Seattle City Light

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2018 Conservation Potential Assessment - Volume I

Seattle City Light is dedicated to exceeding our customers' expectations in producing and delivering environmentally responsible, safe, low-cost and reliable power.

Larry Weis, General Manager and CEO
Jim Baggs, Customer Service, Communications & Regulatory Affairs Officer

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Definition of Terms

aMW	Average Megawatt
AC	Air Conditioning
ACS	American Community Survey
B/C	Benefit-Cost
C&I	Commercial and Industrial
C&S	Codes and Standards
CAC	Central Air Conditioning
CBECS	Commercial Building Energy Consumption Survey
CBSA	Commercial Building Stock Assessment
CFL	Compact Fluorescent Lamp
CPA	Conservation Potential Assessment
Council	Northwest Power and Conservation Council
DEER	Database of Energy Efficient Resources
DOE	Department of Energy
DSM	Demand-Side Management
ECM	Energy Conservation Measure
EIA	Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPA	Environmental Protection Agency
EUIs	Energy Use Intensities
EUL	Effective Useful Life
HVAC	Heating Ventilation and Air Conditioning
I-937	Initiative 937
IRP	Integrated Resource Plan
kW	Kilowatt
kWh	Kilowatt-hour
LCOE	Levelized Cost of Energy
LED	Light-Emitting Diode

MW	Megawatt
MWh	Megawatt-Hour
NEEA	Northwest Energy Efficiency Alliance
NPV	Net Present Value
O&M	Operations and Maintenance
PV	Present Value
RCW	Revised Code of Washington
REC	Renewable Energy Credit
RECS	Residential Energy Consumption Survey
RSBA	Residential Building Stock Assessment
RTF	Regional Technical Forum
RUL	Remaining Useful Life
SCC	Social Cost of Carbon
SEEM	Simple Energy and Enthalpy Model
SWH	Solar Water Heating
T&D	Transmission and Distribution
TRC	Total Resource Cost
UCT	Utility Cost Test
UEC	Unit Energy Consumption
UES	Unit Energy Savings
WAC	Washington Administrative Code
WH	Water Heating
WHF	Waste Heat Factor

Acknowledgements

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1. Executive Summary

1.1. Overview

Seattle City Light (City Light) engaged Cadmus to complete a Conservation Potential Assessment (CPA) to produce rigorous estimates of the magnitude, timing and costs of conservation resources within City Light's service territory over the next 20 years, beginning in 2018. This study identifies all cost-effective conservation potential in each of City Light's major customer sectors, including residential, commercial, industrial and street lighting. The study accomplishes the following objectives:

- Fulfills statutory requirements of Chapter 194-37 of the Washington Administrative Code (WAC), Energy Independence. This WAC requires City Light to identify all achievable, cost-effective, conservation potential for the upcoming 10 years.[1] City Light's public biennial conservation target should be no less than the pro rata share of conservation potential over the first 10 years. The study estimates will inform City Light's targets for the 2018–2019 biennium.
- Provides inputs into City Light's Integrated Resource Plan (IRP). Completed every two years, City Light's IRP determines the mixture of supply-side and conservation resources required over the next 20 years to meet customer demand. The IRP requires a thorough analysis of conservation potential to properly assess the reliability, cost, risk and environmental impacts of different power generation resource portfolios.

This study relies on City Light-specific data, compiled from their oversample of the 2017 Residential Building Stock Assessment (RBSA),[2] 2014 Commercial Building Stock Assessment (CBSA)[3] and other regional data sources. This study uses a methodology consistent with the Northwest Power and Conservation Council's Seventh Power Plan. It incorporates savings and costs for all energy conservation measures (ECMs) in the Council's final Seventh Plan workbooks and active Regional Technical Forum (RTF) unit energy savings (UES) workbooks.[4]

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[1] Washington State Legislature. *Energy Independence Act,* Washington Administrative Code Chapter 194-37.

[2] Northwest Energy Efficiency Alliance. *2017 Residential Building Stock Assessment.*

[3] Northwest Energy Efficiency Alliance. *2014 Commercial Building Stock Assessment*.

[4] RCW 19.285.040 requires CPAs to use methodologies consistent with those used by the Council's most recent regional power plan.

1.2. Scope of Analysis

This study includes analysis of four sectors. In most of these sectors, Cadmus considered multiple market segments, construction vintages—new and existing—and end uses. Specifically, the analysis addressed the following sectors:

- **Residential:** Single-family and three types of multifamily homes including low-rise, mid-rise and high-rise.
- **Commercial:** 18 major commercial segments, including offices, retail and other segments. The commercial sector includes enterprise data centers.
- **Industrial:** Energy-intensive manufacturing and primarily process-driven customers.
- **Street Lighting:** City-owned street lighting.

For each sector, Cadmus developed a baseline end-use load forecast that assumes no new future programmatic conservation. The baseline forecast largely captures savings from building energy codes, equipment standards and other naturally occurring market forces. Cadmus calculated energy efficiency potential estimates by assessing the impact of each ECM on this baseline forecast. Therefore, conservation potential estimates presented in this report represent savings beyond naturally occurring savings.

This study considers three types of energy efficiency potential:

- **Technical potential** includes all technically feasible conservation measures, regardless of costs and market barriers. This is the theoretical upper bound of available conservation potential, estimated after accounting for technical constraints. The Methodology section of this report includes a description of the data sources Cadmus used to estimate these technical constraints for individual measures.
- **Economic potential** represents a subset of technical potential, consisting only of measures meeting cost-effectiveness criteria based on City Light's avoided supply costs for delivering electricity. Adherent to WAC 194-37-070, Cadmus uses the total resource cost (TRC) to identify cost-effective measures using a method consistent with the council. The Economic Potential section of this report includes a detailed description of benefits and costs considered.
- **Achievable economic potential** represents the portion of economic potential that might be reasonably achievable during the 20-year study horizon, given the possibility of market barriers impeding customer adoption. Ramp rates, defined as the acquisition rates for specific technologies, determine the amount of economic potential considered achievable on an annual basis, beginning in 2018. The Achievable Economic Potential section includes discussion of Cadmus' approach to estimating achievable potential.

1.3. Summary of Results

1.3.1. Achievable Economic Potential

Study results indicate a 10-year achievable conservation potential of 93.9 average megawatt (aMW) (cumulative in 2027) within City Light's service territory. Two-year conservation potential equals 24.5 aMW, and 20 percent of 10-year conservation potential is 18.8 aMW. Table 1 summarizes achievable conservation potential for each sector—all values include line losses at generator.

TABLE 1. CUMULATIVE ACHIEVABLE POTENTIAL BY SECTOR

Sector	Achievable Economic Potential (aMW)			
	Two Year (2018-2019)	Ten Year (2018-2027)	20 Year (2018-2037)	20% of 10-Year Potential
Residential	1.7	12.5	16.3	2.5
Commercial	17.2	72.0	104.8	14.4
Industrial	4.4	8.2	8.5	1.6
Street Lighting	1.2	1.2	1.2	0.2
Total	**24.5**	**93.9**	**130.9**	**18.8**

The commercial sector accounts for approximately 80 percent of cumulative, 20-year achievable potential, while the residential and industrial sectors account for roughly 12 percent and 7 percent of the 20-year potential, respectively. The street lighting sector accounts for approximately one percent of cumulative achievable potential. The Energy Efficiency Potential section of this report provides detailed estimates of achievable economic potential for each sector.

Figure 1 shows incremental achievable potential over the study horizon. Approximately 72 percent of the 20-year conservation potential is achieved within the first 10 years, partly due to the mixture of measures with high conservation potential. This acceleration is particularly pronounced in the residential and industrial sectors, where 77 percent and 96 percent, respectively, of potential is acquired within the first ten years. Cadmus determined the acquisition rate of incremental achievable potential by each measure's ramp rate, applying ramp rates developed by the Council for the Seventh Power Plan and accelerated the application of these ramp rates based on Seattle's historic conservation achievements.

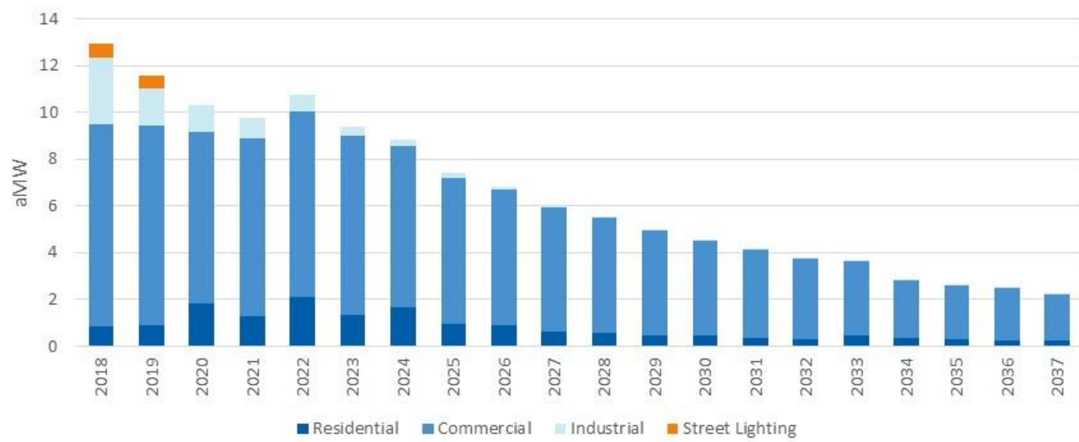

Figure 1. Incremental Achievable Economic Potential

Lighting measures in the commercial sector account for a large portion of savings, and many of these measures have relatively aggressive ramp rates, which is based on the availability of measures and utilities' program accomplishments. The Achievable Economic Potential section includes discussions of Cadmus' application of ramp rates to determine incremental achievable potential, and the Energy Efficiency Potential section includes descriptions of top-saving measures in each sector.

Figure 2 shows the amount of achievable potential at different, levelized cost thresholds. Levelized costs represent the present value of the incremental measure cost, including reinstallations over the course of the study horizon divided by the net present value of energy savings over the study's horizon.[5] Levelized costs of conserved energy are often used to compare the cost of conservation to supply-side resources.

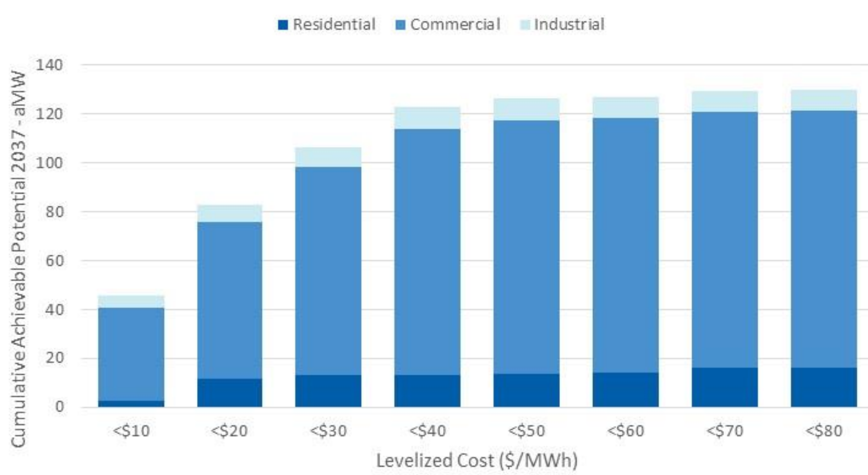

Figure 2. Conservation Supply Curves

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5 The Economic Potential section of this report includes a detailed discussion of the levelized cost calculation, including the methodology and components.

Potential conservation remains a low-cost resource: study results indicate roughly 45 aMW of conservation is achievable at a cost of less than $10 per megawatt-hour (MWh). This roughly accounts for 34 percent of the 20-year cumulative achievable potential. Approximately 94 percent of the 20-year cumulative achievable potential costs less than $40/MWh, levelized.

1.3.2. Technical and Economic Potential

1.3.2.1 Technical Potential

Table 2 shows the cumulative technical potential for each sector in 2037. Overall, study results identify 279 aMW of technically feasible conservation potential by 2037, which is equivalent to 22 percent of forecasted baseline sales.

TABLE 2. TECHNICAL POTENTIAL

Sector	Baseline Sales - 20 Year (aMW)	Technical Potential - 20 Year (aMW)	Technical Potential as % of Baseline Sales
Residential	336	85	25%
Commercial	747	180	24%
Industrial	150	13	9%
Street Lighting	10	1	12%
Total	**1,242**	**279**	**22%**

The commercial, residential and industrial sectors account for 65 percent, 30 percent and 5 percent of 20-year technical potential, respectively, while street lighting accounts for less than 1 percent.

1.3.2.2 Economic Potential

Cadmus developed two estimates of economic potential to reflect different avoided cost forecasts. According to WAC 194-37-070, City Light must consider estimates of conservation potential using avoided costs equal to a forecast of regional market prices. Regional market price forecasts, however, do not necessarily reflect costs associated with City Light's preferred portfolio of generation resources selected in its previous IRP. To assess the impact of avoided cost uncertainty, Cadmus prepared estimates of economic and achievable potential using the following two avoided cost forecasts:

- **Market (I-937):** These avoided costs, based on market prices, assume that the marginal generating unit is a conventional combined cycle turbine.
- **IRP:** These avoided costs assume City Light builds a blended renewable resource in 2022. This resource reflects a mixture of wind, cogeneration and solar present value (PV) selected in City Light's preferred portfolio from the 2015 IRP.

Both scenarios include additions for renewable energy credits, the social cost of carbon (SCC), and a 10 percent conservation credit.[6] Each scenario also accounted for forecasts of avoided transmission and distribution (T&D) costs. Because City Light's capacity is not constrained, these scenarios do not include costs associated with adding generation capacity.

Table 3 summarizes cumulative economic potential in 2037 for each avoided cost scenario. Higher avoided costs have a larger impact in the residential sector compared to the commercial and industrial (C&I) sectors. This partly results from a lower proportion of cost-effective residential savings in the market price avoided-cost scenario. Using market price avoided costs, approximately 21 percent of technical potential proves cost-effective in the residential sector, compared to 67 percent in the commercial sector and 76 percent in the industrial sector. With avoided costs from City Light's IRP preferred scenario, approximately 25 percent of technical potential proves cost-effective in the residential sector, compared to 72 percent in the commercial sector and 77 percent in the industrial sector.

TABLE 3. ECONOMIC POTENTIAL – MARKET AND IRP SCENARIOS

Sector	Market Avoided Costs			IRP Avoided Costs		
	Economic Potential - 20 Year (aMW)	EP as % of Baseline Sales	Economic as a % of Technical Potential	Economic Potential - 20 Year (aMW)	EP as % of Baseline Sales	Economic as a % of Technical Potential
Residential	18	5%	21%	21	6%	25%
Commercial	122	16%	67%	131	17%	72%
Industrial	10	7%	76%	10	7%	77%
Street Lighting	1	12%	100%	1	12%	100%
Total	**150**	**12%**	**54%**	**163**	**13%**	**58%**

6 The Northwest Power Act requires the Bonneville Power Administration to provide a 10 percent benefit to conservation over other sources of electric generation. Northwest Power Act, Section 3(4)(D), 94 Stat. 2699.

Figure 3 shows the cumulative economic potential for each scenario in 2037 relative to forecasted baseline sales, by sector.

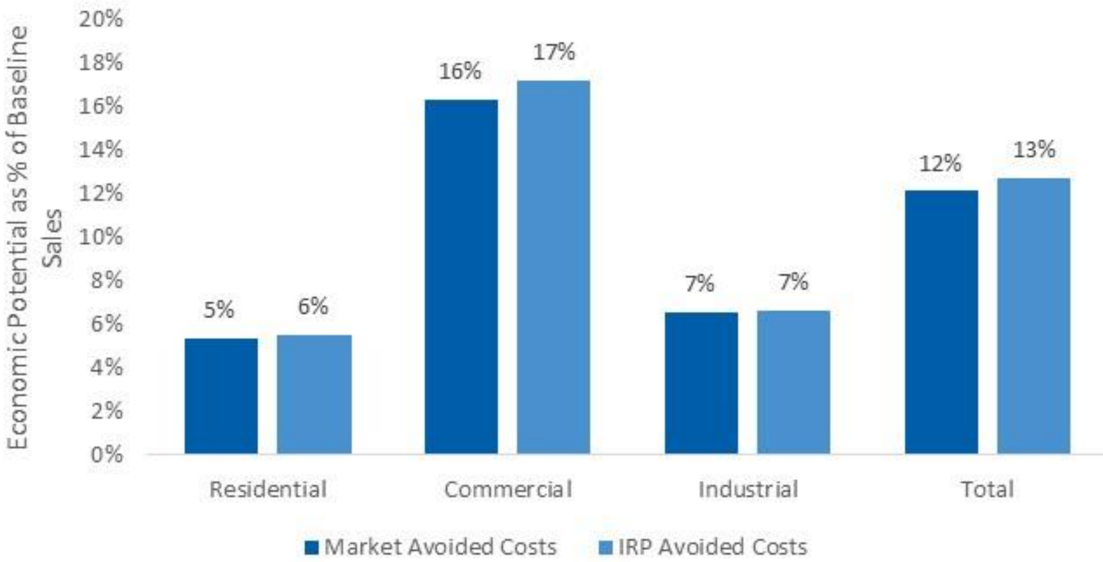

Figure 3. Economic Potential as a Fraction of Baseline Sales – 2037 Cumulative

Estimates of achievable potential and City Light's conservation target are based on the IRP avoided cost scenario. WAC 194-070 requires City Light to test multiple scenarios and incorporate risk into estimates of achievable potential. By using the higher IRP avoided-cost scenario instead of a scenario based on avoided costs that reflect market prices, Cadmus accounted for risk associated with market price forecasts.

1.3.3. Comparison to the 2016 CPA

Overall, the 2018 CPA identified lower technical, economic and achievable potential than the 2016 CPA. This section compares results from the two assessments and identifies reasons for the lower identified potential. The focus is on 20-year cumulative estimates of technical and economic potential, and incremental estimates of achievable economic potential. The factors that drive cumulative 20-year technical and economic potential lower are the same as those that drive achievable potential lower (because 20-year achievable potential generally 85 percent of economic potential). The main difference in achievable potential between the two studies is due to the application of different ramp rates.

Table 4 compares 20-year cumulative technical potential, by sector, from the 2016 and 2018 CPAs.

TABLE 4. TECHNICAL POTENTIAL COMPARISON

Sector	2018 CPA			2016 CPA		
	Baseline Sales - 20 Year (aMW)	Technical Potential - 20 Year (aMW)	Technical Potential as % of Baseline Sales	Baseline Sales - 20 Year (aMW)	Technical Potential - 20 Year (aMW)	Technical Potential as % of Baseline Sales
Residential	336	85	25%	370	121	33%
Commercial	747	180	24%	740	226	31%
Industrial	150	13	9%	208	12	6%
Street Lighting	10	1	12%	10	2	22%
Total	1,242	279	22%	1,328	362	27%

The 2018 CPA identified 279 aMW of technical potential, compared to 362 aMW in the 2016 CPA. This decrease is almost entirely due to changes in the residential and commercial sectors. Changes that contribute to lower technical potential include:

- **Lower residential baseline load forecasts**: Residential baseline forecasts were approximately 10 percent lower in the 2018 CPA, compared to baseline forecasts in the 2016 CPA. This contributed to a similar decrease in residential achievable technical potential.
- **Lower residential lighting, water heating and home electronics potential due to high naturally occurring savings and savings from residential equipment standards:** The 2018 CPA incorporated stock assessment and unit shipment data which indicates high saturations of light-emitting diode (LED) lighting and ENERGY STAR home electronics. Also, while heat pump water heaters were marginally cost-effective in the 2016 CPA, they did not pass the economic screening in the 2018 CPA. These factors contributed to lower residential achievable economic potential.
- **Lower unit energy savings for commercial lighting measures due to updates to baselines and savings analysis:** Commercial lighting baselines were more efficient, compared to the 2016 CPA, due to a higher penetration of LED lighting and the impact of 2018 lighting standards.

We discuss each of these factors in detail in the Comparison to 2016 CPA section of this report. Table 5 compares economic potential for the IRP preferred avoided cost scenario in the 2018 and 2016 CPAs.

TABLE 5. ECONOMIC POTENTIAL COMPARISON						
	2018 CPA (IRP Avoided Costs)			2016 CPA (IRP Avoided Costs)		
Sector	Economic Potential - 20 Year (aMW)	EP as % of Baseline Sales	Economic as a % of Technical Potential	Economic Potential - 20 Year (aMW)	Economic Potential as % of Baseline Sales	Economic Potential as % of Baseline Sales
Residential	21	6%	25%	59	16%	49%
Commercial	131	17%	72%	186	25%	82%
Industrial	10	7%	77%	10	5%	84%
Street Lighting	1	12%	100%	2	22%	100%
Total	163	13%	58%	257	19%	71%

The 2018 CPA identified 163 aMW of economic potential, compared to 257 aMW in the 2016 CPA. Lower avoided costs contributed to a decrease in economic potential in the residential, commercial and industrial sectors.[7] However, the residential sector had the most pronounced decline in economic potential. The decrease is almost entirely due to one measure—heat pump water heaters. This measure had benefit-cost ratios slightly above 1.0 in the 2016 CPA and are not cost-effective in the 2018 CPA.

As with assessments of technical and economic potential, Cadmus identified lower 20-year cumulative achievable economic potential. Because 20-year cumulative achievable potential is a subset of economic potential, the factors that contributed to lower cumulative achievable potential are the same as those previously discussed for economic potential. While the 2018 CPA identified lower 20-year cumulative achievable potential than the 2016, incremental achievable potential in the early years of the 20-year horizon are comparable. Figure 4 shows incremental achievable economic potential from the 2018 and 2016 CPAs.

[7] This is in addition to the factors that contributed to lower technical potential.

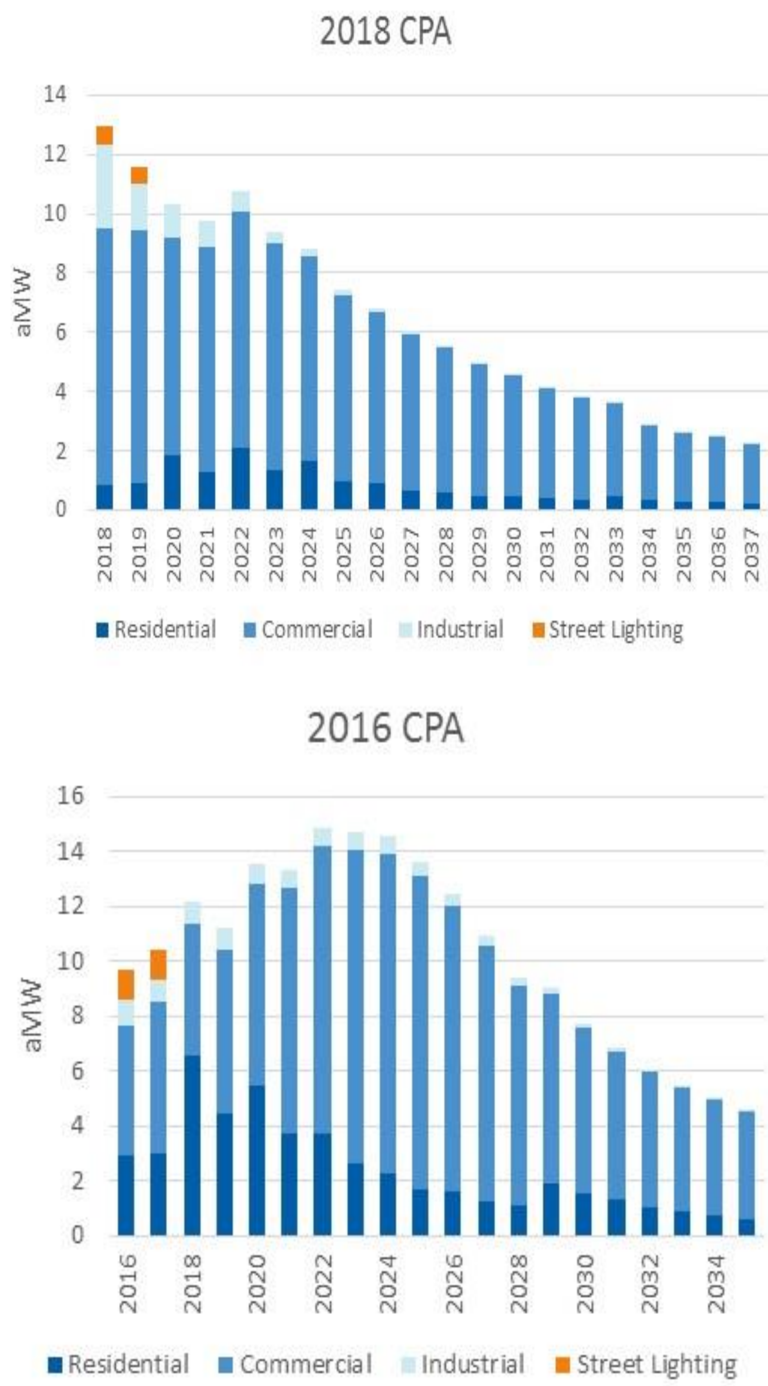

Figure 4. Incremental Achievable Potential – 2018 and 2016 CPAs

Figure 50 and Figure 51 illustrates how, compared to the 2016 CPA, the 2018 CPA determines that a higher proportion of the total available potential will be realized in the early years of the study. This change is due to a couple factors: the shift in the timeframe (moving from a start year of 2016 to 2018) and the application of faster ramp rates. Cadmus reviewed City Light's recent program accomplishments adjusted ramp rates for each measure to align incremental achievable potential with the first few years of the study with City Light's recent program data. Generally, this involved starting with the Seventh Power Plan ramp rate for each measure, then selecting the next-fastest ramp rate. This resulted in achieving a higher proportion of long-term potential in the early years of the study, as illustrated in Figure 5.

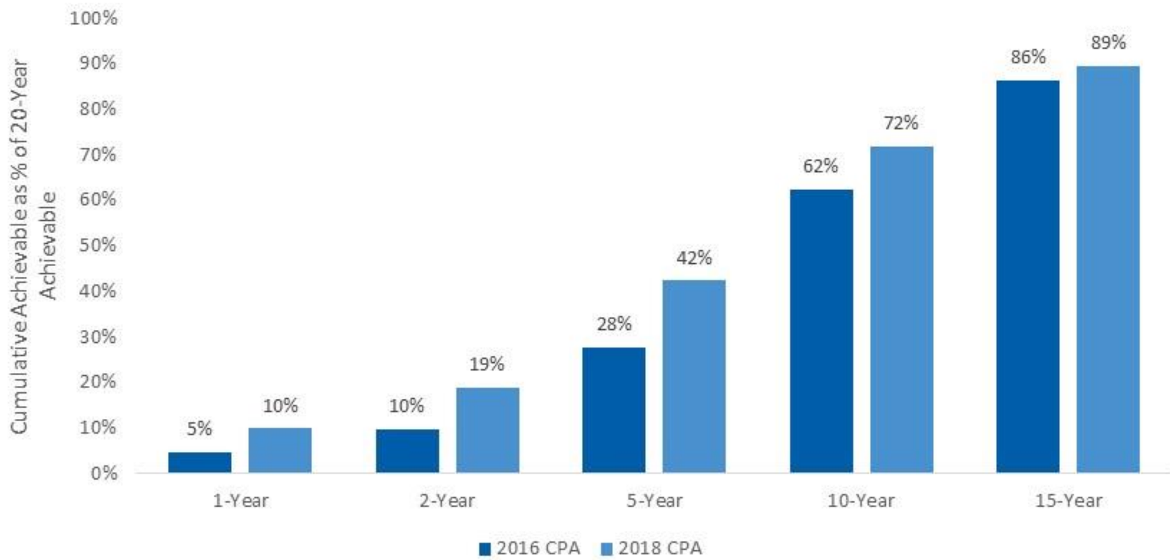

Figure 5. Cumulative Achievable Potential as % of 20-Year Achievable

1.4. Organization of this Report

This report presents the study's finding in two volumes. Volume I—this document—presents the methodologies and findings. Volume II contains the appendices and provide detailed study results and supplemental materials.

Volume I include the following sections:

- **Methodology** provides an overview of the methodology Cadmus used to estimate technical, economic and achievable economic potential. This section also includes a discussion of Cadmus' approach to the following:
  - **Developing Baseline Forecasts** provides an overview of Cadmus' approach to produce baseline end use forecasts for each sector.
  - **Measure Characterization** describes Cadmus' approach for developing a database of energy conservation measures, from which were derived estimates of conservation potential. This section discusses how Cadmus adapted measure data from the Seventh Power Plan, RTF, and other sources for this study.
  - **Estimating Conservation Potential** discusses assumptions and the underlying equations used to calculate technical, economic and achievable economic potential.
- **Baseline Forecasts** provides detailed sector-level results for Cadmus' baseline end-use forecasts.
- **Energy Efficiency Potential** provides detailed sector, segment and end-use specific estimates of conservation potential, as well as discussion of the top-saving measures in each sector.
- **Comparison to 2016 CPA** shows how this study's results (the 2018 CPA) compare to City Light's prior CPA.

Volume II includes the following sections:

- Appendix A: Washington Initiative 937 (I-937) Compliance Documentation
- Appendix B: Baseline Data
- Appendix C: Energy Efficiency Measure Descriptions
- Appendix D: Detailed Assumptions and Energy Efficiency Potential
- Appendix E: Measure Details

2. Methodology

2.1. Overview of Methodology

Estimating conservation potential draws upon a sequential analysis of various ECMs in terms of technical feasibility (technical potential), cost-effectiveness (economic potential) and expected market acceptance, considering normal barriers possibly impeding measure implementation (achievable economic potential).

Cadmus' assessment took the following primary steps:

- **Baseline forecasting** which involved determining 20-year future energy consumption by sector, market segment and end use. The study calibrated the base year, 2017, to City Light's sector load forecasts. Baseline forecasts presented in this report include Cadmus' estimated impacts of naturally occurring potential.[8]
- **Estimation of technical potential** based on alternative forecasts that reflected technical impacts of specific energy efficiency measures.
- **Estimation of economic potential** based on alternative forecasts that reflected technical impacts of cost-effective ECMs.
- **Estimation of achievable economic potential** calculated by applying ramp rates and an achievability percentage to the economic potential which this section describes in detail.

This approach offered two advantages:

- First, savings estimates would be driven by a baseline calibrated to City Light's forecasted sales—2017 through 2037. Other approaches may simply generate the total potential by summing estimated impacts of individual measures. This can result in total savings estimates representing unrealistically high or low baseline sales percentages.
- Second, the approach maintained consistency among all assumptions underlying the baseline and alternative—technical, economic and achievable technical—forecasts. The alternative forecasts changed relevant inputs at the end-use level to reflect ECM impacts. As estimated savings represented the difference between baseline and alternative forecasts, they could be directly attributed to specific changes made to analysis inputs.

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8 Cadmus' baseline forecast accounted for codes and standards not embedded in City Light's load forecast. Due to these adjustments, 2037 baseline sales presented in this report may not match City Light's official load forecast.

Cadmus' general methodology can be best described as a combined top-down/bottom-up approach. As shown in Figure 6, the top-down component began with the most current load forecast, adjusting for building codes, equipment efficiency standards and market trends the forecast did not account for; then disaggregated this load forecast into its constituent customer sector, customer segment, and end-use components. The bottom-up component considered potential technical impacts of various ECMs and practices on each end use. Impacts could then be estimated, based on engineering calculations and accounting for fuel shares, current market saturations, technical feasibility and costs.

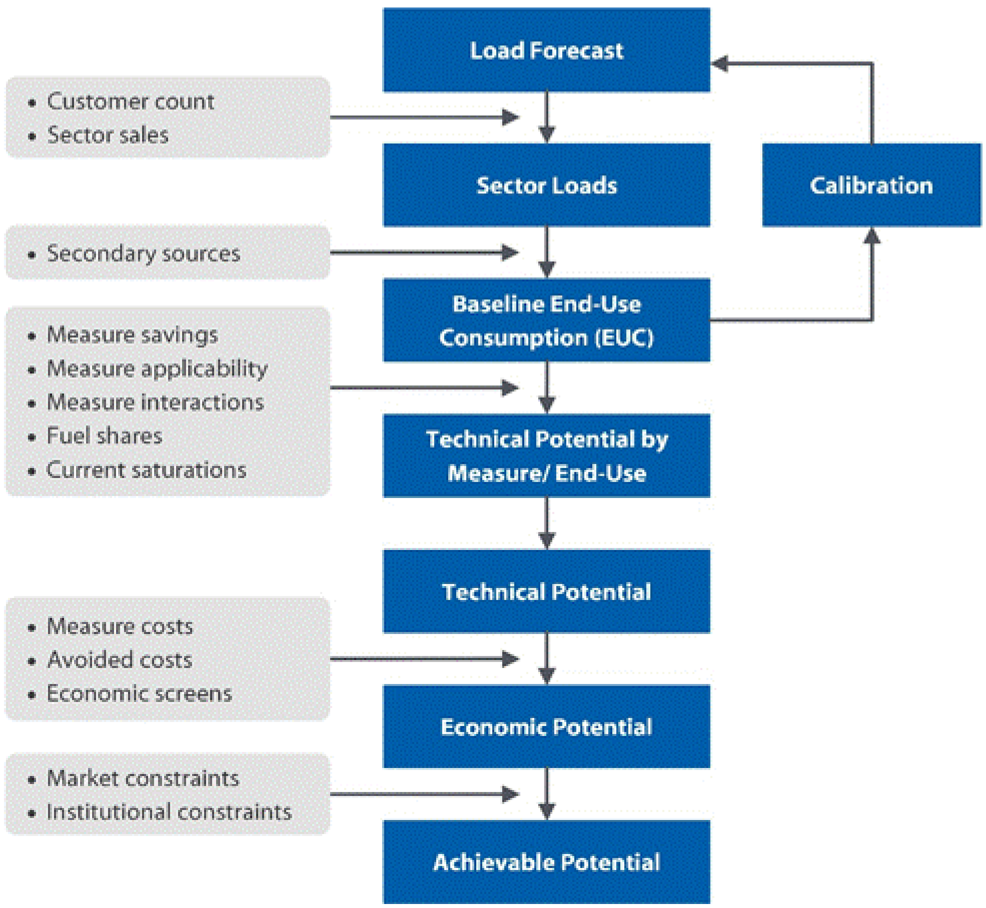

Figure 6. General Methodology for Assessment of Conservation Potential

2.2. Developing Baseline Forecasts

City Light's sector-level sales and customer forecasts provided the basis for assessing energy efficiency potential. Prior to estimating potential, the study disaggregated sector-level load forecasts by customer segment—business, dwelling, or facility types—building vintage—existing structures and new construction—and end uses—all applicable end uses in each customer sector and segment.

The first step in developing the baseline forecasts determined the appropriate customer segments within each sector. Designations drew upon categories available in key data sources used in the study, primarily City Light's nonresidential customer database for the C&I sectors and the U.S. Census Bureau's American

Community Survey for the residential sector, followed by mapping appropriate end uses to relevant customer segments.

Once appropriate customer segments and end uses were determined for each sector, the study produced the baseline end-use forecasts, based on integration of current and forecasted customer counts with key market and equipment usage data.

For the commercial and residential sectors, calculating total baseline annual consumption for each end use in each customer segment using the following equation:

$$EUSE_{ij} = \Sigma_e\ ACCTS_i * UPA_i * SAT_{ij} * FSH_{ij} * ESH_{ije} * EUI_{ije}$$

Where:

$EUSE_{ij}$	=	total energy consumption for end use *j* in customer segment *i*
$ACCTS_i$	=	the number of accounts/customers in customer segment *i*
UPA_i	=	units per account in customer segment *i* (UPA_i generally equaling the average square feet per customer in commercial segments, and 1.0 in residential dwellings, assessed at the whole-home level)
SAT_{ij}	=	the share of customers in customer segment *i* with end use *j*
FSH_{ij}	=	the share of end use *j* of customer segment *i* served by electricity
ESH_{ije}	=	the market share of efficiency level *e* in equipment for customer segment and end use *ij*
EUI_{ije}	=	end-use intensity: energy consumption per unit (per square foot for commercial) for the electric equipment configuration *ije*

For each sector, total annual consumption could be determined as the sum of *EUSEij* across the end uses and customer segments; ensuring accuracy of the baseline forecasts depended on the calibration of end-use model estimates of total consumption to City Light's forecasted sales from 2017 through 2037.

Consistent with other conservation potential studies, and commensurate with industrial end-use consumption data—which varied widely in quality—allocating the industrial sector's loads to end uses in various segments drew upon data available from the U.S. Department of Energy (DOE) Energy Information Administration.[9] Street lighting loads were allocated based on City Light's data regarding the number of fixtures present in their service territory.

9 U.S. Department of Energy, Energy Information Administration. *Manufacturing Energy Consumption Survey*. 2006.

2.2.1. Derivation of End-Use Consumption

Estimates of end-use energy consumption by segment, end use and efficiency level (EUI_{ije}) provided one of the most important components in developing a baseline forecast. In the residential sector, the study based estimates on unit energy consumption, representing annual energy consumption associated with an end use; represented by a specific type of equipment, such as a central air conditioner or heat pump.

For the commercial sector, the study treated consumption estimates as end-use intensities, representing annual energy consumption per square foot served. The accuracy of these estimates proved critical—they accounted for weather and other factors, described below, that drove the differences among various segments.

For the industrial sector, end-use energy consumption represented total annual industry consumption by end use, as allocated by the secondary data described above.

2.3. Measure Characterization

Because technical potential drew upon an alternative forecast, reflecting installation of all technically feasible measures, selecting appropriate ECMs to include in this study posed a central concern. To alleviate that concern and arrive at the most robust set of appropriate measures, Cadmus developed a comprehensive database of technical and market data for ECMs; these applied to all end uses in various market segments. This database included the following measures:

- All measures included in the Council's final Seventh Northwest Power Plan conservation supply curve workbooks.[10]
- Active RTF UES Measures[11]
- Particular technologies City Light identified as relevant to the study, such as enterprise data center, indoor agriculture and street lighting measures.

Cadmus only included Council and RTF measures applicable to sectors and market segments within City Light's service territory. For example, the study did not characterize measures for the agriculture sector or for the residential manufactured home segment because these represented a small fraction of City Light's customer mix.

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10 Conservation Supply Curve Workbooks. Available online at: https://www.nwcouncil.org/energy/powerplan/7/technical.

11 RTF UES Measures. Available online at: http://rtf.nwcouncil.org/measures/Default.asp.

Cadmus added measures if the RTF developed UES workbooks that were not included in the Seventh Power Plan. For the residential sector, these were:

- ENERGY STAR room air conditioners
- Residential refrigerator and freezer decommissioning
- Interior fluorescent high-performance T8 lamps

In the commercial sector, additional RTF measures were:

- Commercial refrigerator and freezer decommissioning
- Efficient commercial ice makers

After creating a list of electric energy efficiency measures applicable to City Light's service territories, Cadmus classified the measures into two categories:

- **High-efficiency equipment measures** directly affect end-use equipment—e.g., high-efficiency domestic water heaters—which follow normal replacement patterns based on expected lifetimes.
- **Non-equipment (retrofit) measures** affect end-use consumption without replacing end-use equipment—e.g., insulation. Such measures do not include timing constraints from equipment turnover—except for new construction—and should be considered discretionary as savings can be acquired at any point over the planning horizon.

The following are the relevant inputs for each measure type.

Equipment and non-equipment measures:

- **Energy savings:** average annual savings attributable to installing the measure, in absolute and/or percentage terms.
- **Equipment cost:** full or incremental, depending on the nature of the measure and the application.
- **Labor cost:** the expense of installing the measure, accounting for differences in labor rates by region, urban versus rural areas and other variables.
- **Technical feasibility:** the percentage of buildings where customers can install this measure, accounting for physical constraints.
- **Measure life:** the expected life of the measure equipment.

Non-equipment measures only:

- **Technical feasibility:** the percentage of buildings where customers can install this measure, accounting for physical constraints.
- **Percentage incomplete:** the percentage of buildings where customers have not installed the measure, but where it is technically feasible to install. This equals 1.0 minus the current saturation of the measure.
- **Measure competition:** for mutually exclusive measures, accounting for the percentage of each measure likely installed to avoid double-counting savings.
- **Measure interaction:** accounting for end-use interactions—e.g., a decrease in lighting power density causing heating loads to increase.

Cadmus derived these inputs from various sources, though primarily from the following:

- Northwest Energy Efficiency Alliance's (NEEA) CBSA, including City Light's oversample
- NEEA's RBSA
- The Council's Seventh Power Plan supply curve workbooks
- The RTF's UES measure workbooks

For many equipment and non-equipment inputs, Cadmus reviewed a variety of sources. To determine which source to use for this study, Cadmus developed the following hierarchy for costs and savings:

- The Council's Seventh Power Plan supply curve workbooks
- RTF UES measure workbooks
- Various secondary sources, such as American Council for an Energy-Efficient Economy work papers, Simple Energy and Enthalpy Model (SEEM) building simulations, or various technical reference manuals

Cadmus also developed a hierarchy to determine the source for various applicability factors, such as the technical feasibility and the percentage incomplete. This hierarchy differed slightly for residential and commercial measure lists. Generally, the study sought to achieve 90 percent confidence with a ± 10 percent precision for each estimate.

For residential estimates, Cadmus relied on City Light's oversample in NEEA's 2016 RBSA. If City Light's subset included an insufficient sample to achieve 90 percent confidence with a ±10 percent precision for a given estimate, estimates were derived from the sample of Puget Sound-area customers—e.g., City Light, Puget Sound Energy, Snohomish County Public Utility District and Tacoma Power—or for the broader Northwest found in the RBSA. If we could not calculate applicability factors from NEEA's RBSA, applicability factors from the Council's Seventh Power Plan workbooks were used. These estimates reflected averages for the Northwest region and were not necessarily specific to City Light's service territory.

For the commercial sector, Cadmus first used the subset of City Light's customers, including City Light's and the Bonneville Power Administration's oversample in NEEA's CBSA. If NEEA's CBSA had an insufficient number of customers to achieve estimates with 80 percent confidence with a ± 20 percent precision for a given building type, Cadmus developed estimates from the sample of urban buildings in the regional CBSA data. If NEEA's CBSA did not include sufficient data to estimate an applicability factor for a given measure, Cadmus relied on factors from the Council's Seventh Power Plan supply curve workbooks.

Table 6 lists the primary sources referenced in this study, per data input.

TABLE 6. KEY MEASURE DATA SOURCES

Data	Residential Source	Commercial Source	Industrial Source
Energy savings	Seventh Power Plan supply curve workbooks; RTF; Cadmus research	Seventh Power Plan supply curve workbooks; RTF; Cadmus research	Seventh Power Plan supply curve workbooks; RTF; DOE Industrial Assessment Center database; Cadmus research
Equipment and labor costs	Seventh Power Plan supply curve workbooks; RTF; Cadmus research	Seventh Power Plan supply curve workbooks; RTF; Cadmus research	Seventh Power Plan supply curve workbooks; RTF; DOE Industrial Assessment Center database; Cadmus research
Measure life	Seventh Power Plan supply curve workbooks; RTF; Cadmus research	Seventh Power Plan supply curve workbooks; RTF; Cadmus research	Seventh Power Plan supply curve workbooks; RTF; DOE Industrial Assessment Center database; Cadmus research
Technical feasibility	NEEA RBSA; Cadmus research	NEEA CBSA; Cadmus research	Cadmus research; Industrial Council data; NEEA Industrial Facilities Site Assessment (IFSA)
Percentage incomplete	NEEA RBSA; City Lights program accomplishments; Cadmus research	NEEA CBSA; City Lights program accomplishments; Cadmus research	Cadmus research; Industrial Council data; NEEA IFSA
Measure interaction	Seventh Power Plan supply curve workbooks; RTF; Cadmus research	Seventh Power Plan supply curve workbooks; RTF; Cadmus research	Cadmus research

2.3.1. Incorporating Codes and Standards

Cadmus' assessment accounted for changes in codes and standards over the planning horizon. These changes not only affected customers' energy-consumption patterns and behaviors, they also determined which energy efficiency measures would continue to produce savings over minimum requirements. Cadmus captured current efficiency requirements, including those enacted but not yet in effect.

Cadmus did not attempt to predict how energy codes and standards might change in the future. Rather, the study factored in only legislation that had already been enacted—notably, the Energy Independence and Security Act of 2007 (EISA) provisions slated to take effect over the course of the analysis. EISA requires that general service lighting become approximately 30 percent more efficient than current incandescent technology, with standards phased in by wattage from 2012 to 2014. In addition, EISA includes a backstop provision that requires even higher-efficiency technologies beginning in 2020.

Cadmus explicitly accounted for several other pending federal codes and standards. For the residential sector, these included appliance, HVAC and water-heating standards. For the commercial sector, these included appliance, HVAC, lighting, motor and water heating standards. Figure 7 provides a comprehensive list of equipment standards considered in this study.[12] Bars indicate the year in which a new equipment standard will be enacted—some products will be subject to multiple standards over the planning horizon.

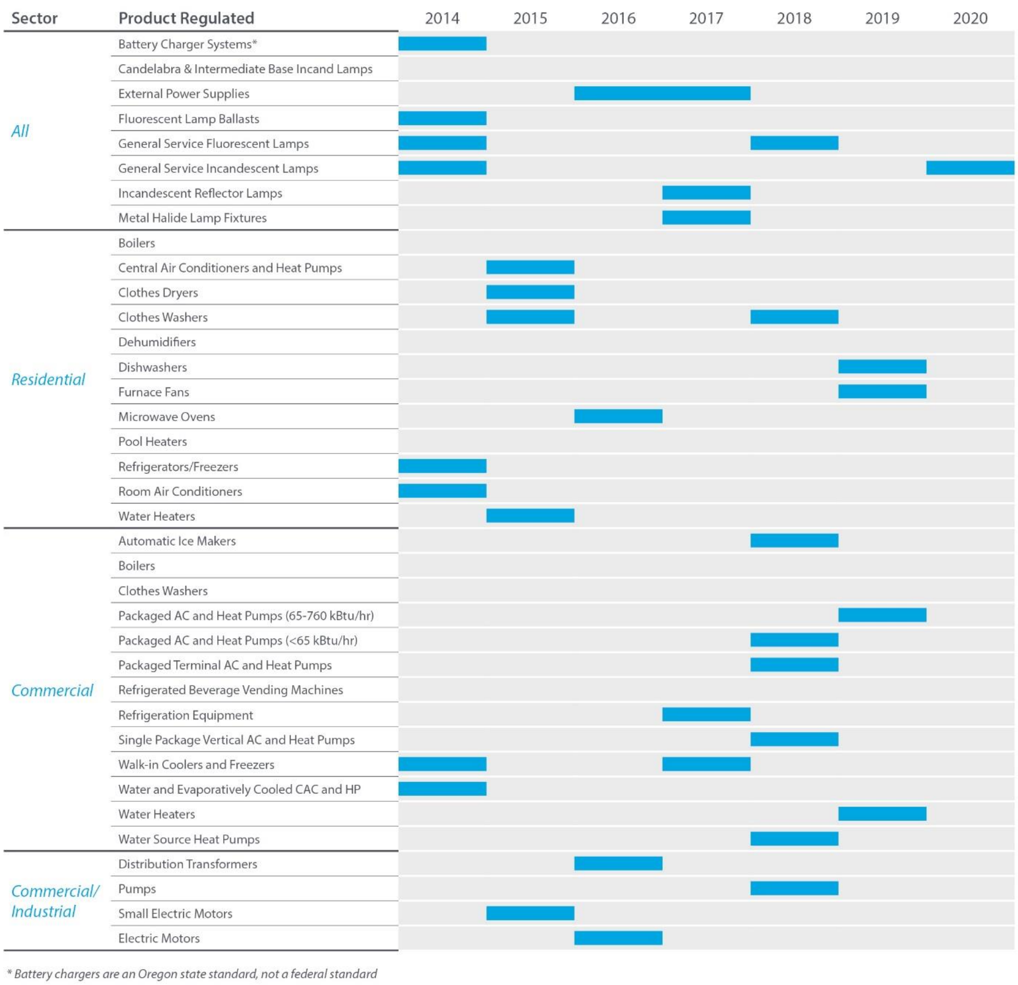

Figure 7. Equipment Standards Considered

12 All applicable standards enacted prior to 2014 have been accounted for, such as the 2013 commercial clothes washer standard, the 2012 lighting general service fluorescent lamp standard, the 2012 lighting incandescent reflector lamp standard, the 2012 dehumidifier standard, the 2012 cooking oven and range standard, the 2010 icemaker standard and the 2010 electric motor standard.

To ensure the accurate assessment of the remaining potential, Cadmus accounted for the effects of future standards. Based on a strict interpretation of the legislation, we assumed customers would replace affected equipment with more efficient alternatives that would meet minimum federal standards. In other words, we assumed complete compliance.

2.3.2. Adapting Measures from the RTF and Seventh Power Plan

To ensure consistency with methodologies employed by the Council and to fulfill requirements of WAC 194-37-070, Cadmus relied on ECM workbooks developed by the RTF and the Council to estimate measure savings, costs and interactions. In adapting these ECMs for this study, Cadmus adhered to the following principles:

- **Deemed ECM savings in RTF or Council Workbooks must be preserved:** As City Light relies on deemed savings estimates provided by the Bonneville Power Administration that largely remains consistent with savings in RTF workbooks to demonstrate compliance with I-937 targets, Cadmus sought to preserve these deemed savings in the potential study. Doing so avoided possible inconsistencies between estimates of potential, targets and reported savings.
- **Use inputs specific to City Light's service territory:** Some Council and RTF workbooks relied on regional estimates of saturations, equipment characteristics and building characteristics derived from RBSA and CBSA. Cadmus updated regional inputs with estimates calculated from either City Light's oversample of CBSA and RBSA or on estimates from the broader Puget Sound area. This approach preserved consistency with Council methodologies while incorporating Seattle-specific data

Cadmus' approach for adapting Council and Seventh Plan workbooks varied by sector, as described in the following sections.

2.3.2.1 Residential and Commercial

Cadmus reviewed each residential Council workbook and extracted savings, costs, and measure lives for inclusion in this study. Applicability factors (such as the current saturation of an ECM) largely derived from City Light's oversample of RBSA, adjusted for City Lights program accomplishments. If Cadmus could not develop a City Lights-specific applicability factor from RBSA, it used the Council's regional value.

In addition to extracting key measure characteristics, Cadmus identified each measure as an equipment replacement measure or a retrofit measure. Key distinctions between these two types of measures included the following:

- **Savings for equipment replacement measures** were calculated as the difference between the measure consumption and baseline consumption. For instance, concerning the heat pump water heater measure, Cadmus estimated the baseline consumption of an average market water heater and used deemed Council savings to calculate the consumption for a heat pump water heater. This approach preserved deemed savings found in Council workbooks.

- **Savings for retrofit measures** were calculated in percentage terms relative to the baseline end-use consumption, yet reflected deemed Council and RTF values. For instance, if the Council deemed savings of 1,000 kilowatt-hour (kWh) per home for a given retrofit measure and Cadmus estimated the baseline consumption for the end use to which this measure was applicable as 10,000 kWh, relative savings for the measure were 10 percent. Cadmus did not apply relative savings from the Council's workbooks to baseline end-use consumption; doing so would lead to per-unit estimates that differed from Council and RTF values.

Cadmus also accounted for interactive effects included in Council and RTF workbooks. For instance, the Council estimated water heating, heating and cooling savings for residential heat pump water heaters—with the heating and cooling savings as the interactive savings. Because installation of a heat pump water heater represented a single installation, Cadmus employed a stock accounting model, which combined interactive and primary end-use effects into one savings estimate. Though Cadmus recognized this approach could lead to overstating or understating savings in end use, in aggregate—across end uses—savings matched deemed Council values.

Cadmus generally followed the same approach with the commercial sector; however, because of the mixture of measures considered in the Seventh Power Plan, Cadmus chose to model all commercial measures as retrofits and none as equipment replacements. Although many commercial measures represent equipment improvements, commercial building operators often replace these measures before the end of their effective useful life (EUL). Savings and costs for these measures reflected this decision.

2.3.2.2 Industrial

Cadmus adapted measures from the Council's Industrial_tool_7thPlan_v09 workbook for inclusion in this study; the workbook defined values for the following key industrial measure inputs:

- Measure savings (expressed as end-use percentage savings)
- Measure costs (expressed in dollar per kWh saved)
- Measure lifetimes (expressed in years)
- Measure applicability (percentage)

Cadmus mapped each Council industry type to industries found in City Light's service territory. These industries included foundries, miscellaneous manufacturing, stone and glass, transportation equipment manufacturing, other food, frozen food, water and wastewater. Cadmus identified applicable end uses using the Council's assumed distribution of end-use consumption in each industry. Table 7 shows the distribution of end-use consumption and the list of industries considered in this study.

TABLE 7. DISTRIBUTION OF END USE CONSUMPTION BY SEGMENT

Cadmus Segment	Process Aircomp	Lighting	Fans	Pumps	Motors Other	Process Other	Process Heat	HVAC	Other	Process Electro Chemical	Process Refrigeration
Foundries	7%	9%	10%	18%	6%	0%	21%	9%	1%	6%	14%
Frozen Food	4%	9%	4%	8%	16%	0%	4%	8%	6%	3%	39%
Other Food	6%	5%	28%	5%	16%	0%	0%	1%	6%	19%	15%
Transportation, Equip	6%	15%	6%	8%	14%	0%	11%	19%	12%	4%	5%
Misc. Manufacturing	7%	11%	7%	10%	16%	0%	12%	17%	9%	5%	5%
Water	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
Wastewater	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
Stone and Glass	9%	5%	8%	14%	22%	3%	22%	6%	3%	0%	7%

To incorporate broader secondary data, Cadmus aggregated some Council end uses into broader end uses. Table 8 shows the mapping of Council end uses to Cadmus end uses.

TABLE 8. COUNCIL AND CADMUS END USES	
Council End Use	**Cadmus End Use**
Pumps	Pumps
Fans and Blowers	Fans
Compressed Air	Process Aircomp
Material Handling	Process Electro Chemical
Material Processing	Motors Other
Low Temp Refer	Process Refrig
Med Temp Refer	Process Refrig
Pollution Control	Other
Other Motors	Motors Other
Drying and Curing	Process Heat
Heat Treating	Process Heat
Heating	Process Heat
Melting and Casting	Process Heat
HVAC	HVAC
Lighting	Lighting
Other	Other

2.4. Estimating Conservation Potential

As discussed, Cadmus estimated three types of conservation potential, as shown in Figure 8.

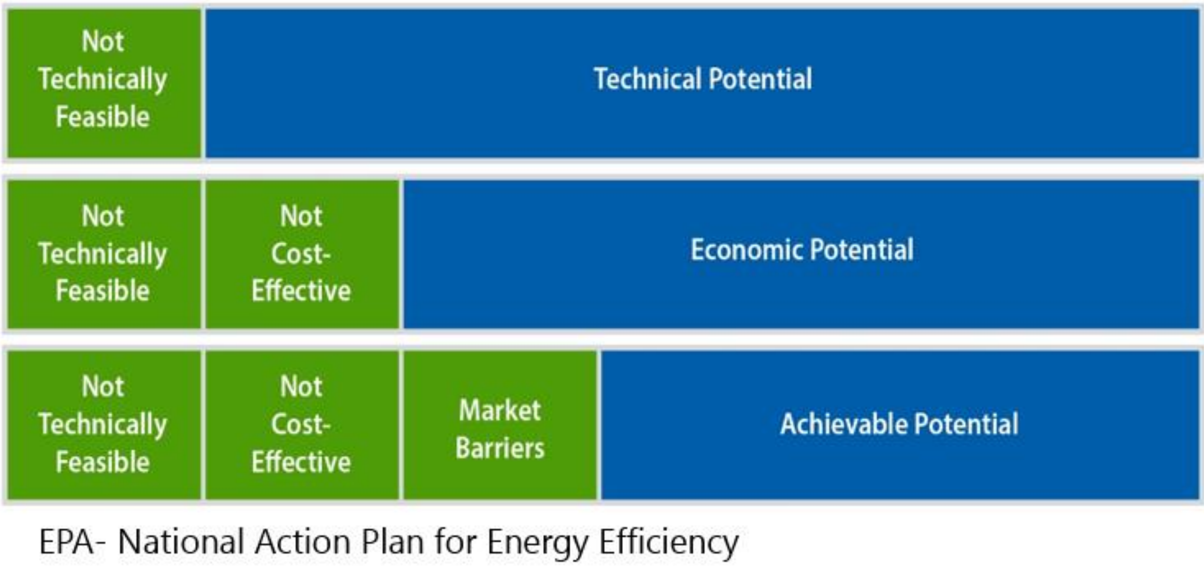

Figure 8. Types of Conservation Potential

The following sections describe Cadmus' approach to estimating each type of potential.

2.4.1. Technical Potential

Technical potential includes all technically feasible ECMs, regardless of costs or market barriers. Technical potential divides into two classes: discretionary—retrofit—and lost opportunity—new construction and replacement of equipment on burnout.

Another important aspect in assessing technical potential is, wherever possible, to assume installation of the highest-efficiency equipment. For example, this study examined compact fluorescent lamp (CFL) and LED general service lighting in residential applications and, in assessing technical potential, assumed that, as equipment fails or new homes are built, customers will install LED lighting wherever technically feasible, regardless of cost. Where applicable, CFLs would be assumed installed in sockets ineligible for LEDs. This study treated competing non-equipment measures the same way, assuming installation of the highest-saving measures where technically feasible.

In estimating technical potential, one cannot merely sum up savings from individual measure installations. Significant interactive effects can result from the installation of complementary measures. For example, upgrading a heat pump in a home where insulation measures have already been installed can produce fewer savings than upgrades in an uninsulated home. Analysis of technical potential accounts for two types of interactions:

- **Interactions between equipment and non-equipment measures:** As equipment burns out, technical potential assumes it will be replaced with higher-efficiency equipment, reducing average consumption across all customers. Reduced consumption causes non-equipment measures to save less than they would have had equipment remained at a constant average efficiency. Similarly, savings realized by replacing equipment decrease upon installation of non-equipment measures.
- **Interactions between non-equipment measures:** Two non-equipment measures applying to the same end use may not affect each other's savings. For example, installing a low-flow shower head does not affect savings realized from installing a faucet aerator. Insulating hot water pipes, however, would cause water heaters to operate more efficiently, thus reducing savings from either measure. This study accounted for such interactions by stacking interactive measures—iteratively reducing baseline consumption as measures were installed, thus lowering savings from subsequent measures.

Although theoretically, all retrofit opportunities in existing construction—often called discretionary resources—could be acquired in the study's first year, this would skew the potential for equipment measures and provide an inaccurate picture of measure-level potential. Therefore, the study assumed these opportunities would be realized in equal, annual amounts, over the 20-year planning horizon. By applying this assumption, natural equipment turnover rates, and other adjustments described above, the annual incremental and cumulative potential could be estimated by sector, segment, construction vintage, end use and measure.

This study's estimates of technical potential drew upon best-practice research methods and standard analytic techniques in the utility industry. Such techniques remained consistent with conceptual approaches and methodologies used by other planning entities, such as those of the Council in developing regional energy-efficiency potential, and remained consistent with methods used in City Light's previous CPAs.

2.4.2. Economic Potential

Economic potential represents a subset of technical potential, consisting only of measures meeting cost-effectiveness criteria based on City Light's avoided supply costs for delivering electricity. Adherent to WAC 194-37-070, Cadmus used the TRC to identify cost-effective measures in a manner consistent with the Council. Table 9 summarizes benefits and costs considered in the calculation of benefit-cost ratios.

TABLE 9. TRC BENEFITS AND COSTS

Type	Component
Costs	Incremental Measure Equipment and Labor Cost
	Incremental O&M Cost [a]
	Administrative Adder
Benefits	Avoided supply ($/kWh)
	Present Value of Non-Energy Benefits
	Present Value of T&D Deferrals ($/kW)
	10% Conservation Credit
	Secondary Energy Benefits

[a] Some measures may have a reduction in O&M costs, which is effectively treated as a benefit in the levelized cost calculation.

- **Incremental measure cost:** This study considered costs required to sustain savings over a 20-year horizon, including reinstallation costs for measures with useful lives less than 20 years. If a measure's useful life extended beyond the end of the 20-year study, Cadmus incorporated an end effect that treated the measure's cost over its EUL[13] as an annual reinstallation cost for the remainder of the 20-year period.[14]
- **Incremental operations and maintenance (O&M) costs or benefits:** As with incremental measure costs, O&M costs were considered annually over the 20-year horizon. Cadmus used the present value to adjust the levelized cost upward for measures with costs above baseline technologies and downward for measures that decrease O&M costs.
- **Administrative adder:** Cadmus assumed program administrative costs of 20 percent in the residential sector and 23 percent for the commercial and industrial sectors. These were based on City Light's actual 2015 program expenditures.

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13 This refers to levelizing over the measure's useful life, equivalent to spreading incremental measure costs in equal payments, assuming a discount rate of City Light's weighted average cost of capital.

14 This method is applied to measures with a useful life of greater than 20 years and those with a useful life extending beyond the 20^{th} year at the time of reinstallation.

- **Non-energy benefits** were treated as a reduction in levelized costs for measures that saved resources, such as water or detergent. For example, the value of reduced water consumption from installing a low-flow shower head would reduce the levelized cost of that measure.
- **The regional 10 percent conservation credit, capacity benefits during City Light's system peak, and T&D deferrals** were similarly treated as reductions in levelized cost for electric measures. The addition of this credit, per the Northwest Power Act, was consistent with Council methodology and effectively served as an adder to account for unquantified external benefits of conservation when compared to other resources.[15]
- **Secondary energy benefits** were treated as a reduction in levelized costs for measures that saved energy on secondary fuels. This treatment was necessitated by Cadmus' end-use approach to estimating technical potential. For example, consider the cost of R-60 ceiling insulation for a home with a gas furnace and an electric cooling system. For the gas furnace end use, Cadmus classified energy savings that R-60 insulation produces for electric cooling systems, conditioned on the presence of a gas furnace, as a secondary benefit that reduced the levelized cost of the measure. This adjustment affected only the measure's levelized costs; the magnitude of energy savings for the R-60 measure on the gas supply curve was not affected by considering secondary energy benefits.

2.4.2.1 About Levelized Costs of Conserved Energy

In addition to benefit-cost ratios, the levelized cost of conserved energy had to be determined to characterize each measure-in-conservation supply curves. Where possible, the study aligned its approach for calculating levelized costs for each measure to the Council's levelized-cost methodology—levelized costs include all costs and benefits described above.

The approach to calculating a measure's levelized cost of conserved energy aligned with that of the Council, considering the costs required to sustain savings over a 20-year study horizon, including reinstallation costs for measures with useful lives less than 20 years. If a measure's useful life extended beyond the end of the 20-year study, Cadmus incorporated an end effect, treating the measure's levelized cost over its useful life as an annual reinstallation cost for the remainder of the 20-year period.[16] For example, Figure 9 shows the timing of initial and reinstallation costs for a measure with an eight-year lifetime, in context with the 20-year study. Because a measure's lifetime in this study ends after the study horizon, the final four years (Year 17 through Year 20) were treated differently, levelizing measure costs over the measure's eight-year life and treating these as annual reinstallation costs.

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15 Northwest Power & Conservation Council. *Northwest Power Act*. Available online: http://www.nwcouncil.org/library/poweract/default.htm.

16 This method applied to measures with a useful life greater than 20 years and those with useful lives extending beyond the twentieth year at the time of reinstallation.

FIGURE 9. ILLUSTRATION OF CAPITAL AND REINSTALLATION COST TREATMENT

	Year																			
Component	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Initial Capital Cost																				
Reinstallation Cost																	End Effect			

As with incremental measure costs, O&M costs were considered annually over the 20-year horizon. The present value was used to adjust the levelized cost upward for measures with costs above baseline technologies and downward for measures that decrease O&M costs.

2.4.3. Achievable Economic Potential

Achievable economic potential can be defined as the portion of technical potential expected to be reasonably achievable during a planning horizon. The quantity of energy efficiency potential that is realistically achievable depends on several factors, such as: the customers' willingness to participate in energy efficiency programs (partially as a function of incentive levels), retail energy rates and various market barriers that have historically impeded the adoption of energy efficiency measures and practices by consumers.[17] These barriers tend to vary, depending on the customer sector, local energy market conditions and other factors that are difficult to quantify.

The calculation of achievable technical potential, however, must assume a central tenet—that the amount of achievable technical potential is ultimately a function of the customers' willingness and ability to adopt energy efficiency measures. This information can best be ascertained through direct intel from potential participants.

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[17] Consumers' apparent unwillingness to invest in energy efficiency has been attributed to certain energy efficiency market barriers. A rich body of literature exists concerning the "market barriers to energy efficiency." In one such study, market barriers identified fell into five broad classes of market imperfections, thought to inhibit energy-efficiency investments: misplaced or split incentives; high upfront costs and a lack of access to capital; a lack of information and uncertainty concerning the benefits, costs, and risks of energy-efficiency investments; investment decisions guided by convention and custom; and time and "hassle" factors. For a discussion of these barriers, see: William H. Golove and Joseph H. Eto. *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy.* Lawrence Berkeley National Laboratory, University of California, Berkeley, California. LBL-38059. March 1996.

Although methods for estimating achievable technical potential vary across potential assessment efforts, two dominant approaches appear to be most widely utilized:

- **Option 1.** This approach assumes a hypothesized relationship between incentive levels and market penetration of energy efficiency programs. This achievable potential generally can be defined as that achieved solely through utility incentive programs. Often, it is based on an incentive level at 50 percent of the incremental cost.
- **Option 2.** This approach generally relies on a fixed percentage of technical potential that is based on past experiences with similar programs. In the Northwest, for example, the Council has historically assumed that, by the end of the 20-year assessment horizon, 85 percent of the economic potential could be achieved and would include savings from utility programs, market transformation and changes in codes and standards.

Consistent with the Council, this study used option two, assuming that up to 85 percent of economic potential could be acquired over the 20-year planning horizon. In addition to applying a fixed percentage, this study incorporated ramp rates to estimate annual achievable technical potential.

Developing sound utility IRPs requires knowledge of alternative resource options and reliable information on the long-run resource potential of achievable technologies. CPAs principally seek to develop reasonably reliable estimates of the magnitude, costs and timing of the resources that will likely be available over the planning horizon's course; they do not, however, provide guidance as to how or by what means identified resources might be acquired. For example, identified potential for electrical equipment or building shell measures might be attained through utility incentives, legislative action instituting more stringent efficiency codes and standards or by other means.

2.4.3.1 About Measure Ramp Rates

The study applied measure ramp rates to lost opportunity and discretionary resources, although interpretation and application of these rates differed for each class, as described below. Measure ramp rates generally matched those proposed for the Council's Seventh Power Plan. For measures not specified in the Seventh Power Plan, the study assigned a ramp rate considered appropriate for that technology—i.e., the same ramp rate as a similar measure in Sixth Power Plan or Seventh Power Plan.

Lost Opportunity Resources

Quantifying achievable economic potential for lost opportunity resources in each year required determining amounts technically available through new construction and natural equipment turnover. New construction rates drew directly from City Light's customer forecast. The study developed equipment turnover rates by dividing units into each year by the measure life. For example, if 100 units initially had a 10-year life, one-tenth of units (10) would be replaced. The following year, 90 units would remain, and one-tenth of these (9) would be replaced and so on over the study's course.

As the mix of existing equipment stock ages, the remaining useful life (RUL) would be, on average, one-half of the EUL.[18] The fraction of equipment turning over each year would be a function of this RUL; thus, the economic potential for lost opportunity measures would have an annual shape before application of any ramp rates, as shown in Figure 10. The same concept applied to new construction, where resource acquisition opportunities become available only during home or building construction. In addition to showing an annual shape, Figure 10 demonstrates that the amounts of equipment turning over during the study period are a function of the RUL: the shorter the RUL, the higher the percentage of equipment assumed to turn over.

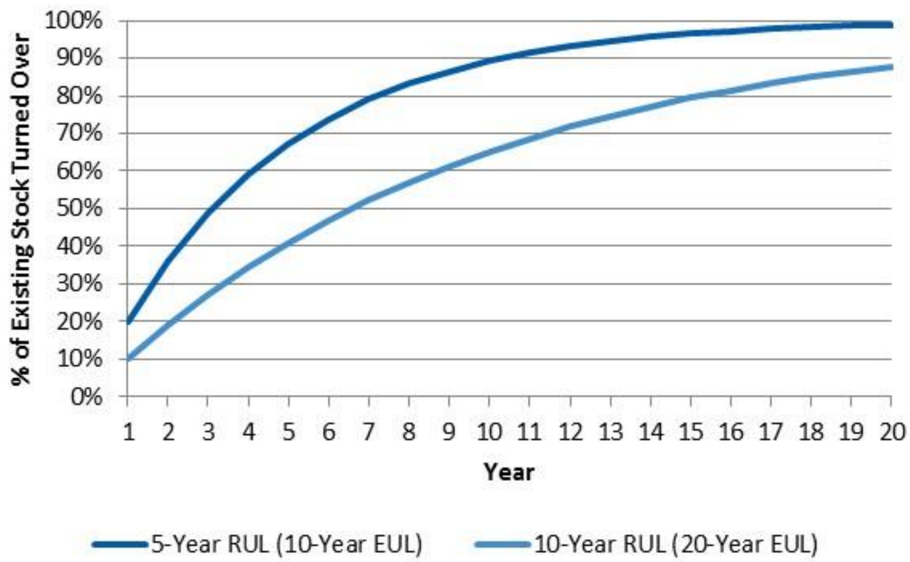

Figure 10. Existing Equipment Turnover for Varying RULs

In addition to natural timing constraints of equipment turnover and new construction rates, Cadmus applied measure ramp rates to reflect other resource acquisition limitations, such as market availability, over the study's horizon. These measure ramp rates had a maximum value of 85 percent, reflecting the Council's assumption that, on average across all measures, up to 85 percent of technical potential could be achieved over a 20-year planning horizon. As illustrated by Figure 11, a measure that ramps up over 10 years would reach full market maturity—85 percent of annual technical potential—by the end of that period, whereas another measure might take 20 years to reach full maturity.

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[18] EULs represented median lifetimes, defined as the year that one-half of measures installed remained in place and operable and one-half did not, as defined by the RTF: https://nwcouncil.app.box.com/v/OperativeGuidelines-20151208

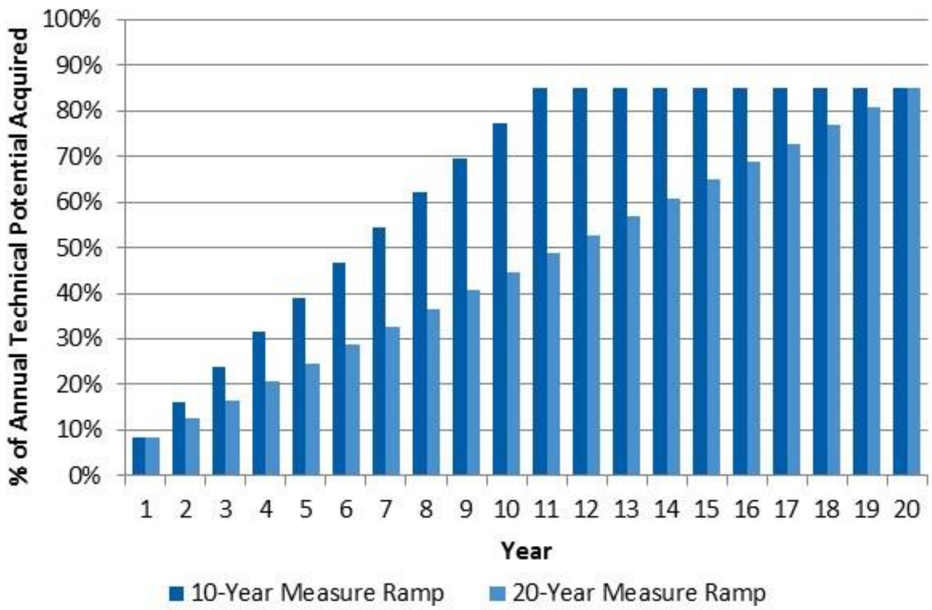


Figure 11. Examples of Lost Opportunity Measure Ramp Rates

To calculate annual achievable technical potential for each lost opportunity measure, Cadmus multiplied technical resource availability and measure ramping effects together, consistent with the Council's methodology. In the early years of the study horizon, a gap occurs between assumed acquisition and the 85 percent maximum achievability. These lost resources can be assumed as not available until the measure's EUL elapses. Therefore, depending on EUL and measure ramp rate assumptions, some potential may be pushed beyond the 20th year, and the total lost opportunity achievable economic potential may be less than 85 percent of economic potential.

Figure 12 shows a case for a measure with a five-year RUL/10-year EUL. The spike in achievable technical potential starting in year 2023—after the measure's EUL—resulting from acquisition of opportunities missed at the beginning of the study period.

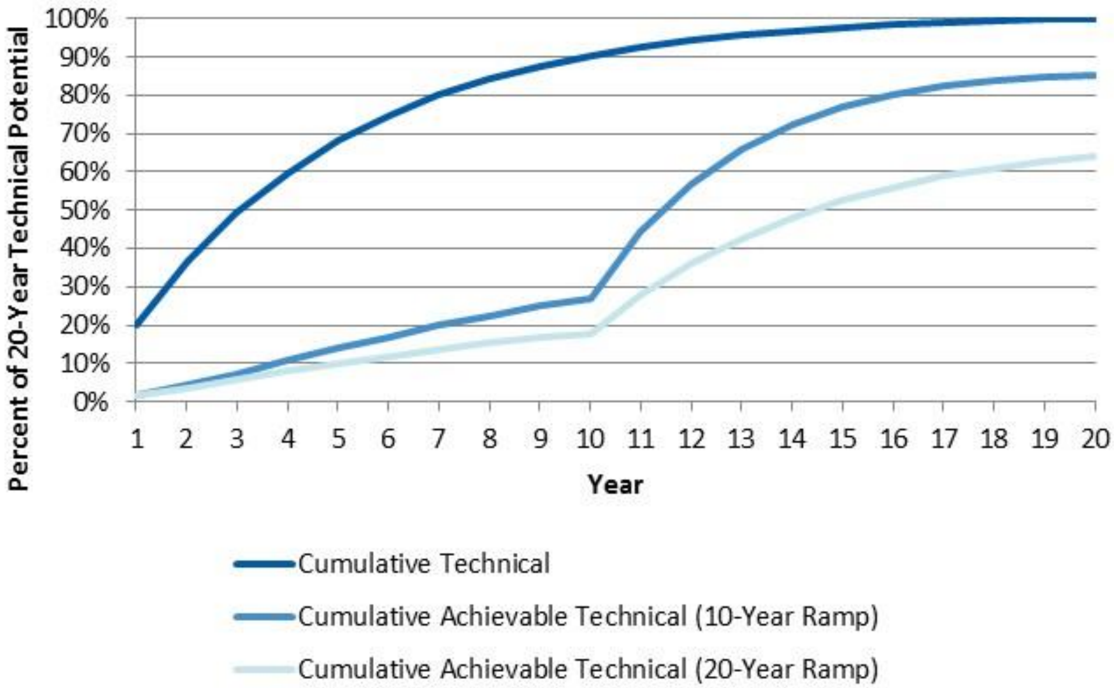


Figure 12. Example of Combined Effects of Technical Resource Availability and Measure Ramping Based on 10-Year EUL

Table 10 illustrates this method, based on the same five-year RUL/10-year EUL measure on a 10-year ramp rate (the light blue line in Figure 12), assuming 1,000 inefficient units would be in place by Year One. In the first 10 years, lost opportunities accumulate as the measure ramp-up rate caps availability of high-efficiency equipment. Starting in the 11th year, the opportunities that were lost 10 years previously become available again. Table 10 also shows this EUL and measure ramp rate combination results in 85 percent of technical potential achieved by the close of the study period.

As described, the amounts of achievable technical potential are a function of the EUL and measure ramp rate. The same 10-year EUL measure, on a slower 20-year ramp rate, would achieve less of its 20-year technical potential, also shown in Figure 12. Across all lost opportunity measures in this study, approximately 80 percent of technical potential appears achievable over the 20-year study period, a finding consistent with the Council's assumption that less than 85 percent of lost opportunity resources can be achieved.[19]

[19] Northwest Power and Conservation Council. *Achievable Savings: A Retrospective Look at the Northwest Power and Conservation Council's Conservation Planning Assumptions.* August 1, 2007. http://www.nwcouncil.org/library/2007/2007-13.htm

TABLE 10. EXAMPLE OF LOST OPPORTUNITY TREATMENT: 10-YEAR EUL MEASURE ON A 10-YEAR RAMP RATE

Year	Incremental Stock Equipment Turnover (Units)	Cumulative Stock Equipment Turnover (Units)	Measure Ramp Rate	Installed High-Efficiency Units	Missed Opportunities for Acquisition in Later Years (Units)	Missed Opportunities Acquired (Units)	Cumulative Units Installed	Cumulative Percent of Technical Achieved
1	200	200	9%	17	180	0	17	9%
2	160	360	16%	26	130	0	43	12%
3	128	488	24%	30	92	0	73	15%
4	102	590	31%	32	65	0	106	18%
5	82	672	39%	32	44	0	138	20%
6	66	738	47%	31	29	0	168	23%
7	52	790	54%	29	19	0	197	25%
8	42	832	62%	26	11	0	223	27%
9	34	866	70%	23	6	0	246	28%
10	27	893	77%	21	2	0	267	30%
11	21	914	85%	18	0	153	438	48%
12	17	931	85%	15	0	110	563	60%
13	14	945	85%	12	0	78	653	69%
14	11	956	85%	9	0	55	717	75%
15	9	965	85%	7	0	38	762	79%
16	7	972	85%	6	0	25	793	82%
17	6	977	85%	5	0	16	814	83%
18	5	982	85%	4	0	10	828	84%
19	4	986	85%	3	0	5	836	85%
20	3	988	85%	2	0	2	840	85%

Discretionary Resources

Discretionary resources differ from lost opportunity resources due to their acquisition availability at any point within the study horizon. From a theoretical perspective, this suggests that all achievable economic potential for discretionary resources could be acquired in the study’s first year, although, from a practical perspective, this outcome is realistically impossible because of infrastructure and budgetary constraints and customer considerations.

Furthermore, due to interactive effects between discretionary and lost opportunity resources, immediate acquisition would distort the potential for lost opportunity resources. For example, if one assumes that all homes would be weatherized in the first year of a program, potentially available high-efficiency HVAC equipment would decrease significantly (i.e., a high-efficiency heat pump would save less energy in a fully weatherized home).

Consequently, the study addressed discretionary resources in two steps:

1. Developing a 20-year estimate of discretionary resource economic potential, assuming technically feasible and cost-effective measure installations would occur equally (at 5 percent of the total available) for each year of the study and avoiding distortion of interactions between discretionary and lost opportunity resources, as previously described.
2. Overlaying a measure ramp rate to specify the timing of achievable discretionary resource potential, thus transforming a 20-year cumulative technical value into annual, incremental, achievable values.

The discretionary measure ramp rates specify only the timing of resource acquisition and do not affect the portion of the 20-year economic potential achievable over the study period.

Figure 13 shows incremental (bars) and cumulative (lines) acquisitions for two different discretionary ramp rates. A measure on the 10-year discretionary ramp rate reaches full maturity—85 percent of its total economic potential—in 10 years, with market penetration increasing in equal increments each year. A measure on the emerging technology discretionary ramp rate would take longer to reach full maturity, also 85 percent of total economic potential, but ultimately it would arrive at the same cumulative savings as the measure on the 10-year ramp rate.

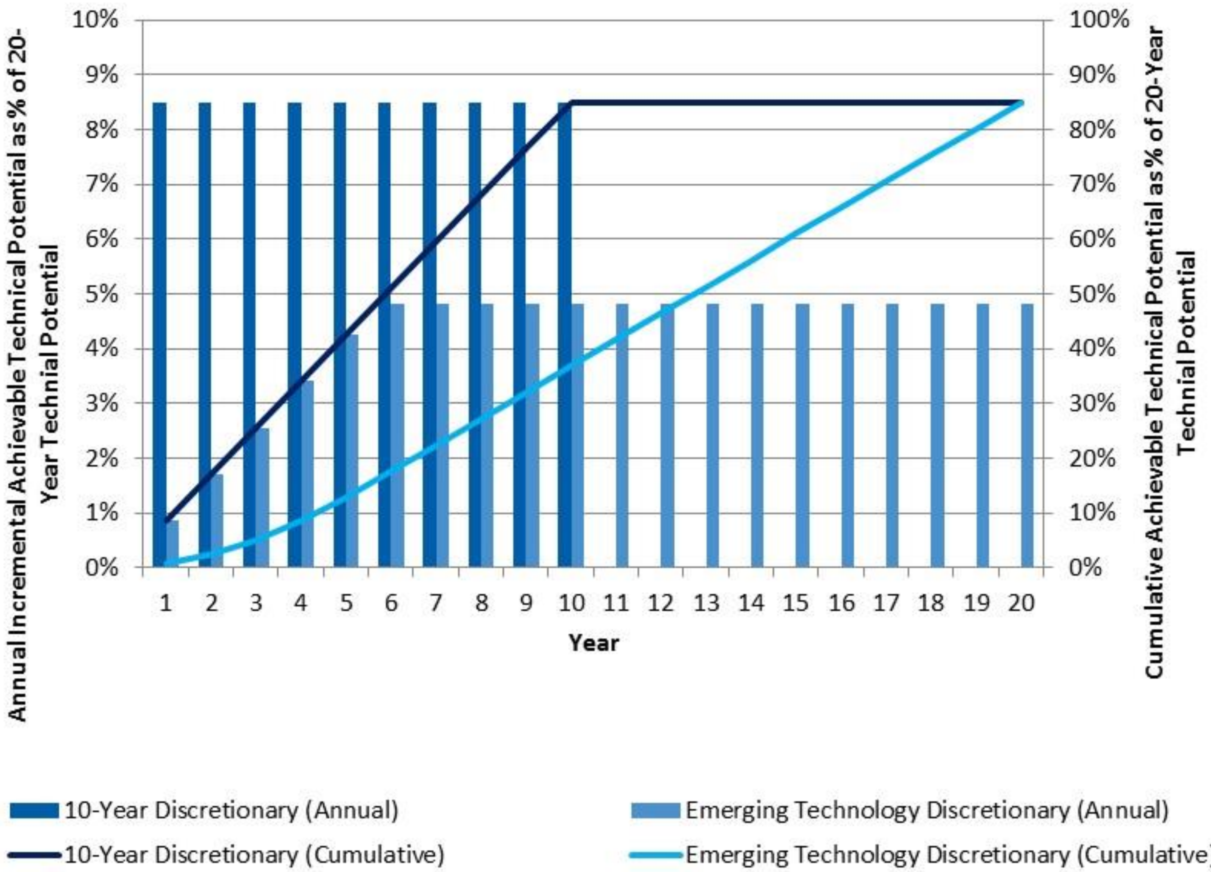


Figure 13. Examples of Discretionary Measure Ramp Rates

3. Baseline Forecasts

3.1. Scope of the Analysis

Assessing conservation potential starts with the development of baseline end use load forecasts over a 20-year—2016 to 2037—planning horizon. These forecasts are calibrated to City Light's econometric load forecasts; they are not adjusted for future programmatic conservation, but they do account for enacted equipment standards and building energy codes. The study separately considers residential, commercial, industrial and street lighting sectors.

Within each sector-level assessment, the study further distinguished customer segments or facility types and their respective applicable end uses. The analysis addressed the following:

- **Eight residential segments** existing and new construction for single-family, multifamily low-rise, multifamily mid-rise and multifamily high-rise. Multifamily low-rise is defined as multifamily buildings with one to three floors, mid-rise is defined as buildings with four to six floors and high-rise is defined as buildings with greater than six floors.
- **43 commercial segments**. This includes new and existing construction for 19 standard commercial segments, three indoor agriculture segments and enterprise data centers. Cadmus considered one vintage for indoor agriculture segments and enterprise data centers.
- **Eight industrial segments** (existing construction only).
- **One segment for street lighting**.

Figure 14 shows the distribution of projected sales in 2037 by sector. The commercial sector will account for roughly 58 percent of projected sales, while the residential, industrial, and street lighting sectors account for 28 percent, 13 percent and 1 percent, respectively.

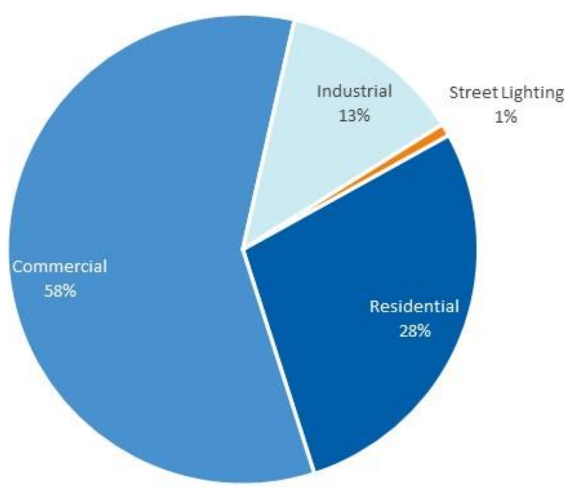


Figure 14. Baseline Sales by Sector - 2037

3.2. Residential

Cadmus considered four residential segments and 34 end uses within these segments. Table 11 lists each residential segment and the end uses considered, as well as the broad end-use groups used in this study. Overall, the residential sector accounts for approximately 28 percent of total baseline sales.

TABLE 11. RESIDENTIAL SEGMENT AND END USES

Segments	End Uses	
	End-Use Group	End Use
Single-Family Multifamily – High-Rise Multifamily – Mid-Rise Multifamily – Low-Rise	Appliances	Cooking Oven
		Cooking Range
		Dryer
		Freezer
	Appliances	Refrigerator
	Cooling	Cool Central
		Cool Room
	Electronics	Computer - Desktop
		Computer - Laptop
		Copier
		DVD
		Home Audio System
		Microwave
		Monitor
		Multifunction Device
		Plug Load Other
		Printer
		Set Top Box
		Television
		Television-Big Screen
	Exterior Lighting	Lighting Exterior
	Heating	Heat Central
		Heat Pump
		Heat Room
		Ventilation and Circulation
	Interior Lighting	Lighting Interior Linear Fluorescent
		Lighting Interior Specialty
		Lighting Interior Standard

TABLE 11. RESIDENTIAL SEGMENT AND END USES		
Segments	**End Uses**	
	End-Use Group	**End Use**
	Miscellaneous	Air Purifier
		Other
		Waste Water
		Pool Pump
	Water Heating	Water Heat GT 55 Gal
		Water Heat LE 55 Gal

City Light produces separate forecasts of single-family and multifamily households. Cadmus' used City Light's forecast of single-family households directly in the baseline forecast. Cadmus disaggregated multifamily household forecasts based on the distribution of the estimated number of households for the following multifamily segments:

- Multifamily low-rise: Up to three floors
- Multifamily mid-rise: four to six floors
- Multifamily high-rise: more than six floors

We relied on three-year American Community Survey (ACS) estimates of the number of households for each multifamily segment to determine the distribution used to disaggregate City Light's multifamily forecast. Using the approach described in the Developing Baseline Forecasts section, Cadmus combined residential household forecasts, estimates of end-use saturations, fuel shares, efficiency shares and end-use consumption to produce a sales forecast through 2037.

Figure 15 and Figure 16 show the distribution of residential sales in 2037 by segment and end use, respectively. The single-family segment accounts for 65 percent of residential baseline sales in 2037. This segment accounts for nearly 50 percent of City Light's forecasted households and has a higher overall consumption per household than multifamily segments.

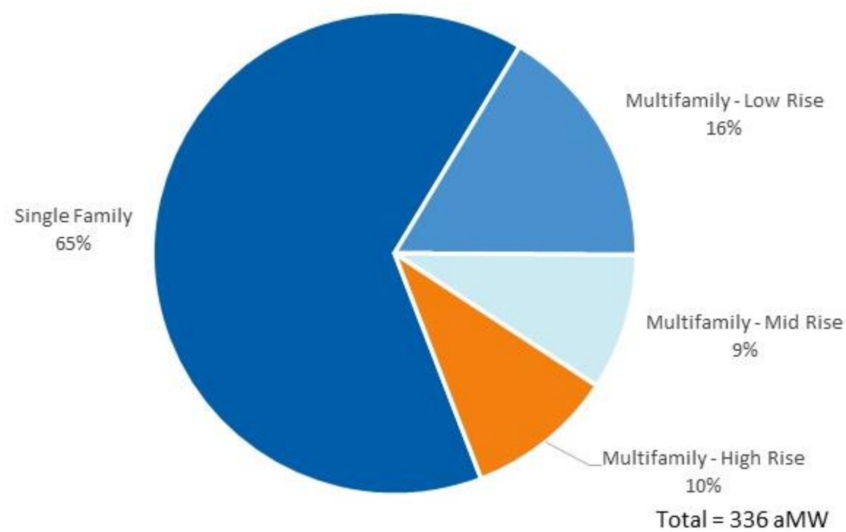


Figure 15. Residential Baseline Sales by Segment - 2037

Figure 16 shows that heating and electronics are the top two consuming end uses and account for over one-half (53 percent) of residential consumption. The next three highest forecasted uses are water heating (19 percent), appliances (16 percent) and interior lighting (7 percent).

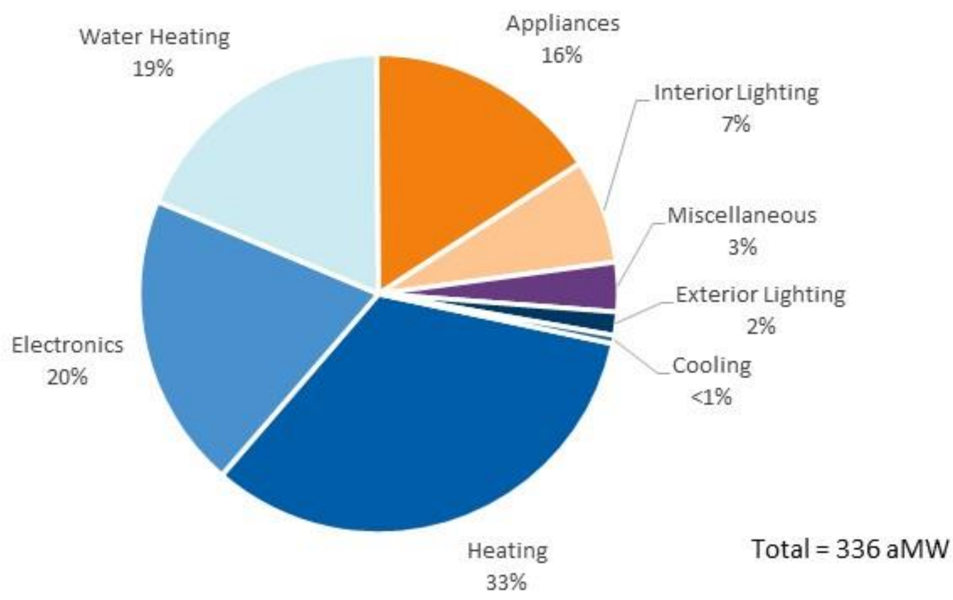


Figure 16. Residential Baseline Sales by End Use - 2037

Table 12 and Figure 17 shows the assumed average consumption per household for each residential segment. Differences in average consumption for each segment are driven by either—or any combination of—differences in end-use consumption, saturations or fuel shares. Appendix C includes detailed baseline data for the residential sector.

TABLE 12. PER HOUSEHOLD BASELINE SALES (KWH/HOME) - 2037				
End Use	**Single-Family**	**Multifamily – Low-Rise**	**Multifamily – Mid-Rise**	**Multifamily – High-Rise**
Heating	2,992	1,468	1,646	1,646
Electronics	1,730	1,117	956	956
Water Heating	1,742	1,173	569	569
Appliances	1,267	1,041	866	866
Interior Lighting	673	310	289	289
Miscellaneous	249	210	210	210
Exterior Lighting	206	18	6	6
Cooling	60	16	17	17
Total	**8,918**	**5,354**	**4,559**	**4,559**

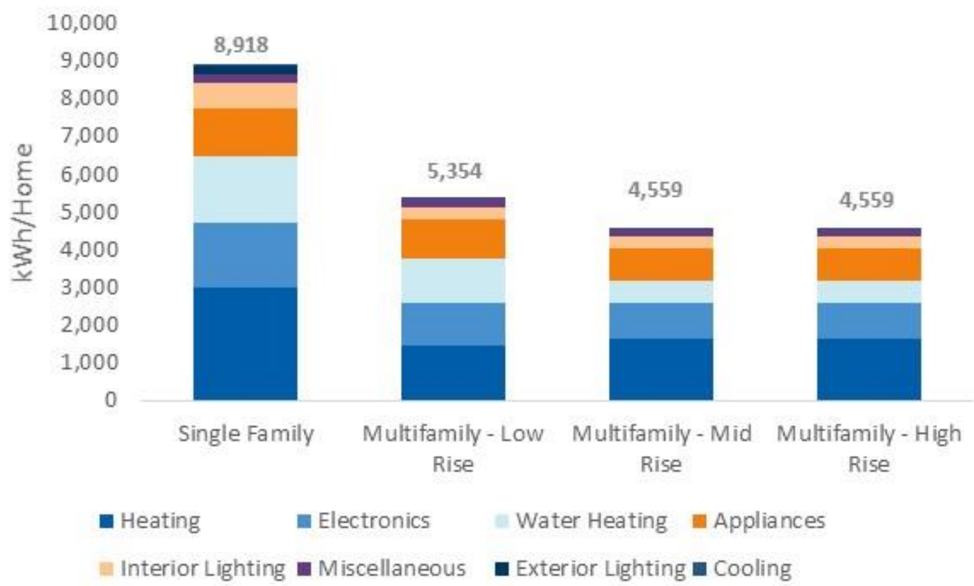


Figure 17. Residential Baseline Consumption Per Household - 2037

Cadmus calibrated baseline forecasts to City Light's econometric load forecasts—this ensured that the assumed load growth in the CPA is based on forecasted load in City Light's IRP. Cadmus adjusted then produced a residential forecast that explicitly accounts for federal lighting standards enacted under EISA, as this standard has little impact on City Light's sales history and is not explicitly accounted for in City Light's econometric forecast. After including federal equipment standards, Cadmus' residential baseline load forecast is slightly lower than City Light's forecast.

Figure 18 shows the residential baseline forecast by end use. Overall, City Light's residential forecast declines by approximately 8 percent over the 20-year horizon. This is due to a declining use per customer in City Light's load forecast.

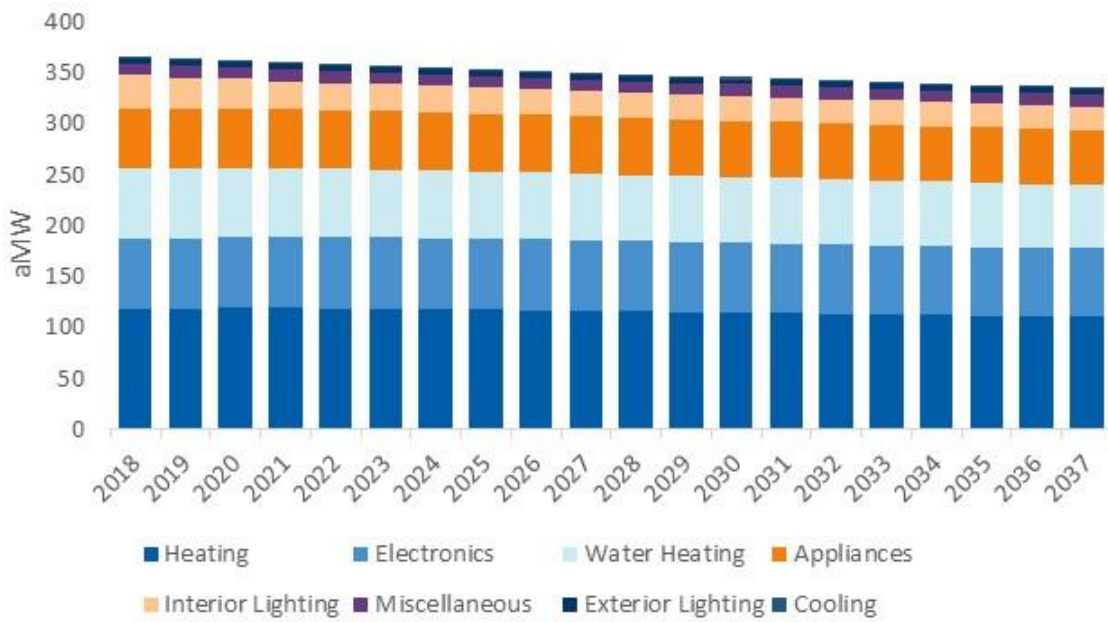


Figure 18. Residential Baseline Forecast by End Use

Figure 19 shows forecasted residential sales by construction vintage over the study horizon. Study results indicate approximately 9 percent of sales will be from homes constructed after 2017 (new construction). Use per customer for existing homes decreases over the 20-year study timeframe—this decline in use per customer is partly driven by equipment standards and other naturally occurring efficiency.

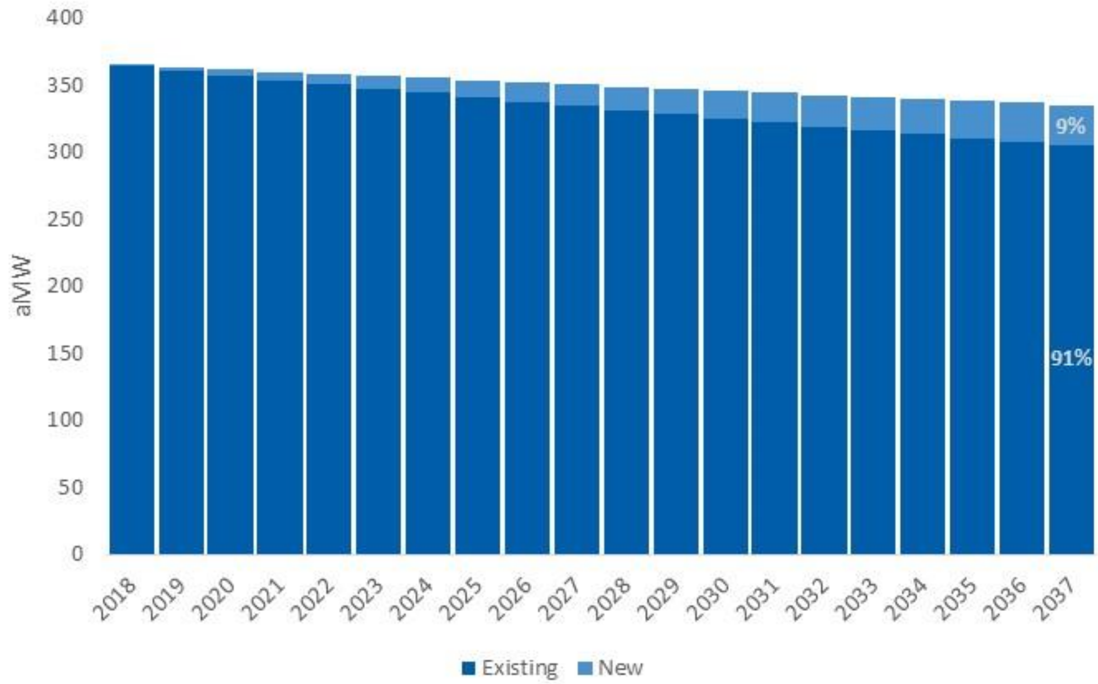


Figure 19. Residential Baseline Forecast by Construction Vintage

3.3. Commercial

Cadmus considered 23 commercial segments and up to 15 end uses within these segments. Table 13 shows each commercial segment and end use considered in this study, as well as the broad segment and end-use groups used in this report. Segments are largely based on those included in the Council's Seventh Power Plan. However, Cadmus added additional segments such as enterprise data centers and three indoor agriculture segments (tier 1, tier 2 and tier 3) that are based on the size of the facility. Overall, the commercial sector accounts for 747 aMW, or 60 perccent of total baseline sales in 2037.

TABLE 13. COMMERCIAL SEGMENTS AND END USES

Segments		End Uses	
Segment Group	**Segment**	**End Use Group**	**End Use**
Assembly	Assembly	Cooking	Cooking
Data Center	Enterprise Data Centers	Cooling	Cool Central
Hospital	Hospital	Data Center	Data Center
Indoor Agriculture	Indoor Agriculture - Production Facility Tier 1	Heat Pump	Heat Pump
	Indoor Agriculture - Production Facility Tier 2	Heating	Heat Central
	Indoor Agriculture - Production Facility Tier 3	Lighting	Exterior Lighting
Large Grocery	Supermarket		Interior Lighting
Large Office	Large Office	Miscellaneous	Compressed Air
	Medium Office		Other
Lodging	Lodging		Plug Load Other
MF Common Area	Multifamily Common Area		Waste Water
Miscellaneous	Other	Refrigeration	Refrigeration
Other Health	Residential Care	Ventilation	Ventilation
Restaurant	Restaurant	Water Heat	Water Heat GT 55 Gal
Retail	Large Retail		Water Heat LE 55 Gal
	Medium Retail		
	Small Retail		
	Extra Large Retail		
School	School K-12		
Small Grocery	Mini Mart		
Small Office	Small Office		
University	University		
Warehouse	Warehouse		

Cadmus used City Light's nonresidential database to identify the sales and number of customers for each commercial market segment. The database combines City Light's billing data with data from the King County assessor, as well as other secondary sources, to identify the customer segment, floor space, and consumption for each nonresidential customer—these data were the basis for Cadmus' commercial sector segmentation. In addition, Cadmus classified customers as either commercial or industrial per the segment identified in City Light's database. Commercial customers included those identified as one of the segments listed in Table 13, while industrial customers mapped to one of the segments listed in Table 14, which follows in the Industrial section.

Cadmus chose commercial segments for consistency with the Seventh Power Plan, except for the multifamily common area, which is not a stand-alone segment in the Seventh Power Plan.

Figure 20 shows the distribution of baseline commercial consumption by segment in 2037.

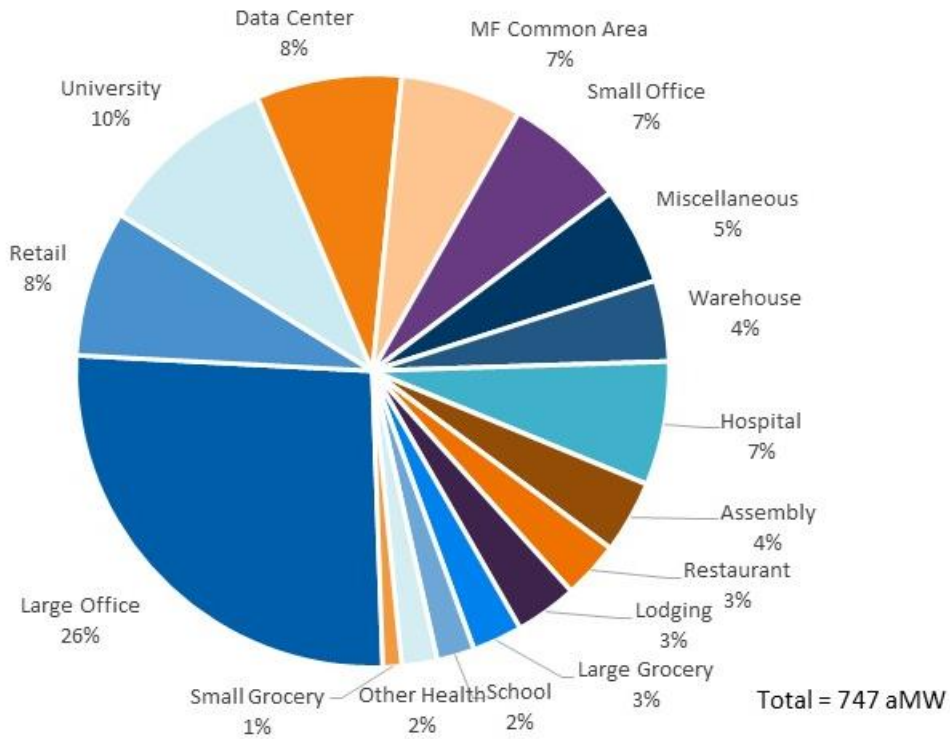


Figure 20. Baseline Sales by Segment - 2037

Large offices account for over one quarter (26 percent) of commercial baseline sales. Retail, universities, and data centers account for 8 percent, 10 percent and 8 percent of baseline sales, respectively. Collectively, these segments represent over one-half (52 percent) of all commercial sector sales. Data center sales represent consumption only in enterprise data centers and do not include consumption from embedded data centers in other segments, such as offices and universities.

Cadmus developed whole-building energy intensities using consumption and floor space estimates from City Light's nonresidential customer database. We further disaggregated these energy intensities into end-use intensities that were based on end-use saturations and fuel shares derived from City Light's CBSA oversample and building simulations. Specifically, Cadmus determined the expected distribution of end-use consumption for each building type based on City Light-specific saturations and building simulations and disaggregated energy intensities—derived from City Light's customer data—using these distributions. Figure 21 shows energy intensities for each building type and end use.

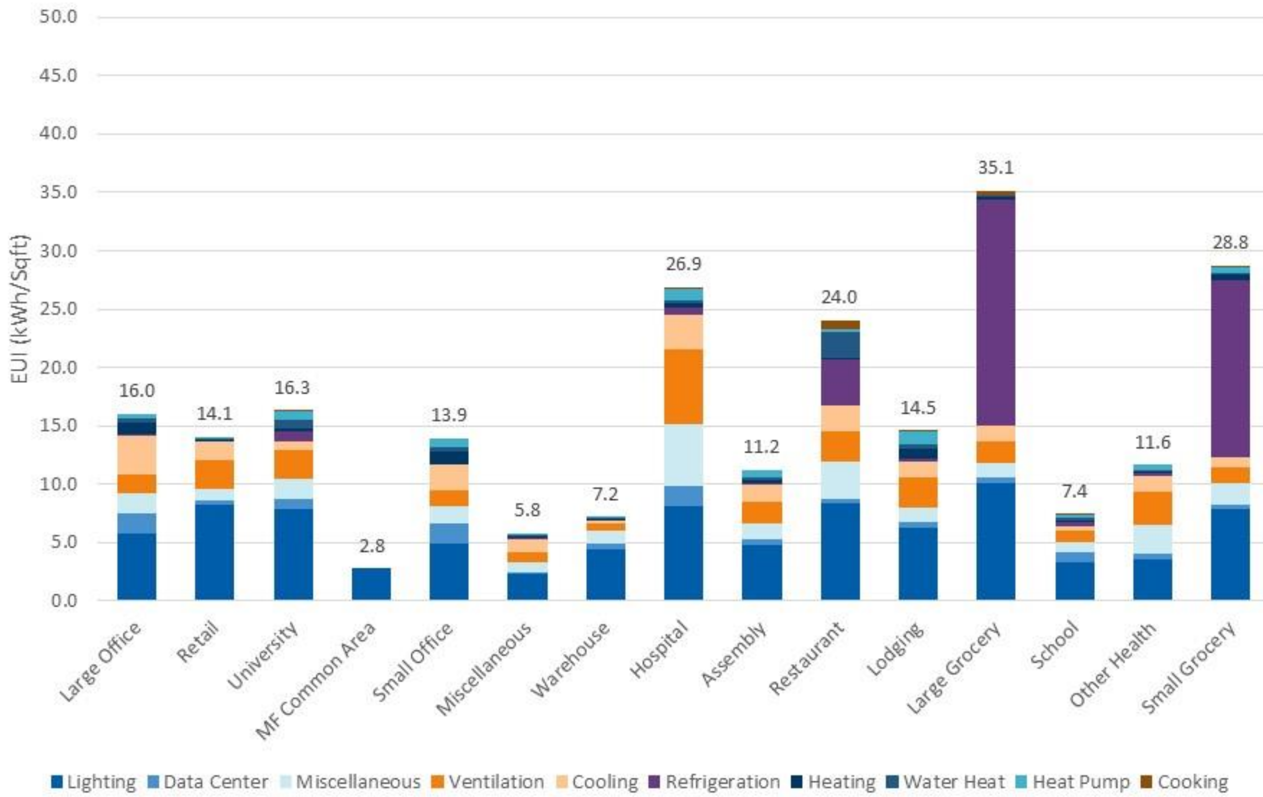


Figure 21. Commercial EUIs by Building Type

Figure 22 shows the overall distribution of commercial baseline sales by end use. The highest consuming end use is lighting, which accounts for 41 percent of projected commercial consumption in 2037. Data centers, ventilation and cooling end uses also account for a large share of consumption, representing 14 percent, 12 percent and 11 percent of projected commercial sales, respectively.

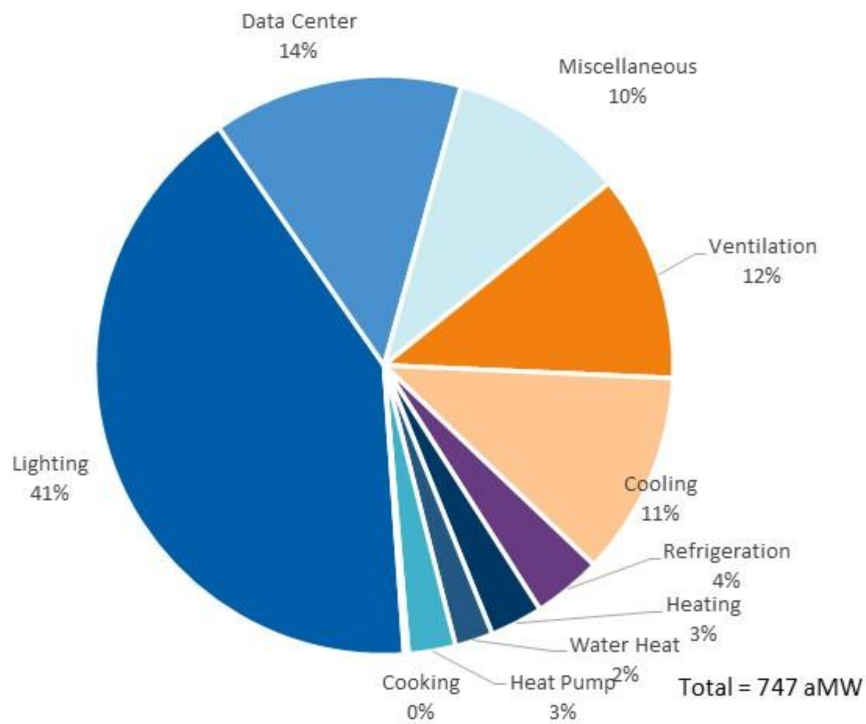


Figure 22. Baseline Sales by End Use – 2037

Cadmus' commercial baseline forecasts includes moderate load growth—commercial sales increase by roughly 0.7 percent per year over the study horizon. Figure 23 shows the commercial baseline forecast by end use.

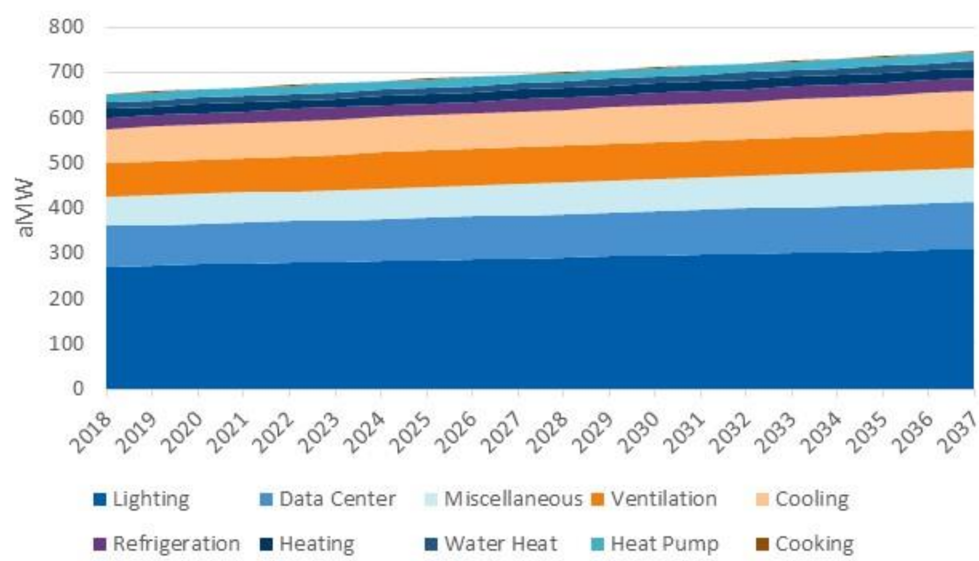


Figure 23. Commercial Forecast by End Use

Much of commercial load growth is in the new construction vintage. By 2037, 13 percent of the forecasted load is from buildings constructed after 2016. Figure 24 shows the commercial baseline forecast by construction vintage.

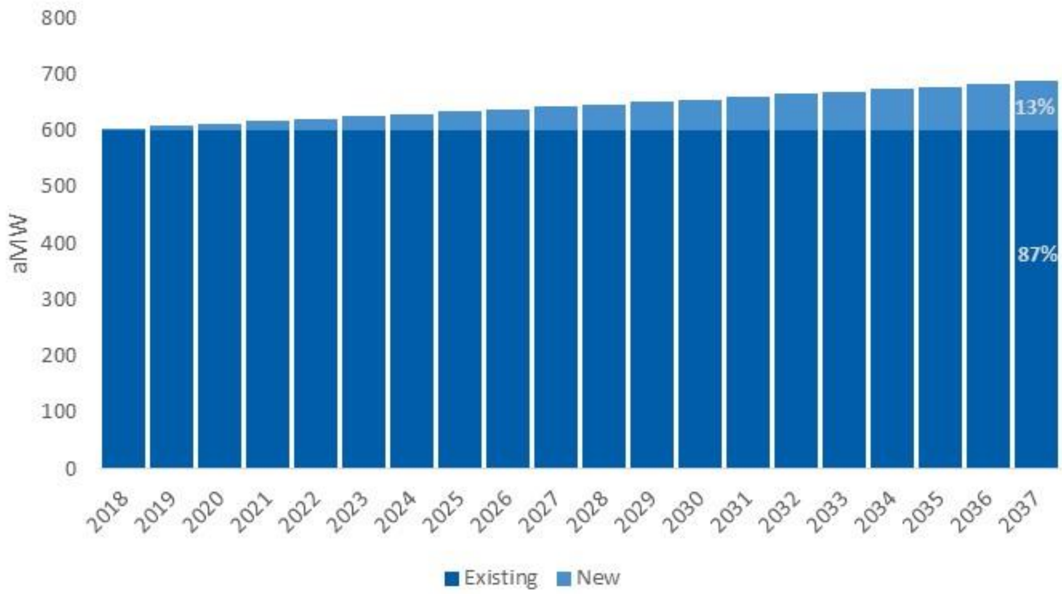


Figure 24. Commercial Forecast by Construction Vintage

3.4. Industrial

Cadmus disaggregated City Light's forecasted industrial sales into eight facility types/segments and 10 end uses (Table 14). Overall, the industrial sector accounts for 150 aMW, or 12 percent of City Light's overall forecasted baseline sales in 2037.

TABLE 14. INDUSTRIAL SEGMENTS AND END USES

Segment	End Use
Foundries	Fans
Frozen Food	HVAC
Miscellaneous Manufacturing	Lighting
Other Food	Other Motors
Stone and Glass	Other
Transportation, Equipment	Process Air Compressors
Wastewater	Process Electro Chemical
Water	Process Heat
	Process Other
	Process Refrigeration
	Pumps

Like the commercial sector, Cadmus relied on City Light's nonresidential customer database to determine the distribution of baseline industrial sales by segment. Figure 25 shows the distribution of industrial sales by segment in 2037. Transportation equipment manufacturing accounts for 30 percent of industrial baseline sales. The next largest segments are foundries (23 percent), miscellaneous manufacturing (21 percent) and stone and glass (16 percent).

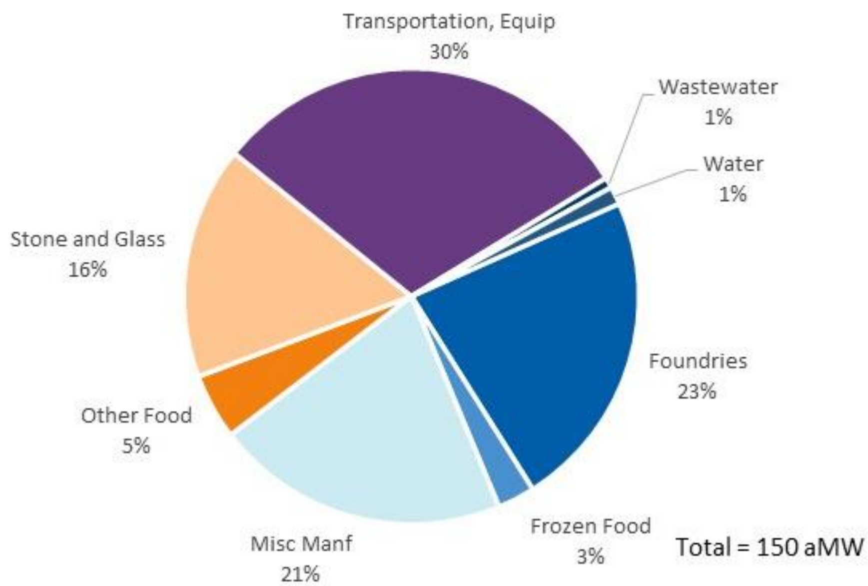


Figure 25. Industrial Baseline Sales by Segment – 2037

Cadmus relied on end-use distributions provided in the Council's Seventh Plan industrial tool to disaggregate segment-specific consumption into end uses. Table 7 includes end-use distributions for each segment, and Figure 26 shows the overall distribution of industrial baseline sales in 2037 by end use.

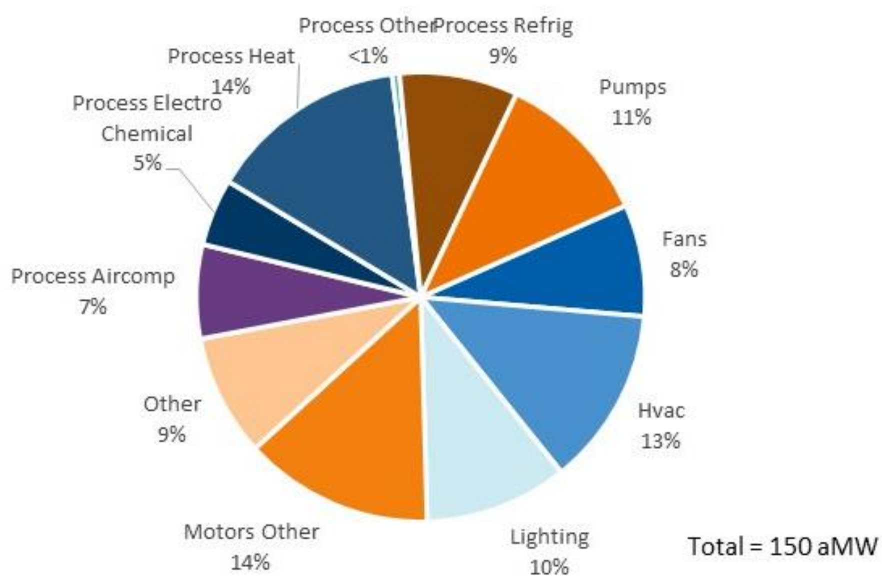


Figure 26. Industrial Baseline Sales by End Use - 2037

Industrial load growth is moderate over the study horizon, amounting to approximately a 0.7 percent annual average growth rate over the study horizon. Figure 27 shows the industrial forecast by segment.

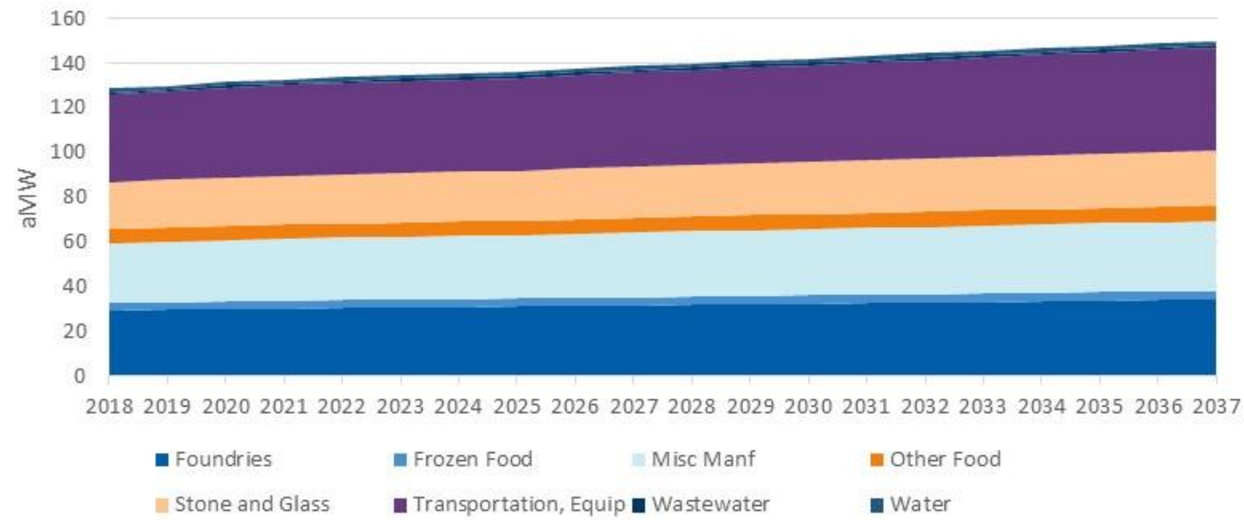


Figure 27. Industrial Baseline Forecast

4. Energy Efficiency Potential

4.1. Overview

4.1.1. Scope of the Analysis

This study involved a comprehensive set of conservation measures, incorporating measures assessed by the Council in the Seventh Power Plan and the RTF. Analysis began by assessing the technical potential of hundreds of unique conservation measures. These measures were considered for each applicable sector, segment, and construction vintage discussed in the Baseline Forecasts section. In total, Cadmus considered over 4,200 permutations of conservation measures. Table 15 lists the number of conservation measures and permutations considered in this study.

TABLE 15. MEASURE AND PERMUTATIONS

Sector	Measures[a]	Permutations
Residential	242	904
Commercial	1,286	3,012
Industrial	39	321
Street Lighting	6	24
Total	**1,573**	**4,261**

[a] Measure counts for some sectors include segment-specific permutations; thus, measure counts are higher than typically seen in CPAs.

4.1.2. Summary of Results

Table 16 shows baseline sales and cumulative potential by sector.[20] Study results indicate 279 aMW of technically feasible conservation potential—22 percent of baseline sales—by 2037, the end of the 20-year study horizon, with an estimated 163 aMW—13 percent of baseline sales—that is both cost-effective and technically feasible—this is economic potential. Cumulative achievable economic potential equals 131 aMW in 2037—11 percent of baseline sales. These results account for line losses and represent cumulative energy savings at generator.

These savings draw upon forecasts of future consumption, absent future City Light conservation program activities. Although these consumption forecasts accounted for past City Light-funded conservation, the identified estimated potential is inclusive of—not in addition to—forecasted program savings. As discussed, the 2037 forecast may differ from City Light's official sales forecast due to the treatment of standards and the assignment of commercial and industrial sales.

20 Economic potential and achievable economics potential reflect the IRP avoided cost scenario.

TABLE 16. TECHNICAL, ECONOMIC, AND ACHIEVABLE POTENTIAL BY SECTOR – 2037							
Sector	**Baseline Sales**	**Technical Potential**		**Economic Potential - IRP**		**Achievable Potential**	
		aMW	**Percent of Baseline**	**aMW**	**Percent of Baseline**	**aMW**	**Percent of Baseline**
Residential	336	85	25%	21	6%	16	5%
Commercial	747	180	24%	131	17%	105	14%
Industrial	150	13	9%	10	7%	9	6%
Street Lighting	10	1	12%	1	12%	1	12%
Total	**1,242**	**279**	**22%**	**163**	**13%**	**131**	**11%**

The commercial sector, which represents 60 percent of baseline energy use, accounts for approximately 80 percent of achievable economic conservation potential. The residential sector, industrial sector, and street lighting account for 12 percent, 7 percent and 1 percent, respectively (Figure 28). Although the residential sector's share of baseline energy consumption is higher than its share of achievable economic potential, the industrial sector's share of total achievable economic potential (7 percent) is much lower than its share of baseline energy consumption (12 percent).

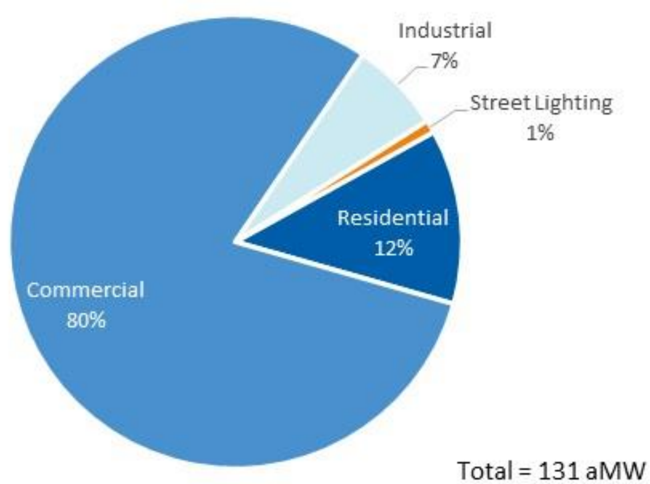


Figure 28. Achievable Economic Potential by Sector - 2037

Incremental achievable potential in each year of the study horizon is determined by the rate at which equipment naturally turns over and measure specific ramp rates (as discussed in the About Measure Ramp Rates section of this report). Table 17 shows cumulative two-year, 10-year, and 20-year achievable potential by sector, as well as 20 percent of the 10-year achievable potential, which is equivalent to City Light's pro rata share of 10-year potential for the 2018–2019 biennium.

TABLE 17. ACHIEVABLE POTENTIAL BY SECTOR

Sector	Achievable Economic Potential – aMW			
	Two Year (2018-2019)	Ten Year (2018-2027)	20 Year (2018-2037)	20% of 10-Year Potential
Residential	1.7	12.5	16.3	2.5
Commercial	17.2	72.0	104.8	14.4
Industrial	4.4	8.2	8.5	1.6
Street Lighting	1.2	1.2	1.2	0.2
Total	**24.5**	**93.9**	**130.9**	**18.8**

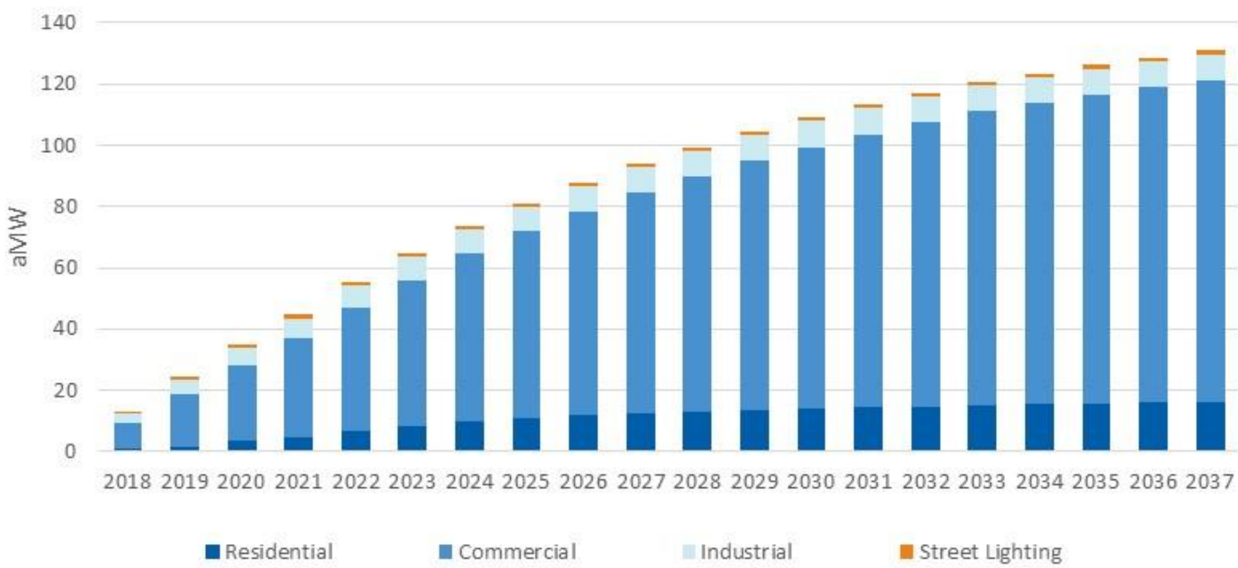


Figure 29. Cumulative Achievable Economic Potential

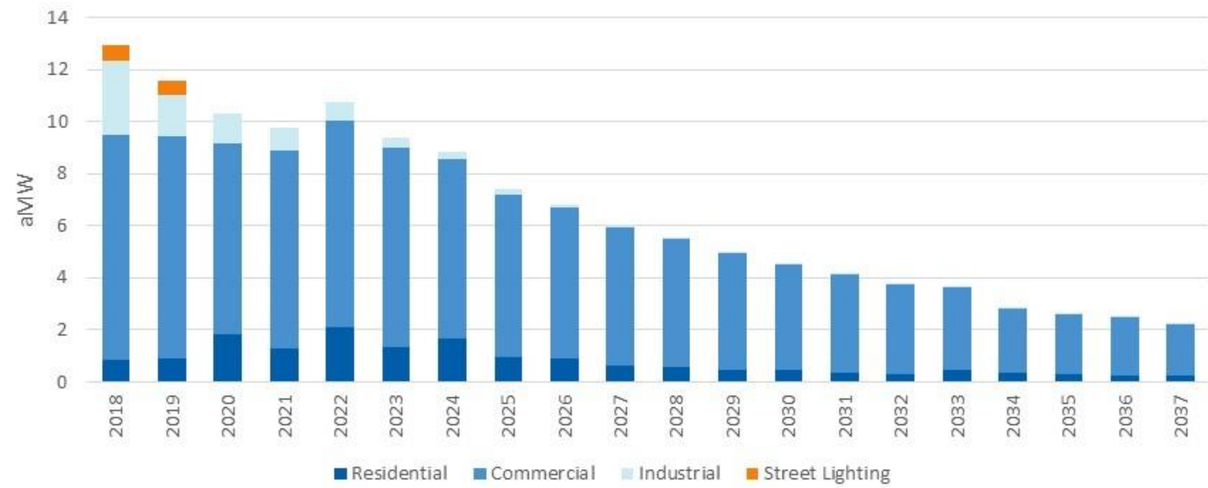


Figure 30. Incremental Achievable Economic Potential

Approximately 42 percent of 20-year achievable potential is acquired in the first five years, and 72 percent of 20-year achievable potential is acquired in the first 10 years. This acquisition rate reflects the mixture of measures for which there are high savings potential and is aligned with City Light's prior program accomplishments. Residential exterior and specialty lighting, for instance, account for a large portion of five-year potential because of their short baseline measure life (two years) and a relatively fast ramp rate. The spikes in residential achievable economic potential shown in Figure 30 are because of the interaction between measure ramp rates and a short baseline measure life for lighting. Refer to the About Measure Ramp Rates section of this report for more information on how Cadmus performs this calculation.

Study results indicate that conservation is a low-cost resource, with roughly 120 aMW of achievable economic potential at a cost of less than $40/MWh levelized—this represents nearly 94 percent of total cumulative 20-year achievable potential. The conservation supply curve in Figure 31 shows cumulative achievable potential in $10/MWh levelized cost increments.

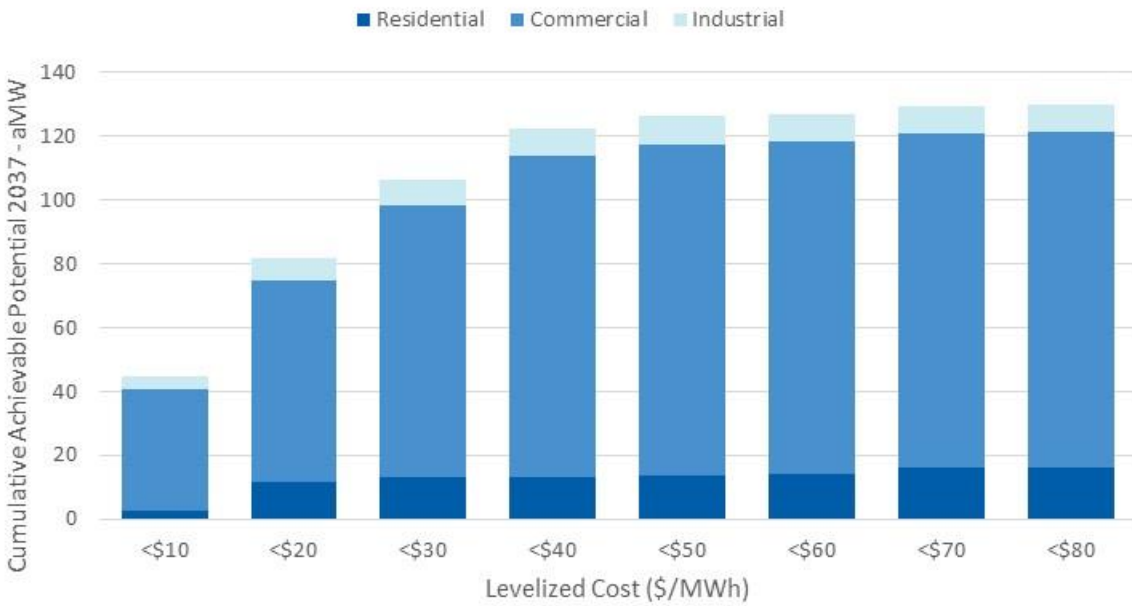


Figure 31. Supply Curve – Achievable Economic Potential (All Sectors)

Cadmus identified cost-effective conservation potential up to $70/MWh—cost-effective measures with relatively high levelized costs tend to either have long measure lives or significant deferred T&D benefits.

Appendix F shows detailed measure-level results, including levelized costs and both technical and achievable economic conservation potential for each measure.

The remainder of this section provides detailed results by sector.

4.2. Residential

Residential customers in City Light's service territory account for 27 percent of total baseline sales. The sector, which is divided into single-family, multifamily low-rise, multifamily mid-rise, and multifamily high-rise homes, presents of variety of potential savings sources, including equipment efficiency upgrades (e.g., water heaters and appliances), improvements to building shells (e.g., windows, insulation, and air sealing), and increases in lighting efficiency.

Based on resources included in this assessment, Cadmus estimated residential cumulative achievable potential of 16 aMW over 20 years, corresponding to nearly a 5 percent reduction in baseline sales by 2037. Table 18 shows cumulative 20-year residential conservation potential by segment.

TABLE 18. RESIDENTIAL POTENTIAL BY SEGMENT

Segment	Baseline Sales	Cumulative 2037 - aMW						
		Technical Potential (TP)	TP % of Baseline	Economic Potential (EP)	EP % of Baseline	EP % of TP	Achievable Potential (AP)	AP % of EP
Single-Family	216	62	29%	17	8%	27%	13	77%
Multifamily – High-Rise	33	4	11%	1	3%	25%	1	85%
Multifamily – Mid-Rise	31	3	11%	1	3%	25%	1	85%
Multifamily – Low-Rise	55	15	28%	2	4%	13%	2	85%
Total	**336**	**85**	**25%**	**21**	**6%**	**25%**	**16**	**78%**

As shown in Table 18 and Figure 32, single-family homes account for 81 percent (13 aMW) of total achievable economic potential, followed by multifamily low-rise (2 aMW), multifamily mid-rise (1 aMW), and multifamily high-rise (1 aMW). Each home type's proportion of baseline sales drives this distribution, but segment-specific end-use saturations and fuel shares have a role as well. Appendix A includes detailed data on saturations and fuel shares for each segment.

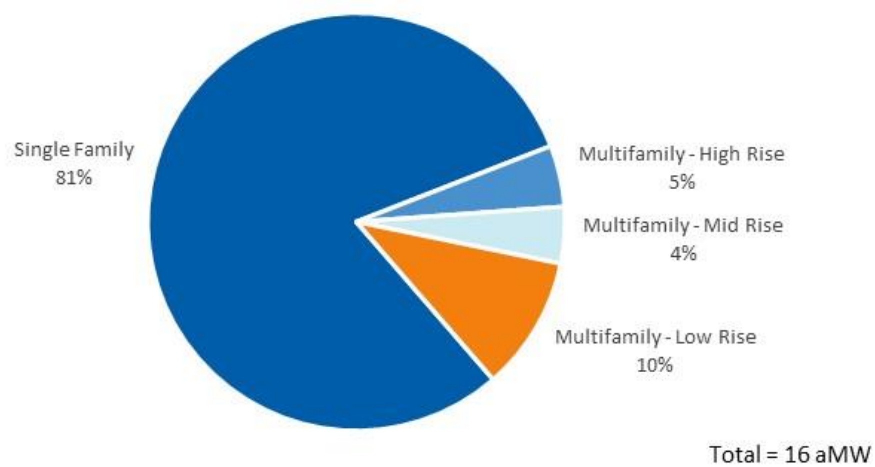


Figure 32. Residential Achievable Economic Potential by Segment - 2037

Interior lighting accounts for approximately one-quarter (27 percent) of total cumulative achievable economic potential by end use (as shown in Table 19 and Figure 33)—this savings is nearly entirely from the installation of LED lighting in specialty and exterior fixtures. Efficient upgrades to linear fluorescent fixtures in homes account for a small portion of total residential lighting savings.

TABLE 19. RESIDENTIAL POTENTIAL BY END USE								
End Use	**Baseline Sales**	**Cumulative 2037 - aMW**						
		Technical Potential (TP)	**TP % of Baseline**	**Economic Potential (EP)**	**EP % of Baseline**	**EP % of TP**	**Achievable Potential (AP)**	**AP % of EP[a]**
Interior Lighting	24	12	50%	6	24%	49%	4	77%
Water Heating	62	21	33%	5	8%	23%	4	84%
Heating	111	29	26%	6	6%	22%	5	71%
Electronics	67	4	6%	1	1%	16%	1	85%
Exterior Lighting	5	3	62%	3	62%	100%	3	85%
Appliances	54	9	17%	0	0%	0%	0	0%
Miscellaneous	11	7	60%	0	0%	0%	0	84%
Cooling	2	0	19%	0	0%	0%	0	0%
Total	**336**	**85**	**25%**	**21**	**6%**	**25%**	**16**	**78%**

[a] Some measures do not reach the maximum achievability of 85 percent due to the application of ramp rates. These measures tend to have long measure lives, such as efficient heat pumps—which is accounted for in the heating end use—or efficient water heaters.

Water heating savings includes both upgrades to efficient equipment, such as heat pump water heaters for units less than 55 gallons, and the installation of water-saving measures, such as high-efficiency aerators and showerheads. Clothes washer savings are also accounted for in the water heating end use, as most energy savings comes from reduced hot water use.

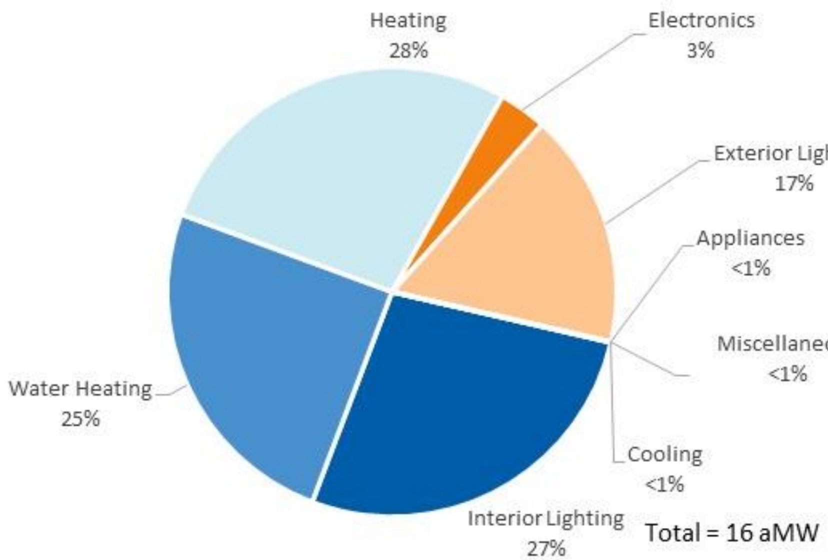


Figure 33. Residential Achievable Economic Potential by End Use - 2037

Incremental and cumulative potential over the 20-year study horizon varies by end use due to the application of ramp rates—ramp rates were assigned to each measure based on multiple factors, including availability, existing program activity and market trends. Cadmus used the same ramp rates for each measure as assigned by the Council in the Seventh Power Plan. Figure 34 and Figure 35 show cumulative and incremental residential achievable potential, respectively.

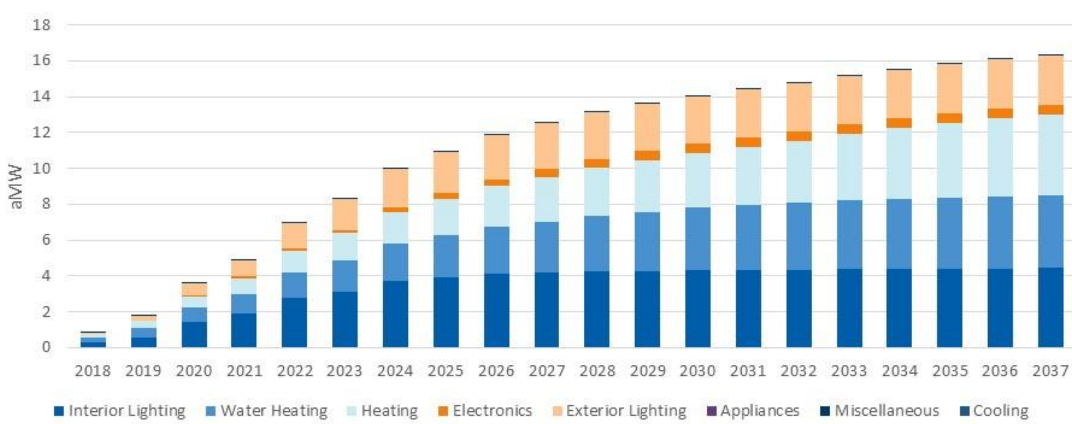


Figure 34. Residential Cumulative Achievable Economic Potential

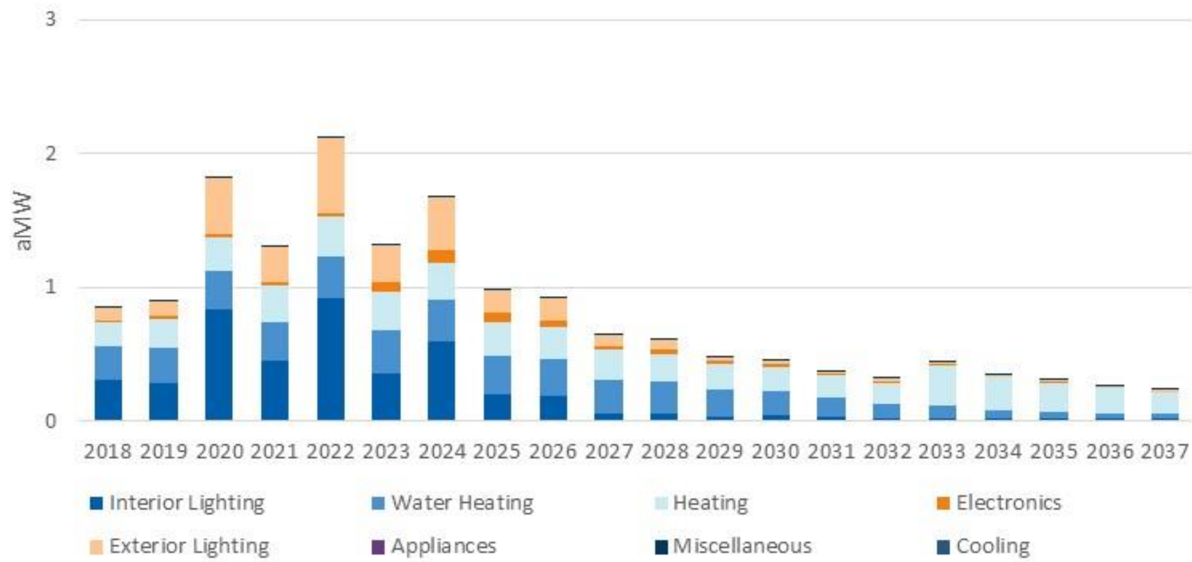


Figure 35. Residential Incremental Achievable Economic Potential

Measure ramp rates and effective useful lives (for equipment replacement measures only) determine the timing of savings shown in Figure 35. The spike in lighting savings in 2020 and 2022 is due to the interaction between lighting ramp rates and the relatively short baseline measure life for standard and specialty lighting measures (two years). Specifically, LED bulbs that were not installed in 2018 due to the application of a ramp rate are largely available for installation in 2020.

Overall, most (79 percent) of residential conservation potential is achievable within the first 10 years. Approximately 43 percent of 20-year residential achievable economic potential comes in the first five years and 77 percent of this five-year potential comes from interior lighting. The rapid acquisition of lighting savings is consistent with research that points to a transformation in the lighting market—CFL sales have declined in recent years, while the availability of LED bulbs (measured by the percentage of total bulbs stocked) has increased.

Figure 36 shows 20-year cumulative residential potential by levelized cost (in $10/MWh increments).

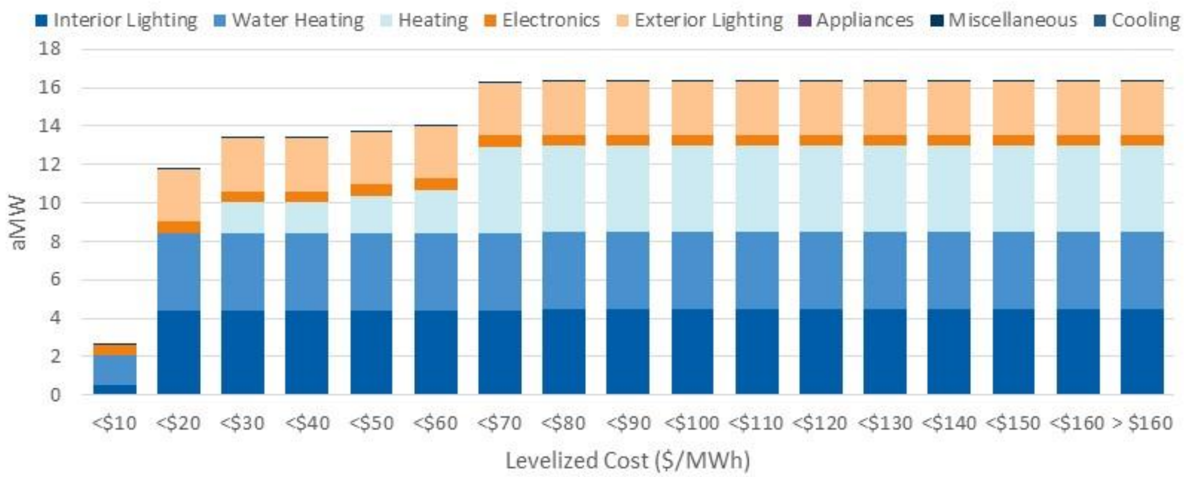


Figure 36. Residential Supply Curve

Nearly 82 percent of total residential achievable economic potential comes from measures with a levelized cost of conserved energy of $40/MWh or less. Few measures have levelized costs above $70/MWh—these are generally measures in the heating end use that have long measure lives and benefits that span multiple end uses.

LED lighting for specialty and exterior fixtures are the top two saving residential measures, respectively. Table 20 lists the 15 top-saving residential measures.

TABLE 20. TOP-SAVING RESIDENTIAL MEASURES

Measure Name	Achievable Economic Potential - aMW			Percent of Total (20-Year)
	2-Year	10 - year	20 -Year	
LED - Specialty	0.44	3.69	3.90	24%
LED - Exterior	0.21	2.55	2.77	17%
Motor - ECM	0.06	0.71	1.43	9%
Install Ductless Heat Pump in House with Existing FAF - Single-Family Home + HZ1	0.05	0.63	1.78	11%
SF Showerhead Replace_2_00gpm_Any Shower_ AnyWH	0.33	1.36	1.68	10%
Bathroom Aerator	0.01	0.80	1.51	9%
MF Showerhead Replace_2_00gpm_Any Shower_ AnyWH	0.16	0.66	0.81	5%
Floor Insulation	0.16	0.64	0.73	4%
Wall Insulation	0.11	0.43	0.48	3%
Set Top Box - ENERGY STAR	0.02	0.24	0.32	2%
TV LCD - ENERGY STAR	0.01	0.15	0.21	1%
Attic Insulation	0.02	0.07	0.08	1%
ENERGY STAR Dishwasher	0.01	0.03	0.04	0%
Multifunction Device (All-in-one) - ENERGY STAR	0.00	0.03	0.03	0%

It is important to note that Table 20 includes only measures that pass the benefit-cost screen. Efficient windows, for instance, have the highest technical potential of any measures; however, they are not cost-effective from a TRC perspective.

Cadmus assessed potential for a home energy reports measure using estimates of per-home impacts and costs from City Lights 2014-2015 Home Energy Reports program. An evaluation of City Light's HER program identified savings equivalent to between 1.0 percent and 5.0 percent of household electricity use, with weighted average savings of approximately 2.4 percent for City Light's program. While this program demonstrated higher savings than similar programs offered by peer utilities, the Home Energy Reports measure in this assessment did not pass the benefit-cost screen. It should be noted that the cost-effectiveness of this measure is sensitive to the assumed measure life. Cadmus used a one-year measure life, however, we tested longer measure lives and found the measure is cost-effective if we assume that savings persist for two to three years.

4.3. Commercial

City Light's commercial sector accounts for 60 percent of City Light's baseline sales in 2037 and 80 percent of total achievable economic potential. The commercial sector makes up a higher proportion of potential compared to its share of baseline sales because commercial measures are generally more cost-effective and have more savings potential than do measures found in other sectors. Cadmus estimated potential for the 23 commercial segments in Table 13 which were grouped into 17 segments for this report. Table 21 summarizes 20-year cumulative technical, economic, and achievable economic potential and summarizes the distribution of achievable economic potential by commercial segment.

TABLE 21. COMMERCIAL POTENTIAL BY SEGMENT

Segment	Baseline Sales	Cumulative 2037 - aMW						
		Technical Potential (TP)	TP % of Baseline	Economic Potential (EP)	EP % of Baseline	EP % of TP	Achievable Potential (AP)	AP % of EP
Assembly	30	7	24%	5	18%	73%	4	78%
Data Center	59	3	5%	3	5%	100%	3	100%
Hospital	50	8	16%	6	12%	74%	5	84%
Large Grocery	20	7	36%	6	31%	86%	5	85%
Large Office	197	50	25%	32	16%	65%	26	80%
Lodging	25	4	15%	3	10%	71%	2	80%
MF Common Area	50	20	40%	16	32%	79%	12	75%
Miscellaneous	40	16	41%	13	32%	77%	10	80%
Other Health	14	4	27%	3	22%	81%	3	84%
Restaurant	23	6	25%	4	19%	77%	4	83%
Retail	60	14	23%	11	19%	81%	9	81%
School	15	5	33%	4	23%	71%	3	77%
Small Grocery	8	3	35%	2	30%	85%	2	85%
Small Office	49	12	24%	8	16%	69%	6	77%
University	73	14	20%	10	14%	69%	8	81%
Warehouse	33	5	16%	4	12%	72%	3	75%
Indoor Agriculture	N/A	2	N/A	0	N/A	13%	0	85%
Total	**747**	**180**	**24%**	**131**	**17%**	**72%**	**105**	**80%**

Approximately one-quarter of 20-year commercial achievable potential is within the large office segment (Figure 37). Collectively, large and small offices account for 31 percent of commercial achievable economic potential. The multifamily common area segment has the highest savings relative to baseline sales due to high savings potential for interior, exterior, and parking lighting upgrades.

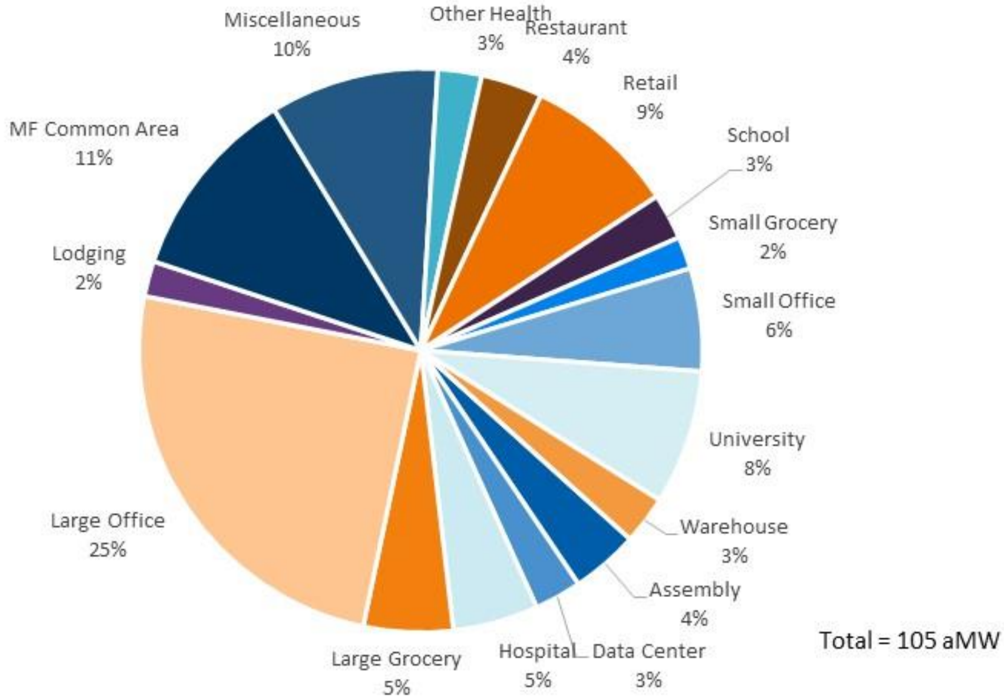


Figure 37. Commercial Achievable Potential by Segment - 2037

Across each of these segments, lighting accounts for a high portion of total achievable economic potential. Table 22 shows 20-year cumulative commercial potential by end use and Figure 38 shows the distribution of 20-year achievable economic potential by end use.

TABLE 22. COMMERCIAL POTENTIAL BY END USE								
Segment	**Baseline Sales**	**Cumulative 2037 - aMW**						
		Technical Potential (TP)	**TP % of Baseline**	**Economic Potential (EP)**	**EP % of Baseline**	**EP % of TP**	**Achievable Potential (AP)**	**AP % of EP**
Cooking	2	1	47%	1	40%	86%	1	85%
Cooling	85	25	30%	12	14%	45%	9	82%
Data Center	104	21	20%	20	19%	97%	18	87%
Heat Pump	20	3	14%	1	3%	18%	0	85%
Heating	22	7	34%	5	23%	67%	4	80%
Lighting	309	93	30%	72	23%	78%	56	77%
Miscellaneous	74	10	13%	2	3%	23%	2	85%
Refrigeration	29	6	21%	5	18%	87%	4	85%
Ventilation	86	14	16%	12	14%	87%	10	84%
Water Heat	16	1	5%	1	5%	97%	1	85%
Total	**747**	**180**	**24%**	**131**	**17%**	**72%**	**105**	**80%**

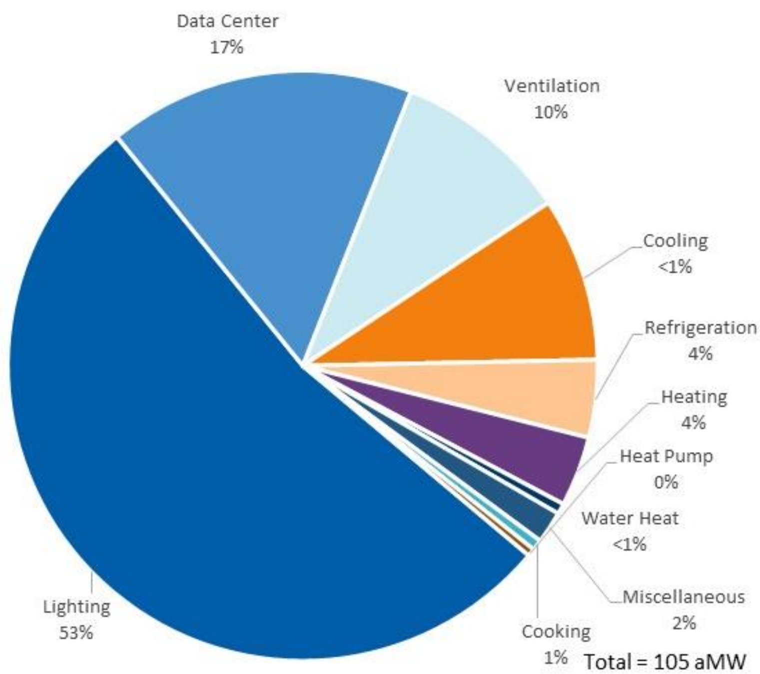


Figure 38. Commercial Achievable Economic Potential by End Use - 2037

Over one-half (53 percent) of commercial achievable potential comes from interior lighting equipment upgrades, exterior lighting equipment upgrades and controls. Lighting 20-year technical potential is equivalent to a 30 percent reduction in baseline lighting consumption. Overall, 77 percent of lighting technical potential is cost-effective. Only 77 percent of lighting potential is achievable over the study horizon because a high portion of savings for the end use comes from natural replacement measures—which do not always reach 85 percent achievability, depending on the measure's lifetime and ramp rate.

Like the residential sector, a large portion commercial potential is achieved within the first 10 years of the study horizon. Figure 39 and Figure 40 show cumulative and incremental achievable potential for the commercial sector, respectively.

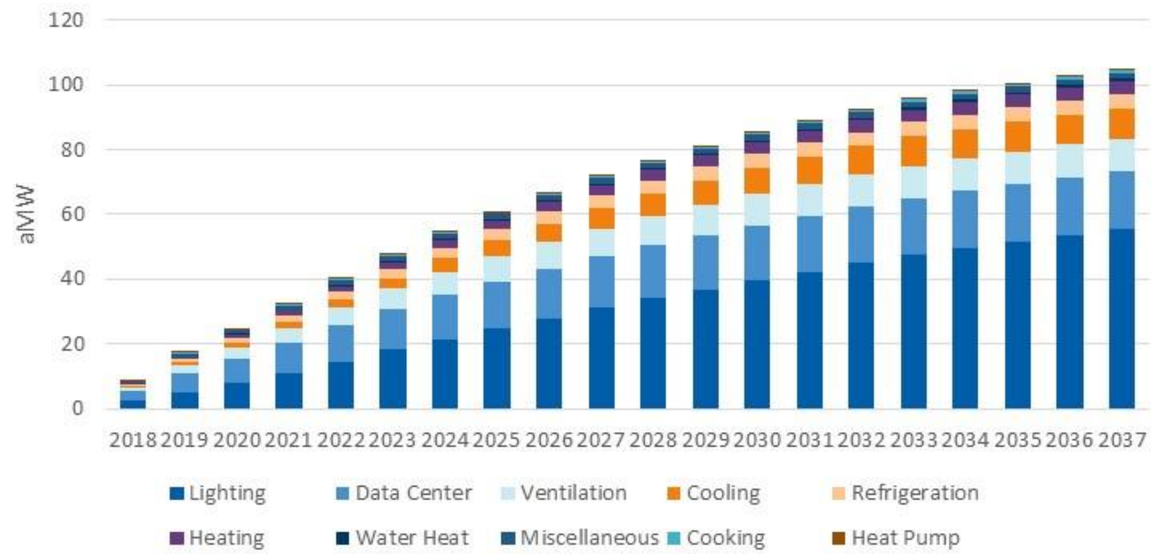


Figure 39. Commercial Cumulative Achievable Economic Potential

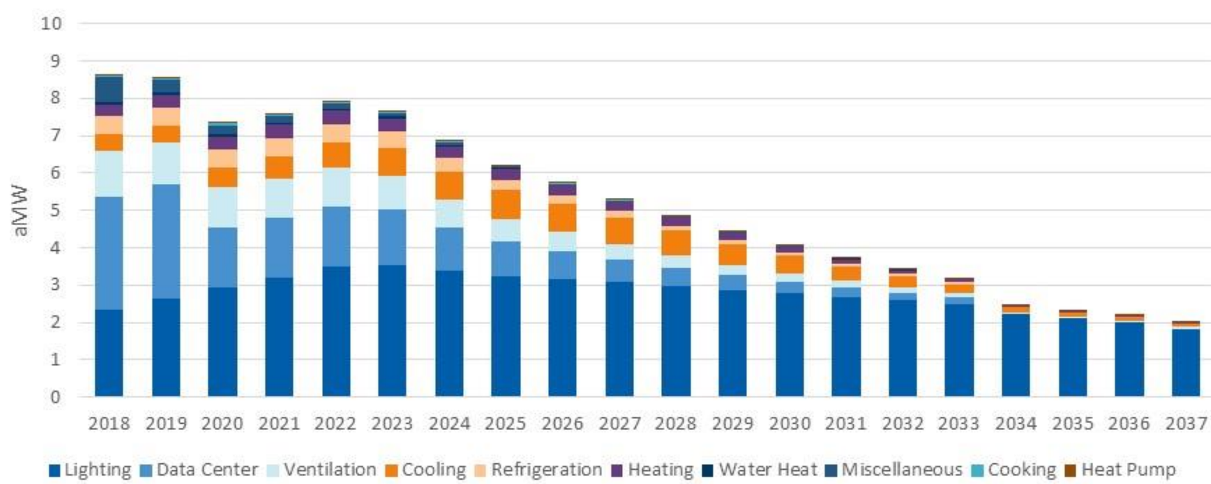


Figure 40. Commercial Incremental Achievable Economic Potential

Approximately 69 percent of 20-year commercial achievable economic potential is within the first 10 years of the study horizon. Incremental savings decreases in 2020, compared to 2018 and 2019, because these first two years include planned savings from enterprise data centers. Much of the commercial retrofit potential for existing buildings is exhausted within the first 10 years—most savings within the last 10 years of the study horizon come from the natural turnover and replacement of inefficient lighting fixtures with LEDs.

Commercial savings is not only abundant, it is cheap. Figure 41 shows the cumulative 2037 achievable economic for the commercial sector by end use and levelized cost.

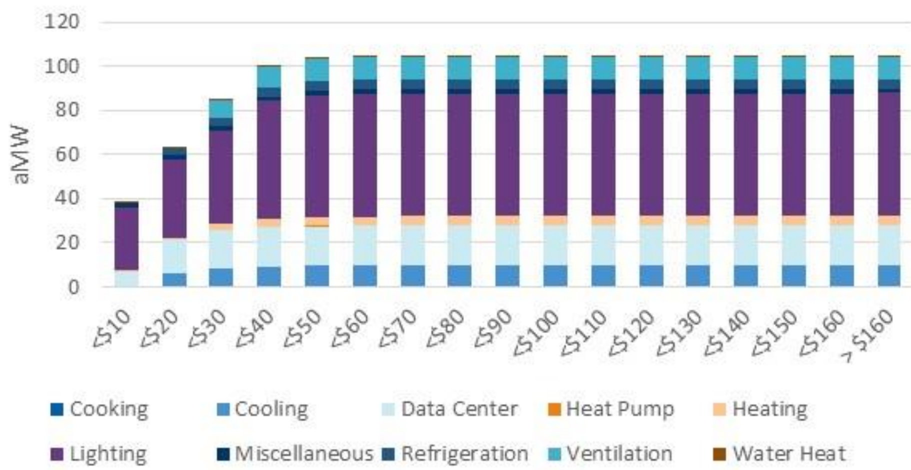


Figure 41. Commercial Supply Curve by End Use

Most of the cumulative achievable economic potential by 2037 costs less than $10/MWh from a TRC perspective—84 percent of this savings comes from lighting measures. Although LED technologies are still more expensive than their incandescent, halogen and fluorescent counterparts, the technology often has a much longer measure life, which means by installing it, future replacements of the baseline technology are deferred. For some measures, these deferred replacement costs exceed the incremental measure cost, which produces negative levelized costs.

Lighting, data center and HVAC measures have significant conservation potential. Table 23 shows the top 15 commercial measures, sorted by 20-year achievable economic potential.

TABLE 23. TOP SAVING COMMERCIAL MEASURES				
Measure Name	**Achievable Economic Potential - aMW**			**Percent of Total (20-Year)**
	2-Year	**10 - year**	**20 -Year**	
LED - Linear Fluorescent	1.01	10.98	25.19	24%
ECM VAV	2.42	9.91	11.78	11%
LED - Recessed Can	0.37	3.37	6.89	7%
Server virtualization/consolidation	1.62	6.50	7.38	7%
Exterior Lighting: Façade - LED	1.30	5.38	6.67	6%
Advanced Rooftop Controller	0.05	2.56	4.46	4%
Demand Controlled Ventilation	0.64	2.57	2.92	3%
LEC Exit Sign	0.05	0.88	2.26	2%
LED - Highbay	0.13	0.94	1.92	2%
VRF	0.01	0.85	1.87	2%
Enterprise Data Centers	2.83	2.83	2.83	3%
LED - Display or Track	0.32	1.60	2.22	2%
Linear Fluorescent RDX - Linear Fluorescent	0.04	0.59	1.65	2%
Grocery Retrocommisioning	0.46	1.83	2.08	2%

LED tube replacements of linear fluorescent lighting is the highest saving measure, accounting for 25.2 aMW by 2037—24 percent of total commercial potential. Electronically commuted motors for HVAC systems are the second-highest saving measure, with nearly 12 aMW of potential by 2037. Data centers also have significant savings potential—server virtualization and consolidation in embedded data centers is the fourth highest saving commercial measure with 7 aMW of achievable economic potential by 2037—7 percent of total.

4.4. Industrial

Cadmus estimated conservation potential for the industrial sector using the Council's Seventh Power Plan analysis tool. Cadmus also included estimates of known potential combined heat and power projects, which were provided by City Light. The conservational potential was assessed for eight industrial segments in City Light's service territory, which were based on allocations developed from City Light's nonresidential database. The assessment identified approximately 8.5 aMW of achievable economic potential by 2037. Table 24 shows cumulative industrial potential by segment in 2037, and Figure 42 shows the distribution of industrial achievable economic potential by segment.

TABLE 24. INDUSTRIAL POTENTIAL BY SEGMENT								
Segment	**Baseline Sales**	**Cumulative 2037 – aMW**						
		Technical Potential (TP)	**TP % of Baseline**	**Economic Potential (EP)**	**EP % of Baseline**	**EP % of TP**	**Achievable Potential (AP)**	**AP % of EP**
Foundries	34.0	1.8	5%	1.2	4%	66%	1.1	93%
Frozen Food	4.0	0.9	23%	0.5	13%	57%	0.5	85%
Misc Manf	56.1	3.5	6%	2.7	5%	78%	2.3	85%
Other Food	7.0	1.3	19%	0.7	10%	51%	0.6	85%
Transportation, Equip	45.7	4.8	11%	4.2	9%	88%	3.6	85%
Wastewater	1.1	0.4	34%	0.4	34%	100%	0.3	85%
Water	1.9	0.2	8%	0.2	8%	100%	0.1	85%
Total	**149.9**	**13.0**	**9%**	**9.9**	**7%**	**77%**	**8.5**	**86%**

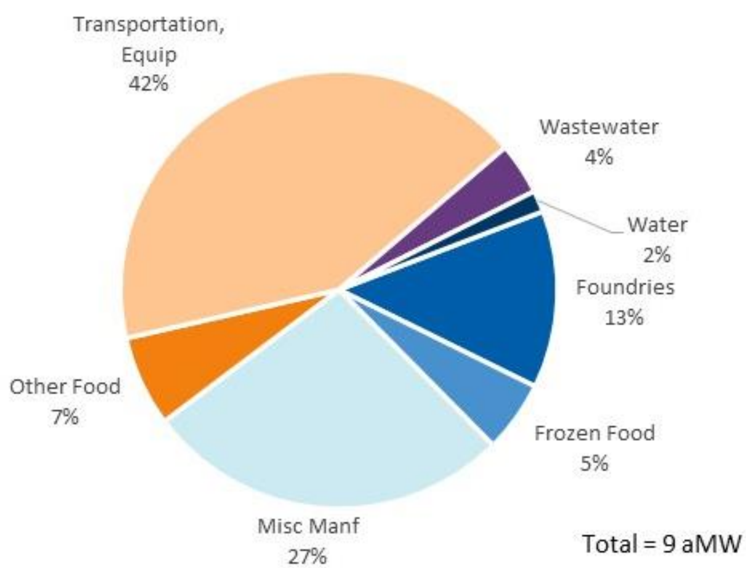


Figure 42. Industrial Achievable Economic Potential by Segment

The distribution of industrial achievable economic potential by segment is like the distribution of baseline sales. Transportation equipment manufacturing accounts for 42 percent of 20-year industrial achievable economic potential—3.6 aMW.

Table 25 shows 20-year potential by industrial end use, and Figure 43 shows the distribution of industrial achievable economic potential by end use.

TABLE 25. INDUSTRIAL POTENTIAL BY END USE									
Segment	Baseline Sales	Cumulative 2037 - aMW							
		Technical Potential (TP)	TP % of Baseline	Economic Potential (EP)	EP % of Baseline	EP % of TP	Achievable Potential (AP)	AP % of EP
Fans	12.1	1.7	14%	0.8	6%	45%	0.6	85%
HVAC	19.3	0.5	3%	0.5	3%	100%	0.4	85%
Lighting	15.4	6.2	40%	6.2	40%	100%	5.3	85%
Motors Other	20.5	0.6	3%	0.2	1%	24%	0.1	85%
Other	13.2	0.5	4%	0.5	4%	100%	0.5	85%
Process Aircomp	10.1	0.8	8%	0.4	4%	44%	0.3	85%
Process Electro Chemical	7.2	0.1	1%	0.1	1%	100%	0.1	85%
Process Heat	21.5	0.0	0%	0.0	0%	0%	0.0	0%
Process Other	0.8	0.0	0%	0.0	0%	0%	0.0	0%
Process Refrig	12.8	0.8	7%	0.4	3%	46%	0.3	85%
Pumps	17.0	1.0	6%	0.3	2%	29%	0.2	85%
Co-Generation	N/A	0.6	N/A	0.6	N/A	100%	0.6	100%
Total	**149.9**	**13.0**	**9%**	**9.9**	**7%**	**77%**	**8.5**	**86%**

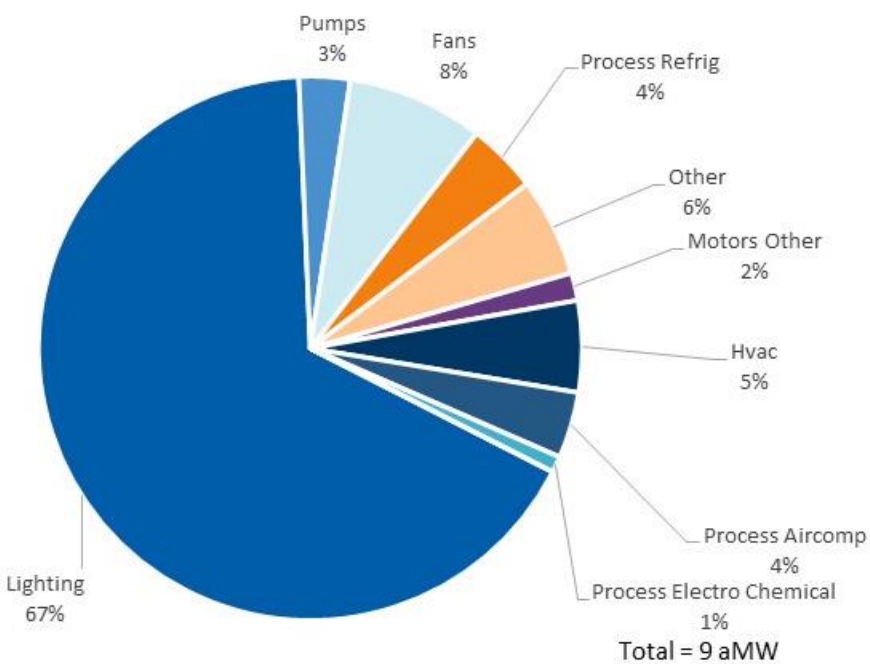


Figure 43. Industrial Achievable Economic Potential by End Use

Roughly two-thirds (67 percent) of industrial achievable economic potential comes from lighting measures, followed by fans (8 percent) and HVAC (5 percent).

Figure 44 and Figure 45 show cumulative and incremental achievable economic potential over the 20-year study horizon, respectively.

Figure 44. Industrial Cumulative Achievable Economic Potential

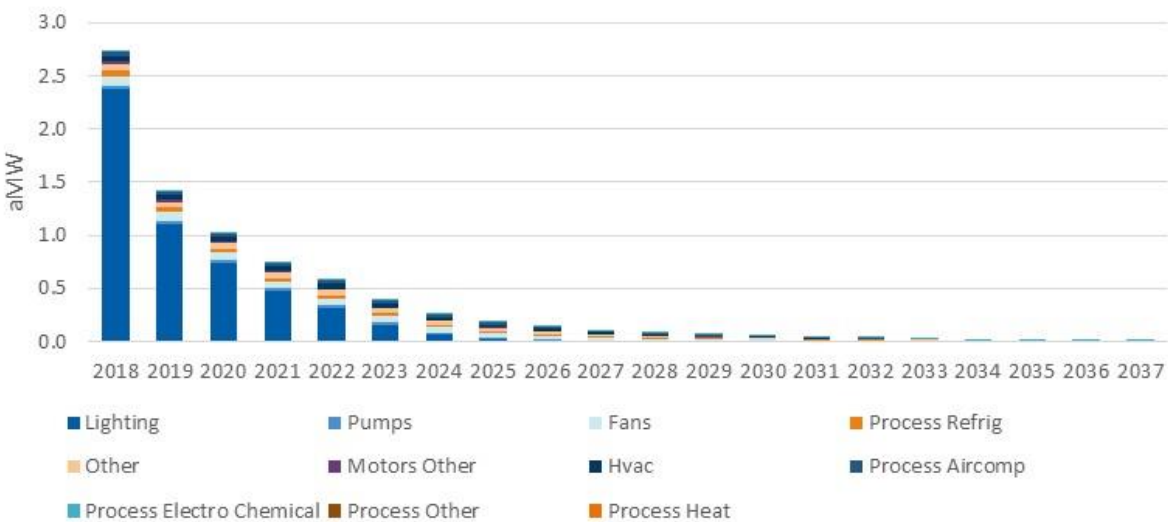


Figure 45. Industrial Incremental Achievable Economic Potential

Consistent with the Council's approach to the industrial sector, Cadmus modeled all industrial measures as retrofit and did not distinguish between new and existing construction. After applying ramp rates, approximately 96 percent of 20-year achievable economic potential is realized within the first 10 years.

Industrial measures are generally low cost—97 percent of technical potential is cost-effective—and all measures that contribute to achievable potential have a levelized cost of $50/MWh or lower. Figure 46 shows cumulative achievable economic potential in 2037 for different levelized cost thresholds.

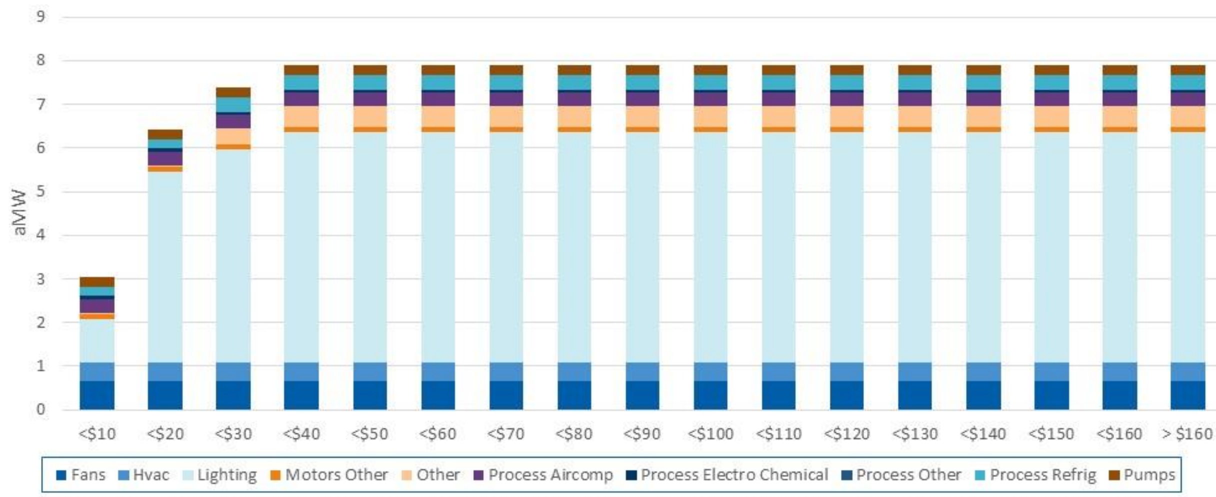


Figure 46. Industrial Supply Curve – Cumulative Achievable Economic Potential in 2037 by Levelized Cost

Table 26 shows the top 15 saving industrial measures—collectively, these represent 85 percent of 20-year cumulative achievable economic potential

TABLE 26. TOP-SAVING INDUSTRIAL MEASURES				
Measure Name	Achievable Economic Potential - aMW			Total Percentage (20-Year)
	2-Year	10-Year	20-Year	
HighBay Lighting 2 Shift	0.88	1.33	1.33	16%
HighBay Lighting 1 Shift	0.73	1.11	1.11	13%
Lighting Controls	0.62	0.94	0.94	11%
HighBay Lighting 3 Shift	0.46	0.70	0.70	8%
Integrated Plant Energy Management	0.22	0.51	0.57	7%
CoGen	0.25	0.63	0.63	7%
Fan System Optimization	0.11	0.43	0.48	6%
Efficient Lighting 1 Shift	0.26	0.40	0.40	5%
Efficient Lighting 3 Shift	0.19	0.29	0.29	3%
Air Compressor Optimization	0.06	0.24	0.27	3%
Pump System Optimization	0.04	0.17	0.19	2%
Optimize Municipal Sewage; <1 MGD Design Capacity	0.04	0.16	0.18	2%
Clean Room: Chiller Optimize	0.04	0.14	0.16	2%
Clean Room: Change Filter Strategy	0.03	0.14	0.16	2%

4.5. Street Lighting

City Light provided counts of remaining arterial high pressure sodium to LED conversions for arterial street lights, which will be completed in 2018 and 2019. Planned conversions include

- 200W High Pressure Sodium (HPS) to 135W LED
- 250W High Pressure Sodium (HPS) to 135W LED
- 400W High Pressure Sodium (HPS) to 135W LED
- 400W High Pressure Sodium (HPS) to 270W LED

Cadmus calculated savings for each conversion using methods consistent with the Seventh Power Plan—this includes an efficacy adjustment to account for 2017 high pressure sodium standards. Table 27 shows savings potential for each conversion type.

TABLE 27. ACHIEVABLE ECONOMIC STREET LIGHTING POTENTIAL BY TECHNOLOGY

Measure Name	Baseline Description	aMW	
		2018	2019
135W LED	200W HPS	0.03	0.03
135W LED	250W HPS	0.22	0.22
135W LED	400W HPS	0.02	0.02
270W LED	400W HPS	0.32	0.32
Total		**0.59**	**0.59**

5. Comparison to 2016 CPA

5.1.1. Overview

Overall, the 2018 CPA identified lower technical, economic and achievable potential than the 2016 CPA. This section compares results from the two assessments and identifies reasons for the lower identified potential. The focus was on 20-year cumulative estimates of technical and economic potential and incremental estimates of achievable economic potential. The factors that drive cumulative 20-year technical and economic potential lower are the same as those that drive achievable potential lower (because 20-year achievable potential generally 85 percent of economic potential). The main difference in achievable potential between the two studies is due to the application of different ramp rates.

Table 28 compares 20-year cumulative technical potential, by sector, from the 2016 and 2018 CPAs.

Table 28. Technical Potential Comparison

Sector	2018 CPA			2016 CPA		
	Baseline Sales - 20 Year (aMW)	Technical Potential - 20 Year (aMW)	Technical Potential as % of Baseline Sales	Baseline Sales - 20 Year (aMW)	Technical Potential - 20 Year (aMW)	Technical Potential as % of Baseline Sales
Residential	336	85	25%	370	121	33%
Commercial	747	180	24%	740	226	31%
Industrial	150	13	9%	208	12	6%
Street Lighting	10	1	12%	10	2	22%
Total	1,242	279	22%	1,328	362	27%

The 2018 CPA identified 279 aMW of technical potential, compared to 362 aMW in the 2016 CPA. This decrease is almost entirely due to changes in the residential and commercial sectors. Changes that contribute to lower technical potential include:

- Lower residential baseline load forecasts
- Lower residential lighting, water heating and home electronics potential due to high naturally occurring savings and savings from residential equipment standards

Each of these factors are discussed in following sections.

Table 29 compares economic potential for the IRP preferred avoided cost scenario in the 2018 and 2016 CPAs.

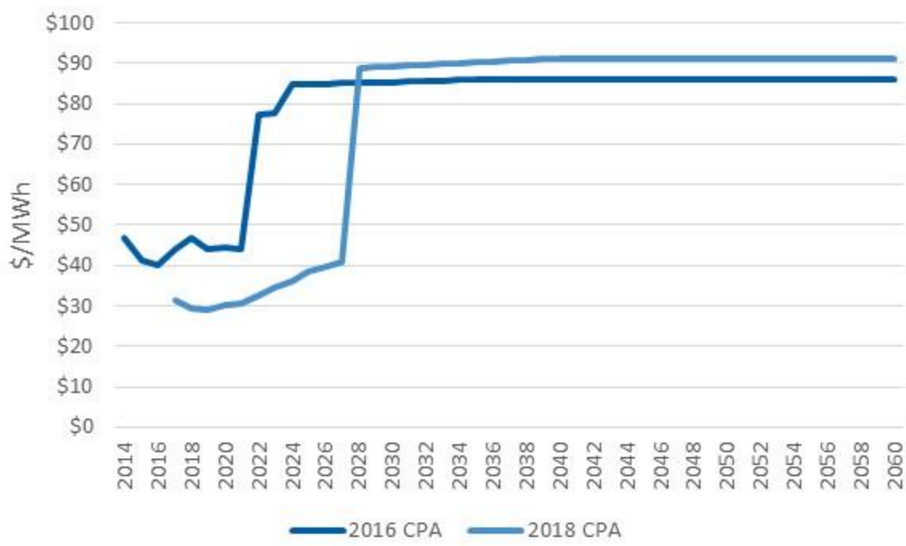
Table 29. Economic Potential Comparison

	2018 CPA (IRP Avoided Costs)			2016 CPA (IRP Avoided Costs)		
Sector	Economic Potential - 20 Year (aMW)	EP as % of Baseline Sales	Economic as a % of Technical Potential	Economic Potential - 20 Year (aMW)	Economic Potential as % of Baseline Sales	Economic Potential as % of Baseline Sales
Residential	21	6%	25%	59	16%	49%
Commercial	131	17%	72%	186	25%	82%
Industrial	10	7%	77%	10	5%	84%
Street Lighting	1	12%	100%	2	22%	100%
Total	163	13%	58%	257	19%	71%

The 2018 CPA identified 163 aMW of economic potential, compared to 257 aMW in the 2016 CPA. Lower avoided costs contributed to a decrease in economic potential in the residential, commercial and industrial sectors.[21] Figure 47 compares avoided costs forecasts for the IRP preferred scenario in the 2016 and 2018 CPAs. 20-year levelized avoided costs for the 2017 to 2036 period in the 2018 CPA are $58/MWh, compared to $75/MWh in the 2016 CPA, nearly 23 percent lower.

[21] This is in addition to the factors that contributed to lower technical potential.

Figure 47. Avoided Cost Forecast Comparison – IRP Preferred Scenario



The lower avoided costs illustrated in Figure 47 contribute to the lower economic potential in each sector. However, the residential sector had the most pronounced decline in economic potential, as illustrated in Table 30, which shows economic potential expressed as a fraction of technical potential.

Table 30. Comparison of 20-Year Cumulative Economic Potential as a Percent of Technical Potential

Sector	2018 CPA	2016 CPA
Residential	25%	49%
Commercial	72%	82%
Industrial	77%	84%
Street Lighting	100%	100%
Total	58%	71%

The decrease is almost entirely due to one measure—heat pump water heaters. This measure had benefit-cost ratios slightly above 1.0 in the 2016 CPA and are not cost-effective in the 2018 CPA. This change is discussed in more detail in a following section.

5.1.2. Residential Sector Changes

The residential sector had a notable decline in technical, economic and achievable potential, which was driven by factors including a lower load forecast, lower potential in three key end uses, and lower avoided costs. Table 31 compares technical and economic potential in the 2016 and 2018 CPA, and identifies reasons for the changes.

Table 31. Residential Technical and Economic Potential Comparison

Component	2016 CPA	2018 CPA	Reason for Decrease
Baseline Sales	370	336	• Lower load forecast and actuals; approximately 9 percent decline in actual residential sales
Technical Potential	121	85	• Lower load forecast • Decline in lighting, water heating, and electronics potential
Technical Potential as % of Baseline	33%	25%	
Economic Potential	59	21	• Lower load forecast • Decline in lighting, water heating, and electronics potential • Lower avoided costs. • Lower cost-effective water heating potential
Economic Potential as % of Baseline	16%	6%	
Economic Potential as % of Technical	49%	25%	

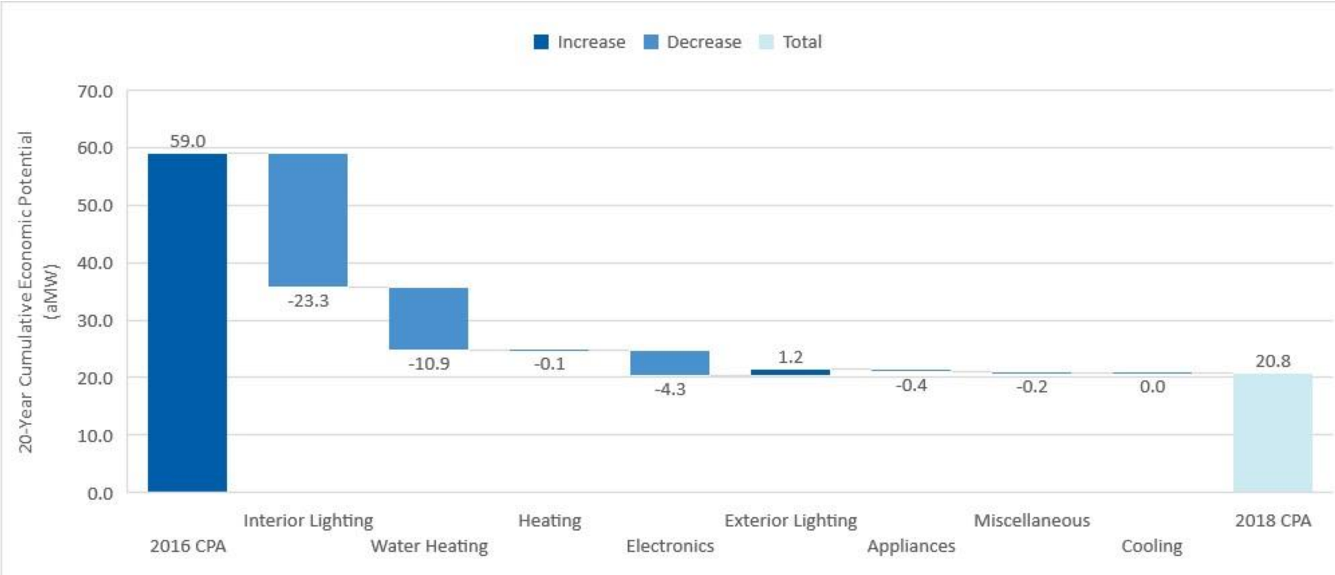
5.1.2.1 Lower residential actual and forecast sales

City Light's forecasted residential sales were approximately 9 percent lower in each year of the study horizon. Because Cadmus calibrates baseline load forecasts to City Light's econometric forecasts, any reduction in forecasted sales from one study to the next will result in a similar reduction of technical, economic and achievable potential. In other words, holding all else equal, due the reduction in baseline residential sales, we would expect residential conservation potential would be 9 percent lower. Technical potential, however, declined by nearly 30 percent and not 9 percent. Therefore, other factors drove potential estimates lower. Cadmus compared estimates of residential potential across each end use, and we found two groups of end uses—interior lighting and water heating—explain the decline in residential conservation potential, discussed below.

5.1.2.2 Decline in lighting and water heating potential

Figure 48 illustrates the change in residential economic potential. Declines in economic potential for the interior lighting, water heating and electronics end uses contributed to the overall decline in residential economic potential.

Figure 48. Change in Residential Economic Potential by End Use



The decline in residential interior lighting potential is due to the higher baseline saturation of efficient lighting for both general service and specialty fixtures in the 2018 CPA, compared to the 2016 CPA. The 2018 CPA relied on the 2017 Residential Building Stock Assessment (RBSA) to determine the baseline mixture of efficient and inefficient lighting, while the 2016 CPA relied on the 2012 RBSA. Between the completion of the 2012 and 2017 RBSAs, LED bulb prices have rapidly declined, which has contributed to a higher saturation of LED lighting. At the same time, incandescent bulbs have turned over, being replaced with more-efficient halogen, compact fluorescent and LED technologies. This move to more efficient lighting reduced the achievable economic potential for the end use. Table 32 and Table 33 illustrate the distribution lighting technologies in the 2016 and 2018 CPA for general service and specialty bulbs, respectively.

Table 32. Distribution of Standard General Service Lighting Technologies in Single Family Homes

Technology	2016 CPA	2018 CPA
Incandescent	50%	30%
Halogen	10%	3%
Compact Fluorescent	38%	46%
LED/Other	2%	21%

LED lighting accounts for 21 percent of general service interior bulbs in single family homes in the 2018 CPA, compared to approximately 2 percent in the 2016 CPA. Incandescent lighting only accounts for 30 percent of general service bulbs in single family homes in the 2018 CPA, compared to 50 percent in the 2016 CPA.

Table 33. Distribution of Specialty Lighting Technologies in Single Family Homes

Technology	2016 CPA	2018 CPA
Incandescent	77%	43%
Halogen	<1%	20%
Compact Fluorescent	23%	9%
LED/Other	<1%	28%

LED lighting accounts for 24 percent of specialty interior bulbs in single family homes in the 2018 CPA, compared to less than 1 percent in the 2016 CPA. Incandescent lighting only accounts for 43 percent of specialty interior bulbs in single family homes in the 2018 CPA, compared to 77 percent in the 2016 CPA.

5.1.2.3 Lower Cost-Effective Water Heating Potential

The decline in residential water heating economic potential (illustrated in Figure 48) is due to a decrease in benefit-cost ratios for heat pump water heater measures. In the 2016 CPA heat pump water heaters measures in the residential sector were marginally cost-effective. Benefit-cost ratios for Tier 1 units ranged from 0.98 to 1.03. In the 2018 CPA, lower avoided costs drove benefit-cost ratios for these measures below 1.0—now benefit-cost ratios for Tier 1 units range from 0.54 to 0.68. In the 2016 CPA, heat pump water heaters had the third-highest economic potential of all residential measures, with estimated 20-year cumulative economic potential of 8.2 aMW.

5.1.3. Commercial Sector Changes

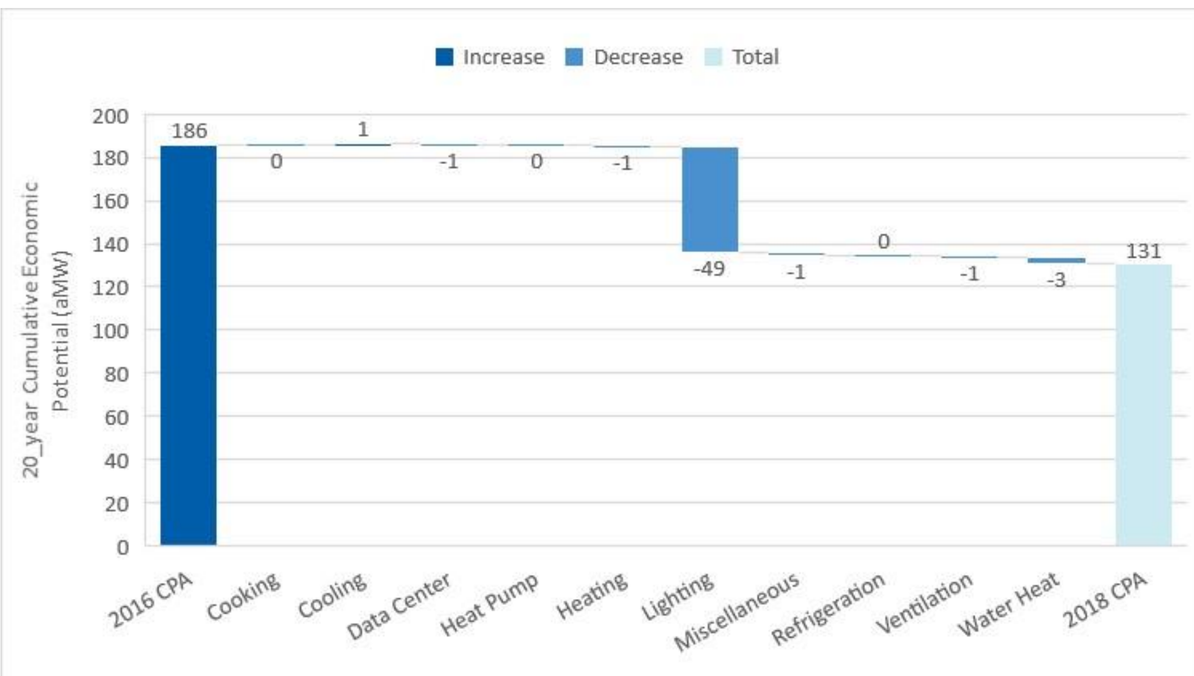
The 2018 CPA identified lower 20-year cumulative technical and economic potential than the 2016 CPA. The decrease in technical was almost entirely due to changes in baselines and unit energy savings values for lighting measures. These changes also contributed to the decrease in economic potential; also, lower avoided costs contributed to lower economic potential, as discussed in the previous section about avoided costs. Table 34 compares technical and economic potential in the commercial sector for the 2016 and 2018 CPAs.

Table 34. Commercial Technical and Economic Potential Comparison

Component	2016 CPA	2018 CPA	Reason for Change
Baseline Sales	740	747	N/A; Small change in commercial baseline forecasts does not significantly affect estimates
Technical Potential	226	180	• Lower lighting potential due to updates to baselines and savings estimates
Technical Potential as % of Baseline	31%	24%	
Economic Potential	186	131	• Lower lighting potential due to updates to baselines and savings estimates • Lower avoided costs
Economic Potential as % of Baseline	25%	17%	
Economic Potential as % of Technical	82%	72%	

Figure 49 illustrates the change in commercial economic potential between the 2016 and 2018 CPAs by end use. Nearly all of the decrease can be attributed to the lighting end use.

Figure 49. Change in Commercial Economic Potential by End Use



This decrease is due to a thorough review and update to commercial lighting measures. Updates to unit energy savings values to reflect DOE rulemaking on various lighting applications. These federal standards have the largest impact on linear fixtures, which require a higher efficacy in 2018. Cadmus' analysis of all lighting measures, including linear applications, are consistent with the final lighting workbooks from the Council's Seventh Power Plan.

5.1.4. Achievable Potential and Ramping

As with assessments of technical and economic potential, Cadmus identified lower 20-year cumulative achievable economic potential. Because 20-year cumulative achievable potential is a subset of economic potential, the factors that contributed to lower cumulative achievable potential are the same as those previously discussed for economic potential. While the 2018 CPA identified lower 20-year cumulative achievable potential than the 2016, incremental achievable potential in the early years of the 20-year horizon are comparable. Figure 50 shows incremental achievable economic potential from the 2018 CPA and Figure 51 shows incremental achievable economic potential from the 2016 CPA.

Figure 50. Incremental Achievable Potential – 2018 CPA

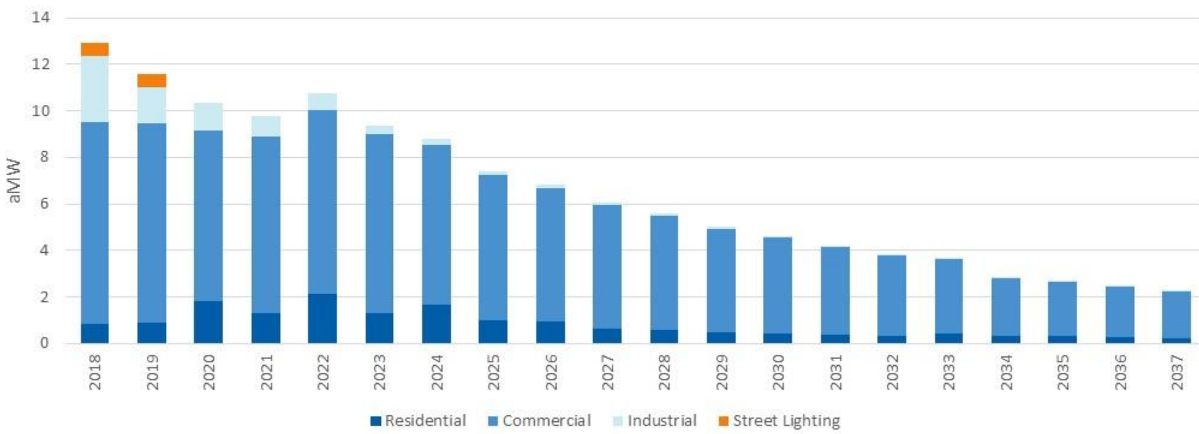


Figure 51. Incremental Achievable Potential – 2016 CPA

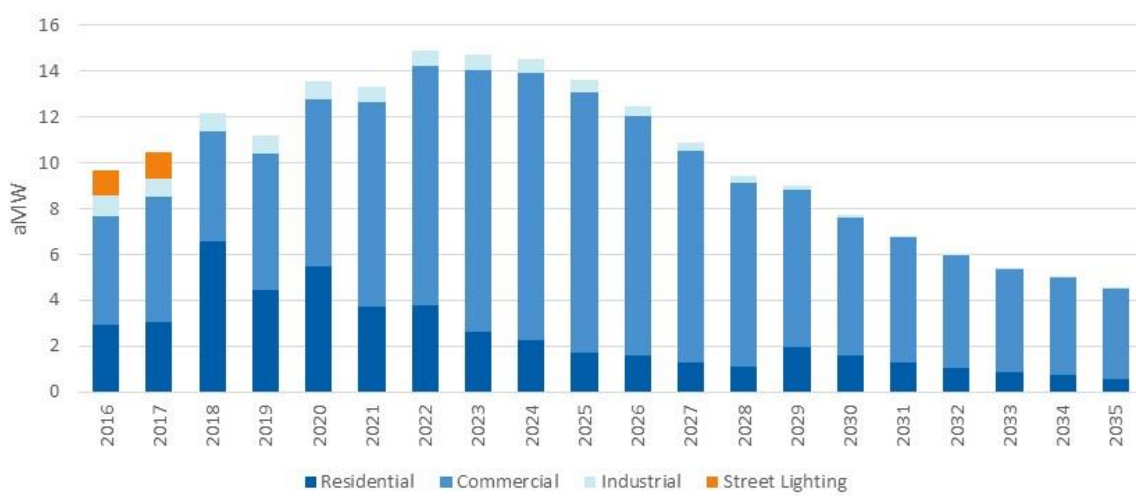
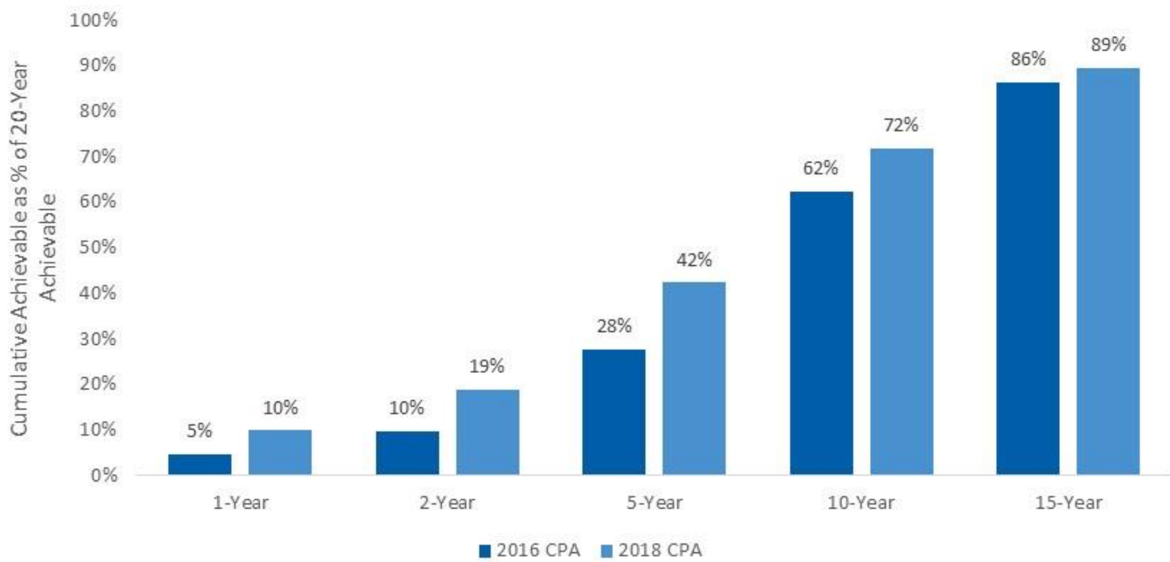


Figure 50 and Figure 51 illustrates how, compared to the 2016 CPA, the 2018 CPA determines that a higher proportion of the total available potential will be realized in the early years of the study. This change is due to a couple factors: the shift in the timeframe—moving from a start year of 2016 to 2018—and the application of faster ramp rates. Cadmus reviewed City Light's recent program accomplishments adjusted ramp rates for each measure to align incremental achievable potential with the first few years of the study with City Light's recent program data. Generally, this involved starting with the Seventh Power Plan ramp rate for each measure, then selecting the next-fastest ramp rate. This resulted in achieving a higher proportion of long-term potential in the early years of the study, as illustrated in Figure 52.

Figure 52. Cumulative Achievable Potential as Percent of 20-Year Achievable



6. Glossary of Terms

These definitions draw heavily from the NAPEE Guide for Conducting Energy Efficiency Potential Studies and the State and Local Energy Efficiency Action Network.[22]

Benefit-cost ratio: The ratio—as determined by the Total Resource Cost test—of the discounted total benefits of the program to the discounted total costs over some specified amount of time.

Cost-effectiveness: A measure of the relevant economic effects resulting from the implementation of an energy efficiency measure. If the benefits of this selection outweigh its cost, the measure is said to be cost-effective.

Economic potential: Refers to the subset of the technical potential that is economically cost-effective as compared to conventional supply-side energy resources.

End use: A category of equipment or service that consumes energy (e.g., lighting, refrigeration, heating, process heat, etc.).

End-use consumption: Used for the residential sector, the per unit energy consumption for a given end use, expressed in annual kWh per unit. Also referred to as unit energy consumption (UEC).

End-use intensities: Used in the commercial and institution sectors, the energy consumption per square foot for a given end use, expressed in annual kWh per square foot per unit.

Energy efficiency: The use of less energy to provide the same or an improved level of service to the energy consumer in an economically efficient way.

Effective useful life: An estimate of the duration of savings from a measure. EUL is estimated through various means, including median number of years that the energy efficiency measures installed under a program are still in place and operable. Also, EUL is sometimes defined as the date at which 50 percent of Installed units are still in place and operational.

Levelized cost: The result of a computational approach used to compare the cost of different projects or technologies. The stream of each project's net costs is discounted to a single year using a discount rate—creating a net present value—and divided by the project's expected lifetime output in megawatt-hours.

Lost opportunity: Refers to an efficiency measure or efficiency program that seeks to encourage the selection of higher-efficiency equipment or building practices than would typically be chosen at the time of a purchase or design decision.

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22 SEEAction. *Energy Efficiency Program Impact Evaluation Guide*. NAPEE Guide for Conducting Energy Efficiency Potential Studies and the State and Local Energy Efficiency Action Network. 2012. Prepared by Steven R. Schiller, Schiller Consulting, Inc. Available online: www.seeaction.energy.gov

Achievable potential: The amount of energy use that efficiency can realistically be expected to displace.

Measure: Installation of equipment, subsystems, or systems, or modification of equipment, subsystems, systems, or operations on the customer side of the meter, to improve energy efficiency.

Portfolio: Either (a) a collection of similar programs addressing the same market, technology, or mechanisms or (b) the set of all programs conducted by one organization.

Conservation potential assessment: A quantitative analysis of the amount of energy savings that either exists, is cost-effective, or could potentially be realized through the implementation of energy efficient programs and policies.

Program: A group of projects with similar characteristics and installed in similar applications.

Retrofit: Refers to an efficiency measure or efficiency program that seeks to encourage the replacement of functional equipment before the end of its operating life with higher efficiency units (also referred to as early-retirement) or the installation of additional controls, equipment, or materials in existing facilities for purposes of reducing energy consumption (e.g., increased insulation, lighting occupancy controls, economizer ventilation systems).

Technical potential: The theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures.

Total resource cost (TRC) test: A cost-effectiveness test that assesses the impacts of a portfolio of energy efficiency initiatives on the economy at large. The test compares the present value of costs of efficiency for all members of society (including costs to participants and program administrators) compared to the present value of benefits, including avoided energy supply and demand costs.

Utility cost test (UCT): A cost-effectiveness test that evaluates the impacts of the efficiency initiatives on the administrator or energy system. It compares the administrator costs (e.g., incentives paid, staff labor, marketing, printing, data tracking, and report) to accrued benefits, including avoided energy and demand supply costs. Also, referred to as the program administrator cost test (PACT).

Seattle City Light

December 2017

2018 Conservation Potential Assessment Volume II - Appendices

Seattle City Light is dedicated to exceeding our customers' expectations in producing and delivering environmentally responsible, safe, low-cost and reliable power.

Larry Weis, General Manager and CEO
Jim Baggs, Customer Service, Communications & Regulatory Affairs Officer

Contents

Volume II contains appendices to Seattle City Light's 2018 Conservation Potential Assessment. Appendices include:

- **Appendix A: Washington Initiative 937 (I-937) Compliance Documentation.** Appendix A includes documentation demonstrating methodological consistency of this CPA with the Northwest Power Council's Seventh Power Plan.
- **Appendix B: Baseline Data.** Appendix B provides tables and figures summarizing the baseline end use forecasts for each sector. It also includes summaries of saturations, fuel shares, and end use energy consumption.
- **Appendix C: Energy Efficiency Measure Descriptions**. Appendix D describes each Energy Conservation Measure (ECM) included in this assessment. Cadmus derived nearly all ECMs from the Council's Seventh Plan—this appendix identifies each Council workbook from which we developed costs, savings, and measure lives.
- **Appendix D: Detailed Energy Efficiency Potential**. Appendix E includes pie charts summarizing cumulative 20-year achievable economic potential for the IRP avoided cost scenario by sector, segment, and end use.
- **Appendix E: Measure Details.** Appendix F includes cost and savings assumptions, benefit-cost ratios, levelized costs, and estimates of technical, economic, and achievable potential for each ECM permutation considered in this study.

Appendix A. Washington Initiative 937 (I-937) Compliance Documentation

The Washington Administrative Code chapter 194-37-070 says CPAs must use methodologies consistent with the most recently published regional power plan and satisfy the fifteen criteria. Table A-1 lists these items and describes how City Light's 2018 CPA satisfies the criteria.

Following Table A-1, the Methodology Comparison section discusses key parts of the Council's methodology for assessing conservation potential and explains how Cadmus' approach for City Light's 2018 CPA is consistent.

TABLE A-1 WAC 194-37-070 DOCUMENTATION

Northwest Power and Conservation Council Methodology	Cadmus Methodology
(a) Analyze a broad range of energy efficiency measures considered technically feasible;	All the most up-do-date, active measures from the Regional Technical Forum (RTF) and measures from the Northwest Power and Conservation Council's (Council) Seventh Power Plan were analyzed. Over 4,200 measure permutations were considered for this study.
(b) Perform a life-cycle cost analysis of measures or programs, including the incremental savings and incremental costs of measures and replacement measures where resources or measures have different measure lifetimes;	Life-cycle cost analysis was performed in a manner consistent with the Council's PROCOST model. Incremental costs, energy savings, and measure lives from the Seventh Power Plan and RTF workbooks were used as the basis for this analysis.
(c) Set avoided costs equal to a forecast of regional market prices, which represents the cost of the next increment of available and reliable power supply available to the utility for the life of the energy efficiency measures to which it is compared;	Avoided cost forecasts were provided by City Light, consistent with the City Light's IRP. Cadmus estimated potential for two avoided cost scenarios—one based on regional market prices and second based on City Light's preferred portfolio selected by City Light's previous IRP. Conservation potential and the conservation target are based on City Light's "IRP preferred" avoided costs.
(d) Calculate the value of the energy saved based on when it is saved. In performing this calculation, use time differentiated avoided costs to conduct the analysis that determines the financial value of energy saved through conservation;	Measure load shapes were used to calculate time of day and year usage and measure values were weighted based upon peak and off-peak pricing. This was performed in a manner consistent with the Council's PROCOST model.

TABLE A-1 WAC 194-37-070 DOCUMENTATION	
Northwest Power and Conservation Council Methodology	**Cadmus Methodology**
(e) Conduct a total resource cost analysis that assesses all costs and all benefits of conservation measures regardless of who pays the costs or receives the benefits. The NWPCC identifies conservation measures that pass the total resource cost test as economically achievable;	Benefit-cost analysis was conducted according to the Council's methodology. Capital cost, administrative cost, annual O&M cost and periodic replacement costs were all considered on the cost side. Energy, non-energy, O&M and all other quantifiable benefits were included on the benefits side. The Total Resource Cost (TRC) benefit cost ratio was used to screen measures for cost-effectiveness (I.e., those greater than 1 are cost-effective).
(f) Identify conservation measures that pass the total resource cost test, by having a benefit/cost ratio of one or greater as economically achievable;	Measures achieving a benefit-cost ratio (on a TRC basis) greater than or equal to 1 are considered achievable and cost-effective.
(g) Include the increase or decrease in annual or periodic operations and maintenance costs due to conservation measures;	Operations and maintenance costs for each measure were accounted for in the total resource cost per the Council's assumptions.
(h) Include deferred capacity expansion benefits for transmission and distribution systems in its cost-effectiveness analysis;	Cost-benefit ratios and levelized costs incorporate City Light's avoided transmission and distribution cost forecasts.
(i) Include all non-power benefits that a resource or measure may provide that can be quantified and monetized;	Quantifiable non-energy benefits were included for the appropriate measures. Non-energy benefits include, for example, water savings from clothes washers. The source of these benefits was either the RTF or the Seventh Plan, depending upon the measure.
(j) Include an estimate of program administrative costs;	A 20 percent residential and 23 percent commercial and industrial administrative cost (percent of incremental cost) was used for this study. Cadmus derived these cost adders from City Light's 2015 program expenditures.
(k) Discount future costs and benefits at a discount rate based on a weighted, after-tax, cost of capital for utilities and their customers for the measure lifetime;	Discount rates were applied to each measure in the study using the Council's methodology. The real discount rate used is 3 percent.

TABLE A-1 WAC 194-37-070 DOCUMENTATION	
Northwest Power and Conservation Council Methodology	**Cadmus Methodology**
(l) Include estimates of the achievable conservation penetration rates for conservation measures;	Achievable potential estimates for each measure was determined by applying the Council's 85 percent achievability factor and ramp rates consistent with the Council's methodology.
(m) Include a ten percent bonus for conservation measures as defined in 16 U.S.C. § 839a of the Pacific Northwest Electric Power Planning and Conservation Act;	The 10 percent bonus for conservation measures as defined in 16 U.S.C. § 839a of the Pacific Northwest Electric Power Planning and Conservation Act was applied to all measures in the study. This adder was included in avoided cost forecasts for cost-benefit analysis and in the calculation of levelized costs.
(n) Analyze the results of multiple scenarios. This includes testing scenarios that accelerate the rate of conservation acquisition in the earlier years; and	Cadmus considered two scenarios reflecting different avoided cost forecast. For each scenario, Cadmus tested scenarios with accelerated ramp rates, increasing conservation in early years.
(o) Analyze the costs of estimated future environmental externalities in the multiple scenarios that estimate costs and risks.	The study considers two avoided cost scenarios to capture price uncertainty. Both forecasts include the value of avoided CO2 offsets and the market price forecast includes the value of avoided renewable energy credit purchases.

A.1 Methodology Comparison

To facilitate a comparison with the Seventh Power Plan, the Council prepared an overview of the methodology used in developing the Seventh Power Plan's conservation potential estimates. This appendix compares the methodology used in City Light's 2018 CPA to the benchmarks established by the Council.

Italics denote descriptions of methodologies used in this study.

A.1.1 Technical Resource Potential Assessment

The assessment reviewed a wide array of energy-efficiency technologies and practices across all sectors and major end uses.

The study considered measures from a variety of sources, including the Seventh Plan and RTF. Appendix D provides descriptions of all measures analyzed.

A.1.1.1 Methodology

- Technically feasibility savings = Number of applicable units * incremental savings/applicable unit
- Applicable units accounted for:
  - **Fuel saturations** (e.g., electric vs. gas DHW).

    Whenever possible, fuel saturations were based on data specific to City Light's service territory. City Light's oversamples for the 2014 Commercial Building Stock Assessment (CBSA) and the 2017 Residential Building Stock Assessment (RBSA) served as the primary sources of this information.
  - **Building characteristics** (e.g., single-family vs. mobile homes, basement/non-basement).

    Data derived from NEEA's 2017 Residential Building Stock Assessment (RBSA), CBSA, and City Light's customer database.
  - **System saturations** (e.g., heat pump vs. zonal, central AC vs. window AC).

    Whenever possible, system saturations were based on data specific to City Light's service territory. City Light's oversamples for the 2014 Commercial Building Stock Assessment (CBSA) and the 2017 Residential Building Stock Assessment (RBSA) served as the primary sources of this information.
  - **Current measure saturations.**

    Current saturations were incorporated into the applicability, based on information from RBSA, CBSA, the Seventh Plan and RTF.
  - **New and existing units.**

    Existing and new units were calculated based on current and forecasted customers, respectively.
  - **Measure life** (stock turnover cycle).

    Measure decay rates were applied to lost opportunity measures, based on measure life. Discretionary measures were assumed to be reinstalled at the end of their useful life.
  - **Measure substitutions** (e.g., duct sealing of homes with forced-air resistance furnaces vs. conversion of homes to heat pumps with sealed ducts).

    The measure share applicability factor accounted for competition between measures to avoid double-counting.
- Incremental savings/applicable unit accounted for:
  - **Expected kW and kWh savings**, shaped by time-of-day, day of week and month of year.

    Energy and demand savings were either based on deemed values or calculated as a percent reduction in baseline end-use consumption.
  - **Savings over baseline efficiency.**

    Baseline set by codes/standards or current practices.

    Baselines were set based on current codes, standards, or current practices. Standards passed but not yet implemented became the baseline at the time mandated in the new standard.

Not always equivalent to savings over current use (e.g., new refrigerator savings measured as increment above current federal standards, not the refrigerator being replaced).

Savings from equipment upgrades were calculated based on the market average efficiency level available at the time of burnout.

- **Climate**—heating, cooling degree days and solar availability.

  Savings were based on the typical climate in City Light's service territory.

- **Measure interactions** (e.g., lighting and HVAC, duct sealing and heat pump performance, heat pump conversion, and weatherization savings).

  These interactive effects were treated as a reduction in measure savings (e.g., commercial lighting measures might save less due to increased heating requirements).

A.1.2 Economic Potential: Ranking Based on Resource Valuation

- The total resource cost (TRC) served as the criterion for economic screening, and included all cost and benefits of measures, regardless of the parties paying for or receiving them.
  - **TRC B/C Ratio > = 1.0**

    Benefit-cost analysis was conducted according to the Council's methodology. Capital cost, administrative cost, annual O&M cost and periodic replacement costs were all considered on the cost side. Energy, non-energy, O&M and all other quantifiable benefits were included on the benefits side. The Total Resource Cost (TRC) benefit cost ratio was used to screen measures for cost-effectiveness (I.e., those greater than 1 are cost-effective).

  - **Levelized cost of conserved energy** (CCE) < levelized avoided cost for the load shape of the savings could substitute for TRC if "CCE" was adjusted to account for "non-kWh" benefits, including deferred T&D, non-energy benefits, environmental benefits, and the Act's 10% conservation credit.

    Levelized costs, on a TRC basis, were calculated for each measure in comparison with the Integrated Resource Planning's (IRP) supply-side resources. The levelized cost calculation incorporated deferred T&D (for electric resources), non-energy benefits, secondary fuel benefits, and the Act's 10% conservation credit (for electric resources).

A.1.2.1 Methodology

- **The energy and capacity value** (i.e., benefit) of savings was based on the avoided cost of future wholesale market purchases (forward price curves).

  The study considered two avoided cost forecasts—one based on the avoided cost of future wholesale market purchases and a second based on the avoided cost of future market purchases and the construction of new renewable generation

- **The energy and capacity value** accounted for the shape of savings (i.e., used time and seasonally differentiated avoided costs and measure savings).

  The analysis relied time differentiated avoided costs and savings to calculate the value of avoided energy and capacity

- **Uncertainties** in future market prices were accounted for by performing the valuation under a wide range of future market price scenarios during the IRP process.

  Two avoided cost scenarios were considered to account for price uncertainty
- **Costs inputs** (resource cost elements):

  All costs listed below were included in the per-unit measure costs, where appropriate.
  - Full incremental measure costs (material and labor).
  - Applicable ongoing O&M expenses (plus or minus).
  - Applicable periodic O&M expenses (plus or minus).
  - Utility administrative costs (e.g., program planning, marketing, delivery, ongoing administration, evaluation).
- **Benefit inputs** (resource value elements):

  All benefits listed below were assessed in calculating the levelized cost of conserved energy and benefit-cost ratios, where appropriate.
  - Direct energy savings.
  - Direct capacity savings.
  - Avoided T&D losses.
  - Deferral value of transmission and distribution system expansion (if applicable).
  - Non-energy benefits (e.g., water savings).
  - Environmental externalities.
- **Discounted presented value inputs:**
  - Rate = After-tax average cost of capital weighted for project participants (real or nominal).

    The analysis used City Light's discount rate of 3.0 percent.
  - Term = Project life; generally equivalent to life of resources added during the planning period.

    Costs were levelized over each measure's expected useful life. Any reinstallation costs over the 20-year planning period were similarly levelized.
  - Money was discounted, not energy savings.

    The value of energy savings ($) is discounted

A.1.3 Achievable Potential

- **Annual acquisition targets**, established through the IRP process (i.e., portfolio modeling).

  Acquisition targets were established in accordance to WAC 194-37. The CPA determined conservation targets based on the pro-rata share of ten-year conservation potential and 2-year conservation potential. This level of conservation was included in City Light's IRP modeling.
- **Conservation** competed against all other resource options in portfolio analysis:

  Conservation resource supply curves separated into:
  - **Discretionary** (non-lost opportunity).

    Defined as retrofit opportunities in existing facilities.

- **Lost-opportunity.**

  Including equipment replacements in existing facilities and all new construction measures.

- **Annual achievable potential**, constrained by historic "ramp rates" for discretionary and lost-opportunity resources:

  The maximum ramp-up/ramp-down rate for discretionary was 3x the prior year for discretionary, with an upper limit of 85% over the 20-year planning period.

  Analysis assumed 85% of discretionary resources could be acquired within at least a 20-year timeframe.

  The ramp rate for a lost-opportunity was 15% in first year, growing to 85% by the 12th year.

  Lost opportunity ramp rates varied by measure, and were based on City Light's program history.

  Achievable potentials could vary by the type of measure, customer sector, and program design (e.g., measures subject to federal standards could have 100% "achievable" potential).

  While the analysis removed savings from known standards, it did not attempt to predict which savings would be acquired from future codes or standards.

- **Revised technical, economic and achievable potential**, based on changes in market conditions (e.g., revised codes or standards), program accomplishments, evaluations, and experience.

  Changes taking effect after the finalization of the 2016 CPA are reflected in the 2018 CPA.

  - All programs should incorporate measurement and verification (M&V) plans that, at a minimum, track administrative and measure costs and savings.
  - The International Performance Measurement and Verification Protocols (IPMVP) should be used as a guide.

Appendix B. Baseline Data

Appendix B includes summaries of baseline forecasts for the residential, commercial and industrial sectors. These forecasts were calibrated to City Light's load forecasts; however, individual sector forecasts may differ from City Light's due to adjustments for future equipment standards. This appendix also includes detailed baseline inputs for the residential and commercial sectors, such as end use saturations, fuel shares and unit energy consumption (UEC) or end use energy use intensities (EUIs). UECs apply to the residential sector and are expressed in kWh per unit. EUIs apply to the commercial sector and are expressed in kWh per square foot.

Residential Baseline Data

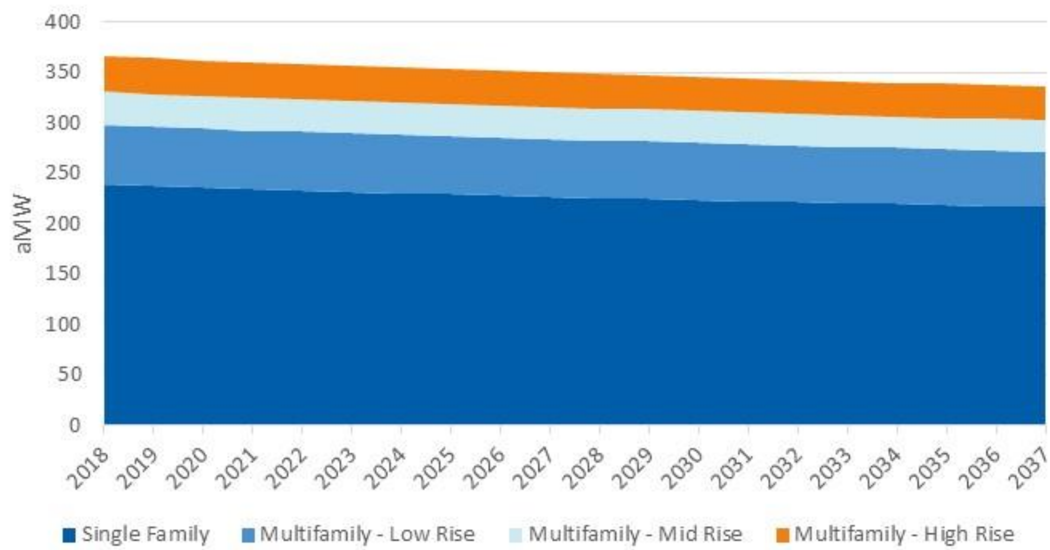

Figure B-1 Residential Baseline Forecast by Segment

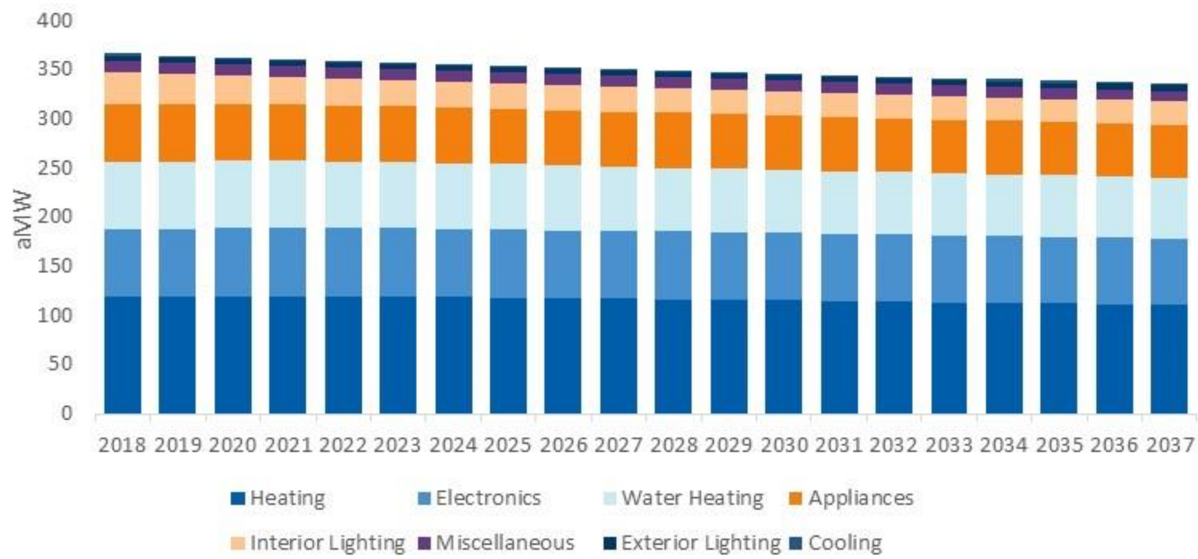

Figure B-2 Residential Baseline Forecast by End Use

Table 1. Residential Saturations, Fuel Shares, and UECs.

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Unit)	Weighted Average UEC New (kWh/Unit)
Multifamily - High Rise	Air Purifier	0.0	100%	217.6	217.6
Multifamily - High Rise	Computer - Desktop	0.4	100%	89.8	80.1
Multifamily - High Rise	Computer - Laptop	0.4	100%	28.2	25.4
Multifamily - High Rise	Cooking Oven	1.0	93%	132.2	132.2
Multifamily - High Rise	Cooking Range	1.0	93%	44.5	44.5
Multifamily - High Rise	Cool Central	0.0	100%	201.6	189.7
Multifamily - High Rise	Cool Room	0.2	100%	96.0	96.0
Multifamily - High Rise	Copier	0.0	100%	413.6	400.3
Multifamily - High Rise	Dryer	0.4	100%	640.4	522.9

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Unit)	Weighted Average UEC New (kWh/Unit)
Multifamily - High Rise	DVD	1.2	100%	17.4	17.4
Multifamily - High Rise	Freezer	0.0	100%	417.5	327.2
Multifamily - High Rise	Heat Central	0.0	0%	4,424.3	2,663.3
Multifamily - High Rise	Heat Pump	0.0	100%	4,215.6	3,024.5
Multifamily - High Rise	Heat Room	0.8	97%	2,014.9	1,224.6
Multifamily - High Rise	Home Audio System	0.5	100%	83.2	83.2
Multifamily - High Rise	Lighting Exterior	0.1	100%	42.2	42.2
Multifamily - High Rise	Lighting Interior Linear Fluorescent	1.8	100%	66.6	66.6
Multifamily - High Rise	Lighting Interior Specialty	6.7	100%	20.1	20.1
Multifamily - High Rise	Lighting Interior Standard	8.8	100%	17.1	15.7
Multifamily - High Rise	Microwave	0.7	100%	110.6	110.6
Multifamily - High Rise	Monitor	0.3	100%	37.1	34.1
Multifamily - High Rise	Multifunction Device	0.9	100%	147.4	138.6
Multifamily - High Rise	Other	1.0	100%	0.0	0.0
Multifamily - High Rise	Plug Load Other	1.0	100%	269.8	269.8
Multifamily - High Rise	Printer	0.4	100%	74.9	70.3
Multifamily - High Rise	Refrigerator	1.0	100%	514.3	510.0
Multifamily - High Rise	Set Top Box	0.4	100%	134.3	134.3
Multifamily - High Rise	Television	1.1	100%	156.3	155.7

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Unit)	Weighted Average UEC New (kWh/Unit)
Multifamily - High Rise	Television Bigscreen	0.4	100%	344.1	342.6
Multifamily - High Rise	Ventilation and Circulation	0.0	100%	483.5	483.5
Multifamily - High Rise	Waste Water	1.0	100%	210.2	210.2
Multifamily - High Rise	Water Heat GT 55 Gal	0.0	100%	2,018.1	890.1
Multifamily - High Rise	Water Heat LE 55 Gal	0.3	100%	1,802.8	1,768.6
Multifamily - Low Rise	Air Purifier	0.0	100%	217.6	217.6
Multifamily - Low Rise	Computer - Desktop	0.4	100%	89.8	80.1
Multifamily - Low Rise	Computer - Laptop	0.5	100%	28.2	25.4
Multifamily - Low Rise	Cooking Oven	1.1	89%	132.2	132.2
Multifamily - Low Rise	Cooking Range	1.1	89%	44.5	44.5
Multifamily - Low Rise	Cool Central	0.0	100%	201.6	189.7
Multifamily - Low Rise	Cool Room	0.2	100%	96.0	96.0
Multifamily - Low Rise	Copier	0.0	100%	413.6	400.3
Multifamily - Low Rise	Dryer	0.6	100%	640.4	522.9
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Multifamily - Low Rise	Freezer	0.1	100%	417.5	327.2
Multifamily - Low Rise	Heat Central	0.0	0%	4,424.3	2,663.3
Multifamily - Low Rise	Heat Pump	0.0	100%	4,215.6	3,024.5
Multifamily - Low Rise	Heat Room	0.8	100%	2,014.9	1,224.6

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Unit)	Weighted Average UEC New (kWh/Unit)
Multifamily - Low Rise	Home Audio System	0.6	100%	83.2	83.2
Multifamily - Low Rise	Lighting Exterior	0.3	100%	58.8	53.9
Multifamily - Low Rise	Lighting Interior Linear Fluorescent	1.7	100%	66.6	66.6
Multifamily - Low Rise	Lighting Interior Specialty	2.7	100%	22.5	22.5
Multifamily - Low Rise	Lighting Interior Standard	13.8	100%	16.1	15.1
Multifamily - Low Rise	Microwave	0.7	100%	110.6	110.6
Multifamily - Low Rise	Monitor	0.6	100%	37.1	34.1
Multifamily - Low Rise	Multifunction Device	0.9	100%	147.4	138.6
Multifamily - Low Rise	Other	1.0	100%	0.0	0.0
Multifamily - Low Rise	Plug Load Other	1.0	100%	269.8	269.8
Multifamily - Low Rise	Printer	0.5	100%	74.9	70.3
Multifamily - Low Rise	Refrigerator	1.1	100%	514.3	510.0
Multifamily - Low Rise	Set Top Box	0.8	100%	134.3	134.3
Multifamily - Low Rise	Television	1.5	100%	156.3	155.7
Multifamily - Low Rise	Television - Big screen	0.4	100%	344.1	342.6
Multifamily - Low Rise	Ventilation and Circulation	0.0	100%	483.5	483.5
Multifamily - Low Rise	Waste Water	1.0	100%	210.2	210.2
Multifamily - Low Rise	Water Heat GT 55 Gal	0.0	0%	2,018.1	890.1
Multifamily - Low Rise	Water Heat LE 55 Gal	0.7	100%	1,802.8	1,768.6

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Unit)	Weighted Average UEC New (kWh/Unit)
Multifamily - Mid Rise	Air Purifier	0.0	100%	217.6	217.6
Multifamily - Mid Rise	Computer - Desktop	0.4	100%	89.8	80.1
Multifamily - Mid Rise	Computer - Laptop	0.4	100%	28.2	25.4
Multifamily - Mid Rise	Cooking Oven	1.0	93%	132.2	132.2
Multifamily - Mid Rise	Cooking Range	1.0	93%	44.5	44.5
Multifamily - Mid Rise	Cool Central	0.0	100%	201.6	189.7
Multifamily - Mid Rise	Cool Room	0.2	100%	96.0	96.0
Multifamily - Mid Rise	Copier	0.0	100%	413.6	400.3
Multifamily - Mid Rise	Dryer	0.4	100%	640.4	522.9
Multifamily - Mid Rise	DVD	1.2	100%	17.4	17.4
Multifamily - Mid Rise	Freezer	0.0	100%	417.5	327.2
Multifamily - Mid Rise	Heat Central	0.0	0%	4,424.3	2,663.3
Multifamily - Mid Rise	Heat Pump	0.0	100%	4,215.6	3,024.5
Multifamily - Mid Rise	Heat Room	0.8	97%	2,014.9	1,224.6
Multifamily - Mid Rise	Home Audio System	0.5	100%	83.2	83.2
Multifamily - Mid Rise	Lighting Exterior	0.1	100%	42.2	42.2
Multifamily - Mid Rise	Lighting Interior Linear Fluorescent	1.8	100%	66.6	66.6
Multifamily - Mid Rise	Lighting Interior Specialty	6.7	100%	20.1	20.1
Multifamily - Mid Rise	Lighting Interior Standard	8.8	100%	17.1	15.7

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Unit)	Weighted Average UEC New (kWh/Unit)
Multifamily - Mid Rise	Microwave	0.7	100%	110.6	110.6
Multifamily - Mid Rise	Monitor	0.3	100%	37.1	34.1
Multifamily - Mid Rise	Multifunction Device	0.9	100%	147.4	138.6
Multifamily - Mid Rise	Other	1.0	100%	0.0	0.0
Multifamily - Mid Rise	Plug Load Other	1.0	100%	269.8	269.8
Multifamily - Mid Rise	Printer	0.4	100%	74.9	70.3
Multifamily - Mid Rise	Refrigerator	1.0	100%	514.3	510.0
Multifamily - Mid Rise	Set Top Box	0.4	100%	134.3	134.3
Multifamily - Mid Rise	Television	1.1	100%	156.3	155.7
Multifamily - Mid Rise	Television - Big screen	0.4	100%	344.1	342.6
Multifamily - Mid Rise	Ventilation and Circulation	0.0	100%	483.5	483.5
Multifamily - Mid Rise	Waste Water	1.0	100%	210.2	210.2
Multifamily - Mid Rise	Water Heat GT 55 Gal	0.0	100%	2,018.1	890.1
Multifamily - Mid Rise	Water Heat LE 55 Gal	0.3	100%	1,802.8	1,768.6
Single Family	Air Purifier	0.0	100%	217.6	217.6
Single Family	Computer - Desktop	0.7	100%	89.8	80.1
Single Family	Computer - Laptop	0.6	100%	28.2	25.4
Single Family	Cooking Oven	1.1	81%	132.2	132.2
Single Family	Cooking Range	1.1	76%	44.5	44.5
Single Family	Cool Central	0.0	100%	520.3	380.6
Single Family	Cool Room	0.2	100%	247.8	247.8

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Unit)	Weighted Average UEC New (kWh/Unit)
Single Family	Copier	0.0	100%	413.6	400.3
Single Family	Dryer	0.9	86%	640.4	522.9
Single Family	DVD	1.6	100%	17.4	17.4
Single Family	Freezer	0.3	100%	417.5	327.2
Single Family	Heat Central	0.5	10%	9,157.0	4,274.4
Single Family	Heat Pump	0.1	100%	6,932.8	3,575.0
Single Family	Heat Room	0.4	87%	6,091.5	2,903.5
Single Family	Home Audio System	0.7	100%	83.2	83.2
Single Family	Lighting Exterior	4.0	100%	54.3	46.9
Single Family	Lighting Interior Linear Fluorescent	3.8	100%	66.6	66.6
Single Family	Lighting Interior Specialty	17.9	100%	18.9	18.9
Single Family	Lighting Interior Standard	22.5	100%	19.7	17.4
Single Family	Microwave	0.8	100%	110.6	110.6
Single Family	Monitor	0.7	100%	37.1	34.1
Single Family	Multifunction Device	1.2	100%	147.4	138.6
Single Family	Other	1.0	100%	0.0	0.0
Single Family	Plug Load Other	1.0	100%	642.2	642.2
Single Family	Pool Pump	0.0	100%	1,522.1	635.2
Single Family	Printer	0.6	100%	74.9	70.3
Single Family	Refrigerator	1.2	100%	514.3	510.0
Single Family	Set Top Box	0.9	100%	134.3	134.3
Single Family	Television	1.8	100%	156.3	155.7
Single Family	Television-Big screen	0.6	100%	344.1	342.6
Single Family	Ventilation and Circulation	0.5	100%	833.0	833.0
Single Family	Waste Water	1.0	100%	210.2	210.2
Single Family	Water Heat GT 55 Gal	0.1	88%	3,311.8	1,460.7

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Unit)	Weighted Average UEC New (kWh/Unit)
Single Family	Water Heat LE 55 Gal	0.8	64%	2,958.5	2,902.4

Commercial Baseline Data

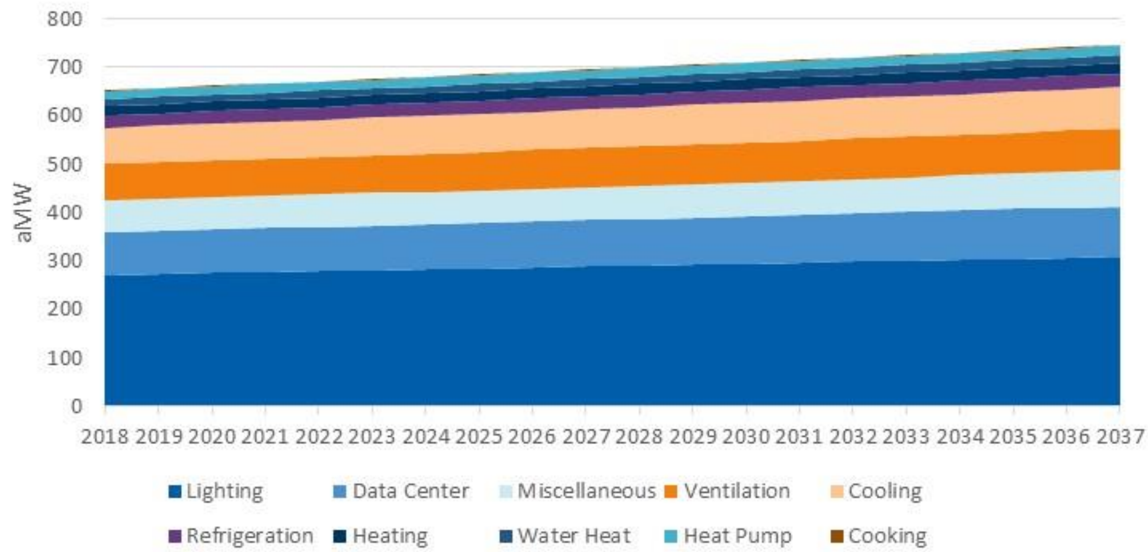

Figure B-3 Commercial Baseline Forecast by End Use

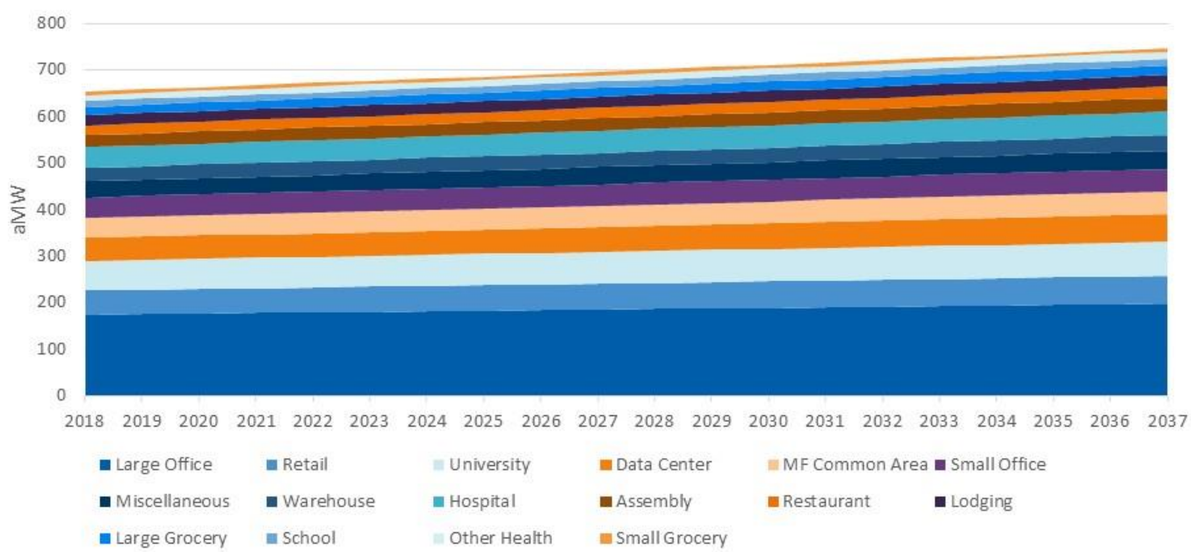

Figure B-4 Commercial Baseline Forecast by Sector

Table 2. Commercial Saturations, Fuel Shares, and EUIs

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Sqft)	Weighted Average UEC New (kWh/Sqft)
Assembly	Compressed Air	3%	100%	0.71	0.71
Assembly	Cooking	0%	0%	0.00	0.00
Assembly	Cool Central	41%	100%	3.32	3.32
Assembly	Data Center	100%	100%	0.44	0.44
Assembly	Exterior Lighting	100%	100%	1.12	1.12
Assembly	Heat Central	75%	13%	2.37	2.37
Assembly	Heat Pump	22%	100%	2.73	2.73
Assembly	Interior Lighting	100%	100%	3.67	3.67
Assembly	Other	100%	100%	0.00	0.00
Assembly	Plug Load Other	100%	100%	1.30	1.30
Assembly	Refrigeration	100%	100%	0.17	0.17
Assembly	Ventilation	97%	100%	1.93	1.93
Assembly	Waste Water	100%	100%	0.12	0.12
Assembly	Water Heat GT 55 Gal	35%	63%	0.35	0.35
Assembly	Water Heat LE 55 Gal	65%	85%	0.32	0.32
Hospital	Compressed Air	0%	100%	0.00	0.00
Hospital	Cooking	100%	13%	0.65	0.65
Hospital	Cool Central	65%	100%	4.56	4.56
Hospital	Data Center	100%	100%	1.75	1.75
Hospital	Exterior Lighting	100%	100%	0.70	0.70
Hospital	Heat Central	76%	34%	1.52	1.52
Hospital	Heat Pump	23%	100%	4.36	4.36
Hospital	Interior Lighting	100%	100%	7.41	7.41
Hospital	Other	100%	100%	0.00	0.00
Hospital	Plug Load Other	100%	100%	5.05	5.05
Hospital	Refrigeration	100%	100%	0.59	0.59
Hospital	Ventilation	99%	100%	6.46	6.46
Hospital	Waste Water	100%	100%	0.26	0.26
Hospital	Water Heat GT 55 Gal	79%	4%	1.70	1.70
Hospital	Water Heat LE 55 Gal	21%	67%	1.59	1.59
Large Off	Compressed Air	0%	100%	0.00	0.00

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Sqft)	Weighted Average UEC New (kWh/Sqft)
Large Off	Cooking	0%	0%	0.00	0.00
Large Off	Cool Central	87%	100%	3.86	3.86
Large Off	Data Center	100%	100%	1.75	1.75
Large Off	Exterior Lighting	100%	100%	0.54	0.54
Large Off	Heat Central	85%	31%	3.39	3.39
Large Off	Heat Pump	14%	100%	3.16	3.16
Large Off	Interior Lighting	100%	100%	5.10	5.10
Large Off	Other	100%	100%	0.00	0.00
Large Off	Plug Load Other	100%	100%	1.47	1.47
Large Off	Refrigeration	100%	100%	0.09	0.09
Large Off	Ventilation	98%	100%	1.62	1.62
Large Off	Waste Water	100%	100%	0.21	0.21
Large Off	Water Heat GT 55 Gal	41%	53%	0.50	0.50
Large Off	Water Heat LE 55 Gal	59%	100%	0.47	0.47
Large Ret	Compressed Air	48%	100%	0.15	0.15
Large Ret	Cooking	0%	0%	0.00	0.00
Large Ret	Cool Central	97%	100%	1.94	1.94
Large Ret	Data Center	100%	100%	0.44	0.44
Large Ret	Exterior Lighting	100%	100%	1.14	1.14
Large Ret	Heat Central	98%	6%	2.07	2.07
Large Ret	Heat Pump	0%	100%	2.98	2.98
Large Ret	Interior Lighting	100%	100%	7.72	7.72
Large Ret	Other	100%	100%	0.00	0.00
Large Ret	Plug Load Other	100%	100%	0.83	0.83
Large Ret	Refrigeration	100%	100%	0.08	0.08
Large Ret	Ventilation	98%	100%	2.79	2.79
Large Ret	Waste Water	100%	100%	0.13	0.13
Large Ret	Water Heat GT 55 Gal	43%	11%	0.30	0.30
Large Ret	Water Heat LE 55 Gal	57%	50%	0.28	0.28
Lodging	Compressed Air	0%	100%	0.00	0.00
Lodging	Cooking	100%	11%	0.53	0.53
Lodging	Cool Central	50%	100%	2.71	2.71
Lodging	Data Center	100%	100%	0.44	0.44

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Sqft)	Weighted Average UEC New (kWh/Sqft)
Lodging	Exterior Lighting	100%	100%	0.54	0.54
Lodging	Heat Central	63%	46%	3.25	3.25
Lodging	Heat Pump	35%	100%	3.08	3.08
Lodging	Interior Lighting	100%	100%	5.74	5.74
Lodging	Other	100%	100%	0.00	0.00
Lodging	Plug Load Other	100%	100%	0.92	0.92
Lodging	Refrigeration	100%	100%	0.22	0.22
Lodging	Ventilation	98%	100%	2.63	2.63
Lodging	Waste Water	100%	100%	0.32	0.32
Lodging	Water Heat GT 55 Gal	87%	12%	1.41	1.41
Lodging	Water Heat LE 55 Gal	13%	100%	1.32	1.32
Medium Off	Compressed Air	0%	100%	0.00	0.00
Medium Off	Cooking	0%	0%	0.00	0.00
Medium Off	Cool Central	87%	100%	4.08	4.08
Medium Off	Data Center	100%	100%	1.75	1.75
Medium Off	Exterior Lighting	100%	100%	0.57	0.57
Medium Off	Heat Central	85%	31%	3.57	3.57
Medium Off	Heat Pump	14%	100%	3.34	3.34
Medium Off	Interior Lighting	100%	100%	5.38	5.38
Medium Off	Other	100%	100%	0.00	0.00
Medium Off	Plug Load Other	100%	100%	1.55	1.55
Medium Off	Refrigeration	100%	100%	0.10	0.10
Medium Off	Ventilation	98%	100%	1.70	1.70
Medium Off	Waste Water	100%	100%	0.21	0.21
Medium Off	Water Heat GT 55 Gal	41%	53%	0.52	0.52
Medium Off	Water Heat LE 55 Gal	59%	100%	0.49	0.49
Medium Ret	Compressed Air	48%	100%	0.15	0.15
Medium Ret	Cooking	0%	0%	0.00	0.00
Medium Ret	Cool Central	97%	100%	1.67	1.67
Medium Ret	Data Center	100%	100%	0.44	0.44
Medium Ret	Exterior Lighting	100%	100%	0.98	0.98
Medium Ret	Heat Central	98%	6%	1.79	1.79
Medium Ret	Heat Pump	0%	100%	2.57	2.57

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Sqft)	Weighted Average UEC New (kWh/Sqft)
Medium Ret	Interior Lighting	100%	100%	6.67	6.67
Medium Ret	Other	100%	100%	0.00	0.00
Medium Ret	Plug Load Other	100%	100%	0.72	0.72
Medium Ret	Refrigeration	100%	100%	0.07	0.07
Medium Ret	Ventilation	98%	100%	2.41	2.41
Medium Ret	Waste Water	100%	100%	0.13	0.13
Medium Ret	Water Heat GT 55 Gal	43%	11%	0.26	0.26
Medium Ret	Water Heat LE 55 Gal	57%	50%	0.24	0.24
MiniMart	Compressed Air	29%	100%	2.62	2.62
MiniMart	Cooking	100%	9%	1.98	1.98
MiniMart	Cool Central	71%	100%	1.27	1.27
MiniMart	Data Center	100%	100%	0.44	0.44
MiniMart	Exterior Lighting	100%	100%	0.78	0.78
MiniMart	Heat Central	74%	45%	1.59	1.59
MiniMart	Heat Pump	13%	100%	3.39	3.39
MiniMart	Interior Lighting	100%	100%	7.07	7.07
MiniMart	Other	100%	100%	0.00	0.00
MiniMart	Plug Load Other	100%	100%	0.91	0.91
MiniMart	Refrigeration	100%	100%	15.11	15.11
MiniMart	Ventilation	87%	100%	1.59	1.59
MiniMart	Waste Water	100%	100%	0.09	0.09
MiniMart	Water Heat GT 55 Gal	1%	33%	0.23	0.23
MiniMart	Water Heat LE 55 Gal	99%	71%	0.21	0.21
Multi Family Common Area	Compressed Air	100%	100%	0.00	0.00
Multi Family Common Area	Cooking	100%	100%	0.00	0.00
Multi Family Common Area	Cool Central	100%	100%	0.00	0.00
Multi Family Common Area	Data Center	100%	100%	0.00	0.00
Multi Family Common Area	Exterior Lighting	100%	100%	0.00	0.00
Multi Family Common Area	Heat Central	100%	100%	0.00	0.00
Multi Family Common Area	Heat Pump	100%	100%	0.00	0.00
Multi Family Common Area	Interior Lighting	100%	100%	2.75	2.75
Multi Family Common Area	Other	100%	100%	0.00	0.00
Multi Family Common Area	Plug Load Other	100%	100%	0.00	0.00

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Sqft)	Weighted Average UEC New (kWh/Sqft)
Multi Family Common Area	Refrigeration	100%	100%	0.00	0.00
Multi Family Common Area	Ventilation	100%	100%	0.00	0.00
Multi Family Common Area	Waste Water	100%	100%	0.00	0.00
Multi Family Common Area	Water Heat GT 55 Gal	100%	100%	0.00	0.00
Multi Family Common Area	Water Heat LE 55 Gal	100%	100%	0.00	0.00
Other	Compressed Air	23%	100%	0.29	0.29
Other	Cooking	0%	0%	0.00	0.00
Other	Cool Central	70%	100%	1.59	1.59
Other	Data Center	100%	100%	0.18	0.18
Other	Exterior Lighting	100%	100%	0.53	0.53
Other	Heat Central	87%	21%	1.13	1.13
Other	Heat Pump	10%	100%	1.30	1.30
Other	Interior Lighting	100%	100%	1.75	1.75
Other	Other	100%	100%	0.00	0.00
Other	Plug Load Other	100%	100%	0.62	0.62
Other	Refrigeration	100%	100%	0.08	0.08
Other	Ventilation	97%	100%	0.92	0.92
Other	Waste Water	100%	100%	0.11	0.11
Other	Water Heat GT 55 Gal	49%	16%	0.16	0.16
Other	Water Heat LE 55 Gal	51%	72%	0.15	0.15
Residential Care	Compressed Air	0%	100%	0.00	0.00
Residential Care	Cooking	0%	0%	0.00	0.00
Residential Care	Cool Central	65%	100%	2.01	2.01
Residential Care	Data Center	100%	100%	0.44	0.44
Residential Care	Exterior Lighting	100%	100%	0.31	0.31
Residential Care	Heat Central	76%	34%	0.67	0.67
Residential Care	Heat Pump	23%	100%	1.92	1.92
Residential Care	Interior Lighting	100%	100%	3.27	3.27
Residential Care	Other	100%	100%	0.00	0.00
Residential Care	Plug Load Other	100%	100%	2.23	2.23
Residential Care	Refrigeration	100%	100%	0.26	0.26
Residential Care	Ventilation	99%	100%	2.85	2.85
Residential Care	Waste Water	100%	100%	0.26	0.26

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Sqft)	Weighted Average UEC New (kWh/Sqft)
Residential Care	Water Heat GT 55 Gal	79%	4%	0.75	0.75
Residential Care	Water Heat LE 55 Gal	21%	67%	0.70	0.70
Restaurant	Compressed Air	0%	100%	0.00	0.00
Restaurant	Cooking	100%	11%	7.08	7.08
Restaurant	Cool Central	73%	100%	3.09	3.09
Restaurant	Data Center	100%	100%	0.44	0.44
Restaurant	Exterior Lighting	100%	100%	1.77	1.77
Restaurant	Heat Central	88%	9%	1.02	1.02
Restaurant	Heat Pump	7%	100%	3.66	3.66
Restaurant	Interior Lighting	100%	100%	6.55	6.55
Restaurant	Other	100%	100%	0.00	0.00
Restaurant	Plug Load Other	100%	100%	1.21	1.21
Restaurant	Refrigeration	100%	100%	4.01	4.01
Restaurant	Ventilation	96%	100%	2.68	2.68
Restaurant	Waste Water	100%	100%	1.92	1.92
Restaurant	Water Heat GT 55 Gal	53%	26%	6.65	6.65
Restaurant	Water Heat LE 55 Gal	47%	43%	6.24	6.24
School K-12	Compressed Air	0%	100%	0.00	0.00
School K-12	Cooking	100%	14%	0.17	0.17
School K-12	Cool Central	53%	100%	0.54	0.54
School K-12	Data Center	100%	100%	0.88	0.88
School K-12	Exterior Lighting	100%	100%	0.57	0.57
School K-12	Heat Central	85%	3%	4.29	4.29
School K-12	Heat Pump	14%	100%	2.04	2.04
School K-12	Interior Lighting	100%	100%	2.72	2.72
School K-12	Other	100%	100%	0.00	0.00
School K-12	Plug Load Other	100%	100%	0.62	0.62
School K-12	Refrigeration	100%	100%	0.37	0.37
School K-12	Ventilation	100%	100%	1.00	1.00
School K-12	Waste Water	100%	100%	0.25	0.25
School K-12	Water Heat GT 55 Gal	63%	21%	1.14	1.14
School K-12	Water Heat LE 55 Gal	37%	35%	1.07	1.07
Small Off	Compressed Air	0%	100%	0.00	0.00

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Sqft)	Weighted Average UEC New (kWh/Sqft)
Small Off	Cooking	0%	0%	0.00	0.00
Small Off	Cool Central	65%	100%	3.35	3.35
Small Off	Data Center	100%	100%	1.75	1.75
Small Off	Exterior Lighting	100%	100%	0.47	0.47
Small Off	Heat Central	67%	51%	2.93	2.93
Small Off	Heat Pump	29%	100%	2.74	2.74
Small Off	Interior Lighting	100%	100%	4.42	4.42
Small Off	Other	100%	100%	0.00	0.00
Small Off	Plug Load Other	100%	100%	1.27	1.27
Small Off	Refrigeration	100%	100%	0.08	0.08
Small Off	Ventilation	96%	100%	1.40	1.40
Small Off	Waste Water	100%	100%	0.21	0.21
Small Off	Water Heat GT 55 Gal	20%	83%	0.43	0.43
Small Off	Water Heat LE 55 Gal	80%	93%	0.40	0.40
Small Ret	Compressed Air	23%	100%	0.52	0.52
Small Ret	Cooking	0%	0%	0.00	0.00
Small Ret	Cool Central	54%	100%	2.05	2.05
Small Ret	Data Center	100%	100%	0.44	0.44
Small Ret	Exterior Lighting	100%	100%	1.20	1.20
Small Ret	Heat Central	79%	18%	2.19	2.19
Small Ret	Heat Pump	15%	100%	3.15	3.15
Small Ret	Interior Lighting	100%	100%	8.16	8.16
Small Ret	Other	100%	100%	0.00	0.00
Small Ret	Plug Load Other	100%	100%	0.88	0.88
Small Ret	Refrigeration	100%	100%	0.08	0.08
Small Ret	Ventilation	94%	100%	2.95	2.95
Small Ret	Waste Water	100%	100%	0.06	0.06
Small Ret	Water Heat GT 55 Gal	4%	100%	0.31	0.31
Small Ret	Water Heat LE 55 Gal	96%	73%	0.29	0.29
Supermarket	Compressed Air	7%	100%	0.06	0.06
Supermarket	Cooking	100%	15%	2.55	2.55
Supermarket	Cool Central	81%	100%	1.64	1.64
Supermarket	Data Center	100%	100%	0.44	0.44

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Sqft)	Weighted Average UEC New (kWh/Sqft)
Supermarket	Exterior Lighting	100%	100%	1.00	1.00
Supermarket	Heat Central	92%	10%	2.04	2.04
Supermarket	Heat Pump	0%	100%	4.36	4.36
Supermarket	Interior Lighting	100%	100%	9.09	9.09
Supermarket	Other	100%	100%	0.00	0.00
Supermarket	Plug Load Other	100%	100%	1.17	1.17
Supermarket	Refrigeration	100%	100%	19.42	19.42
Supermarket	Ventilation	92%	100%	2.04	2.04
Supermarket	Waste Water	100%	100%	0.06	0.06
Supermarket	Water Heat GT 55 Gal	40%	27%	0.29	0.29
Supermarket	Water Heat LE 55 Gal	60%	54%	0.27	0.27
University	Compressed Air	0%	100%	0.00	0.00
University	Cooking	100%	14%	0.77	0.77
University	Cool Central	53%	100%	1.30	1.30
University	Data Center	100%	100%	0.88	0.88
University	Exterior Lighting	100%	100%	1.39	1.39
University	Heat Central	85%	3%	10.36	10.36
University	Heat Pump	14%	100%	4.92	4.92
University	Interior Lighting	100%	100%	6.47	6.47
University	Other	100%	100%	0.00	0.00
University	Plug Load Other	100%	100%	1.50	1.50
University	Refrigeration	100%	100%	0.90	0.90
University	Ventilation	100%	100%	2.42	2.42
University	Waste Water	100%	100%	0.26	0.26
University	Water Heat GT 55 Gal	63%	21%	2.76	2.76
University	Water Heat LE 55 Gal	37%	35%	2.59	2.59
Warehouse	Compressed Air	21%	100%	1.52	1.52
Warehouse	Cooking	0%	0%	0.00	0.00
Warehouse	Cool Central	37%	100%	0.52	0.52
Warehouse	Data Center	100%	100%	0.44	0.44
Warehouse	Exterior Lighting	100%	100%	0.39	0.39
Warehouse	Heat Central	82%	3%	1.56	1.56
Warehouse	Heat Pump	0%	100%	1.00	1.00

Segment	End Use	Saturation	Fuel Share	Weighted Average UEC Existing (kWh/Sqft)	Weighted Average UEC New (kWh/Sqft)
Warehouse	Interior Lighting	100%	100%	4.08	4.08
Warehouse	Other	100%	100%	0.00	0.00
Warehouse	Plug Load Other	100%	100%	0.61	0.61
Warehouse	Refrigeration	100%	100%	0.04	0.04
Warehouse	Ventilation	83%	100%	0.80	0.80
Warehouse	Waste Water	100%	100%	0.19	0.19
Warehouse	Water Heat GT 55 Gal	11%	55%	0.27	0.27
Warehouse	Water Heat LE 55 Gal	89%	80%	0.26	0.26
Xlarge Ret	Compressed Air	48%	100%	0.15	0.15
Xlarge Ret	Cooking	0%	0%	0.00	0.00
Xlarge Ret	Cool Central	97%	100%	1.57	1.57
Xlarge Ret	Data Center	100%	100%	0.44	0.44
Xlarge Ret	Exterior Lighting	100%	100%	0.93	0.93
Xlarge Ret	Heat Central	98%	6%	1.68	1.68
Xlarge Ret	Heat Pump	0%	100%	2.42	2.42
Xlarge Ret	Interior Lighting	100%	100%	6.27	6.27
Xlarge Ret	Other	100%	100%	0.00	0.00
Xlarge Ret	Plug Load Other	100%	100%	0.68	0.68
Xlarge Ret	Refrigeration	100%	100%	0.06	0.06
Xlarge Ret	Ventilation	98%	100%	2.26	2.26
Xlarge Ret	Waste Water	100%	100%	0.13	0.13
Xlarge Ret	Water Heat GT 55 Gal	43%	11%	0.24	0.24
Xlarge Ret	Water Heat LE 55 Gal	57%	50%	0.23	0.00

Industrial Baseline Data

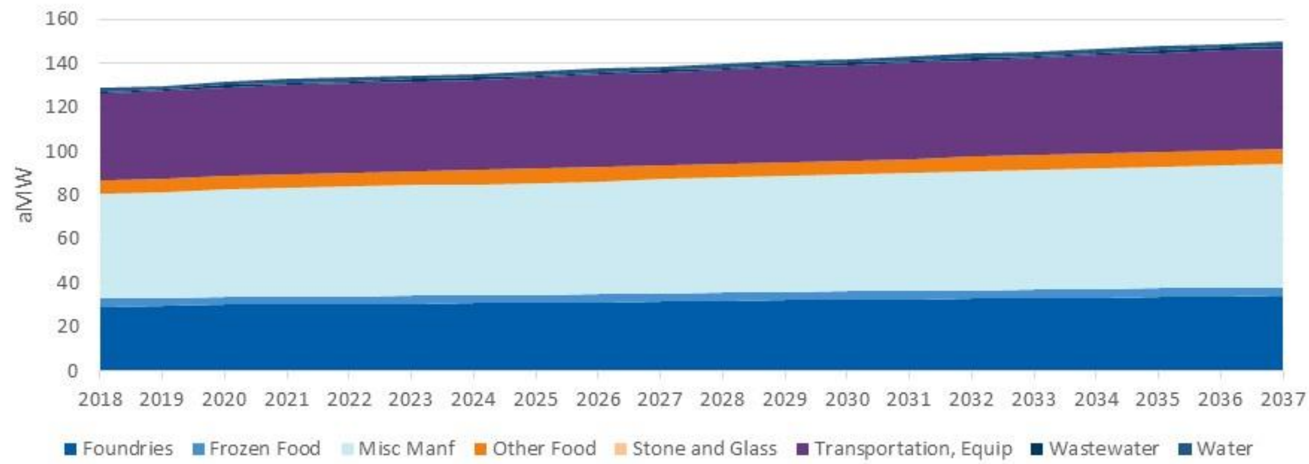

Figure B-5 Industrial Baseline Forecast by Industry

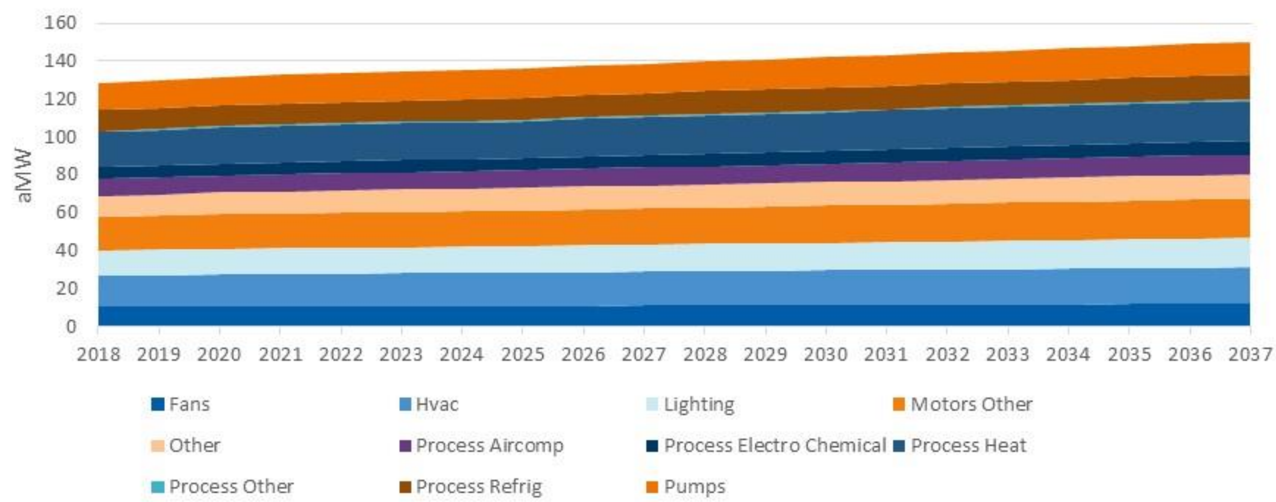

Figure B-6 Industrial Baseline Forecast by End Use

Appendix C. Measure Descriptions

This section contains a brief description of each measure used in the energy-efficiency potential.

C.1. Residential Electric Retrofit Measure Descriptions

C.1.1. Heating and Cooling

Controlled Optimization Program. This measure represents a suite of behavioral measures including:

- Water heater setback thermostat
- Lighting hours of use reduction
- HVAC usage reduction

Based on the Seventh Plan workbook "res-cop-7p_v2".

Measure Name	Measure Efficiency
Controlled Optimization Program - Lighting	Controlled Optimization Program - Lighting
Controlled Optimization Program - HVAC	Controlled Optimization Program - HVAC
Controlled Optimization Program - Water Heat	Controlled Optimization Program - Water Heat

Controls Commissioning and Sizing. The installation of a heat pump with proper sizing and commissioning of the control setpoint temperatures can save energy through enhanced performance. Correctly-sized HVAC systems operate for longer periods of time (instead of cycling on and off frequently), which results in optimum equipment operating efficiency and better control. Based on the Seventh Plan workbook "res-ccs-7p_v4".

Measure Name	Measure Efficiency
SF CC&S + HZ1	Heating Savings
SF CC&S + HZ1	Cooling Savings

Duct Sealing. Duct sealing cost-effectively saves energy, improves air and thermal distribution (comfort and ventilation), and reduces cross contamination between different zones in the building (such as smoking vs. non-smoking, bio-aerosols, and localized indoor air pollutants). Based on the Seventh Plan workbook "res-duct_seal-7p_v4".

Measure Name	Measure Efficiency
SF Performance-based Duct Sealing - Heat Pump + HZ1	SF Performance-based Duct Sealing - Heat Pump + HZ1
New SF Performance-based Duct Sealing - Heat Pump + HZ1	New SF Performance-based Duct Sealing - Heat Pump + HZ1

Heat Pump - Single Family. This measure represents a suite of measures including:

- Converting an electric furnace to a heat pump
- Converting an electric furnace and central air conditioner to a heat pump
- Replace an existing heat pump with a more efficient variable capacity heat pump
- Replace zonal heating and cooling to a ductless heat pump

Based on the Seventh Plan workbook “res-sf_hp-7p_v5”.

Measure Name	Measure Efficiency
Existing Single Family Home HVAC Conversion - Convert FAF w/CAC to Heat Pump - House with "Good Insulation" + HZ1	Heating Savings
Existing Single Family Home HVAC Conversion - Convert FAF w/o CAC to Heat Pump - House with "Good Insulation" + HZ1CZ1	Heating Savings
Existing Single Family Home HVAC Conversion - Convert FAF w/CAC to Heat Pump - House with "Good Insulation" + HZ1	Cooling Savings
Existing Single Family Home HVAC Conversion - Convert FAF w/o CAC to Heat Pump - House with "Good Insulation" + HZ1CZ1	Cooling Savings

Heat Recovery Ventilation. This measure mechanically ventilates homes in cold climates. During the winter, it transfers heat from the air being exhausted to outside air entering the home. Between 50 and 80 percent of the heat normally lost in exhausted air is returned to the house. Air-to-air heat exchangers can be installed as part of a central heating and cooling system or in walls or windows. Wall- and window-mounted units resemble air conditioners and ventilate one room or area. Based on the Seventh Plan workbook “res-hrv-7p_v1”.

Measure Name	Measure Efficiency
SF RNC HRV ACH3 HZ1CZ1	Heating Savings
SF RNC HRV ACH3 HZ1CZ1	Cooling Savings

Weatherization - Multifamily. This measure represents a suite of measures including:

- Attic insulation R-value improvement
- Floor insulation R-value improvement
- Wall insulation R-value improvement
- Window U-value improvement

Based on the Seventh Plan workbook “res-mf_wx-7p_v7”.

Measure Name	Measure Efficiency
WALL R0 - R11_Electric Zonal	WALL R0 - R11
FLOOR R0 - R19_Electric Zonal	FLOOR R0 - R19
FLOOR R0 - R30_Electric Zonal	FLOOR R0 - R30
ATTIC R0 - R19_Electric Zonal	ATTIC R0 - R19
ATTIC R0 - R38_Electric Zonal	ATTIC R0 - R38
ATTIC R0 - R49_Electric Zonal	ATTIC R0 - R49
ATTIC R19 - R30_Electric Zonal	ATTIC R19 - R30
ATTIC R19 - R38_Electric Zonal	ATTIC R19 - R38
ATTIC R19 - R49_Electric Zonal	ATTIC R19 - R49
WINDOW CL22 Prime Window Replacement of Single Pane Base_Electric Zonal	WINDOW CL22 Prime Window Replacement of Single Pane Base
WINDOW CL22 Prime Window Replacement of Double Pane Base_Electric Zonal	WINDOW CL22 Prime Window Replacement of Double Pane Base
WINDOW CL30 Prime Window Replacement of Single Pane Base_Electric Zonal	WINDOW CL30 Prime Window Replacement of Single Pane Base
WINDOW CL30 Prime Window Replacement of Double Pane Base_Electric Zonal	WINDOW CL30 Prime Window Replacement of Double Pane Base
WALL R0 - R11_Electric FAF	WALL R0 - R11
FLOOR R0 - R19_Electric FAF	FLOOR R0 - R19
FLOOR R0 - R30_Electric FAF	FLOOR R0 - R30
ATTIC R0 - R19_Electric FAF	ATTIC R0 - R19
ATTIC R0 - R38_Electric FAF	ATTIC R0 - R38
ATTIC R0 - R49_Electric FAF	ATTIC R0 - R49
ATTIC R19 - R30_Electric FAF	ATTIC R19 - R30
ATTIC R19 - R38_Electric FAF	ATTIC R19 - R38
ATTIC R19 - R49_Electric FAF	ATTIC R19 - R49
WINDOW CL22 Prime Window Replacement of Single Pane Base_Electric FAF	WINDOW CL22 Prime Window Replacement of Single Pane Base
WINDOW CL22 Prime Window Replacement of Double Pane Base_Electric FAF	WINDOW CL22 Prime Window Replacement of Double Pane Base
WINDOW CL30 Prime Window Replacement of Single Pane Base_Electric FAF	WINDOW CL30 Prime Window Replacement of Single Pane Base
WINDOW CL30 Prime Window Replacement of Double Pane Base_Electric FAF	WINDOW CL30 Prime Window Replacement of Double Pane Base
WALL R0 - R11_Heat Pump	WALL R0 - R11
FLOOR R0 - R19_Heat Pump	FLOOR R0 - R19
FLOOR R0 - R30_Heat Pump	FLOOR R0 - R30

Measure Name	Measure Efficiency
ATTIC R0 - R19_Heat Pump	ATTIC R0 - R19
ATTIC R0 - R38_Heat Pump	ATTIC R0 - R38
ATTIC R0 - R49_Heat Pump	ATTIC R0 - R49
ATTIC R19 - R30_Heat Pump	ATTIC R19 - R30
ATTIC R19 - R38_Heat Pump	ATTIC R19 - R38
ATTIC R19 - R49_Heat Pump	ATTIC R19 - R49
WINDOW CL22 Prime Window Replacement of Single Pane Base_Heat Pump	WINDOW CL22 Prime Window Replacement of Single Pane Base
WINDOW CL22 Prime Window Replacement of Double Pane Base_Heat Pump	WINDOW CL22 Prime Window Replacement of Double Pane Base
WINDOW CL30 Prime Window Replacement of Single Pane Base_Heat Pump	WINDOW CL30 Prime Window Replacement of Single Pane Base
WINDOW CL30 Prime Window Replacement of Double Pane Base_Heat Pump	WINDOW CL30 Prime Window Replacement of Double Pane Base

Weatherization - Single Family. This measure represents a suite of measures including:

- Attic insulation R-value improvement
- Floor insulation R-value improvement
- Wall insulation R-value improvement
- Window U-value improvement
- Infiltration reduction

Based on the Seventh Plan workbook “res-sf_wx-7p_v7”.

Measure Name	Measure Efficiency
ATTIC R0 - R38_Electric FAF	ATTIC R0 - R38
ATTIC R0 - R49_Electric FAF	ATTIC R0 - R49
ATTIC R11 - R38_Electric FAF	ATTIC R11 - R38
ATTIC R11 - R49_Electric FAF	ATTIC R11 - R49
ATTIC R19 - R38_Electric FAF	ATTIC R19 - R38
ATTIC R19 - R49_Electric FAF	ATTIC R19 - R49
WALL R0 - R11_Electric FAF	WALL R0 - R11
FLOOR R0 - R19_Electric FAF	FLOOR R0 - R19
FLOOR R0 - R25_Electric FAF	FLOOR R0 - R25
FLOOR R0 - R30_Electric FAF	FLOOR R0 - R30
WINDOW CL30 Prime Window Replacement of Single Pane Base_Electric FAF	WINDOW CL30 Prime Window Replacement of Single Pane Base

Measure Name	Measure Efficiency
WINDOW CL30 Prime Window Replacement of Double Pane Base_Electric FAF	WINDOW CL30 Prime Window Replacement of Double Pane Base
WINDOW CL22 Prime Window Replacement of Single Pane Base_Electric FAF	WINDOW CL22 Prime Window Replacement of Single Pane Base
WINDOW CL22 Prime Window Replacement of Double Pane Base_Electric FAF	WINDOW CL22 Prime Window Replacement of Double Pane Base
CFM50 Infiltration Reduction_Electric FAF	CFM50 Infiltration Reduction
ATTIC R0 - R38_Electric Zonal	ATTIC R0 - R38
ATTIC R0 - R49_Electric Zonal	ATTIC R0 - R49
ATTIC R11 - R38_Electric Zonal	ATTIC R11 - R38
ATTIC R11 - R49_Electric Zonal	ATTIC R11 - R49
ATTIC R19 - R38_Electric Zonal	ATTIC R19 - R38
ATTIC R19 - R49_Electric Zonal	ATTIC R19 - R49
WALL R0 - R11_Electric Zonal	WALL R0 - R11
FLOOR R0 - R19_Electric Zonal	FLOOR R0 - R19
FLOOR R0 - R25_Electric Zonal	FLOOR R0 - R25
FLOOR R0 - R30_Electric Zonal	FLOOR R0 - R30
WINDOW CL30 Prime Window Replacement of Single Pane Base_Electric Zonal	WINDOW CL30 Prime Window Replacement of Single Pane Base
WINDOW CL30 Prime Window Replacement of Double Pane Base_Electric Zonal	WINDOW CL30 Prime Window Replacement of Double Pane Base
WINDOW CL22 Prime Window Replacement of Single Pane Base_Electric Zonal	WINDOW CL22 Prime Window Replacement of Single Pane Base
WINDOW CL22 Prime Window Replacement of Double Pane Base_Electric Zonal	WINDOW CL22 Prime Window Replacement of Double Pane Base
CFM50 Infiltration Reduction_Electric Zonal	CFM50 Infiltration Reduction
ATTIC R0 - R38_Heat Pump	ATTIC R0 - R38_Heat Pump
ATTIC R0 - R49_Heat Pump	ATTIC R0 - R49_Heat Pump
ATTIC R11 - R38_Heat Pump	ATTIC R11 - R38_Heat Pump
ATTIC R11 - R49_Heat Pump	ATTIC R11 - R49_Heat Pump
ATTIC R19 - R38_Heat Pump	ATTIC R19 - R38_Heat Pump
ATTIC R19 - R49_Heat Pump	ATTIC R19 - R49_Heat Pump
WALL R0 - R11_Heat Pump	WALL R0 - R11_Heat Pump
FLOOR R0 - R19_Heat Pump	FLOOR R0 - R19_Heat Pump
FLOOR R0 - R25_Heat Pump	FLOOR R0 - R25_Heat Pump
FLOOR R0 - R30_Heat Pump	FLOOR R0 - R30_Heat Pump

Measure Name	Measure Efficiency
WINDOW CL30 Prime Window Replacement of Single Pane Base_Heat Pump	WINDOW CL30 Prime Window Replacement of Single Pane Base_Heat Pump
WINDOW CL30 Prime Window Replacement of Double Pane Base_Heat Pump	WINDOW CL30 Prime Window Replacement of Double Pane Base_Heat Pump
WINDOW CL22 Prime Window Replacement of Single Pane Base_Heat Pump	WINDOW CL22 Prime Window Replacement of Single Pane Base_Heat Pump
WINDOW CL22 Prime Window Replacement of Double Pane Base_Heat Pump	WINDOW CL22 Prime Window Replacement of Double Pane Base_Heat Pump
CFM50 Infiltration Reduction_Heat Pump	CFM50 Infiltration Reduction_Heat Pump
ATTIC R0 - R38_DHP	ATTIC R0 - R38
ATTIC R0 - R49_DHP	ATTIC R0 - R49
ATTIC R11 - R38_DHP	ATTIC R11 - R38
ATTIC R11 - R49_DHP	ATTIC R11 - R49
ATTIC R19 - R38_DHP	ATTIC R19 - R38
ATTIC R19 - R49_DHP	ATTIC R19 - R49
WALL R0 - R11_DHP	WALL R0 - R11
FLOOR R0 - R19_DHP	FLOOR R0 - R19
FLOOR R0 - R25_DHP	FLOOR R0 - R25
FLOOR R0 - R30_DHP	FLOOR R0 - R30
WINDOW CL30 Prime Window Replacement of Single Pane Base_DHP	WINDOW CL30 Prime Window Replacement of Single Pane Base
WINDOW CL30 Prime Window Replacement of Double Pane Base_DHP	WINDOW CL30 Prime Window Replacement of Double Pane Base
WINDOW CL22 Prime Window Replacement of Single Pane Base_DHP	WINDOW CL22 Prime Window Replacement of Single Pane Base
WINDOW CL22 Prime Window Replacement of Double Pane Base_DHP	WINDOW CL22 Prime Window Replacement of Double Pane Base
CFM50 Infiltration Reduction_DHP	CFM50 Infiltration Reduction

Wi-Fi Thermostat. Thermostats connected to the internet can be controlled from any location with an internet connection and follow occupant schedules for heating and cooling, decreasing run time for heating and cooling. Based on the Seventh Plan workbook “res-wifitstat-7p_v3”.

Measure Name	Measure Efficiency
Single Family WIFI Enabled Thermostat HZ1	WIFI HZ1

C.1.2. Water Heat

Clothes Washer. High efficiency clothes washer which meet the CEE efficiency level tiers[1] uses less energy and water than regular washers. We compared three levels of efficiency—in units of the corresponding Integrated Modified Energy Factor (IMEF) —for this measure. The baseline IMEF represents the average IMEF of non-ENERGY STAR and ENERGY STAR -qualified models below the CEE efficiency tiers. Based on the Seventh Plan workbook "res-clotheswasher-7p_v4".

Measure Name	Measure Efficiency
Single Family CEE Tier 1 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Washer Savings
Single Family CEE Tier 2 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Washer Savings
Single Family CEE Tier 3 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Washer Savings
Single Family CEE Tier 1 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Dryer Savings
Single Family CEE Tier 2 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Dryer Savings
Single Family CEE Tier 3 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Dryer Savings
Single Family CEE Tier 1 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Waste Water Energy
Single Family CEE Tier 2 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Waste Water Energy
Single Family CEE Tier 3 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Waste Water Energy
Multifamily - Low Rise CEE Tier 1 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Washer Savings
Multifamily - Low Rise CEE Tier 2 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Washer Savings
Multifamily - Low Rise CEE Tier 3 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Washer Savings
Multifamily - Low Rise CEE Tier 1 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Dryer Savings
Multifamily - Low Rise CEE Tier 2 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Dryer Savings

[1] http://library.cee1.org/sites/default/files/library/12282/CEE_ResidentialClothesWasherSpec_07Mar2015.pdf

Measure Name	Measure Efficiency
Multifamily - Low Rise CEE Tier 3 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Dryer Savings
Multifamily - Low Rise CEE Tier 1 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Waste Water Energy
Multifamily - Low Rise CEE Tier 2 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Waste Water Energy
Multifamily - Low Rise CEE Tier 3 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Waste Water Energy
Multifamily - High Rise CEE Tier 1 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Washer Savings
Multifamily - High Rise CEE Tier 2 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Washer Savings
Multifamily - High Rise CEE Tier 3 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Washer Savings
Multifamily - High Rise CEE Tier 1 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Dryer Savings
Multifamily - High Rise CEE Tier 2 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Dryer Savings
Multifamily - High Rise CEE Tier 3 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Dryer Savings
Multifamily - High Rise CEE Tier 1 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Waste Water Energy
Multifamily - High Rise CEE Tier 2 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Waste Water Energy
Multifamily - High Rise CEE Tier 3 Clothes Washer - Any DHW, Any Dryer - 54% ENERGY STAR Baseline	Waste Water Energy

Dishwasher. This dishwasher uses advanced technology to clean dishes with less water and energy. The efficient model uses less than 295 kWh/year (including standby consumption). The baseline model consumes 307 kWh/year. Based on the Seventh Plan workbook "res-dishwasher-7p_v4".

Measure Name	Measure Efficiency
Single Family Energy Star Dishwasher - Any DHW	All Except Waste Water Energy
Single Family Energy Star Dishwasher - Any DHW	Waste Water Energy
Multifamily - Low Rise Energy Star Dishwasher - Any DHW	All Except Waste Water Energy
Multifamily - Low Rise Energy Star Dishwasher - Any DHW	Waste Water Energy
Multifamily - High Rise Energy Star Dishwasher - Any DHW	All Except Waste Water Energy
Multifamily - High Rise Energy Star Dishwasher - Any DHW	Waste Water Energy

Drain Water Heat Recovery. Also called gravity film heat exchanges, this device recovers heat energy from domestic drain water, which is then used to pre-heat cold water entering the hot water tank. This minimizes the temperature difference between the heating set point and the temperature of the water entering the system. Based on the Seventh Plan workbook "res-gfx-7p_v3".

Measure Name	Measure Efficiency
Single Family GFHX DHW & Shower Preheat, Electric Resistance	GFHX DHW & Shower Preheat, Electric Resistance
Single Family GFHX DHW & Shower Preheat, Heat Pump	GFHX DHW & Shower Preheat, Heat Pump
Single Family GFHX DHW Preheat, Electric Resistance	GFHX DHW Preheat, Electric Resistance
Single Family GFHX DHW Preheat, Heat Pump	GFHX DHW Preheat, Heat Pump
Multifamily GFHX DHW & Shower Preheat, Electric Resistance	GFHX DHW & Shower Preheat, Electric Resistance
Multifamily GFHX DHW & Shower Preheat, Heat Pump	GFHX DHW & Shower Preheat, Heat Pump
Multifamily GFHX DHW Preheat, Electric Resistance	GFHX DHW Preheat, Electric Resistance
Multifamily GFHX DHW Preheat, Heat Pump	GFHX DHW Preheat, Heat Pump

Faucet Aerators, Bathroom. Faucet aerators, by mixing water and air, reduce amounts of water flowing through faucets. The faucet aerator creates a fine water spray, using a screen inserted in the faucet head. Based on the Seventh Plan workbook "res-aerator-7p_v5".

Measure Name	Measure Efficiency
Single Family Bathroom Aerator 1.0 GPM AnyWH	Aerator 2.48 to 1.0 GPM
Single Family Bathroom Aerator 1.0 GPM AnyWH	Aerator 2.48 to 1.0 GPM
Multifamily - Low Rise Bathroom Aerator 1.0 GPM AnyWH	Aerator 2.48 to 1.0 GPM
Multifamily - High Rise Bathroom Aerator 1.0 GPM AnyWH	Aerator 2.48 to 1.0 GPM
Single Family Bathroom Aerator 1.0 GPM HPWH	Aerator 2.48 to 1.0 GPM

Low-Flow Showerheads. Low-flow showerheads mix water and air to reduce the amount of water that flows through the showerhead. The showerhead creates a fine water spray through an inserted screen in the showerhead. Based on the Seventh Plan workbook "res-showerhead-7p_v5".

Measure Name	Measure Efficiency
SF Showerhead Replace_2_00gpm_Any Shower_ AnyWH	SF Showerhead Replace_2_00gpm_Any Shower_ AnyWH
SF Showerhead Replace_1_75gpm_Any Shower_ AnyWH	SF Showerhead Replace_1_75gpm_Any Shower_ AnyWH
SF Showerhead Replace_1_50gpm_Any Shower_ AnyWH	SF Showerhead Replace_1_50gpm_Any Shower_ AnyWH
SF Showerhead Replace_1_50GPM_any shower_HPWH	SF Showerhead Replace_1_50GPM_any shower_HPWH
MF Showerhead Replace_2_00gpm_Any Shower_ AnyWH	MF Showerhead Replace_2_00gpm_Any Shower_ AnyWH
MF Showerhead Replace_1_75gpm_Any Shower_ AnyWH	MF Showerhead Replace_1_75gpm_Any Shower_ AnyWH
MF Showerhead Replace_1_50gpm_Any Shower_ AnyWH	MF Showerhead Replace_1_50gpm_Any Shower_ AnyWH

C.1.3. Appliances

Fridge and Freezer Decommissioning. This refers to environmentally friendly disposal of unneeded or inefficient appliances such as refrigerators or stand-alone freezers. Based on the RTF workbook "ResFridgeFreezeDecommissioning_v4_4".

Measure Name	
Refrigerator Decommissioning and Recycling	Refrigerator Decommissioning and Recycling
Freezer Decommissioning and Recycling	Freezer Decommissioning and Recycling

C.1.4. Plug Load

Advanced Power Strip. Advanced power strips will turn power to all devices plugged into the strip off, such as computers, desk lights, and entertainment equipment, based on occupancy within the area, reduced load below a certain wattage threshold or lack of infrared activity within a set timeframe. Based on the Seventh Plan workbook "res-powerstrips-7p_v6".

Measure Name	Measure Efficiency
Load sensing advanced power strip	Load sensing advanced power strip
Occupancy sensing advanced power strip	Occupancy sensing advanced power strip
Infrared sensing advanced power strip	Infrared sensing advanced power strip

C.1.5. Other (Pool)

Electric Vehicle Charger. Upgrading the electric vehicle charging equipment from level 1, 120 volt AC, to level 2, 240 volt AC, results in energy savings through increased efficiency of the AC to DC power conversion. Based on the Seventh Plan workbook “res-evcharger-7p_v2”.

C.2. Residential Electric Equipment Measure Descriptions

C.2.1. Heating and Cooling

Air or Ground Source Heat Pump (ASHP or GSHP). Electric heat pumps move heat to or from the air or the ground to cool and heat a home. Based on the Seventh Plan workbooks "res-sf_hp-7p_v5" and "res-gshp-7p_v2".

Measure Name	Measure Efficiency	Baseline Efficiency
Existing Single Family Home HVAC Upgrade + HZ1	Existing Single Family Home HVAC Upgrade + HZ1	Market Average Heat Pump
New SF HVAC Upgrade - Heat Pump Upgrade to 9.0 HSPF/14 SEER	New SF HVAC Upgrade - Heat Pump Upgrade to 9.0 HSPF/14 SEER	Market Average Heat Pump
Existing Single Family Home HVAC Upgrade - Central Heat Pump Upgrade to Variable Capacity Central Heat Pump + HZ1CZ1	Existing Single Family Home HVAC Upgrade - Central Heat Pump Upgrade to Variable Capacity Central Heat Pump + HZ1CZ1	Market Average Heat Pump
New SF HVAC Upgrade - Central Heat Pump Upgrade to Variable Capacity Central Heat Pump	New SF HVAC Upgrade - Central Heat Pump Upgrade to Variable Capacity Central Heat Pump	Market Average Heat Pump
Ground Source Heat Pump Upgrade from Air Source Heat Pump - With Desuperheater - Existing House less than 4000 square feet	Ground Source Heat Pump Upgrade from Air Source Heat Pump - With Desuperheater - Existing House less than 4000 square feet	Market Average Heat Pump
Ground Source Heat Pump Upgrade from Air Source Heat Pump - With Desuperheater - New House less than 4000 square feet	Ground Source Heat Pump Upgrade from Air Source Heat Pump - With Desuperheater - New House less than 4000 square feet	Market Average Heat Pump

Central Air Conditioner. This measure consists of two different air conditioner technology/efficiency levels. The baseline size is the same as the measure size.

Measure Name	Measure Efficiency	Baseline Efficiency
Central Air Conditioner - ENERGY STAR	ENERGY STAR Central Air Conditioner SEER/EER 14.5/12 (Split System)	Market Average Central Air Conditioner SEER/EER 13/11.2 (Split System)
Central Air Conditioner - CEE Tier 3	CEE Tier 3 Central Air Conditioner SEER/EER 16/13 (Split System)	Market Average Central Air Conditioner SEER/EER 13/11.2 (Split System)

Conversion Baseboard Heating to Ductless Heat Pump (DHP). DHPs move heat to or from the air to cool and heat a home without the need for costly ductwork. This method of heating has a HSPF value of 9.5, consuming less energy than baseboard heating that has a HSPF value of 3.412. Based on the Seventh Plan workbook "res-sf_hp-7p_v5".

Measure Name	Measure Efficiency	Baseline Efficiency
Zonal to DHP No Screen + HZ1CZ1	Heating Savings	Market Average Zonal Heating
New SF Zonal to DHP	Heating Savings	Market Average Zonal Heating

Conversion Forced Air Furnace to Ductless Heat Pump (DHP). DHPs move heat to or from the air to cool and heat a home without the need for costly ductwork. This method of heating has a HSPF value of 9.5, consuming less energy than forced air furnace heating that has a HSPF value of 3.412. Based on the Seventh Plan workbook "res-faf_to_dhp-7p_v2".

Measure Name	Measure Efficiency	Baseline Efficiency
Install Ductless Heat Pump in House with Existing FAF - Single Family Home + HZ1	Install Ductless Heat Pump in House with Existing FAF - Single Family Home - HZ1	Standard Electric Furnace HSPF = 3.412

Room AC Conversion to Ductless Heat Pump (DHP). DHPs use less energy than room AC while also producing less noise and requiring no costly ductwork. Based on the Seventh Plan workbook "res-sf_hp-7p_v5".

Measure Name	Measure Efficiency	Baseline Efficiency
New SF Zonal to DHP	Cooling Savings	Room AC - Market Average (8,000-13,999 Btuh)

Motor - ECM. Electronically commutated motors (ECMs) consume less power than the standard motor used in ventilation and circulation systems.

Measure Name	Measure Efficiency	Baseline Efficiency
Motor - ECM	ECM Motor	Standard Motor

C.2.2. Lighting

Lighting Exterior. Represents improvements to exterior lighting technologies by replacing existing lamps with more efficient lighting technologies: CFLs and LEDs. Based on the Seventh Plan workbooks "res-lighting-7p_v5" and "res-lighting_ppa-7p_v5".

Measure Name	Measure Efficiency	Baseline Efficiency
Incandescent - 2020 EISA Backstop Provisions	Incandescent - 2020 EISA Backstop Provisions	Market Average Lighting Exterior Standard
CFL	CFL	Market Average Lighting Exterior Standard
LED - Exterior	LED - Exterior	CFL

- **Compact Fluorescent Lights (CFL) - Exterior.** Standard CFLs use 5 percent less energy than the typical exterior (market average) bulbs.
- **General Service Lamp – 2020 EISA Backstop Provisions.** Energy Independence and Security Act (EISA) contains a backstop provision that requires have a minimum efficacy of 45 lumens per watt lighting technologies, beginning in 2020.
- **Light emitting diodes (LEDs) - Exterior.** Standard LEDs use 21 percent less energy than the CFL bulbs.

Lighting Interior Linear Fluorescent. Represents improvements to interior lighting linear fluorescent technologies replacing existing T12 four foot and eight foot fixtures with the more efficient high performance T8 (T8HP) four foot fixtures. Based on the RTF workbook "ResLightingHPT8Lamps_v1_3".

Measure Name	Measure Efficiency	Baseline Efficiency
Linear Fluorescent - T8HP	T8HP Linear Fluorescent	Market Average Linear Fluorescent

Lighting Interior Specialty. Represents improvements to interior lighting technologies not impacted by EISA by replacing existing lamps with more efficient lighting technologies: CFLs and LEDs. Based on the Seventh Plan workbook "res-lighting-7p_v5".

Measure Name	Measure Efficiency	Baseline Efficiency
CFL - Specialty	CFL - Specialty	Incandescent - Specialty
LED - Specialty	LED - Specialty	Incandescent - Specialty

- **Compact Fluorescent Lights (CFL) - Specialty.** Specialty (or EISA exempt) bulbs include 3-way, candelabra, some globes, and some reflectors. CFLs use up to 77 percent less energy and have a longer life than incandescent specialty light bulb.
- **Light emitting diodes (LEDs) - Specialty.** Specialty LEDs are solid-state devices that convert electricity to light, use 84 percent less energy, and have a long life.

Lighting Interior Standard. Represents improvements to interior lighting technologies impacted by EISA by replacing existing lamps with more efficient lighting technologies: CFLs and LEDs. Based on the Seventh Plan workbooks "res-lighting-7p_v5" and "res-lighting_ppa-7p_v5".

Measure Name	Measure Efficiency	Baseline Efficiency
EISA 2020 Backstop	EISA 2020 Backstop Interior General Purpose Bulb	Market Average Lighting Interior Standard
CFL	CFL	Market Average Lighting Interior Standard
LED Interior General Purpose Bulb	LED Interior General Purpose Bulb	CFL

- **Compact Fluorescent Lights (CFL) - Standard.** Standard CFLs use 14 percent less energy than the typical interior (market average) bulbs.
- **General Service Lamp – 2020 EISA Backstop Provisions.** EISA contains a backstop provision that requires have a minimum efficacy of 45 lumens per watt lighting technologies, beginning in 2020.
- **Light emitting diodes (LEDs) - Standard.** Standard LEDs use 25 percent less energy than the CFL bulbs.

C.2.3. Water Heat

Water Heater, Heat Pump and Solar. This measure represents the two end uses Water Heat LE 55 Gal (less than 55 gallons) and Water Heat GT 55 Gal (greater than 55 gallons). A high-efficiency heat pump water heater measure moves heat from a warm reservoir (such as air) into the hot water system, reducing the amount of heat needed from electric resistance heating. Solar Water Heaters use thermal energy to heat water without the use of electricity, gas, or heating oil. Based on the Seventh Plan workbooks "res-hpwh-7p_v3p" and "res-swh-7p_v1p".

End Use	Measure Efficiency	Baseline Efficiency
Water Heat LE 55 Gal	Single Family Tier1_buffered	Market Standard Storage Water Heater
Water Heat LE 55 Gal	Single Family Tier1_indor2	Market Standard Storage Water Heater
Water Heat LE 55 Gal	Single Family Tier2_buffered	Market Standard Storage Water Heater
Water Heat LE 55 Gal	Single Family Tier2_indor2	Market Standard Storage Water Heater
Water Heat LE 55 Gal	SHW Solar Zone 1	Market Standard Storage Water Heater
Water Heat GT 55 Gal	SHW Solar Zone 1	Market Standard Water Heater

C.2.4. Appliances

Cooking Oven, High Efficiency. A high-efficiency cooking oven uses fans to circulate heat evenly throughout the oven (convection heat), operating at lower temperatures and achieving cook times quicker than a standard oven. The baseline is a standard oven. Based on the Seventh Plan workbook "res-oven-7p_v3".

Measure Name	Measure Efficiency	Baseline Efficiency
Efficient Oven	Efficient Oven	Federal Standard 2012 Cooking Oven

Dryer, High Efficiency. A high-efficiency dryer has features (such as moisture sensors) that minimize energy usage while retaining performance. A heat pump dryer moves heat from a warm reservoir (such as air) into the dryer, reducing the amount of heat needed from electric resistance heating. Based on the Seventh Plan workbook "res-clothesdryer-7p_v2".

Measure Name	Measure Efficiency	Baseline Efficiency
Heat Pump Dryer	Heat Pump Dryer	Market Average Dryer

Freezer, ENERGY STAR. ENERGY STAR -qualified freezers use less energy than standard models due to improvements in insulation and compressors. Based on the Seventh Plan workbook "res-refrigfreezer-7p_v3p".

Measure Name	Measure Efficiency	Baseline Efficiency
Std Size Freezer - ENERGY STAR	Std Size Freezer - ENERGY STAR	Market Average Freezer

Microwave, High Efficiency. High-efficiency microwaves use more efficient power supplies, fans, magnetron, and reflective surfaces that provide energy savings compared to conventional microwaves. Based on the Seventh Plan workbook "res-microwave-7p_v3".

Measure Name	Measure Efficiency	Baseline Efficiency
Microwave Top Tier	TSL4 Efficiency	Market Average Microwave

Refrigerator, High Efficiency. CEE-qualified refrigerators use less energy than standard models, due to improvements in insulation and compressors. Based on the Seventh Plan workbook "res-refrigfreezer-7p_v4".

Measure Name	Measure Efficiency	Baseline Efficiency
Std Size Refrig and Refrig-Freezer - CEE Tier 1	Std Size Refrig and Refrig-Freezer - CEE Tier 1	Market Average Refrigerator
Std Size Refrig and Refrig-Freezer - CEE Tier 2	Std Size Refrig and Refrig-Freezer - CEE Tier 2	Market Average Refrigerator
Std Size Refrig and Refrig-Freezer - CEE Tier 3	Std Size Refrig and Refrig-Freezer - CEE Tier 3	Market Average Refrigerator

C.2.5. Plug Load

Air Purifier, ENERGY STAR. **ENERGY STAR certified room air purifiers** are 40% more energy-efficient than standard models[2].

Measure Name	Measure Efficiency	Baseline Efficiency
Air Purifier - ENERGY STAR	ENERGY STAR Air Purifier	Standard Air Purifier

Computer, ENERGY STAR. ENERGY STAR computers consume less than 2 watts in sleep and off modes, and are more efficient than conventional units in idle mode, resulting in 40 percent energy savings. Based on the Seventh Plan workbook "res-computers-7p_v4".

Measure Name	Measure Efficiency	Baseline Efficiency
ENERGY STAR Desktops	ENERGY STAR Desktop	Standard Desktop Computer
ENERGY STAR Laptops	ENERGY STAR Notebook	Standard Laptop Computer

DVD, ENERGY STAR. ENERGY STAR-qualified DVD products meeting the new requirements use up to 50 percent less energy than standard models.[3] ENERGY STAR DVD players use as little as one-fourth of the energy of standard models in the off mode. The baseline for this measure is a standard DVD player.

2 https://www.energystar.gov/products/certified-products/detail/air-purifiers-cleaners

3 https://www.energystar.gov/products/certified-products/detail/audiovideo

Measure Name	Measure Efficiency	Baseline Efficiency
DVD - ENERGY STAR	ENERGY STAR DVD Player	Standard DVD Player

Home Audio System, ENERGY STAR. ENERGY STAR home audio systems are 20 percent energy savings can be achieved over standard home audio systems.

Measure Name	Measure Efficiency	Baseline Efficiency
Home Audio System - ENERGY STAR	ENERGY STAR Home Audio System	Standard Home Audio System

Monitor, ENERGY STAR. ENERGY STAR monitors feature: (1) on mode, where the maximum allowed power varies based on the computer monitor's resolution; (2) sleep mode, where computer monitors must consume 2 watts or less; and, (3) off mode, where computer monitors must consume 1 watt or less. The baseline equipment does not include these features.[4] Based on the Seventh Plan workbook "res-computers-7p_v4".

Measure Name	Measure Efficiency	Baseline Efficiency
ENERGY STAR Monitors	ENERGY STAR LCD Display	Standard Monitor

Multifunction Device (All-in-One). ENERGY STAR models meeting the most recent ENERGY STAR requirements are more energy efficient, and feature efficient designs helping the equipment run cooler and last longer.

Measure Name	Measure Efficiency	Baseline Efficiency
Multifunction Device (All-in-one) - ENERGY STAR	ENERGY STAR Multifunction Device (All-in-one)	Standard Multifunction Device (All-in-one)

Office Copier, ENERGY STAR. ENERGY STAR copy machines are more efficient and use less energy than standard office copy machines.

Measure Name	Measure Efficiency	Baseline Efficiency
Office Copier - ENERGY STAR	ENERGY STAR Office Copier	Standard Office Copier

Office Printer, ENERGY STAR. Printers that have earned the ENERGY STAR rating are at least 30 percent more efficient than conventional models.[5] The baseline measure is a standard printer.

4 https://www.energystar.gov/products/certified-products/detail/displays
5 https://www.energystar.gov/products/certified-products/detail/imaging-equipment

Measure Name	Measure Efficiency	Baseline Efficiency
Office Printer - ENERGY STAR	ENERGY STAR Office Printer	Standard Office Printer

Set Top Box, ENERGY STAR. Set top boxes that have earned the ENERGY STAR rating are at least 35 percent more efficient than conventional models.[6] The baseline measure is a standard set top box.

Measure Name	Measure Efficiency	Baseline Efficiency
Set Top Box - ENERGY STAR	ENERGY STAR Set Top Box	Standard Set Top Box

TV, ENERGY STAR. ENERGY STAR-qualified TVs use roughly 25 percent less energy than standard units.[7] ENERGY STAR models are required to consume no more than 1 watt while in sleep mode. The baseline is a standard television, which generally consumes more than 3 watts when turned off.

Measure Name	Measure Efficiency	Baseline Efficiency
TV LCD - ENERGY STAR	ENERGY STAR LED-LCD TV (0-40in.)	Standard LCD TV (0-40in.)
TV LCD - ENERGY STAR	ENERGY STAR LED-LCD TV (40+in.)	Standard LCD TV (40+in.)

C.2.6. Other (Pool)

Pool Pumps, VSD. This measure enables a pool pump motor to operate at variable speeds as opposed to constantly running at full power. The baseline for this measure is a standard two speed motor

Measure Name	Measure Efficiency	Baseline Efficiency
Pool Pump - VSD	VSD Pool Pump	2 Speed Pool Pump

6 https://www.energystar.gov/products/certified-products/detail/set-top-boxes-cable-boxes
7 https://www.energystar.gov/products/certified-products/detail/televisions

C.3. Commercial Electric Measure Descriptions

C.3.1. HVAC (and Envelope)

Advanced Rooftop Controller. Advanced controller for rooftop units with single-zone, ducted systems. Retrofitting existing packaged rooftop units with advanced control strategies not ordinarily used for packaged units. Savings come primarily from fan energy savings by using advanced controls with a variable speed drive. Applied only to systems with constant speed fans. Based on the Seventh Plan workbook "com-rooftopcontroller-7p_v6".

Commercial Energy Management. Energy management measures for commercial buildings, excluding single-zone ducted systems. Suite of measures, most of which are focused on making HVAC systems work better through controls changes. Based on the Seventh Plan workbook "com-em-7p_v5".

DCV Hood and DCV Hood w/ MUA. Utilizing sensors and two-speed or variable speed fans, hood controls reduce exhaust (and makeup) airflow when appliances are not at capacity (or have been turned off). The baseline for this measure is no hood controls. Based on the Seventh Plan workbook "com-dcv-kitchenvent-7p_v3".

DCV Parking Garage. Where the ventilation system automatically adjusts air flow when CO_2 rises above a specified level. CO_2 controls maintain a minimum ventilation rate at all times to control non-occupant contaminants, such as off-gassing from furniture, equipment, and building components. The baseline of this measure is an existing ventilation system that runs constantly. Based on the Seventh Plan workbook "com-dcv-garage-7p_v3".

Demand Controlled Ventilation. Evaluates retrofit Demand Control Ventilation (DCV) and Dedicated Outdoor Air Supply (DOAS). Both the DVC and the DOAS measures aim to reduce the amount of ventilation air that needs to be conditioned and the amount of distribution fan energy used to move cooling or heating to occupants. The single zone DOAS measures is a fleet strategy which involves designating some of the fleet of HVAC units as ventilation units and letting other units cycle on call for heating, cooling, or additional ventilation is needed. The designated units can be standalone heat recovery ventilation (HRV) or rooftops with added HRV/ERVs where only a small fraction of units operate, or they can be standard rooftops where half the units operate to provide ventilation. Based on the Seventh Plan workbook "com-dcv-7p_v5".

Ductless Heat Pump. Ductless heat pumps move heat to or from the air, cooling and heating the building without the need for costly ductwork. This measure provides savings when compared to electric resistance heating. Based on the Seventh Plan workbook "com-dhp-7p_v2".

ECM VAV. This measure is for high efficiency electronically commutated permanent magnet (ECM or ECPM) motors with built-in variable speed control for VAV fans. Based on the Seventh Plan workbook "com-ecm-vav-7p_v4".

Economizer. An air-side economizer mixes return air with outside air to cool indoor spaces, which saves energy as less air needs to be cooled. This measure reflects optimizing economizers, coil cleaning, and adjusting refrigerant charge. Based on the Seventh Plan workbook "com-economizer-7p_v2".

Motors Rewind. This measure follows the Green Motors Practices Group™ recommendations of best practices to maintain original efficiency, commonly called a Green Rewind.[8] A failed motor can be rewound to a lower efficiency, rewound to maintain the original efficiency, or replaced. Based on the Seventh Plan workbook "com-motorsrewind-7p_v3".

VRF. A variable refrigerant flow (VRF) system is an energy efficient heating and cooling system using inverter driven compressor technology without ducting. Baseline technology is assumed to be a typical VAV rooftop HVAC system. Based on the Seventh Plan workbook "com-vrf-7p_v6".

WEPT. Web-enabled programmable thermostats (WEPT) control set point temperature automatically, ensuring the HVAC system is not running during low-occupancy hours. Based on the Seventh Plan workbook "com-wept-7p_v2".

Windows - Secondary Glazing Systems. A permanent window unit is installed on the inside of existing primary window. Based on the Seventh Plan workbook "com-windowsgs-7p_v5".

C.3.2. Lighting

Bi-Level Stairway Lighting. This measure allows an occupancy sensor to reduce the light load in an unoccupied stairwell by 50% for a set period of time. The baseline is continuous operation at full power. Based on the Seventh Plan workbook "com-bi-level-stairwell-7p_v4".

Exterior Lighting Improvements. The measures are going from existing technology to LED technology. Based on the Seventh Plan workbook "com-exteriorlighting-7p_v14".

Measure Group
Exterior Lighting: Façade - LED
Exterior Lighting: Parking Lot - LED
Exterior Lighting: Walkway - LED

Interior Lighting Improvements. The measures are going from existing technology to LED technology, or other high performance lighting, fixtures or redesign elements. Based on the Seventh Plan workbook "com-lightinginterior-7p_v41".

8 http://www.bpa.gov/energy/n/industrial/Green_motors/

Measure Group
CFL - Other
LED - Display or Track
LED - Highbay
LED - Linear Fluorescent
LED - Recessed Can
LED - Other
Linear Fluorescent - Highbay
Linear Fluorescent RDX - Linear Fluorescent
Metal Halide - Display or Track

LEC Exit Sign. Light Emitting Capacitor (LEC) exit signs consume less than a watt which results in energy savings over traditional exit signs. The assumed baseline is a LED exit sign. Based on the Seventh Plan workbook "com-exitsign-7p_v3".

LED Case Lighting. LEDs are highly efficient bulbs that can be used for refrigeration case lights, resulting in energy savings over a standard fluorescent case light. Based on the Seventh Plan workbook "com-grocery-7p_v7".

LED Motion Sensors on Display Case. Savings result from a direct reduction in lighting runtimes, and a reduced cooling load from addition of display case motion sensors. Based on the Seventh Plan workbook "com-grocery-7p_v7".

LED Parking Garage Lighting. Replacing inefficient metal halide lamps with LED fixtures and bi-level occupancy control, reduces energy use of covered parking garages. Based on the Seventh Plan workbook "com-parkinggaragelighting-7p_v7".

Lighting Controls. This represents two measures. 1) Embedded unitary controls for occupancy, daylight harvest, personal dimming. 2) Integrated controls where control module is addressable remotely and can log data on conditions. Based on the Seventh Plan workbook "com-interiorlightingcontrols-7p_v10".

Market Average HP Low Power T8 Shift. Shift mix of T8 Fluorescent lamps from 32W to 28W and 25W. Based on the Seventh Plan workbook "com-hplowpowergsfl-7p_v8".

TLED Over Ballast on SP32WT8. Replacing a two-lamp four footT8 fixture with 21W LED linear tubes (TLED). Based on the Seventh Plan workbook "com-hplowpowergsfl-7p_v8".

C.3.3. Water Heat

Efficient Water Tanks. High-efficiency water heaters operate more efficiently than standard electric water heaters due to reduced standby losses. Based on the Seventh Plan workbook "com-whtanks-7p_v6"

Pre-Rinse Spray Valve. Low-flow spray valves mix water and air to reduce amounts of water flowing through the spray head, which creates a fine water spray through an inserted screen in the spray head. Based on the Seventh Plan workbook "com-prerinsespray-7p_v3".

Showerheads. Low-flow showerheads mix water and air to reduce amounts of water flowing through the showerhead. The showerhead creates a fine water spray using an inserted screen in the showerhead. The assumed efficiency of the installed showerhead is 1.5 GPM. Based on the Seventh Plan workbook "com-showerhead-7p_v5".

C.3.4. Refrigeration

Anti-Sweat Heater Controls. This measure enables the user to turn refrigeration display case anti-sweat heaters off when the ambient relative humidity is low enough to prevent sweating. Without controls, heaters generally run continuously. Based on the Seventh Plan workbook "com-grocery-7p_v7".

ECM Controllers on Walk-In Evaporator Motors. A walk-in fan is one component of refrigeration systems. ECMs typically have small horse power motors (less than 1 HP) that are factory programmed to run at certain speeds. ECMs operate from a single-phase power source with an electronic controller in or on the motor. The baseline measure is a standard efficiency motor. Based on the Seventh Plan workbook "com-grocery-7p_v7".

Floating Head Pressure Control. This measure adds controls to float head pressure temperature down during periods of low load. The base case is a standard multiplex system with a fixed condensing set point. Based on the Seventh Plan workbook "com-grocery-7p_v7".

Freezer Decommissioning and Recycling. This refers to the environmentally-friendly disposal of unneeded appliances such as stand-alone freezers. Based on the RTF workbook "ComRefrigeratorFreezerDecommissioning_v2_4".

Refrigerator Decommissioning and Recycling. This refers to the environmentally-friendly disposal of unneeded appliances such as secondary refrigerators. Based on the RTF workbook "ComRefrigeratorFreezerDecommissioning_v2_4".

Replace Shaded Pole with ECM in Walk-in Cooler. A walk-in fan is one component of refrigeration systems. ECMs typically have small horse power motors (less than 1 HP) that are factory programmed to run at certain speeds. ECMs operate from a single-phase power source with an electronic controller in or on the motor. The baseline measure is a standard efficiency motor. Based on the Seventh Plan workbook "com-grocery-7p_v7".

Strip Curtains: Walk-In Coolers/ Freezers. This measure reduces the infiltration of warm air into the refrigerated space by improving the barrier between the refrigerated and the ambient air. Based on the Seventh Plan workbook "com-grocery-7p_v7".

C.3.5. Cooking

Combi Oven. This measure uses both dry heat and steam, which are injected into the oven when the food being cooked needs it. ENERGY STAR combination ovens use less energy than standard combination ovens. Equipment sizes based on ENERGY STAR v2.0 eligibility criteria for ≥ 6 pan and ≤ 20 pan. Based on the Seventh Plan workbook "com-cooking-7p_v5".

Convection Oven (Wt Average). This measure must meet the specification requirements of 70 percent cooking energy efficiency and an idle energy rate of 1.6 kW. Standard electric convection ovens have a 65 percent cooking energy efficiency and an idle energy rate of 2 kW. Equipment sizes based on ENERGY STAR v2.0 eligibility criteria. Based on the Seventh Plan workbook "com-cooking-7p_v5".

Fryers. ENERGY STAR fryers are 80 percent efficient and result in energy savings when compared to a non-ENERGY STAR commercial fryer with a baseline efficiency of 75 percent. Equipment sizes based on ENERGY STAR v2.0 eligibility criteria. Based on the Seventh Plan workbook "com-cooking-7p_v5".

HFHC (Wt Average Size). Installation of a new electric Hot Food Holding Cabinet (HFHC) meeting ENERGYSTAR v2.0 requirements. The baseline measure is a conventional holding cabinet. Based on the Seventh Plan workbook "com-cooking-7p_v5".

Steamer (Wt Average Size). This measure has a cooking efficiency of 68 percent, with idle energy rates that vary depending upon pan size. The baseline efficiency is a standard commercial steam cooker with 26 percent efficiency. Based on the Seventh Plan workbook "com-cooking-7p_v5".

C.3.6. Data Center

Data Center Improvements. Total of twenty-two efficiency measures divided into three tiers; Best Practice, Commercial Technology and Cutting Edge. Based on CBSA 2014 data on data centers embedded in commercial buildings. Based on the Seventh Plan workbook "com-datacenters-7p_v6".

Measure Type	Measure Name
Best Practice	Decommissioning of unused servers
Best Practice	Energy efficient data storage management
Best Practice	Server power management
Best Practice	Server virtualization/consolidation
Commercial Technology	Air-side economizer
Commercial Technology	Efficient network topology
Commercial Technology	Energy efficient lighting
Commercial Technology	Energy efficient power supplies (UPS)
Commercial Technology	Energy efficient servers
Commercial Technology	Energy efficient transformers
Commercial Technology	Hot or cold aisle configuration
Commercial Technology	Hot or cold aisle configuration plus containment (e.g., strip curtains or rigid enclosures)
Commercial Technology	In-row cooling
Commercial Technology	Install misters, foggers, or ultrasonic humidifiers
Commercial Technology	Massive array of idle disks (MAID)
Commercial Technology	Premium efficiency motors
Commercial Technology	Variable speed drives on pumps/fans
Commercial Technology	Water-side economizer
Cutting Edge	Direct current (as opposed to AC) to the racks
Cutting Edge	Direct liquid cooling of chips
Cutting Edge	Efficient network topology
Cutting Edge	Solid state storage

C.3.7. Other

Compressed Air Upgrade. A suite of energy efficient air compressor measures including:

- Demand reduction
- VFD controls
- Equipment upgrades

Based on the Seventh Plan workbook “com-compressedair-7p_v4”.

ENERGY STAR Desktop. ENERGY STAR computers consume less than 2 watts in “sleep” and “off” modes, and operate more efficiently than conventional units in “idle” mode, resulting in 42% energy savings. Based on the Seventh Plan workbook “com-computers-7p_v3”.

ENERGY STAR Display. ENERGY STAR monitors feature the following: (1) an "on" mode, where the maximum allowed power varies, based on the computer monitor's resolution; (2) a "sleep" mode, where computer monitor models must consume 2 watts or less; and (3) an "off" mode, where computer monitor models must consume 1 watt or less. The baseline equipment does not include these features. Based on the Seventh Plan workbook "com-computers-7p_v3".

ENERGY STAR Laptop. ENERGY STAR computers consume less than 2 watts in "sleep" and "off" modes, and operate more efficiently than conventional units in "idle" mode, resulting in 42% energy savings. Based on the Seventh Plan workbook "com-computers-7p_v3".

Indoor Agriculture. A suite of energy efficient indoor agriculture measures including:

- **LED Fixture.** Replacing existing metal halide or high pressure sodium grow lights with LED fixtures results in energy savings due to the reduced wattage of the LED fixture. Additionally, the LED fixture produces less heat than the metal halide or high pressure sodium fixtures resulting in a reduced HVAC cooling load.
- **Premium Air Conditioning Equipment.** Represents installing a 12.0 EER air conditioning system which results in energy savings over a federal standard air conditioner. The baseline equipment efficiency is 11.2 EER.
- **High Efficiency Ventilation System.** Increasing the CFM per watt of the ventilation system saves energy by providing the same amount of ventilation but at a decreased wattage. Represents savings from replacing the room ventilation system and the lighting ventilation system.
- **Mini-Split Heat Pump.** Represents installing a 12.0 EER and 3.6 COP mini-split heat pump which results in energy savings over a federal standard heat pump. The baseline equipment efficiency is 11.2 EER and 3.2 COP.

Premium Fume Hood-NR. A package of high-performance technologies to minimize energy consumption of laboratory fume hoods. The package would include high-efficiency variable speed fans and heat recovery to recover some of the energy in the conditioned air that is being drawn from the laboratory space around the hood. Automatic sash positioning could also be implemented with an occupancy sensor automatically closing the sash when no occupants are detected and the fume hood is not in use. Based on the Seventh Plan workbook "com-fumehood-7p_v2".

Smart Plug Power Strips-Retro. In commercial office spaces, the installation of a power strip which turns office equipment off during times outside of regular office hours results in energy savings. A master outlet controls other outlets which are turned off based on the master outlet's load sensor reading. Does not include computer or monitor savings. Occupancy-sensing power strips are also included. Based on the Seventh Plan workbook "com-powerstrips-7p_v5".

Water Cooler Timer. This represents two measures. The first is upgrading from a market average cooler to ENERGY STAR 2.0 cooler. The second measure is a timer on the ENERGY STAR 2.0 cooler. The timer turns the cooler off during unoccupied periods. Based on the Seventh Plan workbook "com-watercooler-7p_v6".

C.4. Industrial Electric Measure Descriptions

Air Compressor Improvements. These measures improve the overall compressed air system by improved system design, leak repair, usage practices, more efficient dryer and storage systems, and compressor upgrades.

Measure Name
Air Compressor Demand Reduction
Air Compressor Equipment1
Air Compressor Equipment2
Air Compressor Optimization

Clean Room Improvements. These measures aim to save energy through improved clean room equipment and practices. Savings are attributable to optimization of chiller operating parameters, upgrading to more efficient equipment, and improving filter replacement strategies.

Measure Name
Clean Room: Change Filter Strategy
Clean Room: Chiller Optimize
Clean Room: Clean Room HVAC

Efficiency Centrifugal Fan. This measure achieves energy savings through improved fan design.

Measure Name
Efficient Centrifugal Fan

Fan System Optimization. This measure involves the overall optimization of the fan system with improved system design, enhanced flow design, better maintenance practices, and adjustments to system parameters.

Measure Name
Fan System Optimization

Food Manufacturing (Cooling and Storage, Refrigerator Storage Tune-up). These measures maintain and enhance the cooling equipment for each facility type. Tune-ups may include refrigerant charge, equipment cleaning, general maintenance, and improved practices.

Measure Name
Food: Cooling and Storage
Food: Refrig Storage Tuneup

General Process Improvements. This measure includes upgrading/replacing equipment and using optimum size/capacity equipment.

Measure Name
Metal: New Arc Furnace

High Efficiency Fans. This measure involves upgrading motors to higher efficiency. Since NEMA Premium motors are becoming the baseline code requirement in 2010, this measure is based off of super premium motors with efficiency levels at least one efficiency band above NEMA premium.

Measure Name
Fan Equipment Upgrade

Light Emitting Diode (LED) Street Light Conversions. LED street lights can replace standard high-pressure sodium (HPS) street lights, with similar lumens achieved with less wattage.

Measure Name
LED HPS Replacement - 135W LED
LED HPS Replacement - 270W LED

Lighting Improvements. Changes to overall illumination levels, use of natural lighting, or technology improvements to more efficient bulbs or ballasts will decrease the overall lighting energy consumption. These measures include upgrades from T12 to T8 systems, T8 to high-performance T8 systems, HID to fluorescent conversions, standard HID to high-efficiency HID systems, and occupancy and day lighting controls.

Measure Name
Efficient Lighting 1 Shift
Efficient Lighting 2 Shift
Efficient Lighting 3 Shift
HighBay Lighting 1 Shift
HighBay Lighting 2 Shift
HighBay Lighting 3 Shift
Lighting Controls

Motor Rewind. This measure follows the Green Motors Practices Group™ recommendations of best practices to maintain original efficiency, commonly called a Green Rewind.[9] A failed motor can be rewound to a lower efficiency, rewound to maintain the original efficiency, or replaced.

Measure Name
Motors: Rewind 20-50 HP
Motors: Rewind 51-100 HP
Motors: Rewind 101-200 HP
Motors: Rewind 201-500 HP
Motors: Rewind 501-5000 HP

Municipal Water Supply. Municipal water supply savings are primarily from reduced pumping energy. Measures include more efficient pumps/drives, water end-use efficiency improvements, leak reduction, water treatment and compressed air improvements. Based on the Seventh Plan workbook "com-watersupply-7p_v5p".

Measure Name
Municipal Water Supply-Retro

Optimize Municipal Sewage. Measures are defined based the size of the treatment plant: <1 MGD, 1 to 10 MGD, and >10 MGD (MGD = Million Gallons per Day). Baseline consumption are defined for each of these three categories in Million kWh/MGD. Electricity saved per flow rate (Million kWh/MGD flow) based on case studies. Based on the Seventh Plan workbook "com-wastewater-7p_v5p".

[9] http://www.bpa.gov/energy/n/industrial/Green_motors/

Measure Name
Optimize Municipal Sewage ; <1 MGD Design Capacity
Optimize Municipal Sewage ; >10 MGD Design Capacity
Optimize Municipal Sewage ; 1 to 10 MGD Design Capacity

Pump Equipment Upgrade. This measure achieves energy savings through improved pump design and sizing.

Measure Name
Pump Equipment Upgrade

Pump Improvements (Pump Energy Management, Pump System Optimization). This measure involves optimizing the overall pump system with improved system design, enhanced flow design, better maintenance practices, and adjustments to system parameters.

Measure Name
Pump Energy Management
Pump System Optimization

Synchronous Belts. This measure contains mating, corresponding grooves in the drive sprocket, preventing slip and thus reducing energy losses.

Measure Name
Synchronous Belts

Transformers. Energy efficient transformers provide improved power quality while minimizing losses.

Measure Name
Transformers-Retrofit
Transformers-New

Whole Plant Improvements. These measures include synergistic savings of plant-wide energy management and improvements across multiple systems such as compressed air, pumping, and fan systems.

Measure Name
Energy Project Management
Fan Energy Management
Integrated Plant Energy Management
Plant Energy Management

Appendix D. Detailed Energy Efficiency Potential

D.1. Detailed Energy Efficiency Potential

Appendix E summarizes total cumulative achievable economic potential in 2037 (20-year cumulative) for the IRP avoided cost scenario by segment, sector and end use. Note: for end uses for which the share of total potential is less than one percent is expressed as “0%” in the pie charts.

D.2. Energy Efficiency Potential Summary

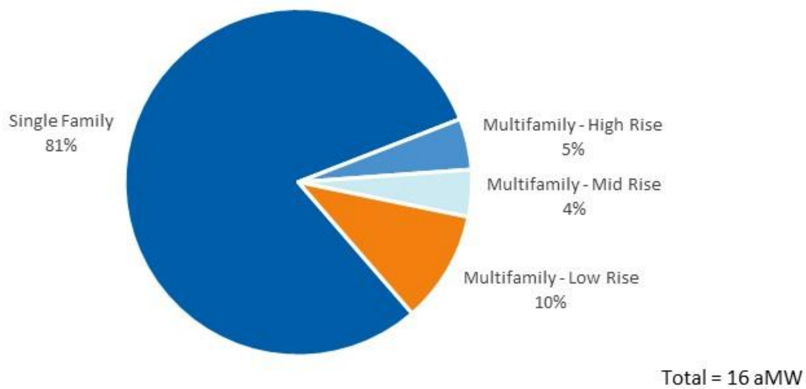

Figure D-1 SCL Achievable Economic Potential: Residential by Segment

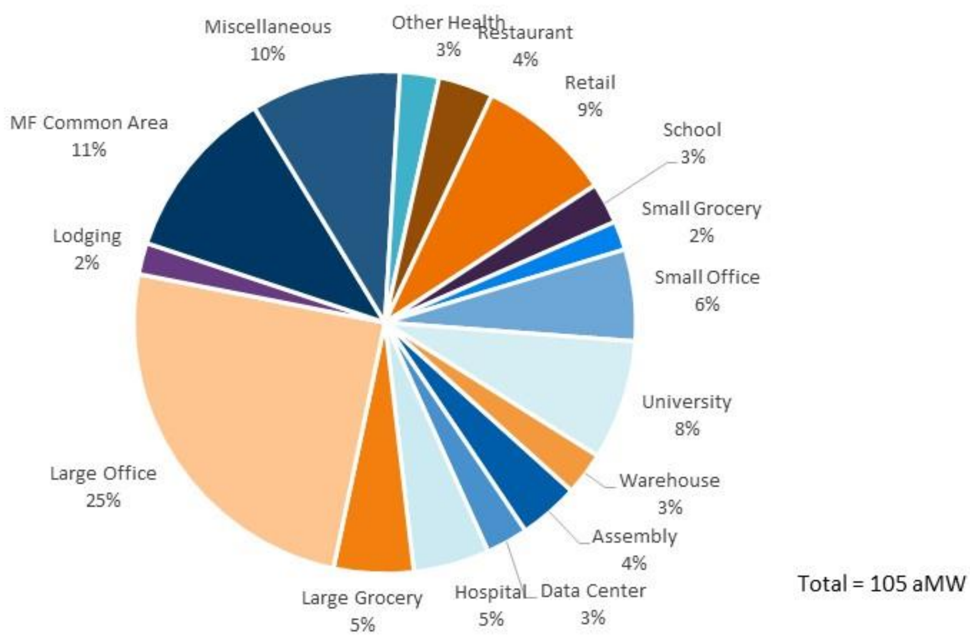

Figure D-2 SCL Achievable Economic Potential: Commercial by Segment

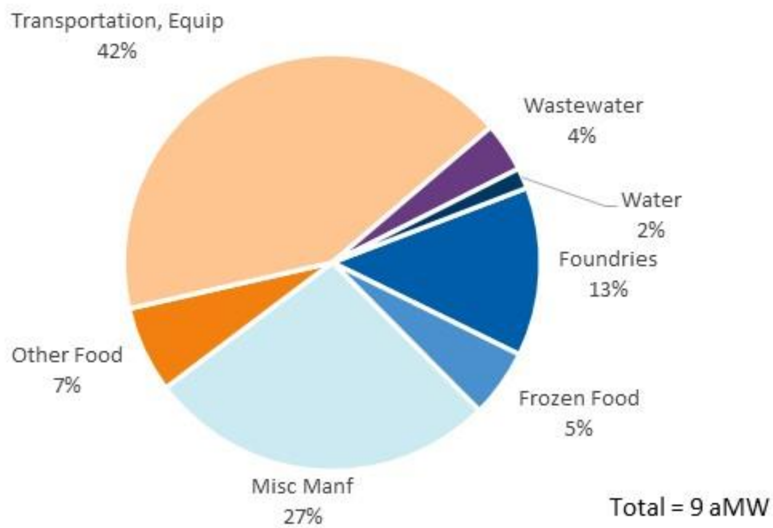

Figure D-3 SCL Achievable Economic Potential: Industrial by Segment

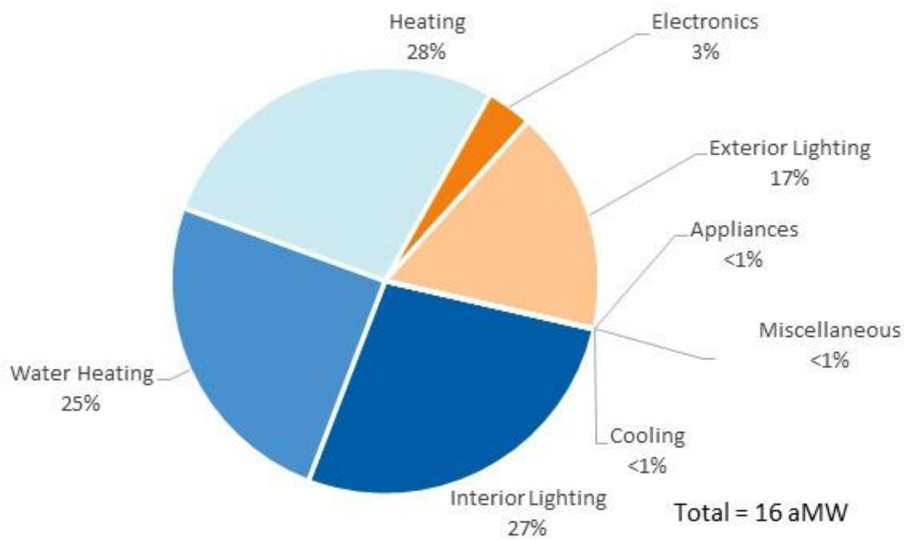

Figure D-4 SCL Achievable Economic Potential: Residential by End Use

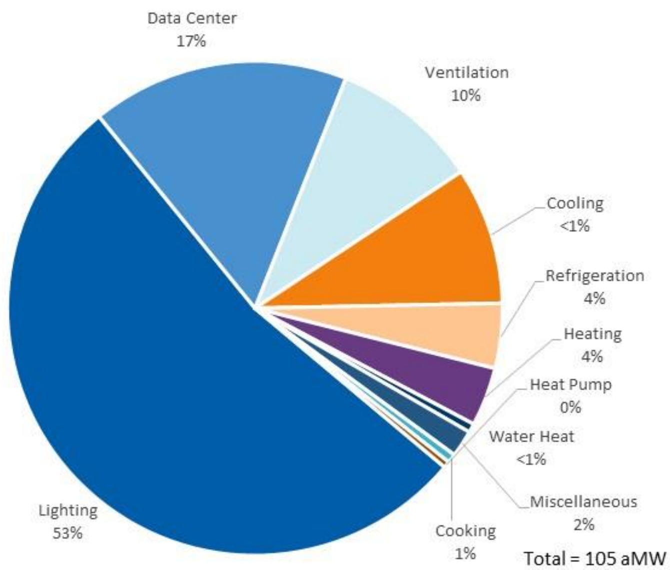

Figure D-5 SCL Achievable Economic Potential: Commercial by End Use

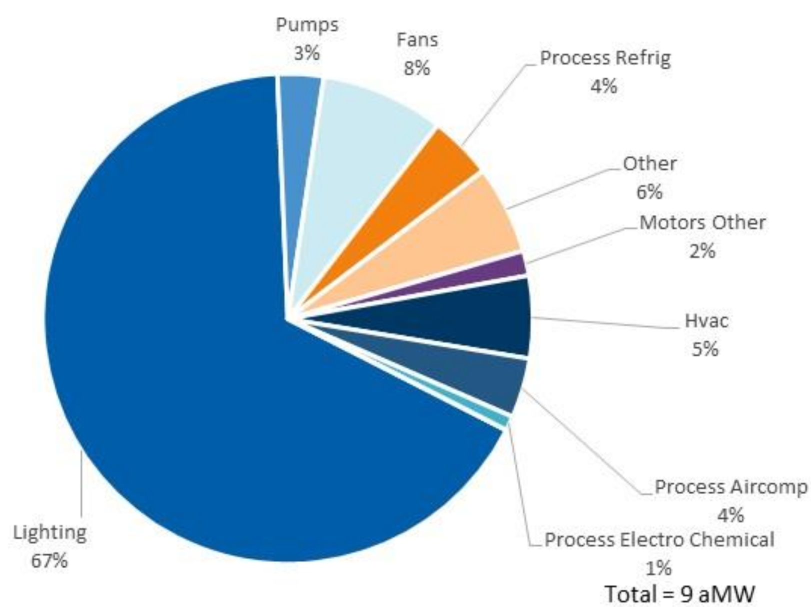

Figure D-6 SCL Achievable Economic Potential: Industrial by End Use

D.3. Residential Segments by End Use

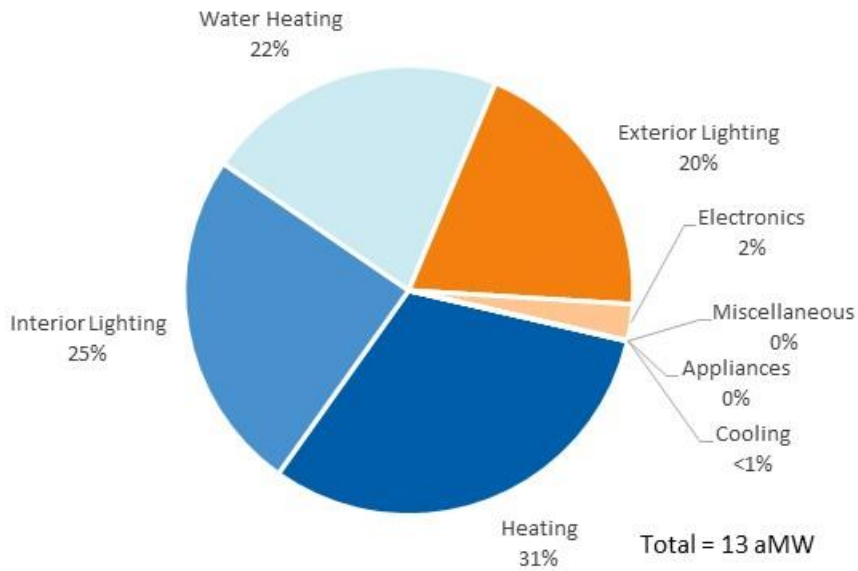

Figure D-7 SCL Achievable Economic Potential: Residential Single Family by End Use

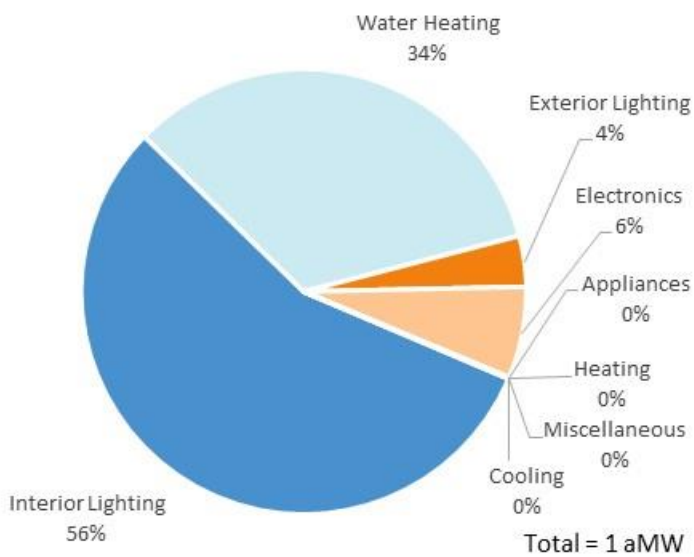

Figure D-8 SCL Achievable Economic Potential: Residential Multifamily – Mid Rise by End Use

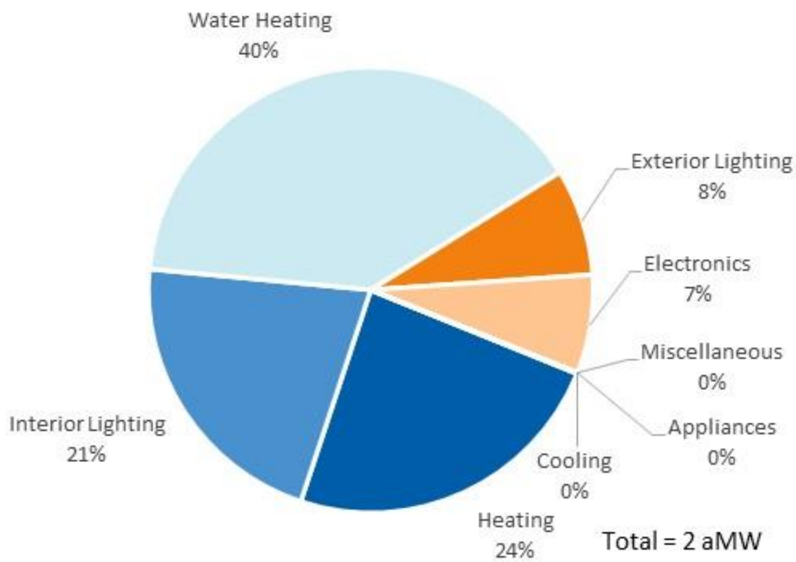

Figure D-9 SCL Achievable Economic Potential: Residential Multifamily – Low Rise by End Use

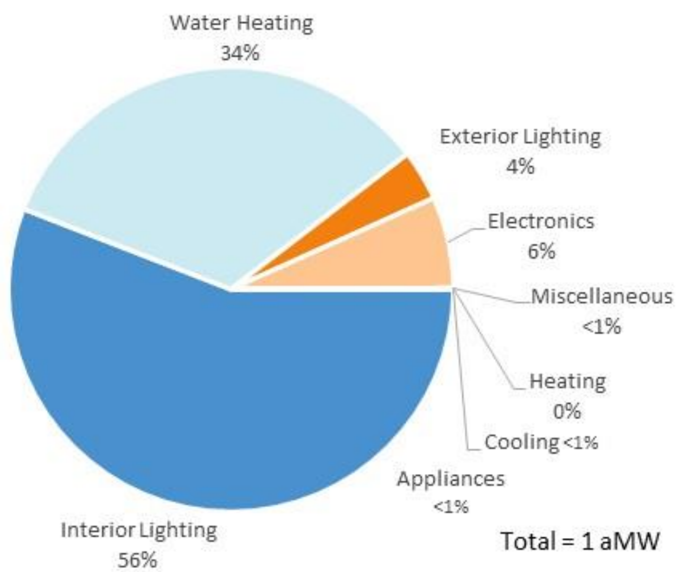

Figure D-10 SCL Achievable Economic Potential: Residential Multifamily – High Rise by End Use

D.4. Commercial Segments by End Use

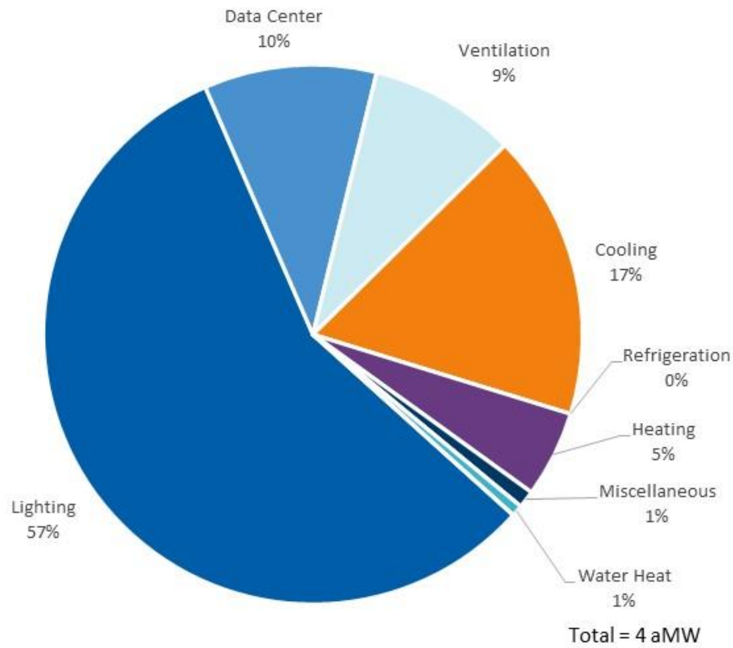

Figure D-11 SCL Achievable Economic Potential: Commercial Assembly by End Use

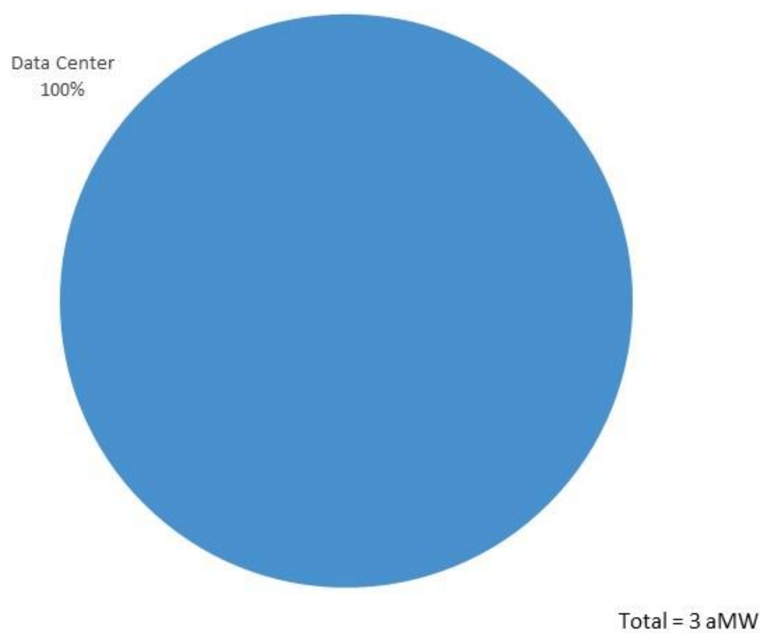

Figure D-12 SCL Achievable Economic Potential: Commercial Data Center by End Use

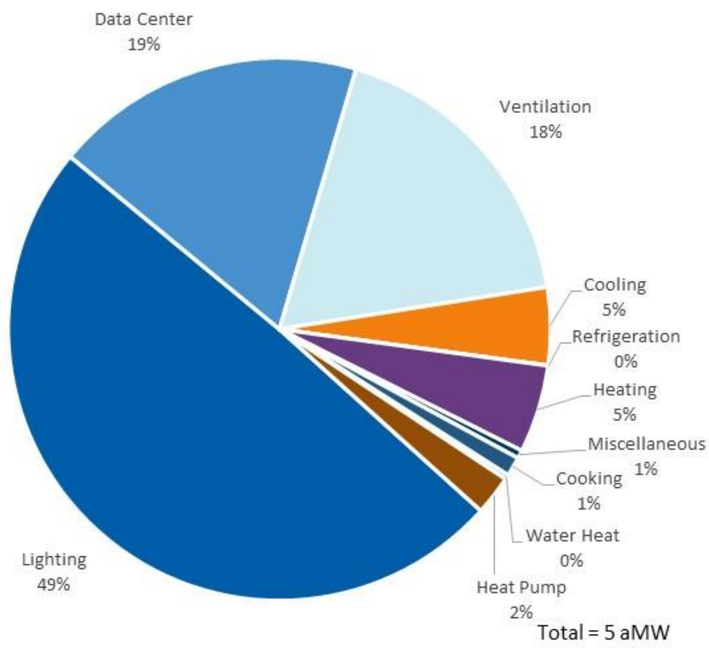

Figure D-13 SCL Achievable Economic Potential: Commercial Hospital by End Use

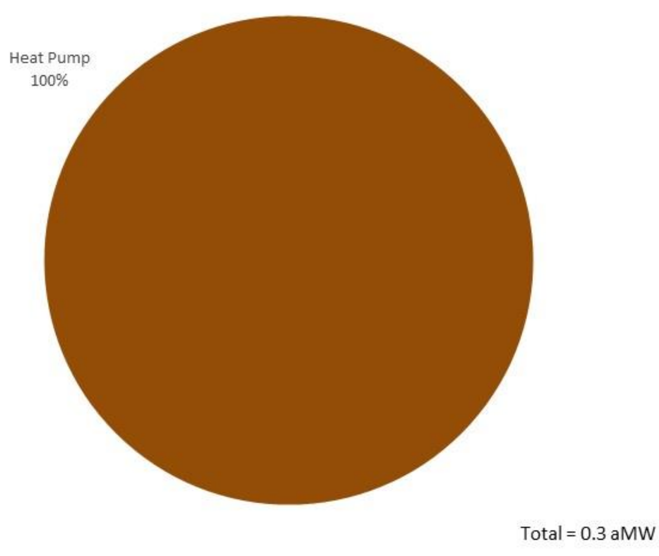

Figure D-14 SCL Achievable Economic Potential: Commercial Indoor Agriculture by End Use

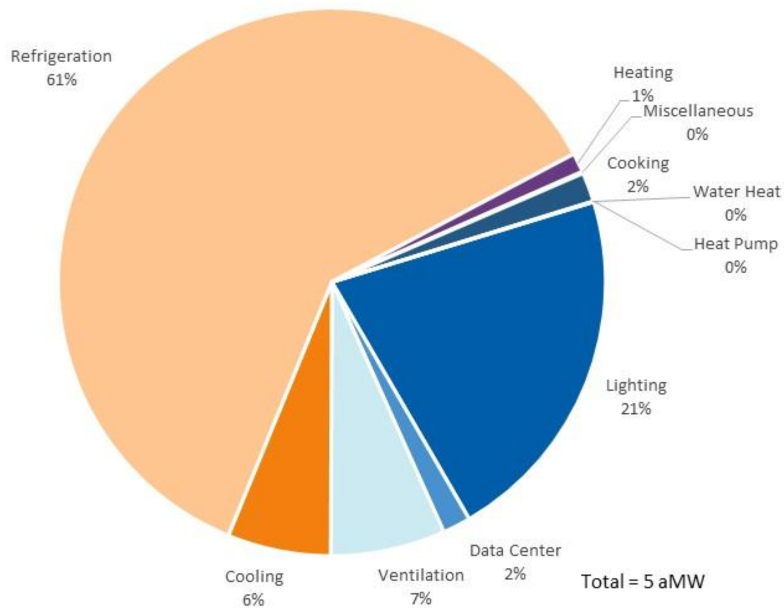

Figure D-15 SCL Achievable Economic Potential: Commercial Large Grocery by End Use

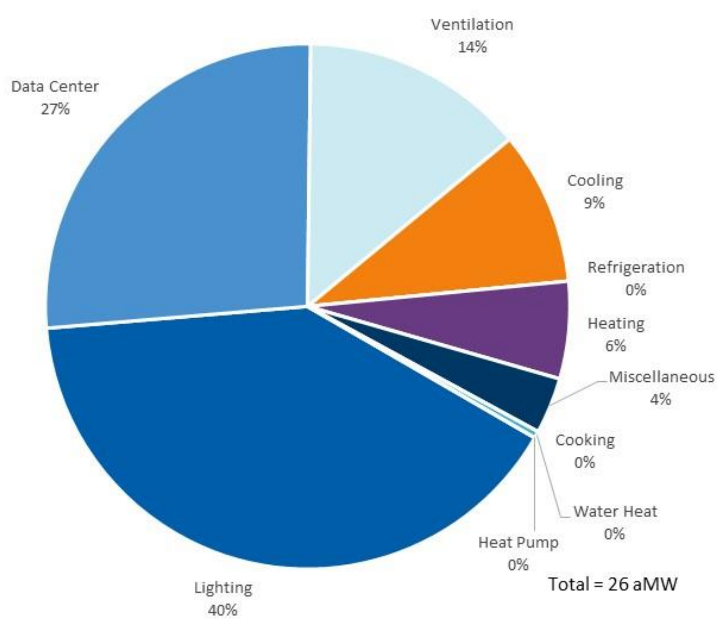

Figure D-16 SCL Achievable Economic Potential: Commercial Large Office by End Use

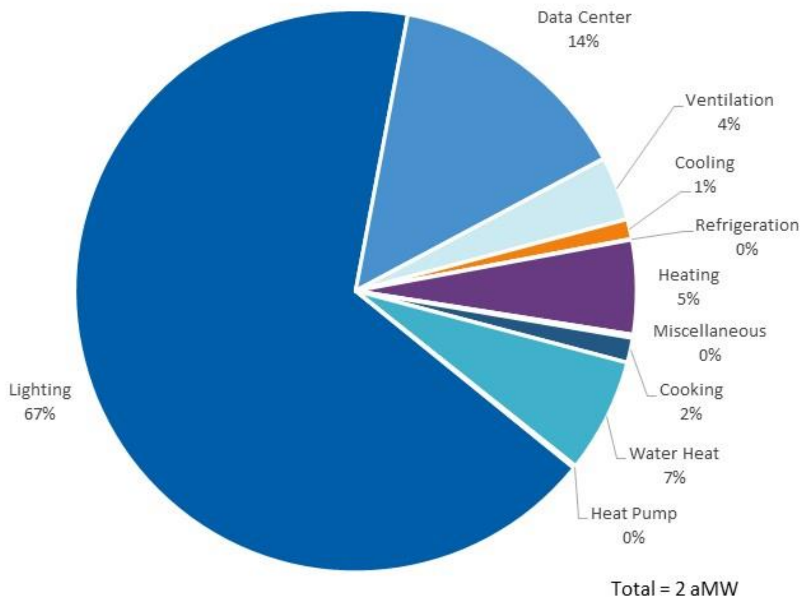

Figure D-17 SCL Achievable Economic Potential: Commercial Lodging by End Use

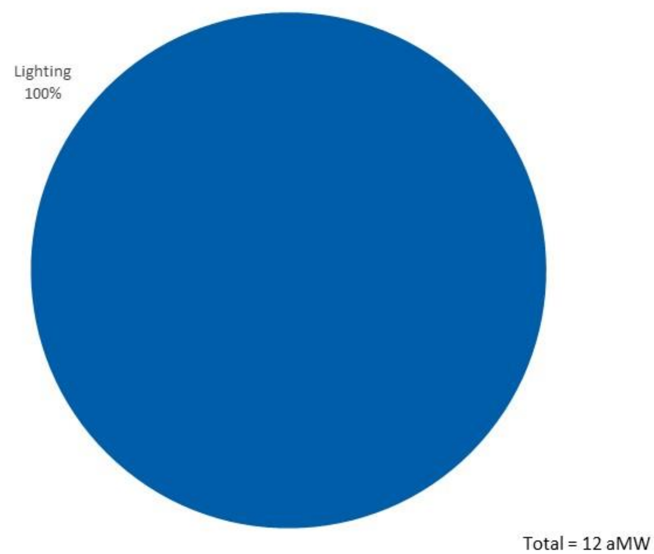

Figure D-18 SCL Achievable Economic Potential: Commercial MF Common by End Use

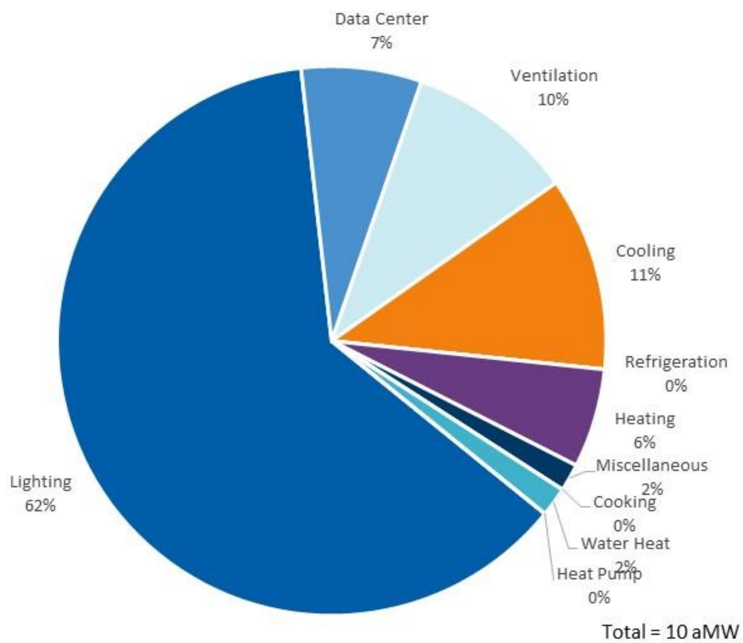

Figure D-19 SCL Achievable Economic Potential: Commercial Miscellaneous by End Use

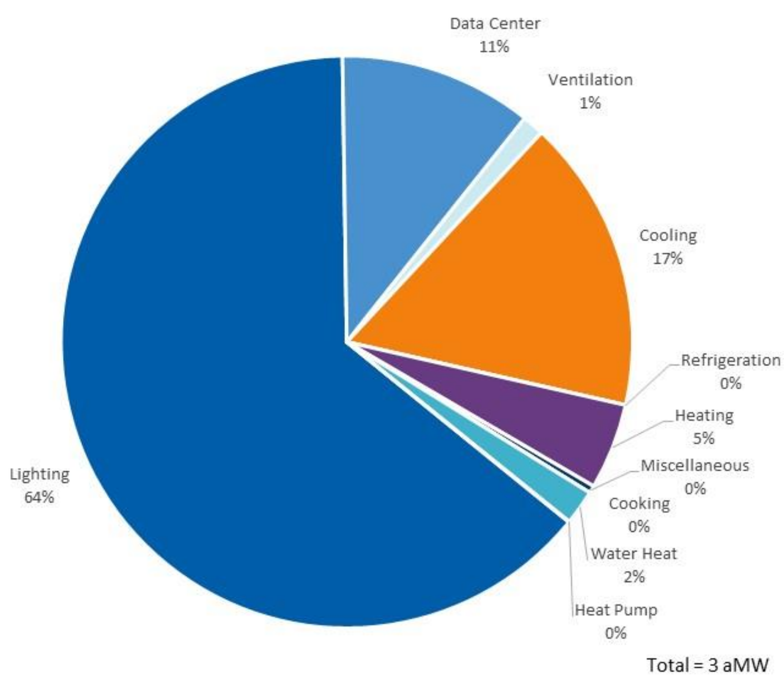

Figure D-20 SCL Achievable Economic Potential: Commercial Other Health by End Use

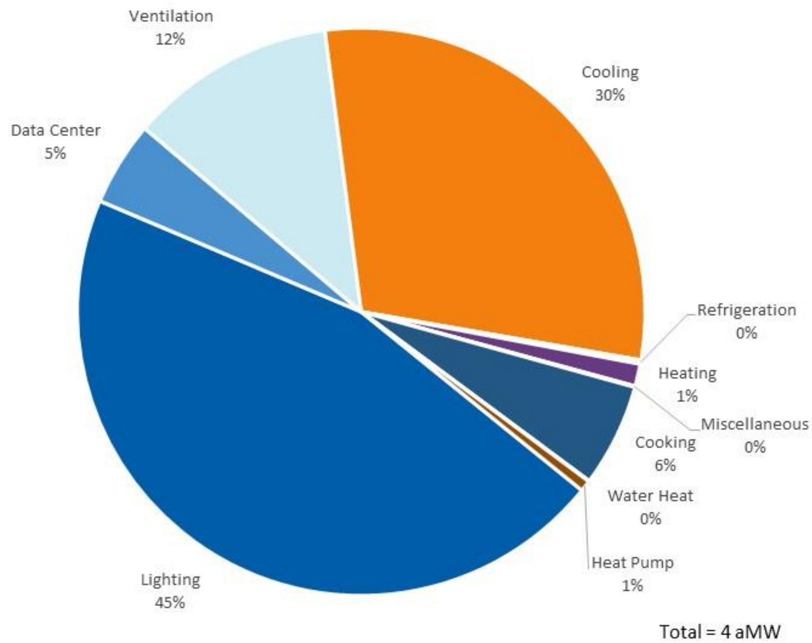

Figure D-21 SCL Achievable Economic Potential: Commercial Restaurant by End Use

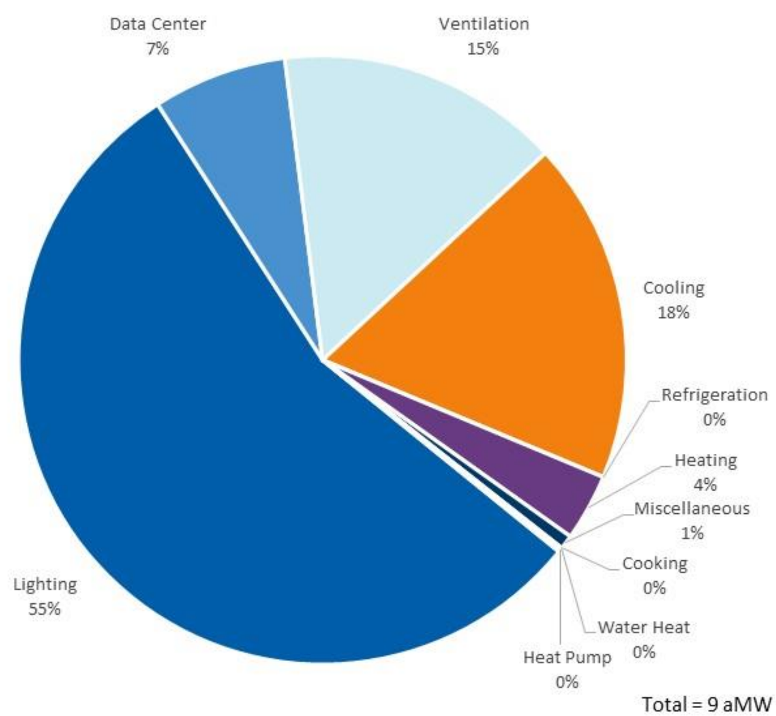

Figure D-22 SCL Achievable Economic Potential: Commercial Retail by End Use

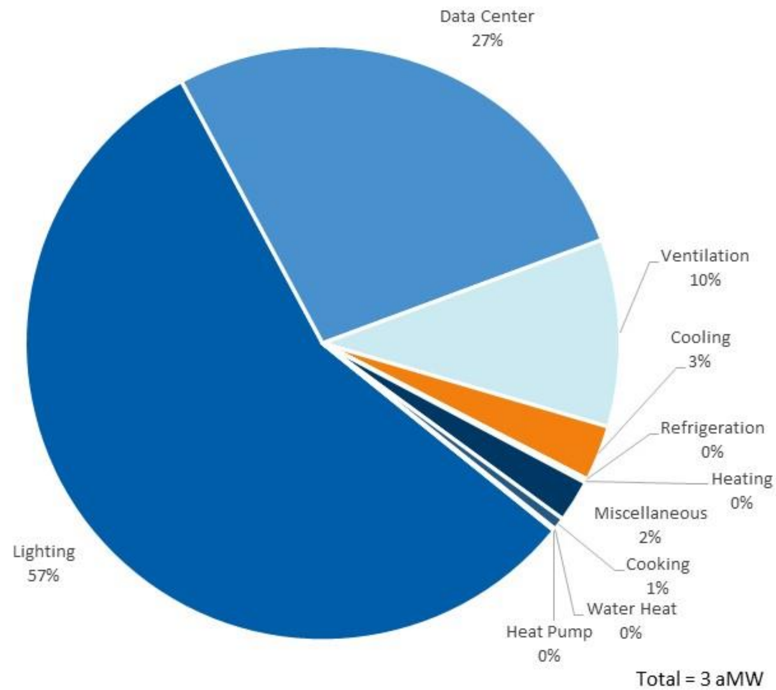

Figure D-23 SCL Achievable Economic Potential: Commercial School by End Use

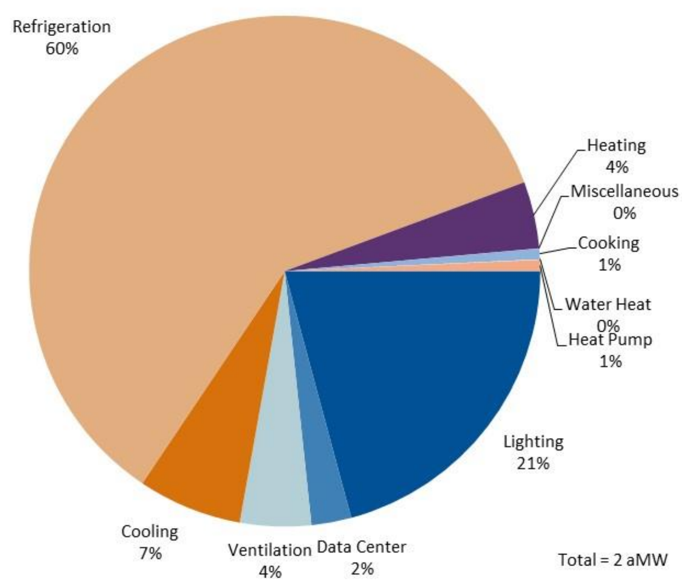

Figure D-24 SCL Achievable Economic Potential: Commercial Small Grocery by End Use

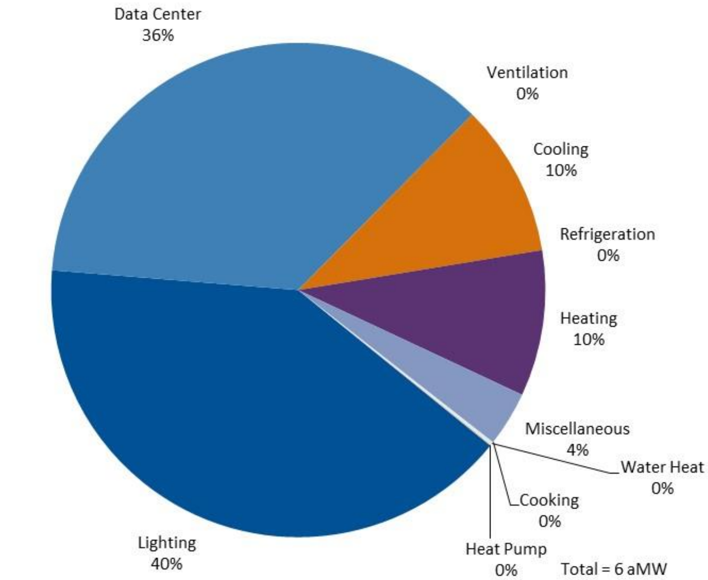

Figure D-25 SCL Achievable Economic Potential: Commercial Small Office by End Use

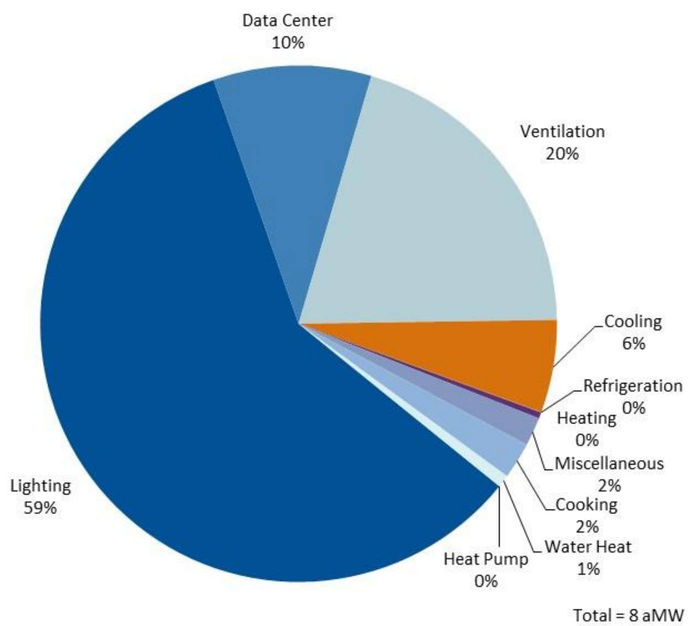

Figure D-26 SCL Achievable Economic Potential: Commercial University by End Use

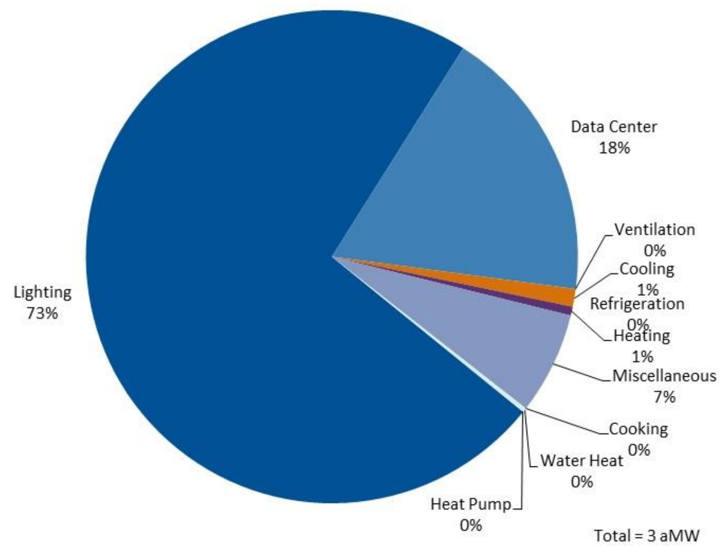

Figure D-27 SCL Achievable Economic Potential: Commercial Warehouse by End Use

D.5. Industrial Segments by End Use

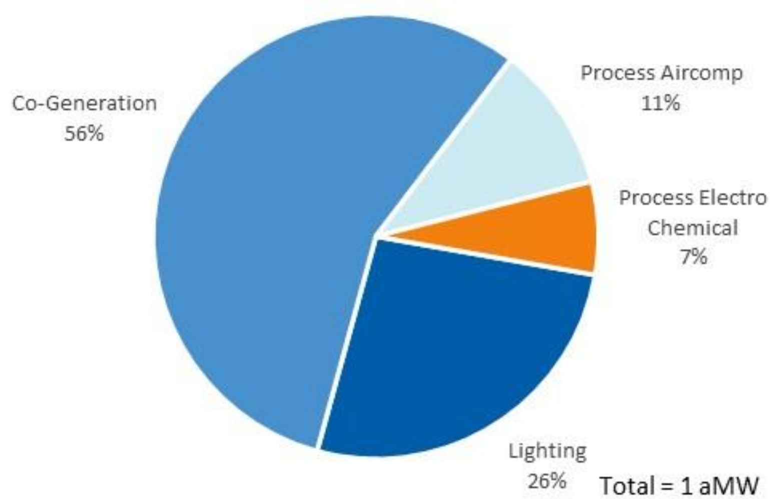

Figure D-28 SCL Achievable Economic Potential: Industrial – Foundries by End Use

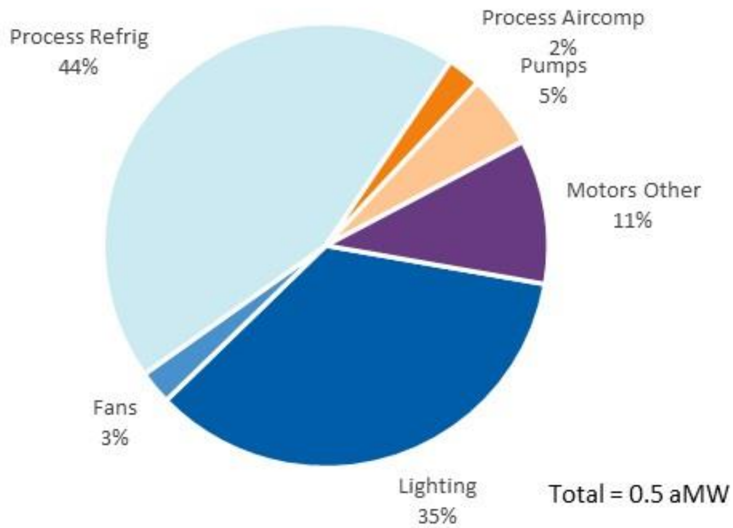

Figure D-29 SCL Achievable Economic Potential: Industrial - Frozen Food by End Use

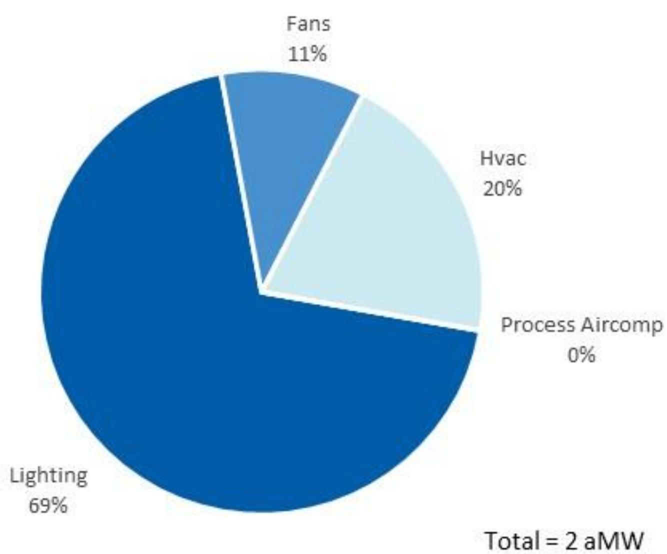

Figure D-30 SCL Achievable Economic Potential: Industrial – Misc. Manufacturing by End Use

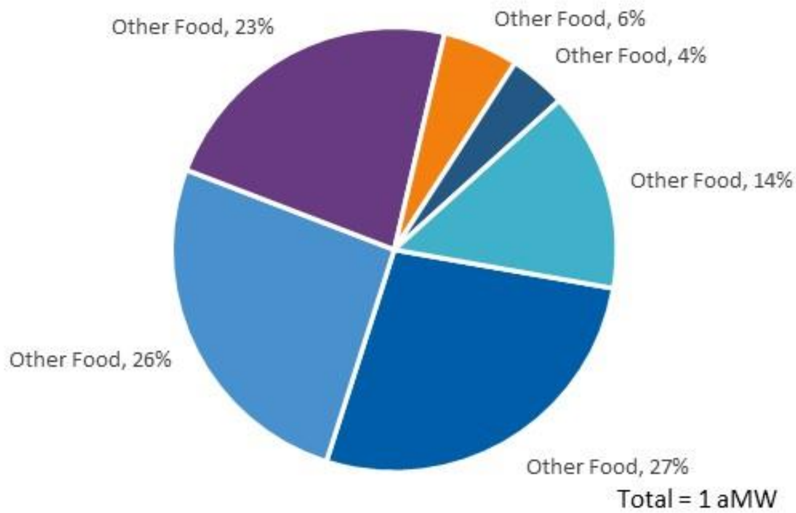

Figure D-31 SCL Achievable Economic Potential: Industrial - Other Food by End Use

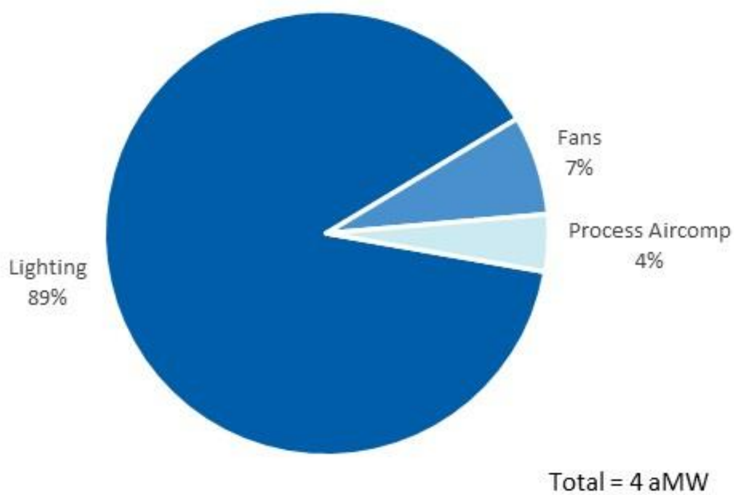

Figure D-32 SCL Achievable Economic Potential: Industrial - Transportation and Equipment by End Use

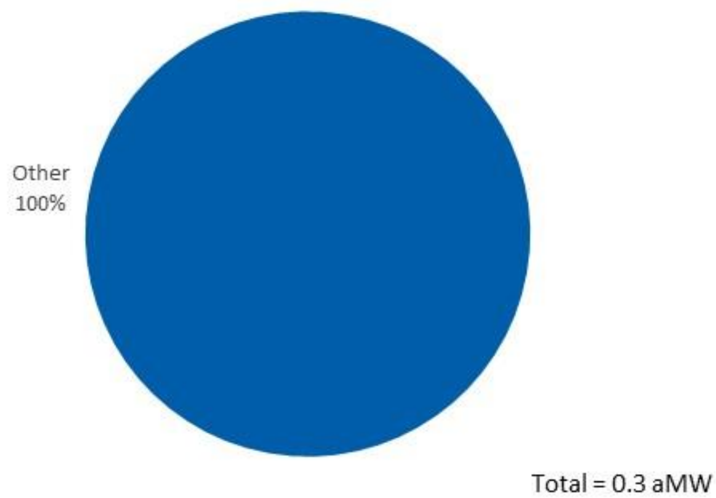

Figure D-33 SCL Achievable Economic Potential: Industrial - Wastewater by End Use

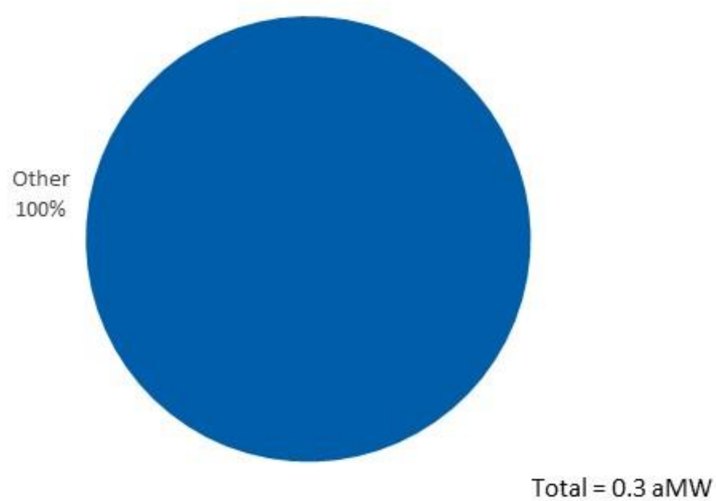

Figure D-34 SCL Achievable Economic Potential: Industrial - Water by End Use

Appendix E. Measure Details

E.1. Measure Details

Appendix E includes detailed measure costs, savings and applicability factors for all measure permutations considered in the study. This appendix includes three separate tables for each sector—residential, commercial, and industrial.

- **Segment**
- **End Use**
- **Construction Vintage:** New or Existing
- **Measure Name**
- **Measure Description**
- **Baseline Description**
- **Unit Description:** Units of savings and costs (e.g. per square foot, per unit, per industry).
- **Savings per Unit:** Per unit stand-alone savings for the energy efficiency measure.
- **Measure Life:** Expected useful lifetime of a given measure (years).
- **Incremental Cost ($):** Incremental cost to install the energy efficiency measure (inclusive of capital costs, labor and annual O&M). Industrial costs are expressed on thousands of dollars.
- **Technical Feasibility:** Percent of installations that are technical feasible.
- **Incomplete Factor:** One minus the current saturation of the ECM.
- **Levelized Cost:** The total resource cost (TRC) levelized cost of conserved energy, discounted over the 20-year study horizon.
- **TRC Benefit-Cost (B/C) Ratio:** The ratio of net present value TRC benefits to net present value TRC costs.
- **Technical Potential:** Cumulative 20-year technically feasible energy efficiency potential, expressed in MWh.
- **Economic Potential:** Cumulative 20-year energy efficiency potential for cost-effective measures, expressed in MWh. Note: economic potential may exceed technical potential for some measures due to interactions.
- **Achievable Economic Potential:** IRP scenario cumulative 20-year achievable potential, expressed in MWh.

Click the graph icon to the right to open the Measure Details file: