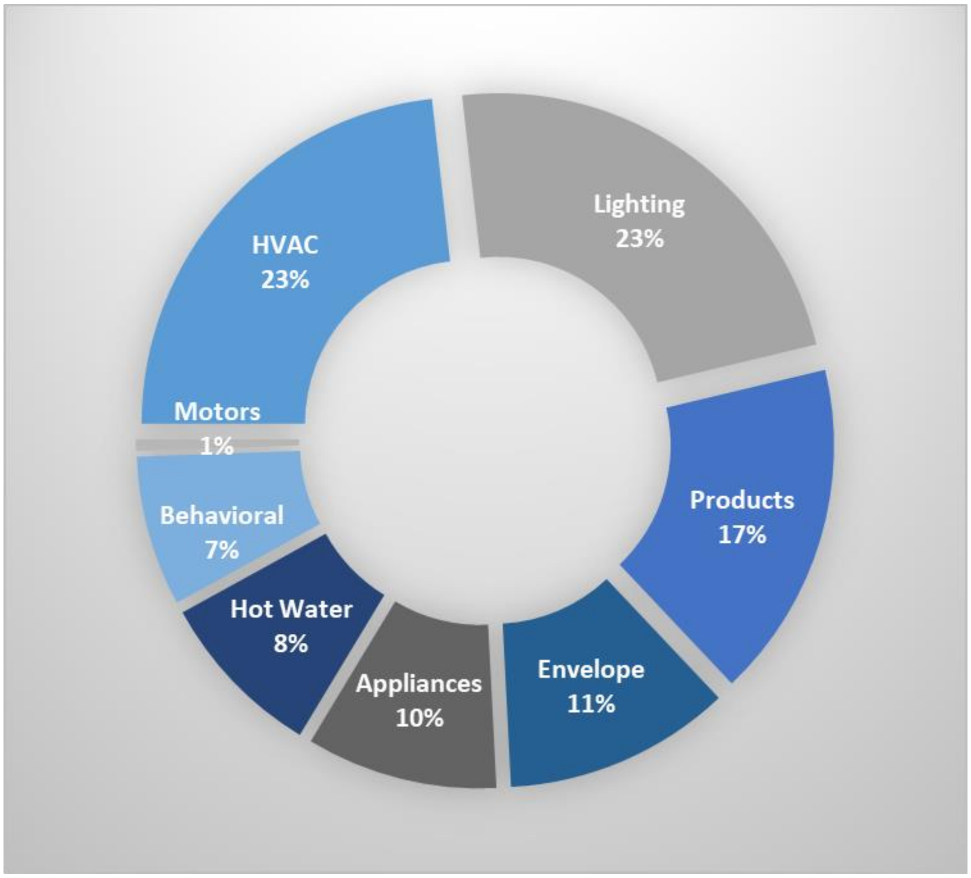
The small contribution of the low income Sector to overall achievable potential (5%) is in line with the sector's number of accounts and annual energy sales. This sector is not affected by seasonality, unlike the residential and C&I sectors.

Figure 6-3. 2019-2021 Cumulative Achievable Savings (MWh) for the Low Income Sector



The main end-uses contributing to achievable potential are HVAC (23%), lighting (23%), and products (17%). Other significant end-uses are building envelope (11%), appliances (10%), hot water (8%), and behavioral (incuding both "feedback only" and "opt-in" programs - 7%) (Figure 6-4). Similar to the residential sector, savings are gained mostly in the lighting, appliances, and products end-uses, compared to the 2014 Study. While procuring higher short-term savings, lighting measures now have a much shorter EUL due to EISA regulation. Heating and cooling equipment savings also increased significantly.

Figure 6-4. 2019-2021 Achievable Potential by End-Use for the Low Income Sector



6.2 Top Five Measures for Low Income Sector

Apart from LED Bulbs, which is the most important measure category[33] as for the other sectors, the Low Income sector is dominated by building-related measures (Building Envelope, Heating System, Air Conditioning). The Products category is far less important due to lower penetration/saturation in low income households.

Table 6-2. 2019-2021 Savings for Top Five Measures in the Low Income Sector

Rank	Measure	MWh
1	LED Bulbs	1,937
2	Air Conditioning	1,053
3	Building Envelope	909
4	Behavioral	625
5	Heating System	561

[33] See Section 0 for a discussion on recent LED market trends and model assumptions.

7. Commercial & Industrial Potential Results

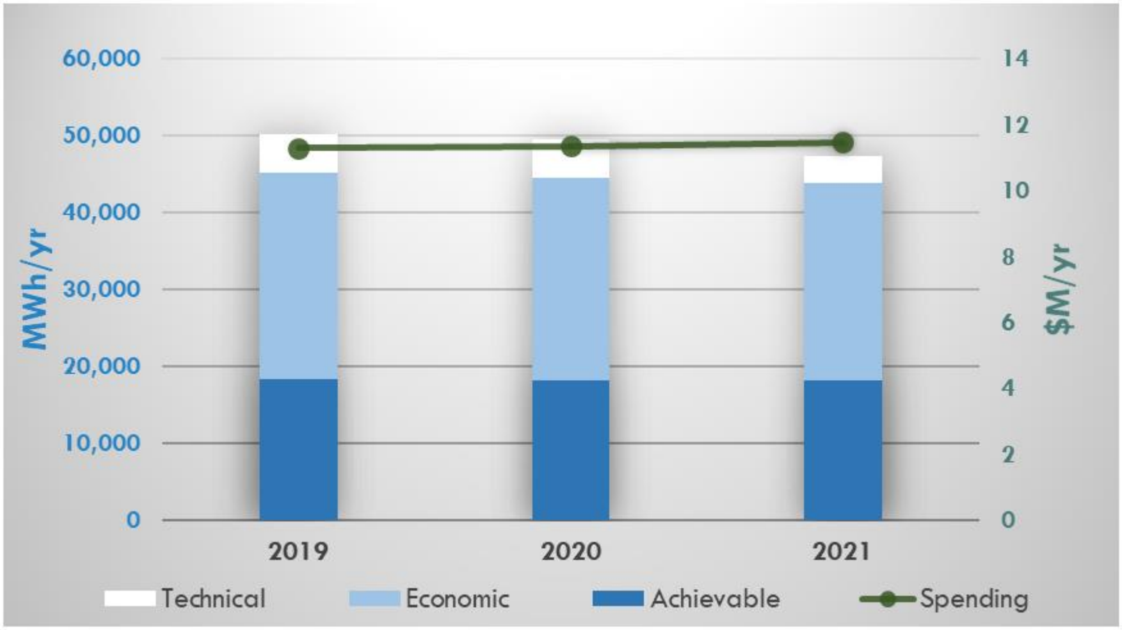
CLC's annual achievable energy efficiency potential for the C&I sector is estimated at 54,722 MWh and 25 MW for the three-year period 2019 to 2021. Achievable potential represents 41% of economic potential and 37% of technical potential. On average, achievable energy savings amount to 2.43% of CLC annual sales to the sector. These savings would cost CLC ratepayers $34 million (incentive and non-incentive program costs), an average of $11 million per year. The total cost (including the participants' net cost) amounts to $39 million for the three-year period. These investments are cost-effective, with a Total Resource Cost (TRC) ratio of 6.8 at the measure level and of 4.1 at the sector level.

Table 7-1. Key Potential Results – C&I Sector

	2019-2021	
Potential (Total)	**MWh**	**MW**
Technical	146,890	143
Economic	133,572	142
Achievable	54,722	25
Potential (Annual)	**MWh**	**MW**
Technical	48,963	47.5
Economic	44,524	47.3
Achievable	18,241	8.4
Annual Achievable as % of Sales	2.43%	
Cost		
Total (millions)	$38.9	
CLC (millions)	$34.1	
CLC Cost/kWh	$0.62	
Cost-Effectiveness		
Total Resource Cost Test (Sector level)	4.1	
Total Resource Cost Test (Measure level)	6.8	

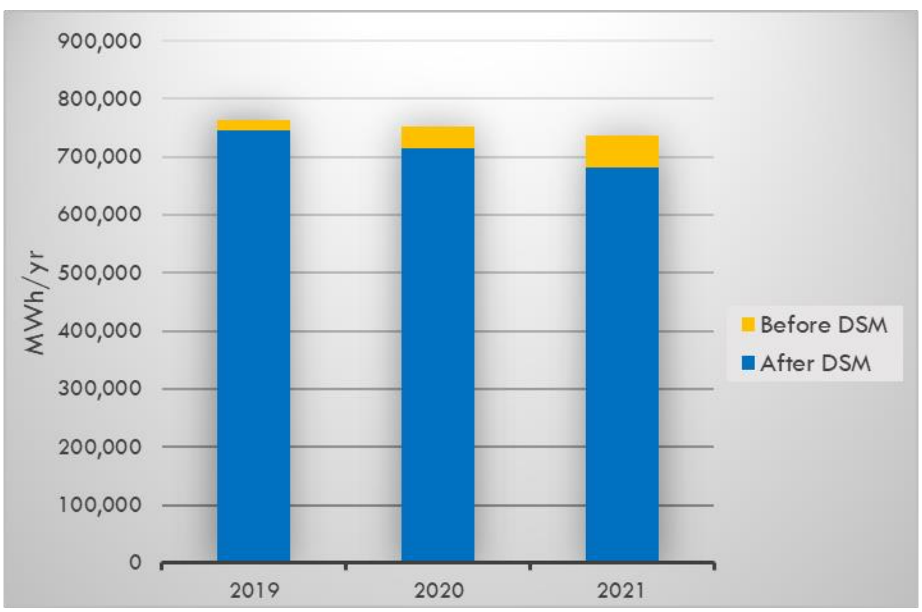
Figure 7-1 presents annual MWh savings for the three types of potential, as well as annual spending required to meet the achievable potential. Both spending and savings are rather flat during the three-year period.

Figure 7-1. Annual Savings and Spending for the C&I Sector



Eversource forecasts declining energy sales for the C&I sector, before EE efforts, over the three-year period, with total 2021 sales of 736,369 MWh compared to 764,360 in 2019. With EE efforts at the level of the achievable potential, energy sales would decline faster, with 2021 sales amounting to 681,647 MWh, a drop of 11% from 2019 sales (Figure 7-2).

Figure 7-2. Impact of Achievable Potential on Annual C&I MWh Sales

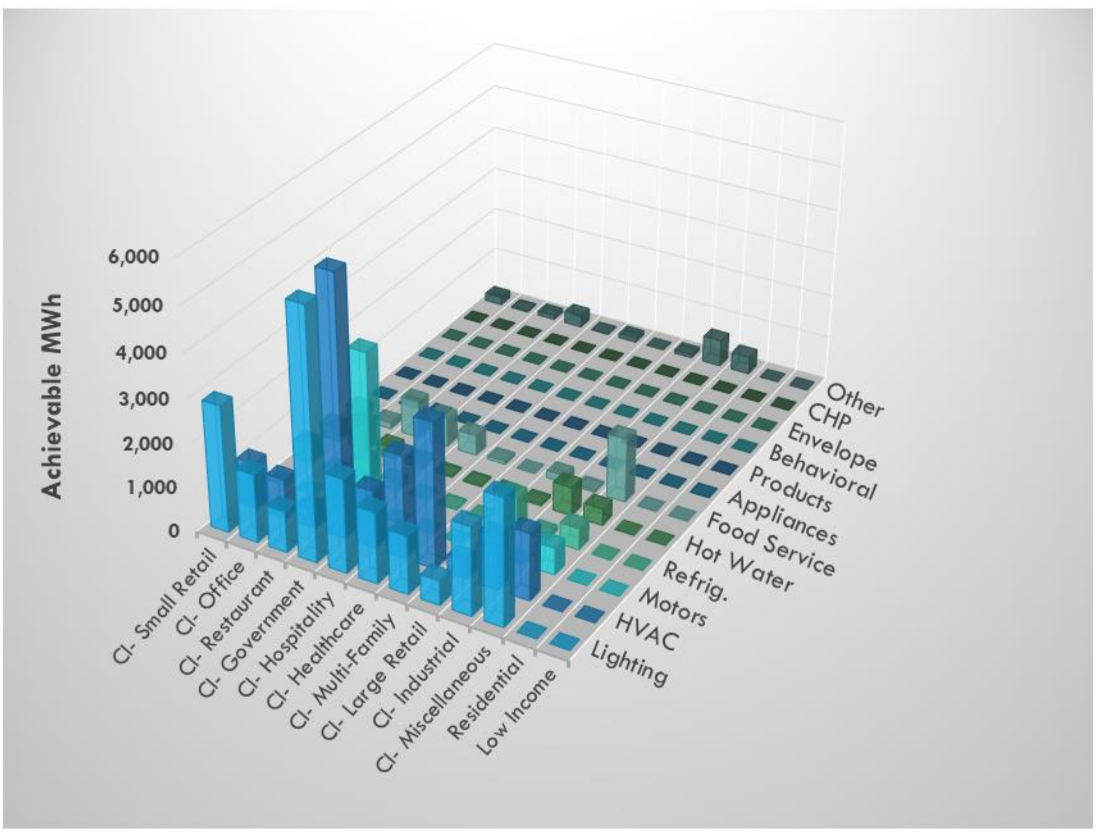


7.1 Results by Segment and End-Use for C&I Sector

The C&I sector accounts for 35% of the overall achievable potential. The relatively small contribution of the C&I sector, which compares to 57% of statewide C&I EE goals for the 2016-18 period, reflects the economic structure of Cape Cod and Martha's Vineyard. CLC's non-residential customer base is dominated by small businesses, with very few large commercial or industrial customers. This structure results in lower potential from the C&I sector as well as higher cost per kWh saved, as it is more expensive to serve smaller customers.

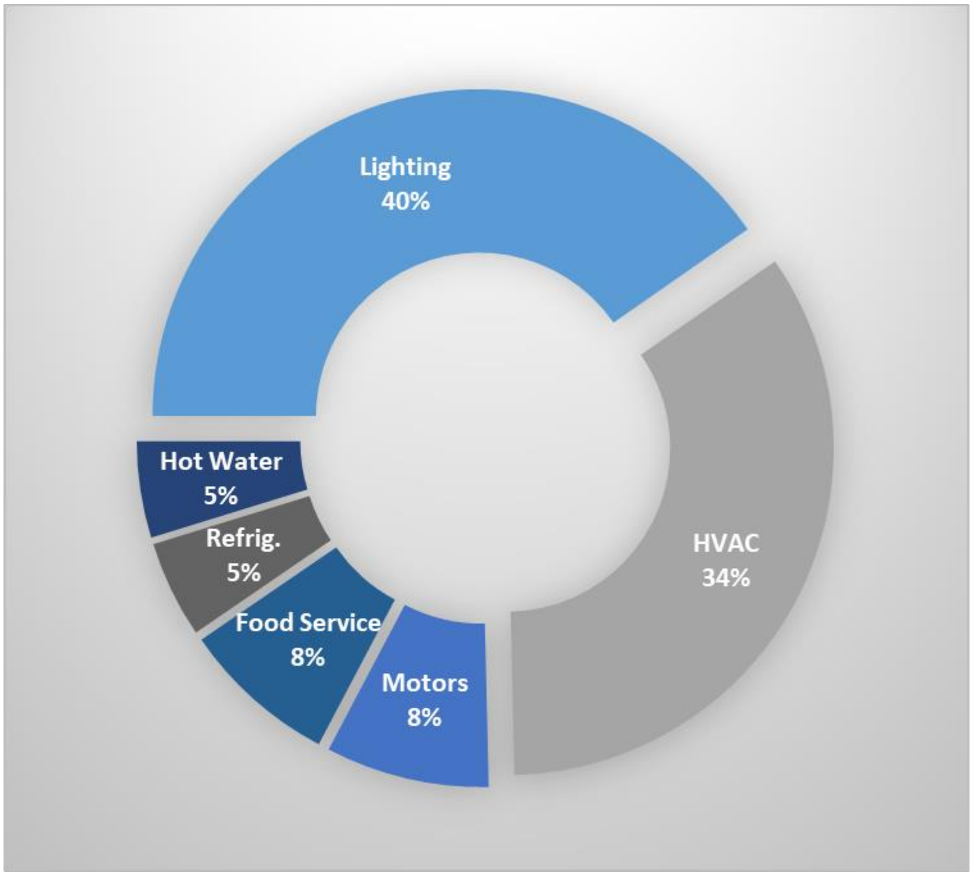
In addition, achievable potential of the C&I sector is affected by seasonality, especially for the restaurant and hospitality segments. A large proportion of businesses have reduced hours of operation and/or occupancy during the off-peak season, and some shut down completely during the winter. Figure 7-3 shows achievable potential for 2019-2021, by C&I segment and end-use.

Figure 7-3. 2019-2021 Cumulative Achievable Savings (MWh) for the C&I Sector



The main end-uses contributing to C&I achievable potential are lighting (40%) and HVAC (34%). Other end-uses contribute less than 10% each (Figure 7-4). Compared to the 2014 Potential Study, lighting, refrigeration, and CHP savings decreased, while HVAC and motor savings increased. Overall, there has been little change in savings for the sector.

Figure 7-4. 2019-2021 Achievable Potential by End-Use for C&I



7.2 Top Five Measures for C&I Sector

LED bulbs are the highest energy-saving measure[34], contributing 9,284 MWh of savings (17% of total achievable potential for the C&I sector) over the three-year period. HVAC Controls, Energy Management Systems, Lighting Controls, and Food Services also account for a substantial share of overall potential.

Table 7-2. 2019-2021 Savings for Top Five Measure Categories in the C&I Sector

Rank	Measure	MWh
1	LED Bulbs	9,284
2	HVAC Control	8,549
3	EMS	6,095
4	Lighting Control	5,167
5	Food Service	4,281

[34] See Section 0 for a discussion on recent LED market trends and model assumptions.

8. Demand Response Potential

This potential study includes potential from demand response (DR) efforts. It should be noted that potential and costs associated with DR measures are already included in results throughout the report, unless noted otherwise, as they are an integral part of the overall estimated potential.

Significant DR efforts will change the load curve and DR event characteristics. However, this load curve shift due to DR (and energy efficiency) measures, and its impact on cumulative demand savings, could not be assessed due to lack of data on CLC's specific demand curves. All demand savings in this report are presented without these cumulative effects.

DR measures currently included in the model include the following:

Residential / Low Income DR Measures	C&I DR Measures
Wi-Fi Thermostats Three-Element Water Heater Thermal Energy Storage Electric Storage Window AC DR Water Heater DR Smart EVSE Pool Pump DR Appliances DR (Refrigerator, Clothes Dryer, Clothes Washer)	WiFi Thermostats Thermal Energy Storage Water Heater DR Refrigeration DR Lighting Controls DR

These measures contribute 42 MW of achievable demand potential during the three-year period, or 53% of the overall demand potential (see Table 8-1). The remaining demand savings come from energy efficiency measures with coincident peak savings.

Table 8-1. Key Potential Results – 2019-2021 Demand Potential

	Total	Demand Response Measures	Energy Efficiency Measures
Potential (Total)		**MW**	
Technical	351	206	145
Economic	329	206	124
Achievable	83	42	41
Potential (Annual)		**MW**	
Technical	116.9	68.6	48.3
Economic	109.8	68.6	41.2
Achievable	27.7	14.0	13.7
Cost			
Total (millions)	219.2	$91.2	128.0
CLC (millions)	201.1	$97.4	103.6
CLC Cost/kW	--	$2,322.32	--
Cost-Effectiveness			
Total Resource Cost Test (Portfolio level)	2.7	2.1	3.1
Total Resource Cost Test (Measure level)	3.8	3.3	4.0

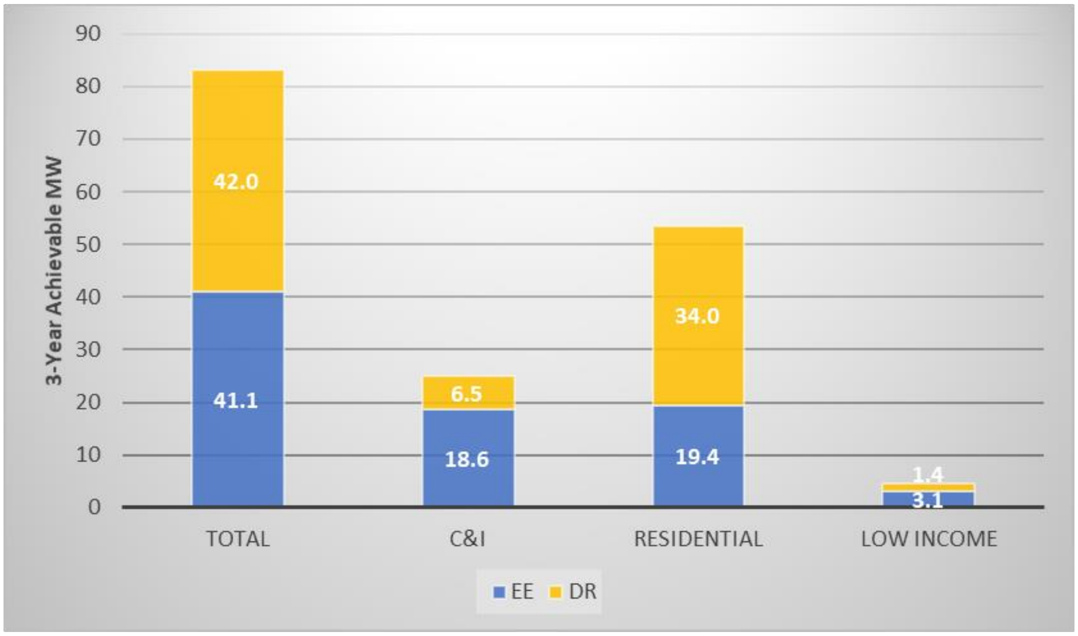
Achievable potential from DR measures represents 20% of both economic and technical DR potential. This rather low achievable potential stems from the adoption model, which accounts for the special nature of DR measures, including relatively low participant benefits compared to energy efficiency measures and a need for active participation in the program over time.

These savings would cost CLC ratepayers $97 million (incentive and non-incentive program costs), an average of $32 million per year. The total cost (including the participants' net cost) amounts to $91 million for the three-year period. Typically, DR programs will pay all of the participants' incremental costs, and will offer an additional yearly incentive for participating in the program. This explains why budget costs are higher than TRC costs.

The CLC proposed DR effort is cost-effective, with a Total Resource Cost (TRC) ratio of 3.3 at the measure level and of 2.1 at the portfolio level.

Figure 8-1 presents MW savings by sector, including the respective contributions of energy efficiency and DR measures. In the residential sector, demand savings from DR measures are much more important than demand savings from energy efficiency, while the C&I sector gets most of the demand savings from energy efficiency measures.

Figure 8-1. Demand Savings by Sector



A large portion (46%) of DR demand savings comes from HVAC measures, including smart thermostats, thermal storage units, and window AC DR. Other DR measures include appliances (mostly clothes dryers), refrigeration systems, water heaters, and smart charging stations for electric vehicles.

Table 8-2. 2019-2021 DR Savings by Sector and End-Use (MW)[35]

Sector/Segment	End-Use						
	HVAC	Motors	Refrig.	Hot Water	Appl.	Other	TOTAL
C&I	4.7	0.0	1.6	0.1	0.0	0.0	6.5
C&I- Small Retail	*0.6*	*0.0*	*0.3*	*0.0*	*0.0*	*0.0*	***0.9***
C&I- Office	*0.5*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	***0.6***
C&I- Restaurant	*0.4*	*0.0*	*0.6*	*0.0*	*0.0*	*0.0*	***1.0***
C&I- Government	*0.6*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	***0.8***
C&I- Hospitality	*0.3*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	***0.3***
C&I- Healthcare	*0.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	***0.3***
C&I- Multifamily	*1.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	***1.2***
C&I- Large Retail	*0.2*	*0.0*	*0.3*	*0.0*	*0.0*	*0.0*	***0.5***
C&I- Industrial	*0.3*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	***0.4***
C&I- Misc.	*0.4*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	***0.5***
Residential	14.0	0.7	0.0	1.4	11.4	6.6	34.0
Low Income	0.8	0.0	0.0	0.1	0.5	0.0	1.4
TOTAL	19.5	0.7	1.6	1.6	11.9	6.6	42.0

[35] Lighting Control DR procures negligible savings due to the small size of CLC's C&I buildings and the high proportion of manually operated fixtures.

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For more information, please contact:

Antje Flanders
Vice President

tel 617 492 1400 x4643
fax 617 497 7944
aflanders@opiniondynamics.com

1000 Winter Street
Waltham, MA 02451