Seattle City Light

# 2020 Conservation Potential Assessment—Volume I

Project Lead/By: Jennifer Finnigan
Prepared by: Lakin Garth, Cadmus
**11/26/2019**

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# Definition of Terms

| | |
|---|---|
| aMW | Average Megawatt |
| AC | Air Conditioning |
| C&I | Commercial and Industrial |
| CBSA | Commercial Building Stock Assessment |
| CFL | Compact Fluorescent Lamp |
| CPA | Conservation Potential Assessment |
| Council | Northwest Power and Conservation Council |
| DOE | Department of Energy |
| ECM | Energy Conservation Measure |
| EISA | Energy Independence and Security Act of 2007 |
| 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 |
| LED | Light-emitting diode |
| MW | Megawatt |
| MWh | Megawatt-hour |
| NEEA | Northwest Energy Efficiency Alliance |
| O&M | Operations and Maintenance |
| RBSA | Residential Building Stock Assessment |
| RCW | Revised Code of Washington |
| REC | Renewable Energy Credit |
| RECS | Residential Energy Consumption Survey |
| RTF | Regional Technical Forum |
| RUL | Remaining Useful Life |
| SCL | Seattle City Light |

| | |
|---|---|
| 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 |

# Acknowledgements

The authors would like to thank the Seattle City Light staff who provided invaluable guidance and support, especially Jennifer Finnigan, John Rudolph, and Villamor Gamponia. The study required a compilation of a large amount of data from many sources, including several departments at City Light. The authors thank Kali Hollenhorst, Carsten Croff, Aliza Seelig, Mike Hamilton, and Saul Villareal for their guidance on load forecasting, avoided costs and economic assumptions.

# 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 21 years, beginning in 2020, which aligned with City Light's Integrated Resource Plan (IRP) timeline. This study identifies all cost-effective conservation potential in each of City Light's major customer sectors, including residential, commercial, and industrial. This study did not estimate street lighting potential as these have all been converted to LED.[1]

This study accomplishes the following objectives:

- Fulfills statutory requirements of Chapter 194-37 of the Washington Administrative Code (WAC), Energy Independence Act. This WAC requires City Light to identify all achievable, cost-effective, conservation potential for the upcoming 10 years.[2] 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 2020-2021 biennium.
- Provides adjustments to the final load forecasts for customers' energy savings from City Light's programs.
- 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 impact 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),[3] the 2014 Commercial Building Stock Assessment (CBSA),[4] 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

1 City Light's 2018 CPA did estimate streetlighting potential and, therefore, some figures and graphs in this report show those results for comparison to the 2020 CPA results

2 Washington State Legislature. *Energy Independence Act.* Washington Administrative Code Chapter 194-37.

3 Northwest Energy Efficiency Alliance. 2017 Residential Building Stock Assessment.

4 Northwest Energy Efficiency Alliance. 2014. Commercial Building Stock Assessment.

measures (ECMs) in the Council's final Seventh Plan workbooks and the active Regional Technical Forum's (RTF) unit energy savings (UES) workbooks.[5]

This study also anticipates upcoming requirements of Washington State's Clean Energy Transformation Act (CETA) which was passed as Senate Bill 5116 in April 2019 as the conservation potential assessment study analysis was being completed. Several CETA requirements, such as the inclusion of the social cost of carbon in avoided energy costs and estimates of demand response and solar photovoltaic (PV) potential were analyzed by this study.

## 1.2. Scope of Analysis

This study includes analysis of three 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: 19 major commercial segments, including offices, retail and other segments;
- Industrial: Energy-intensive manufacturing and primarily process-driven customers

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

Consistent with the Washington Administrative Code (WAC) requirements, this study considers three types of energy efficiency potential, as shown in Figure 1.1.

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

**Figure 1.1. Incremental Achievable Economic Potential**


EPA- National Action Plan for Energy Efficiency

This study defines the three types of potential as follows:

- **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 used the total resource cost (TRC) to identify cost-effective measures using a method consistent with the Council. The report's Economic Potential section 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 21-year study horizon, given the possibility of market barriers impeding customer adoption such as initial first cost, awareness and understanding of energy efficient technologies, and sufficient contractor base for installing efficient technologies. Ramp rates—defined as the acquisition rates for specific technologies—also determine the amount of economic potential considered achievable on an annual basis, beginning in 2020. The Achievable Economic Potential section discusses Cadmus' approach to estimating achievable potential.

## 1.3. Summary of Results

Study results indicate a 10-year achievable conservation potential of 82.7 average megawatts (aMW) (cumulative in 2029) within City Light's service territory. Two-year conservation potential equals 21.3 aMW, and the *pro rata* share (20 percent of 10-year conservation potential) which represents City

Light's minimum biennial target equals 16.5 aMW. Table 1.1 summarizes achievable economic conservation potential for each sector; all values include line losses at the generator.

### 1.3.1. Achievable Economic Potential

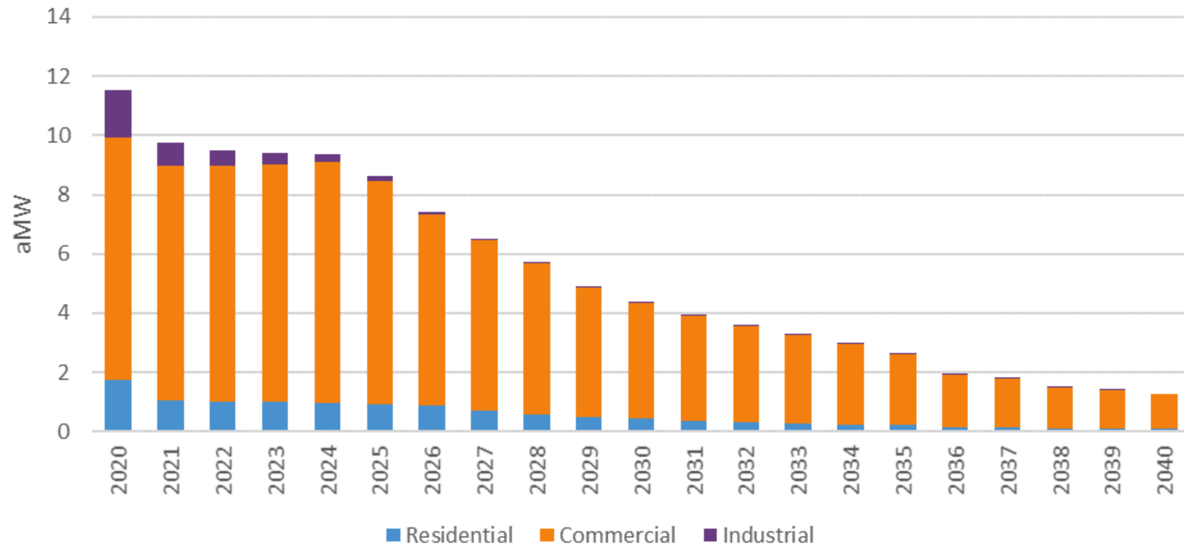
**TABLE 1.1. CUMULATIVE ACHIEVABLE POTENTIAL BY SECTOR**

| Sector | Achievable Economic Potential (aMW) | | | |
|---|---|---|---|---|
| | Two Year (2020-2021) | Ten Year (2020-2029) | 21 Year (2020-2040) | 20% of 10-Year Potential |
| Residential | 2.77 | 9.27 | 11.70 | 1.85 |
| Commercial | 16.10 | 69.43 | 95.54 | 13.89 |
| Industrial | 2.40 | 3.96 | 4.04 | 0.79 |
| Street Lighting | 0 | 0 | 0 | 0 |
| **Total** | 21.27 | 82.67 | 111.28 | 16.53 |

The commercial sector accounts for approximately 86 percent of cumulative, 21-year achievable potential, while the residential and industrial sectors account for roughly 11 percent and 3 percent of the 21-year potential, respectively. The study did not estimate street lighting potential, unlike the 2018 CPA because all streetlights have been upgraded to LED. This report's Energy Efficiency Potential section provides detailed estimates of achievable economic potential for each sector.

Figure 1.2 shows incremental achievable potential over the study horizon. Approximately 72 percent of the 21 year conservation potential will be achieved within the first 10 years, partly due to the mixture of measures with high conservation potential. This acceleration becomes particularly pronounced in the residential and industrial sectors, where 77 percent and 96 percent, respectively, of potential is acquired within the first 10 years. Cadmus determined the acquisition rate of incremental achievable potential using each measure's ramp rate, applying ramp rates developed by the Council for the Seventh Power Plan, and accelerating the application of ramp rates based on Seattle's historic conservation achievements. Historically, City Light has achieved energy savings greater than both its I-937 targets and its share of the regional savings on a percent of sales basis. Therefore, some ramp rates have been adjusted to reflect the greater pace of achievement, particularly with respect to commercial lighting technologies.

**Figure 1.2. Incremental Achievable Economic Potential**

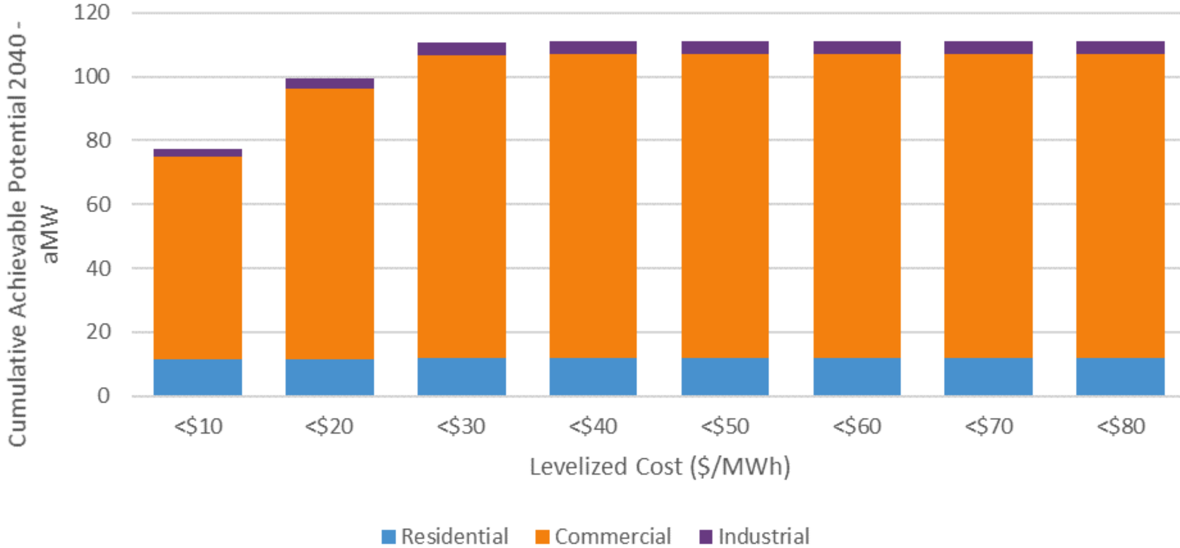



Lighting measures in the commercial sector account for a large portion of savings, and many of these measures have relatively aggressive ramp rates, based on the measures' availability and City Light's' program accomplishments. The Achievable Economic Potential section discusses Cadmus' ramp-rate application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

Figure 1.3 shows the amount of 21-year cumulative achievable potential at different, levelized cost thresholds. Levelized costs (expressed in 2018 dollars) 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.[6] Levelized costs of conserved energy often are used to compare the cost of conservation to supply-side resources.

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

**Figure 1.3. Conservation Supply Curves**




Potential conservation remains a low-cost resource: study results indicate roughly 78 aMW of conservation is achievable at a cost of less than $10 per megawatt-hour (MWh). This roughly accounts for 70 percent of the 21-year cumulative achievable potential. Approximately 89 percent of the 21-year, cumulative, achievable potential costs less than $20/MWh when levelized.

## 1.3.2. Technical and Economic Potential

### 1.3.2.1 Technical Potential

Table 1.2 shows the cumulative technical potential for each sector in 2040. Overall, study results identify 282 aMW of technically feasible conservation potential by 2040—the equivalent of 23 percent of forecasted baseline sales. Study results are presented as a percent of forecasted baseline sales which provides a useful benchmark for comparison against previous CPAs and the Council's 7th Power Plan.

**TABLE 1.2. TECHNICAL POTENTIAL**

| Sector | Baseline Sales–21 Year (aMW) | Technical Potential–21 Year (aMW) | Technical Potential as % of Baseline Sales |
|---|---:|---:|---:|
| Residential | 440 | 100 | 23% |
| Commercial | 693 | 173 | 25% |
| Industrial | 88 | 9 | 10% |
| Street Lighting | 5 | 0 | 0% |
| **Total** | 1,226 | 282 | 23% |

The commercial, residential, and industrial sectors account for 61 percent, 36 percent, and 3 percent of the 21-year technical potential, respectively.

#### 1.3.2.2 Economic Potential

According to WAC 194-37-070, City Light must consider conservation potential estimates using avoided costs equal to a forecast of regional market prices. Regional market price forecasts, however, do not necessarily reflect all the costs associated with City Light's preferred portfolio of generation resources. To assess impacts of avoided cost uncertainty, Cadmus prepared estimates of economic and achievable potential, using an avoided energy cost forecast that assumes continued purchases and delivery from Bonneville Power Administration after City Light's 20-year contract ends in 2028, inclusion of the social cost of carbon based on Washington's Clean Energy Transformation Act (ESSSB 5116), additions for renewable energy credits, market purchases during the month of June since the monthly shaping of the BPA contract assumes no BPA purchases in June so energy efficiency displaces market purchases in June, and a 10 percent conservation credit.[7]

The study also accounted for forecasts of deferred transmission and distribution (T&D) costs. The 2020 CPA updated these values to align with the Council's recently updated assumptions for its upcoming 2021 Power Plan.[8] Cadmus used forecast values from the Council's presentation in March of 2019, which reflected values of $3.08/kW-year and $6.85/kW-year for transmission and distribution, respectively, which were converted from 2016 to 2018 dollars.[9] As City Light does not face constrained generation capacity, these scenarios do not include costs associated with adding generation capacity.

In the 2020 CPA, total levelized avoided costs for the 2020 to 2040 period are approximately $38/MWh, compared to $52/MWh in the 2018 CPA, or nearly 27 percent lower, as shown in Figure 1.4.[10] These lower avoided energy and capacity costs contributed to a decrease in economic potential in the residential, commercial, and industrial sectors, in addition to factors contributing to lower technical potential.

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7 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.

8 https://www.nwcouncil.org/sites/default/files/2019_0312_p3.pdf

9 The Council's values were presented in its March 2019 meeting and reflect weighted average values from several regional utilities and are expressed in $2016, levelized. https://www.nwcouncil.org/sites/default/files/2019_0312_p3.pdf

10 Both the 2018 CPA and 2020 CPA levelized cost values are expressed in 2018 dollars for comparison purposes

**Figure 1.4. Economic Potential as a Fraction of Baseline Sales – 2040 Cumulative**

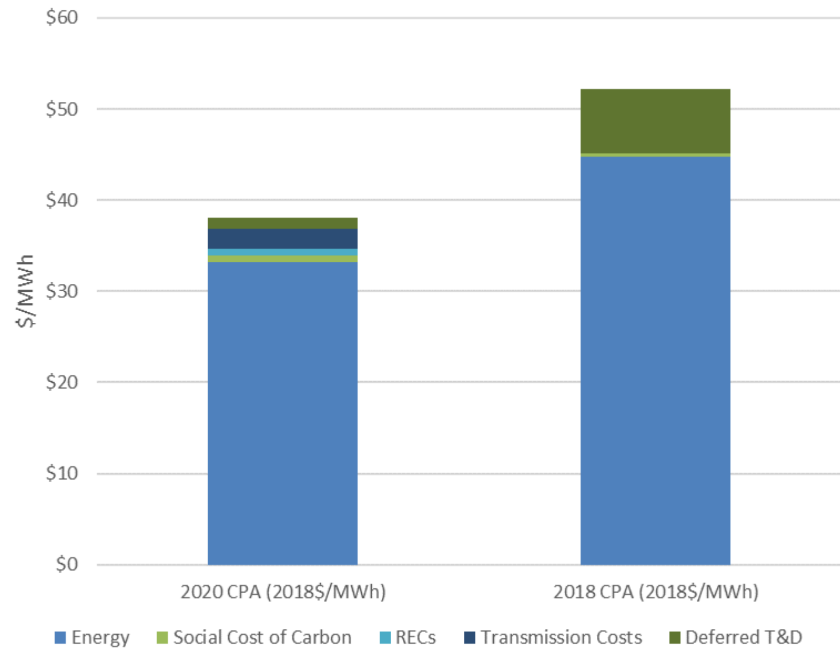


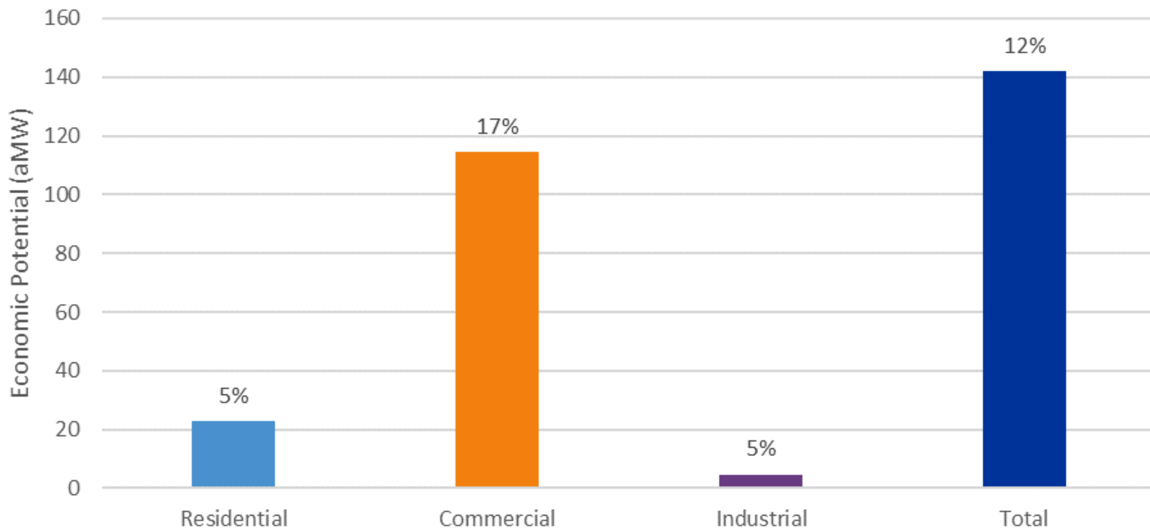

Table 1.3 summarizes cumulative economic potential in 2040 for each avoided-cost scenario. Using updated avoided costs, approximately 23 percent of technical potential proves cost-effective in the residential sector, compared to 66 percent in the commercial sector and 56 percent in the industrial sector. Substantial differences in the percent of technical potential that is economic exist between sectors, particularly for the residential sector, which is much lower than commercial and industrial. The primary reason for this discrepancy is that, relatively speaking, residential measures are typically less cost-effective than commercial and industrial, as unit energy savings are lower due to the relative magnitude of energy consumption between homes, businesses, and industries.

**TABLE 1.3. ECONOMIC POTENTIAL**

| Sector | Economic Potential—21 Year (aMW) | Economic Potential as a % of Baseline Sales | Economic Potential as a % of Technical Potential |
|---|---|---|---|
| Residential | 23 | 5% | 23% |
| Commercial | 115 | 17% | 66% |
| Industrial | 5 | 5% | 56% |
| **Total** | 142 | 12% | 50% |

Figure 1.5 shows the cumulative economic potential in 2040, relative to forecasted baseline sales, by sector.

**Figure 1.5. Economic Potential as a Fraction of Baseline Sales – 2040 Cumulative**




WAC 194-070 requires City Light to test multiple scenarios and incorporate risk into estimates of achievable potential. By using a higher or lower IRP avoided-cost scenario based on the relative change in avoided costs from the last CPA 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 2018 CPA

**TABLE 1.4. TECHNICAL POTENTIAL COMPARISON**

| Sector | 2020 CPA | | | 2018 CPA | | |
|---|---|---|---|---|---|---|
| | Baseline Sales—21 Year (aMW) | Technical Potential—21 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 | 440 | 100 | 23% | 336 | 85 | 25% |
| Commercial | 693 | 173 | 25% | 747 | 180 | 24% |
| Industrial | 88 | 9 | 10% | 150 | 13 | 9% |
| Street Lighting | 5 | 0 | 0% | 10 | 1 | 12% |
| **Total** | 1,226 | 282 | 23% | 1,242 | 279 | 22% |

The 2020 CPA identified 282 aMW of technical potential, compared to 279 in the 2018 CPA. This very slight increase affects changes in both the economic and achievable potential. Changes contributing to the difference in technical potential include the following:

- Higher residential baseline load forecasts
- New residential measures not previously considered in the 2018 CPA
- Additional commercial measures not previously included in the 2018 CPA
- Lower industrial baseline load forecasts due to the re-classification of some industrial customer premise loads in the commercial sector

This report's Comparison to 2018 CPA section discusses each factor in detail. Table 1.5 compares economic potential for the 2020 and 2018 CPAs.

| TABLE 1.5. ECONOMIC POTENTIAL COMPARISON | | | | | | |
|---|---|---|---|---|---|---|
| Sector | 2020 CPA (Market Avoided Costs) | | | 2018 CPA (IRP Avoided Costs) | | |
| | Economic Potential—21 Year (aMW) | Economic Potential as % of Baseline Sales | Economic as a % of Technical Potential | Economic Potential—20 Year (aMW) | Economic Potential as % of Baseline Sales | Economic as a % of Technical Potential |
| Residential | 23 | 5% | 23% | 21 | 6% | 25% |
| Commercial | 115 | 17% | 66% | 131 | 17% | 72% |
| Industrial | 5 | 5% | 56% | 10 | 7% | 77% |
| Street Lighting | 0 | 0% | 0% | 1 | 12% | 100% |
| **Total** | 142 | 12% | 50% | 163 | 13% | 58% |

The 2020 CPA identified 142 aMW of economic potential, compared to 163 aMW of economic potential in the 2018 CPA. Lower avoided energy and deferred T&D capacity costs contributed to decreases in the residential, commercial, and industrial sectors, in addition to factors contributing to lower technical potential for the commercial and industrial sectors only (see Table 1.4).

As with technical and economic potential assessment, Cadmus identified lower 20-year, cumulative achievable economic potential. As 20-year cumulative achievable potential represents a subset of economic potential, factors contributing to lower cumulative achievable potential were the same as those previously discussed for economic potential. Figure 1.5 shows incremental achievable economic potential for the 2020 and 2018 CPAs.

**Figure 1.6. Incremental Achievable Economic Potential 2020 and 2018 CPAs**

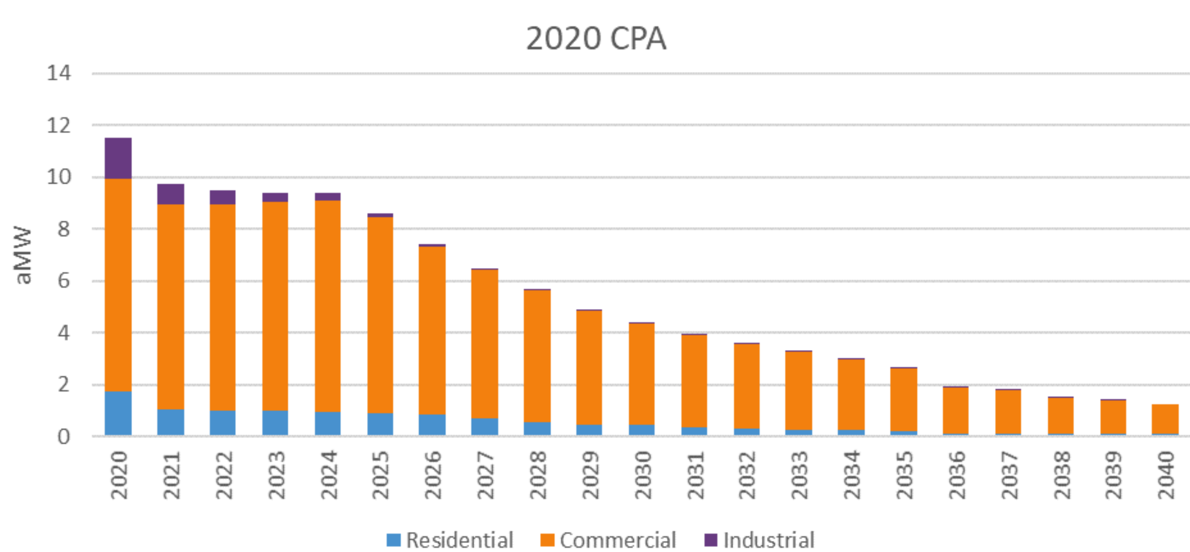


**Figure 1.6. Incremental Achievable Economic Potential 2020 and 2018 CPAs**

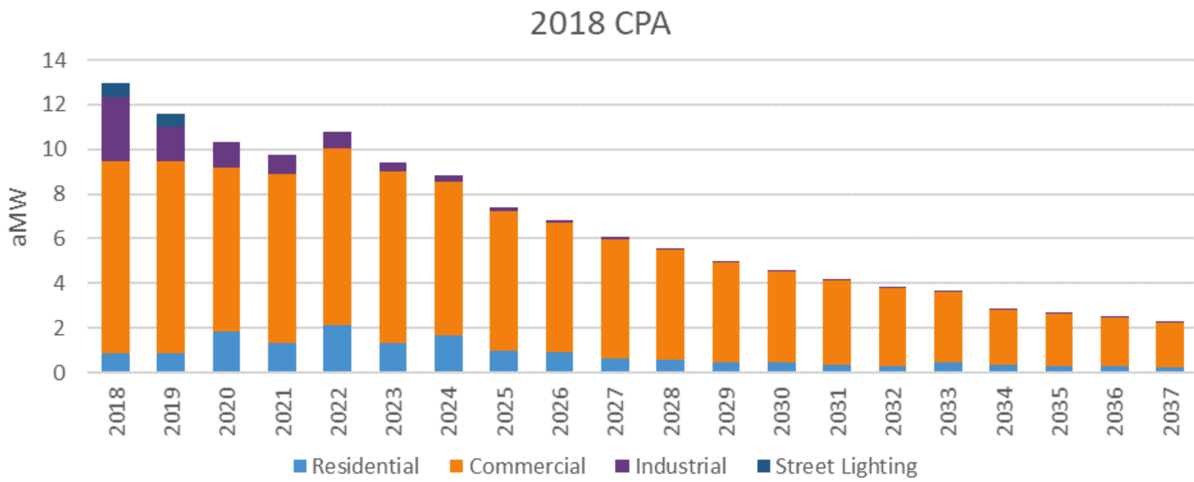



Figure 1.7 illustrates, compared to the 2018 CPA, the 2020 CPA determines a higher proportion of total achievable potential will be realized in the study's early years. This change results from multiple factors:

- The shift in the study horizon (moving from a 2018 start year to 2020)
- The application of faster ramp rates for lost opportunity measures to account for the difference in the 2020 CPA start year (2020) and 7th Plan start year (2016), which is also consistent with the approach taken by BPA's CPA.[11]

As illustrated in Figure 1.7, the cumulative achievable potential as a percent of 21-year achievable potential in the 2020 CPA is comparable to the 2018 CPA.

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11 Bonneville Power Administration. *BPA Conservation Potential Assessment, 2020-2039.* Prepared by The Cadmus Group and EES Consulting, July 2018. Available online: https://www.bpa.gov/EE/Utility/research-archive/Documents/BPA_Conservation_Potential_Assessment_2020-2039.pdf

**Figure 1.7. Cumulative Achievable Potential as a Percent of Total Achievable Potential**

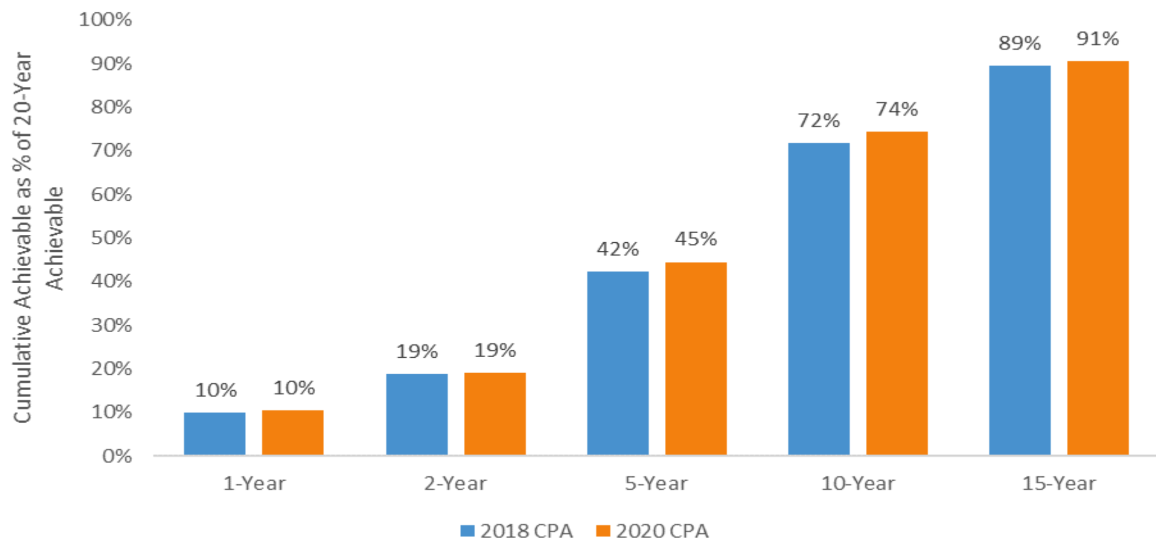



Table 1.6 provides a summary of the technical, economic, and achievable capacity savings from energy efficiency by sector, in 2040. The commercial sector accounts for 87% and 91% of the total, cumulative winter and summer capacity achievable potential, respectively.

| TABLE 1.6. CUMULATIVE 21-YEAR WINTER AND SUMMER CAPACITY SAVINGS BY SECTOR, IN 2040 | | | | | | |
|---|---|---|---|---|---|---|
| **Sector** | **Technical Potential** | | **Economic Potential** | | **Achievable Potential** | |
| | **Winter MW** | **Summer MW** | **Winter MW** | **Summer MW** | **Winter MW** | **Summer MW** |
| Residential | 189 | 69 | 26 | 23 | 15 | 11 |
| Commercial | 243 | 317 | 162 | 189 | 135 | 158 |
| Industrial | 10 | 11 | 6 | 6 | 5 | 5 |
| **Total** | **441** | **398** | **193** | **218** | **155** | **174** |

The residential sector accounts for nearly 43% of the winter capacity technical potential but only 17% of the summer capacity technical potential, reflecting the relatively higher saturation of residential electric space heating loads compared with residential cooling loads. The residential sector's share of winter and summer economic and achievable capacity potential declines compared to its share of technical potential, as many of the highest capacity-savings measures are not cost-effective, including efficiency air source and ductless heat pumps and weatherization measures.

## 1.4. Organization of this Report

This report presents the study's findings in two volumes. Volume I—this document—presents the methodologies and findings. Volume II contains the appendices, and it provides detailed study results, supplemental materials, and summaries of demand response and solar photovoltaic potential.

**Volume I** includes the following sections:

- The methodology overview provides an overview of the methodology Cadmus used to estimate technical, economic, and achievable economic potential.
- 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 ECMs, deriving from this 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 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 top-saving measures in each sector.
- Comparison to 2018 CPA shows how this study's results (the 2020 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. Methodology Overview

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

Cadmus' assessment took the following primary steps:

- Baseline forecasting, which involved determining 21-year future energy consumption by sector, market segment, and end use. The study calibrated the base year (2019) to City Light's sector-load forecasts produced in 2018. Baseline forecasts in this report include Cadmus' estimated impacts of naturally occurring potential and codes and standards.
- Estimation of technical potential, based on alternative forecasts reflecting the technical impacts of specific energy efficiency measures.
- Estimation of economic potential, based on alternative forecasts reflecting technical impacts of cost-effective ECMs.
- Estimation of achievable economic potential, calculated by applying ramp rates and on the achievability percentage to economic potential, which this section describes in detail.

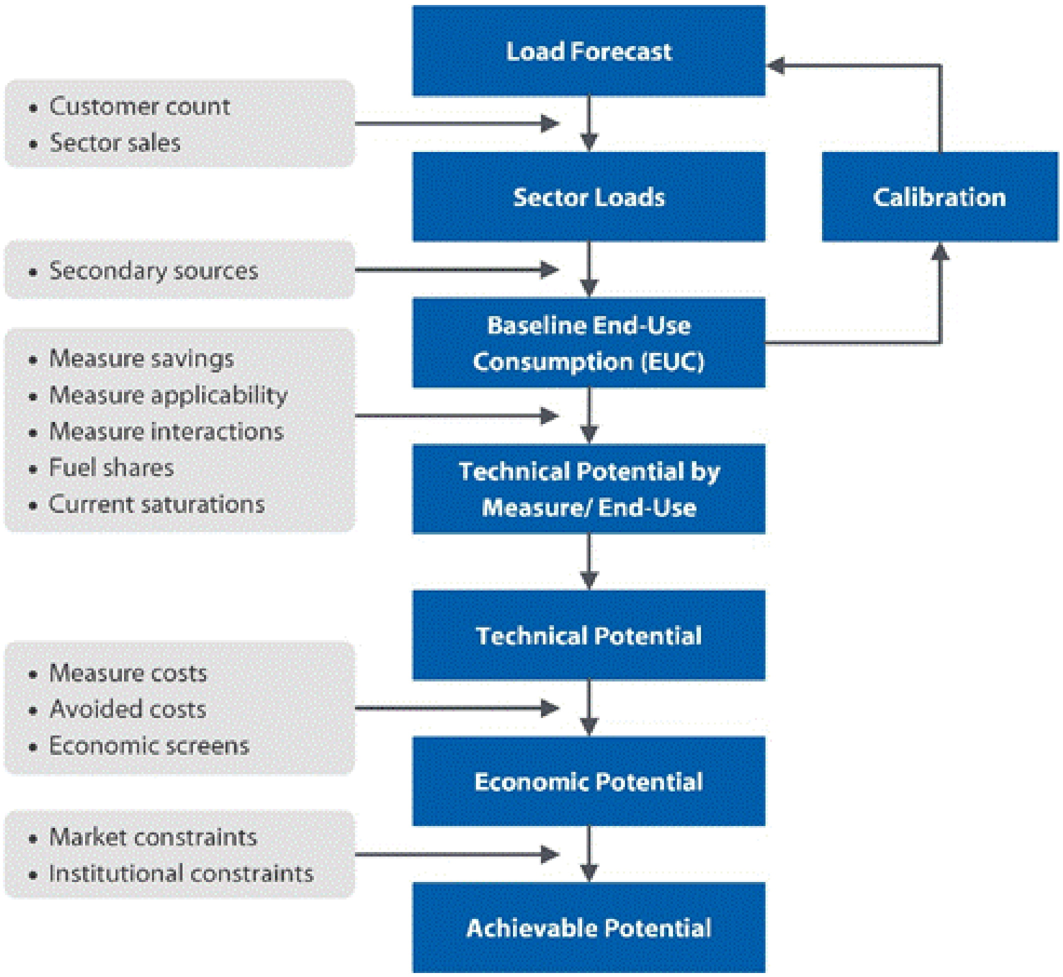
This approach offered two advantages:

- First, savings estimates would be driven by a baseline calibrated to City Light's.
- Second, the approach maintained consistency among all assumptions underlying the baseline and alternative forecasts—technical, economic, and achievable technical. 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.

Cadmus' general methodology can be best described as a combined top-down/bottom-up approach. As shown in Figure 2.1, the top-down component began with the most current load forecast, adjusting for building codes, equipment efficiency standards, and market trends not accounted for through the forecast. It then disaggregated this load forecast into its constituent customer sectors, customer segments, 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 2.1. 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 baseline forecasts determined the appropriate customer segments within each sector. Designations drew upon categories available in the study's key data sources—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.

Upon determining appropriate customer segments and end uses 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 used 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 (UPAi generally equals 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 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 $EUSE_{ij}$ across the end uses and customer segments.

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 and drawing upon data available from the U.S. Department of Energy (DOE) Energy Information Administration.[12]

### 2.2.1. Derivation of End-Use Consumption

End-use energy consumption estimates 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 used estimates on unit energy consumption (UEC), representing annual energy consumption associated with an end use and represented by a specific type of equipment (e.g., 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 differences among various segments.

12 Energy Information Administration. *Manufacturing Energy Consumption Survey.* U.S. Department of Energy. *2010.*

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

As technical potential drew upon an alternative forecast, reflecting installations of all technically feasible measures, selecting appropriate ECMs to include in this study posed a central concern. To alleviate this concern and to 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. The database included the following measures:

- All measures included in the Council's final Seventh Power Plan conservation supply curve workbooks
- Active RTF UES measures
- Particular technologies of interest to City Light, as identified for the study (e.g., residential and commercial central cooling and room cooling 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 the residential manufactured home segment as these represented a small fraction of City Light's customer mix.

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

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

In the commercial sector, additional RTF measures included the following:

- 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 affecting end-use equipment (e.g., high-efficiency domestic water heaters), which follow normal replacement patterns based on expected lifetimes.
- **Non-equipment (retrofit) measures** affecting 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, given that savings can be acquired at any point over the planning horizon.

Each measure type's relevant inputs include the following:

**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 its installation is technically feasible. This equals 1.0 minus the measure's current saturation.
- 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 through 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 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, Tacoma Power) or for the broader Northwest, as found in the RBSA. If Cadmus could not calculate applicability factors from NEEA's RBSA, the study used applicability factors from the Council's Seventh Power Plan workbooks. The resulting 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.

By data input, Table 2.1 lists the primary sources referenced in the study.

| TABLE 2.1. 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 |

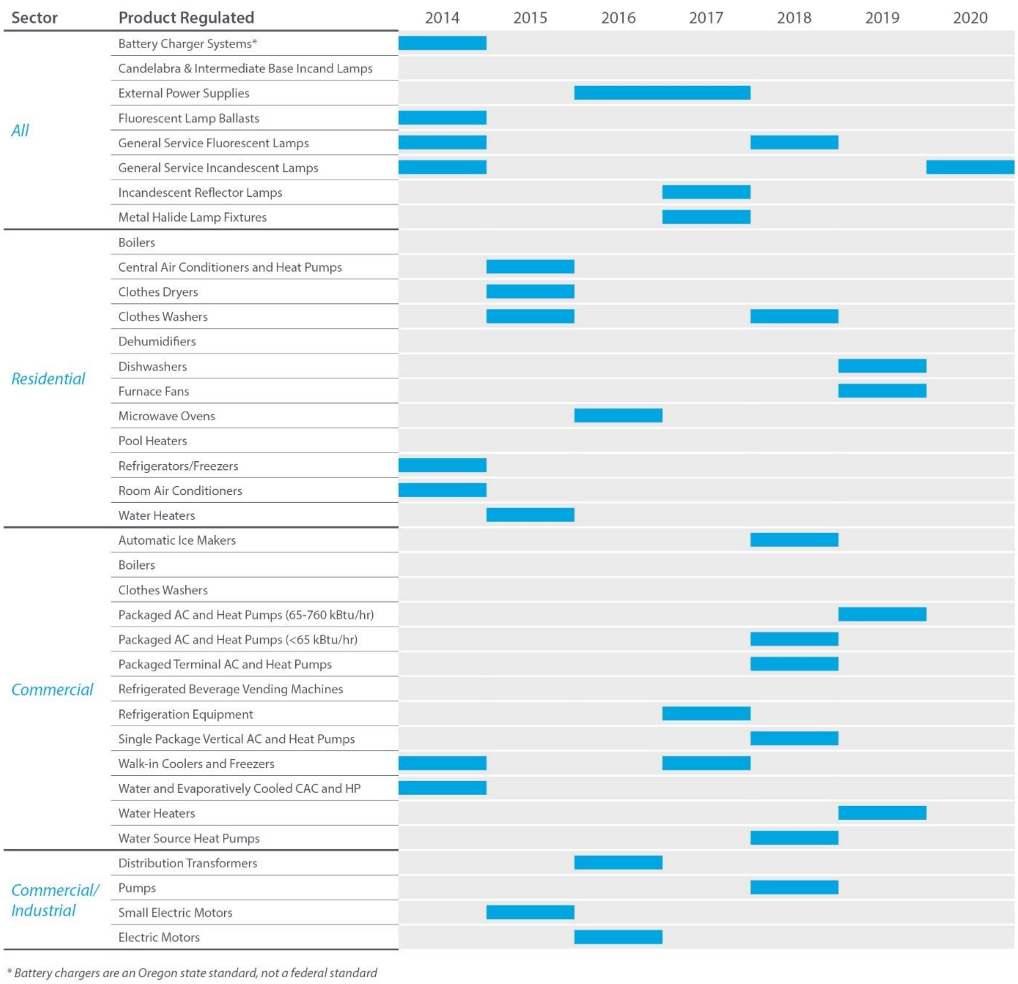
### 2.3.1. Incorporating Codes and Standards

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 only factored in legislation already 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 becomes 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 2.2 provides a comprehensive list of equipment standards considered in the study. 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 2.2. Equipment Standards Considered**




The study considered four codes and standards sources in addition to federal standards:

1. 2015 Washington State Energy Code (WSEC)
2. 2015 City of Seattle Energy Code

3. City of Seattle Office of Sustainability Benchmarking Code
4. Washington State House Bill 1444 Appliance Standards

The study incorporated the WSEC in its baseline development of residential and new construction measures. After reviewing the City of Seattle Energy Code, one small adjustment was made to single family heat pump measures in new construction applications; however, none of these measures passed cost-effectiveness testing. Other measures affected by the City of Seattle Energy Code were either not cost-effective (new construction interior lighting controls) or offered relatively low amounts of technical and economic potential and the code applied to only a portion of measure applications (commercial direct digital control energy management in new construction). Similarly, Cadmus reviewed both the City of Seattle OSE Benchmarking Code and the Washington State HB 1444 appliance standards and concluded the study had either sufficiently considered the standards (in the case of HB 1444) and that, since the effects of the new benchmarking code were still unknown, no additional adjustments were required.

### 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 remain consistent with savings in RTF workbooks in demonstrating 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 either from City Light's oversample of CBSA and RBSA or from estimates affecting 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 Light-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 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 2.2 shows the distribution of end-use consumption and the list of industries considered in this study.

**TABLE 2.2. DISTRIBUTION OF END USE CONSUMPTION BY SEGMENT**

| Cadmus Segment | Process Air Comp | 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 2.3 shows the mapping of Council end uses to Cadmus end uses.

| TABLE 2.3. COUNCIL AND CADMUS END USES | |
|---|---|
| **Council End Use** | **Cadmus End Use** |
| Pumps | Pumps |
| Fans and Blowers | Fans |
| Compressed Air | Process Air Compressor |
| Material Handling | Process Electro Chemical |
| Material Processing | Motors Other |
| Low Temp Refer | Process Refrigeration |
| 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 2.3.

**Figure 2.3. Types of Conservation Potential**


EPA- National Action Plan for Energy Efficiency

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 installations of the highest-efficiency equipment that are commercially available. For example, this study examined CFL and LED general-service lighting in residential applications. In assessing technical potential, Cadmus 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 as installed in sockets ineligible for LEDs. This study treated competing non-equipment measures in the same way, assuming installation of the highest-saving measures where technically feasible.

In estimating technical potential, it is inappropriate to merely sum up savings from individual measure installations. Significant interactive effects can result from installations 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 if had the 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, causes 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 21-year planning horizon. By applying this assumption, natural equipment turnover rates, and other adjustments described above, annual incremental and cumulative potential could be estimated by sector, segment, construction vintage, end use, and measure.

This study's technical potential estimates drew upon best-practice research methods and standard utility industry analytic techniques. Such techniques remained consistent with the conceptual approaches and methodologies used by other planning entities (such as 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 2.4 summarizes benefits and costs considered in calculating benefit-cost ratios.

**TABLE 2.4. TRC BENEFITS AND COSTS**

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

- **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 decreased O&M costs.
- **Administrative adder:** Cadmus assumed program administrative costs of 20 percent in the residential sector and 23 percent in the C&I sectors, basing these 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 20th year at the time of reinstallation.

- **Avoided supply costs**: City Light's portfolio from the 2018 IRP includes the continuation of the BPA block contract in the next 20 years using the net requirement product from BPA. This means that reductions in loads due to conservation displaces the amount of energy City Light can rely from BPA. As a result, the forecast of BPA energy and delivery rates is a major component in the avoided energy costs of conservation. However, the monthly shape of BPA block is such that City Light does not take any BPA power in June based on City light's portfolio shaping. Thus, conservation displaces market purchases in June. In addition, City Light reduces its purchase of RECs when loads are reduced due to conservation. Finally, the social cost of carbon based on the recently passed Clean Energy Transformation Act is applied to determine the avoided carbon cost due to conservation.
- **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 that measure's levelized cost.
- **The regional 10 percent conservation credit 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 the Council methodology and effectively served as an adder to account for unquantified external benefits from conservation when compared to other resources.[15]
- **Secondary energy benefits** were treated as a reduction in levelized costs for measures saving energy on secondary fuels. This treatment was necessitated by Cadmus' end-use approach to estimating technical potential. For example, consider R-60 ceiling insulation costs 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 produced for electric cooling systems, conditioned on the presence of a gas furnace, as a secondary benefit that reduced the measure's levelized cost. This adjustment affected only the measure's levelized costs; the R-60's magnitude of energy savings 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 each measure's levelized costs to the Council's levelized-cost methodology; levelized costs include all costs and benefits described above.

The approach adopted in calculating a measure's levelized cost of conserved energy aligned with that of the Council, considering the costs required to sustain savings over a 21-year study horizon (including reinstallation costs for measures with useful lives less than 21 years). If a measure's useful life extended

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

beyond the end of the 21-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 21-year period.

For example, Figure 2.4 shows the timing of initial and reinstallation costs for a measure with an eight-year lifetime, in context with the 21-year study. As a measure's lifetime in this study ends after the study horizon, the final five years (Year 17 through Year 21) were treated differently, levelizing measure costs over the measure's eight-year life and treating these as annual reinstallation costs.

**Figure 2.4. 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** | **21** |
| Initial Capital Cost | ■ | | | | | | | | | | | | | | | | | | | | |
| Reinstallation Cost | | | | | | | | | ■ | | | | | | | | End Effect | | | | |

As with incremental measure costs, Cadmus considered O&M costs annually over the 21-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 decreased 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 realistically achievable depends on multiple factors, including the following: the customers' willingness to participate in energy efficiency programs (partially as a function of incentive levels); retail energy rates and various market barriers that historically have impeded adoption of energy efficiency measures and practices by consumers. These barriers tend to vary, depending on a customer's sector, local energy market conditions, and other difficult-to-quantify factors.

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

Although methods for estimating achievable economic 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, based on past experiences with similar programs. In the Northwest, for example, the Council has historically assumed that, by the end of a 20-year assessment horizon, 85 percent of the economic potential could be achieved and would include savings from utility programs, evolving market structures, 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 21-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 resources likely available over the planning horizon's course; they do not, however, provide guidance regarding 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 other means.

#### 2.4.3.1 About Measure Ramp Rates

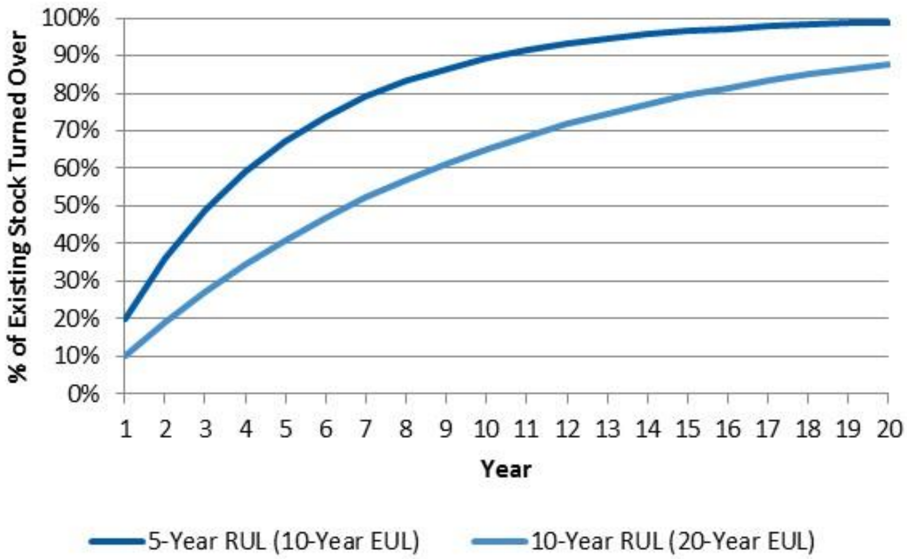
The study applied measure ramp rates to lost opportunity and discretionary resources, although interpretation and application of these rates differed for each class, as described below. Measure ramp rates generally matched those proposed for the Council's Seventh Power Plan. For measures not specified 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.

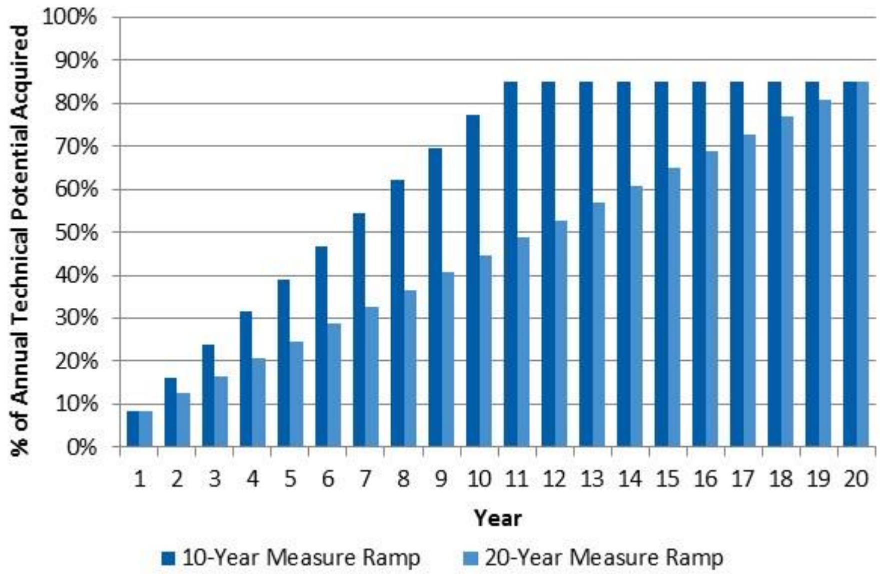
As the mix of existing equipment stock ages, the remaining useful life (RUL) would equal—on average—one-half of the EUL. The fraction of equipment turning over each year would be a function of this RUL; thus, economic potential for lost opportunity measures would have an annual shape before applying ramp rates, as shown in Figure 2.5. The same concept applied to new construction, where resource acquisition opportunities became available only during home or building construction. In addition to showing an annual shape, Figure 2.5 demonstrates that amounts of equipment turning over during the study period were a function of the RUL: the shorter the RUL, the higher the percentage of equipment assumed to turn over.

**Figure 2.5. 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 shown in Figure 2.6, 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, while another measure might take 20 years to reach full maturity. Measures that were ramped over 21 years within this CPA included some newer technologies – such as advanced rooftop controllers or variable refrigerant flow – whereas measures that were ramped over a shorter time period included more mature and accepted technologies, such as various LED lighting technologies.

**Figure 2.6. Examples of Lost Opportunity Ramp Rates**




To calculate annual achievable economic 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 85 percent maximum achievability. These lost resources can be considered unavailable 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 2.7 shows a case for a measure with a five-year RUL/10-year EUL. The spike in achievable economic potential, starting in year 11—after the measure's EUL—results from acquisition of opportunities missed at the beginning of the study period.

**Figure 2.7. Example of Combined Effects of Resource Availability and Measure Ramping Based on 10-Year EUL**

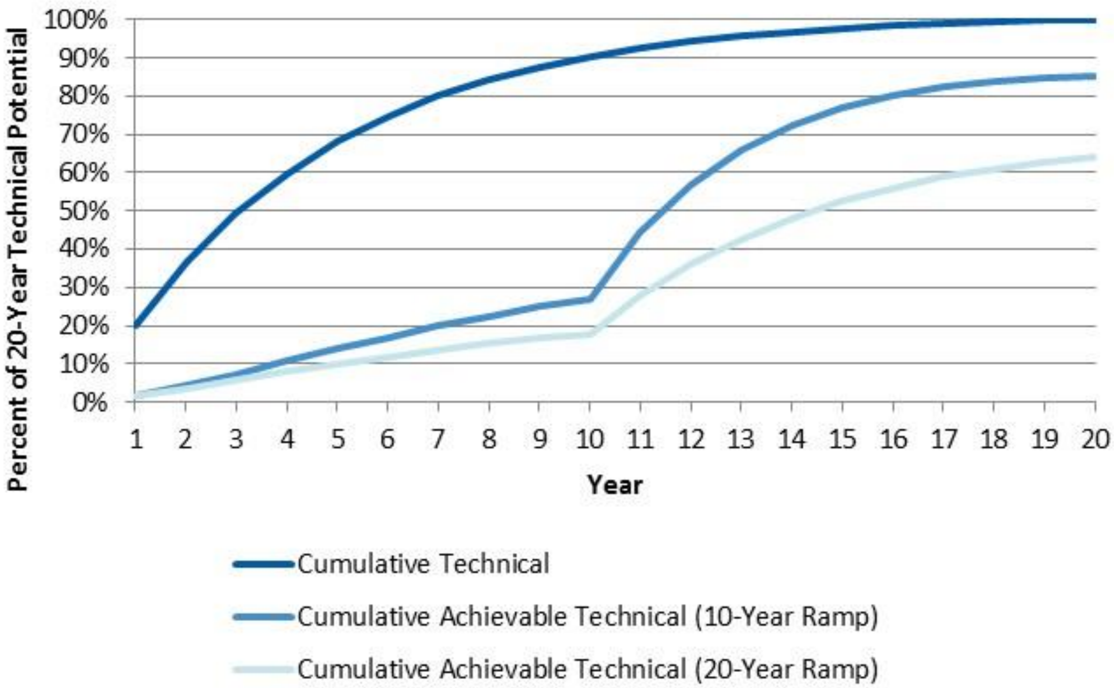



Table 2.5 illustrates this method, based on the same five-year RUL/10-year EUL measures on a 10-year ramp rate (the light blue line in Figure 2.7), assuming 1,000 inefficient units would be in place by Year One. In the first 10 years, lost opportunities would accumulate as the measure ramp-up rate caps availability of high-efficiency equipment. Starting in the 11th year, the opportunities lost 10 years previously become available again. Table 2.5 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, amounts of achievable potential are a function of the EUL and measure ramp rate. The same 10-yearyar EUL measure, on a slower 20-year ramp rate, would achieve less of its 20-year technical potential—also shown in Figure 2.7. 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.

| TABLE 2.5. EXAMPLE OF LOST OPPORTUNITY TREATMENT: 10-YEAR EUL MEASURE ON A 10-YEAR RAMP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 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. From a practical perspective, however, this outcome is realistically impossible due to infrastructure and budgetary constraints and customer considerations.

Furthermore, due to interactive effects between discretionary and lost opportunity resources, immediate acquisition distorts the potential for lost opportunity resources. For example, if one assumes that all homes would be weatherized in the program's first year, 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).

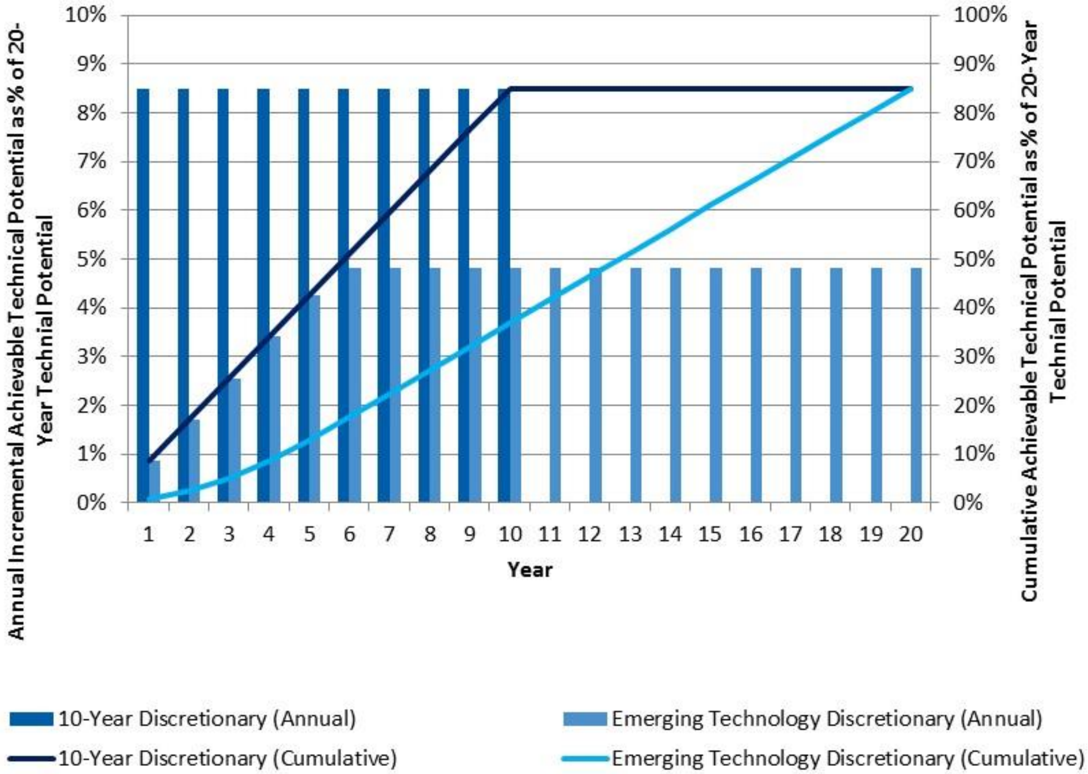
Consequently, the study addressed discretionary resources in two steps:

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, avoiding the distortion of interactions between discretionary and lost opportunity resources 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 only specify the timing of resource acquisition and do not affect the portion of the 20-year economic potential achievable over the study period.

Figure 2.8 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, though also gaining 85 percent of the total economic potential. Ultimately, it would arrive at the same cumulative savings as the measure on the 10-year ramp rate.

**Figure 2.8. Examples of Discretionary Measure Ramp Rates**



# 3. Baseline Forecast

## 3.1. Scope of Analysis

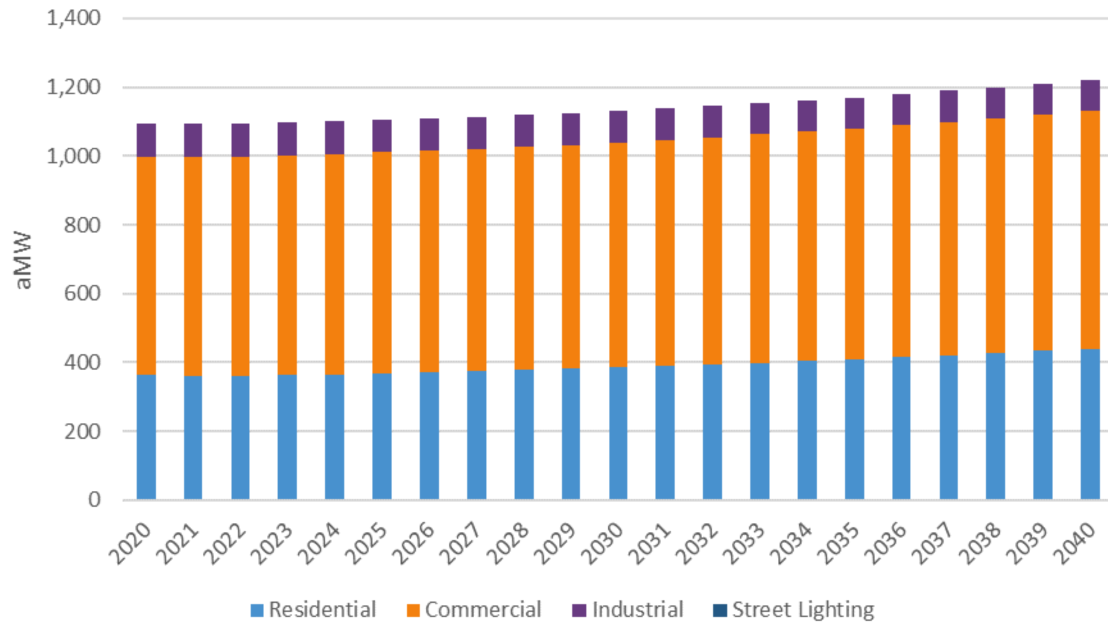
Assessing conservation potential starts with development of baseline end-use load forecasts over a 21-year (2020 to 2040) planning horizon. These forecasts are calibrated to City Light's load forecast in the base year (2019); they are not adjusted for future programmatic conservation, but they do account 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, facility types, and their respective, applicable end uses. The analysis addressed the following:

- Eight residential segments of 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 more than six floors.
- Thirty-eight commercial segments. These include new and existing construction for 19 standard commercial segments.
- Eight industrial segments (existing construction only).
- Street lighting. Although the study included estimates of street lighting in the overall baseline sales forecast, Cadmus did not estimate street lighting potential.

Figure 3.1 shows the distribution of 2040's projected sales by sector. The commercial sector will account for roughly 56 percent of projected sales, while the residential and industrial sectors account for 36 percent, 7 percent respectively.

**Figure 3.1. Baseline Sales by Sector**




## 3.2. Residential

Cadmus considered four residential segments and 34 end uses within these segments. Table 3.1 lists each residential segment and end uses considered as well as broad end-use groups used in this study. Overall, the residential sector accounted for approximately 36 percent of total baseline sales.

**TABLE 3.1. RESIDENTIAL SEGMENT AND END USES**

| Segments | End Uses | |
|---|---|---|
| | End-Use Group | End Use |
| Single-Family<br>Multifamily – High-Rise<br>Multifamily – Mid-Rise<br>Multifamily – Low-Rise | Appliances | Cooking Oven<br>Cooking Range<br>Dryer<br>Freezer<br>Refrigerator |
| | Electric Vehicles | Electric Vehicles |
| | Cooling | Cool Central<br>Cool Room |
| | Electronics | Computer – Desktop<br>Computer – Laptop<br>Copier |

**TABLE 3.1. RESIDENTIAL SEGMENT AND END USES**

| | | |
|---|---|---|
| | | DVD Player<br>Home Audio System<br>Microwave<br>Monitor<br>Multifunction Device<br>Plug Load Other<br>Printer<br>Set Top Box<br>Television<br>Television – Big Screen |
| | Exterior Lighting | Lighting Exterior Standard |
| | Heating | Heat Central<br>Heat Pump<br>Heat Room<br>Ventilation and Circulation |
| | Interior Lighting | Lighting Interior Linear Fluorescent<br>Lighting Interior Specialty<br>Lighting Interior Standard |
| | Miscellaneous | Air Purifier<br>Other<br>Waste Water<br>Pool Pump |
| | Water Heating | Water Heat GT 55 Gal<br>Water Heat LE 55 Gal |

City Light produces separate forecasts of single-family and multifamily households. Cadmus' directly used City Light's single-family household forecast 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

Cadmus 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 2040.

Figure 3.2 shows residential sales by segment for each year of the study. City Light projects to add 98,000 new housing units by 2040. New multi-family units account for about 90 percent of new residential construction. As a result multi-family sector baseline sales are expected to increase at a faster rate than single family as shown in Table 3.2.

**Figure 3.2. Residential Baseline Sales by Segment**

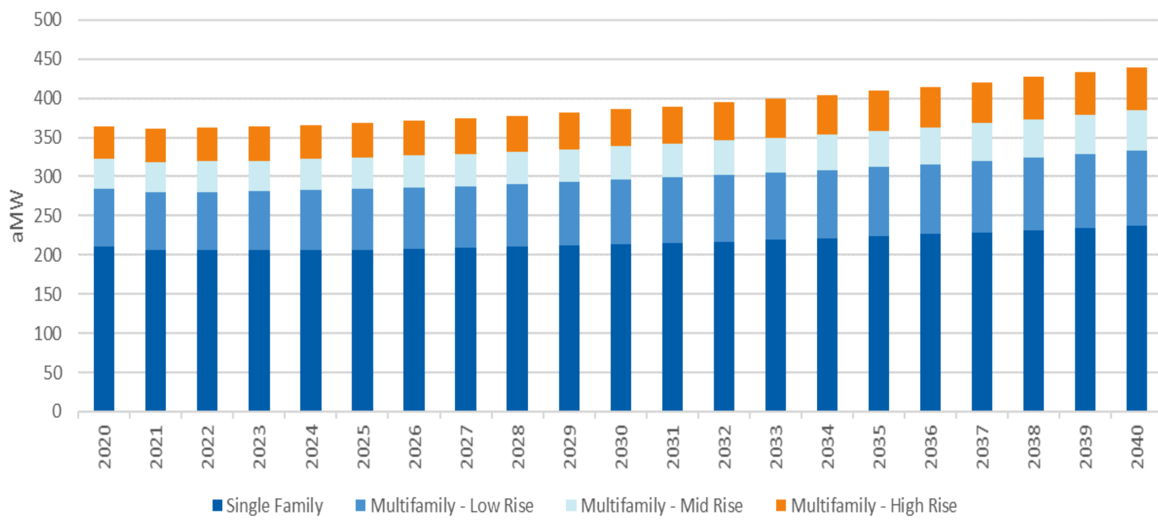



**TABLE 3.2. RESIDENTIAL BASELINE SALES AND HOUSING UNITS BY SEGMENT**

| Sector | Sales (aMW) | | Housing Units | |
|---|---|---|---|---|
| | 2020 Sales (aMW) | 2040 Sales (aMW) | 2020 Housing Units | 2040 Housing Units |
| Single Family | 211 | 238 | 195,057 | 206,208 |
| Multifamily | 73 | 96 | 91,286 | 128,111 |
| Multifamily | 38 | 51 | 59,476 | 83,469 |
| Multifamily | 42 | 56 | 64,585 | 90,639 |
| **Total** | 364 | 440 | 410,403 | 508,428 |

In the base year (2019), Cadmus calibrated baseline forecasts to City Light's load forecast, ensuring that the study's starting point aligned with City Light's starting point forecasts. Cadmus then produced a residential forecast that explicitly accounted for federal lighting standards enacted under EISA, as this standard had little impact on City Light's sales history and was not explicitly accounted for in City Light's forecast.

Figure 3.3 shows the residential baseline forecast by end use. Overall, City Light's residential forecast increases by approximately 21 percent over the 21-year horizon. This primarily due to an increased customer forecast and the addition of new load from electric vehicles.

Figure 3.3 also shows that heating and electronics are the top two consuming end uses, accounting for over one-half (54 percent) of residential consumption, combined. The next three highest forecasted end uses were water heating (14 percent), appliances (15 percent), and electric vehicles (9 percent).

**Figure 3.3. Residential Baseline Forecast by End Use**

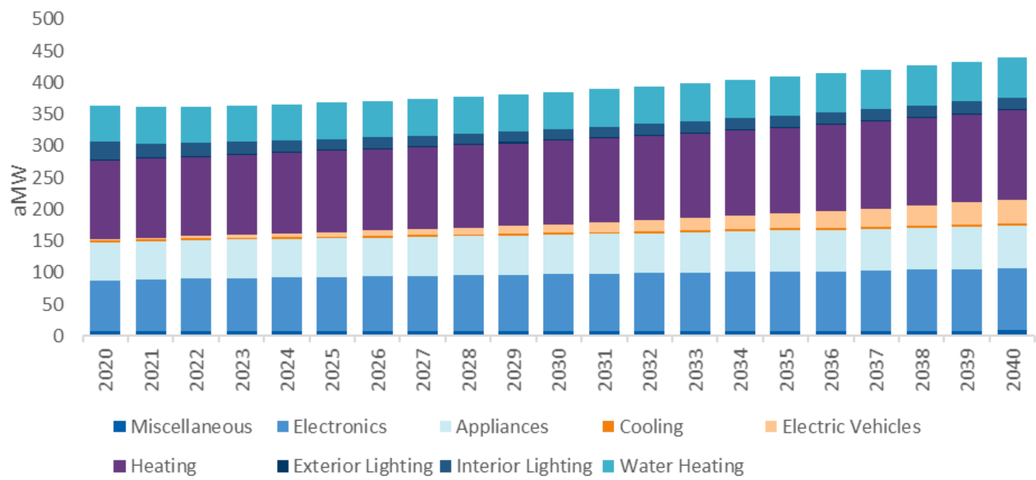


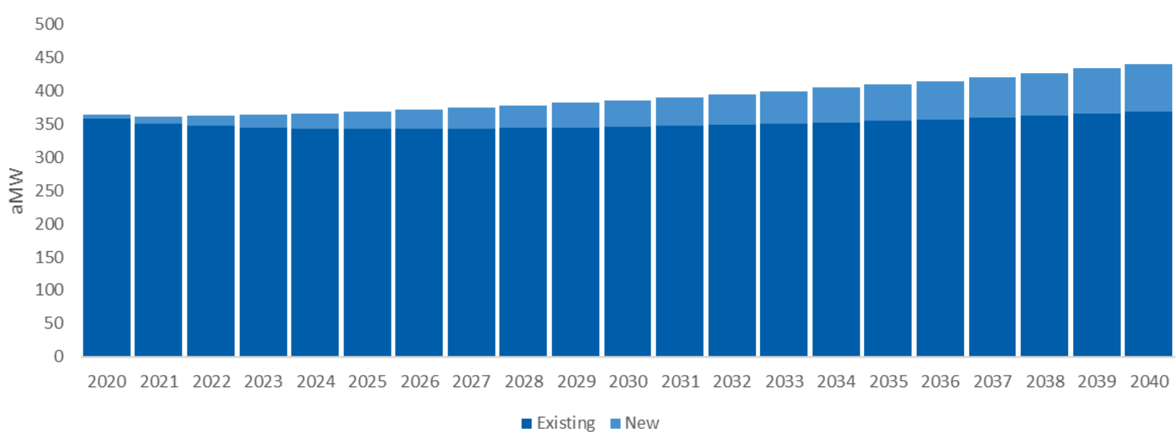

Table 3.3 shows the assumed average consumption per household for each residential segment in 2040. Differences in average consumption for each segment drive either differences in end-use consumption, saturations, fuel shares,[16] or any combination of differences. Appendix C includes detailed baseline data for the residential sector.

16 Fuel shares refer to the percentage of end use equipment that is electric for end uses where customers have at least the option of electricity or another fuel. Residential end uses where multiple fuels are an option include central furnace space heat, water heating, cooking, and dryers.

| TABLE 3.3. PER HOUSEHOLD BASELINE SALES (KWH/HOME) - 2040 | | | | |
|---|---|---|---|---|
| **End Use** | **Single-Family** | **Multifamily – Low-Rise** | **Multifamily – Mid-Rise** | **Multifamily – High-Rise** |
| Heating | 2,120 | 2,744 | 2,113 | 2,165 |
| Electronics | 2,455 | 1,022 | 976 | 976 |
| Water Heating | 1,667 | 951 | 346 | 346 |
| Appliances | 1,631 | 670 | 788 | 788 |
| Interior Lighting | 535 | 140 | 137 | 137 |
| Miscellaneous | 209 | 100 | 83 | 83 |
| Exterior Lighting | 82 | 1 | 1 | 1 |
| Cooling | 111 | 29 | 24 | 24 |
| **Total** | **9,540** | **6,207** | **5,018** | **5,070** |

Figure 3.4 shows forecasted residential sales by construction vintage over the study horizon. Study results indicate approximately 16 percent of sales will derive from homes constructed after 2019 (new construction). Use per customer for existing homes will decrease over the 20-year study timeframe, partly due to equipment standards and other naturally occurring efficiency.

**Figure 3.4. Residential Baseline Sales by Construction Vintage**




## 3.3. Commercial

Cadmus considered 19 commercial segments and up to 15 segments within these end uses. Table 3.4 shows each commercial segment and end use considered in this study as well as the broad segment and end-use groups presented in this report. Segments are largely based on those included in the Council's Seventh Power Plan. Overall, the commercial sector accounts for 693 aMW, or 57 percent of total baseline sales in 2040.

| TABLE 3.4. COMMERCIAL SEGMENTS AND END USES | | | |
|---|---|---|---|
| **Segments** | | **End Uses** | |
| **Segment Group** | **Segment** | **End Use Group** | **End Use** |
| Assembly | Assembly | Cooking | Cooking |
| Hospital | Hospital | Cooling | Cool Central |
| Large Grocery | Supermarket | Data Center | Data Center |
| Large Office | Large Office<br>Medium Office | Heat Pump | Heat Pump |
| Lodging | Lodging | Heating | Heat Central |
| MF Common Area | Multifamily Common Area | Lighting | Exterior Lighting<br>Interior Lighting |
| Miscellaneous | Other | Miscellaneous | Compressed Air<br>Other<br>Plug Load Other<br>Waste Water |
| Other Health | Residential Care | Refrigeration | Refrigeration |
| Restaurant | Restaurant | Ventilation | Ventilation |
| Retail | Large Retail<br>Medium Retail<br>Small Retail<br>Extra Large Retail | Water Heat | Water Heat GT 55 Gal<br>Water Heat LE 55 Gal |
| School | School K-12 | | |
| Small Grocery | Mini Mart | | |
| Small Office | Small Office | | |
| University | University | | |
| Warehouse | Warehouse | | |

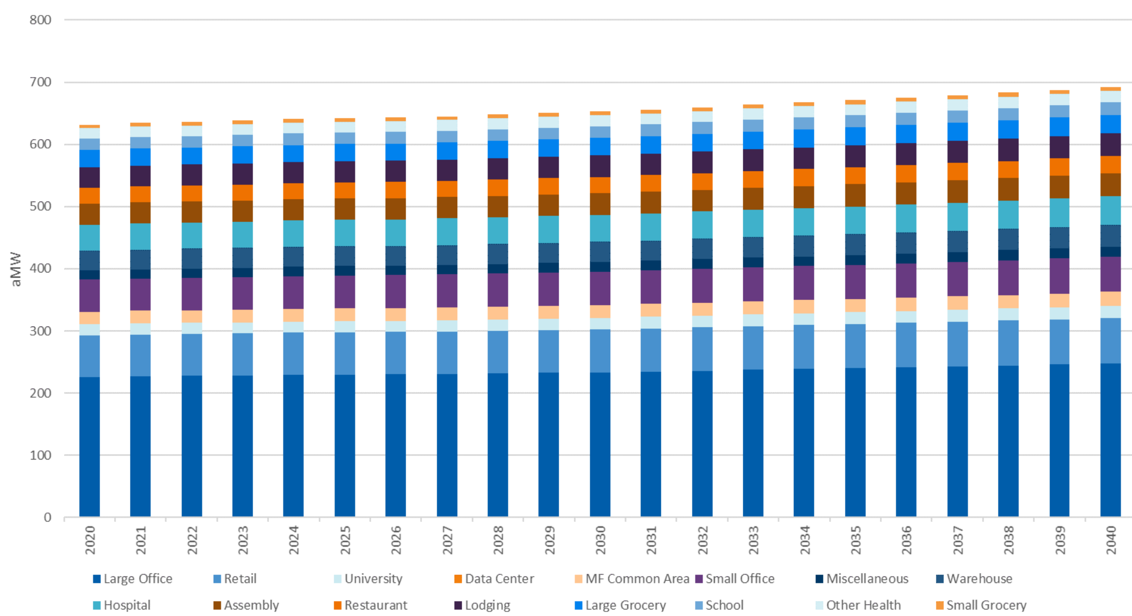
| TABLE 3.4. COMMERCIAL SEGMENTS AND END USES | | | |
|---|---|---|---|
| University | University | | |
| Warehouse | Warehouse | | |

Cadmus used City Light's nonresidential database to identify sales and the number of customers for each commercial market segment. The database combined City Light's billing data with the King County assessor, as well as other secondary data source, to identify the customer segment and consumption for each nonresidential customer. These data served as the basis for Cadmus' commercial sector segmentation.

In addition, Cadmus classified customers as commercial or industrial based on City Light's premise-level nonresidential customer database. Commercial customers included those identified in a segment listed in Table 3.4, while industrial customers mapped to segments listed in Table 3.5, following in the industrial section.

Cadmus chose commercial segments for consistency with the Seventh Power Plan, except for multifamily common area, which was not a standalone segment in the Seventh Power Plan. Figure 3.5 shows the distribution of baseline commercial energy consumption by segment for each year of the study.

**Figure 3.5. Commercial Baseline Sales by Segment**




Large offices accounted for over one-third (36 percent) of commercial baseline sales. Retail, small offices, and hospitals accounted for 11 percent, 8 percent, and 7 percent, respectively, of baseline sales. Collectively, these segments represent over one-half (61 percent) of all commercial sector sales.

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, 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 on disaggregated energy intensities—derived from City Light's customer data—using these distributions. Figure 3.6 shows energy intensities for each building type and end use.

**Figure 3.6. Commercial EUIs by Building Type**

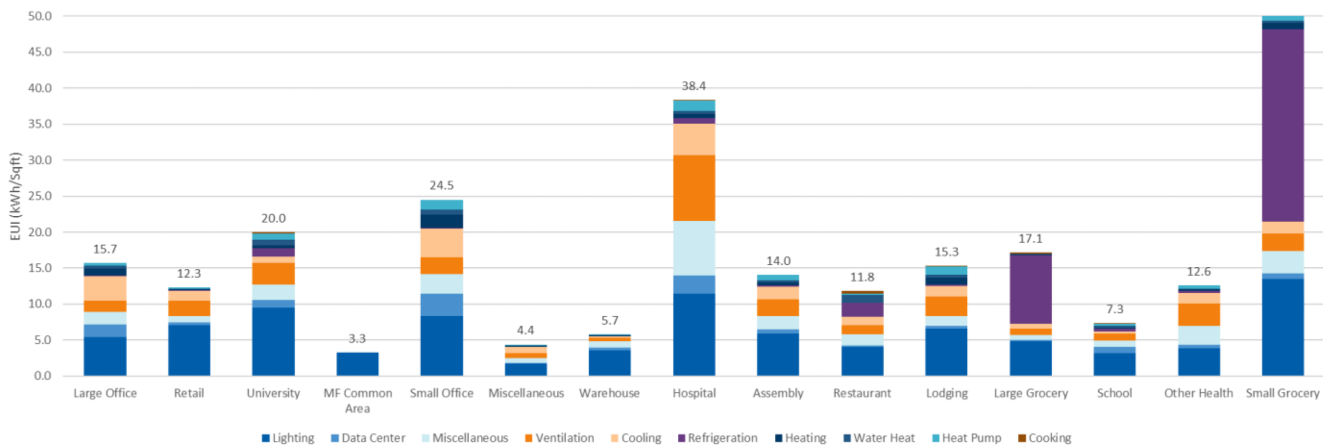
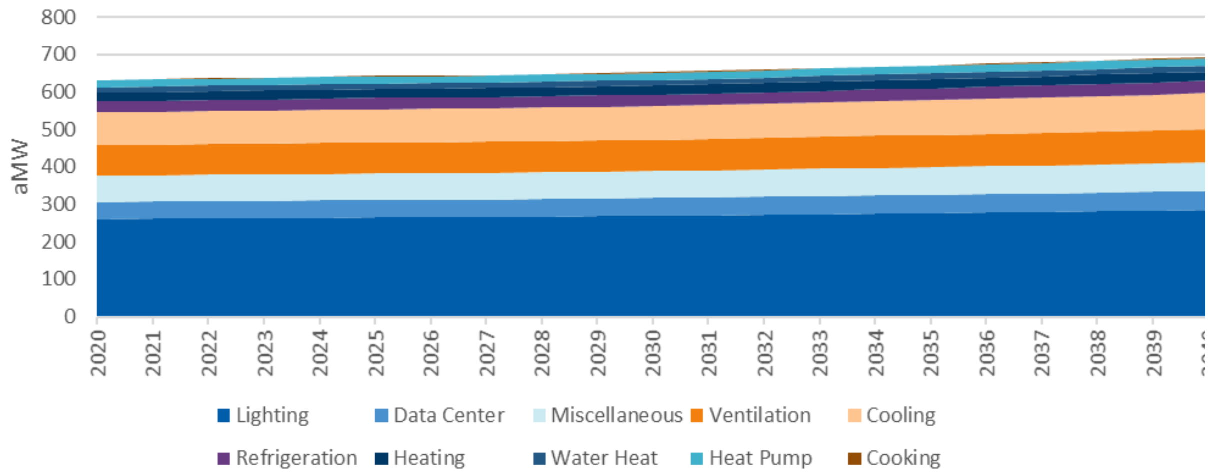


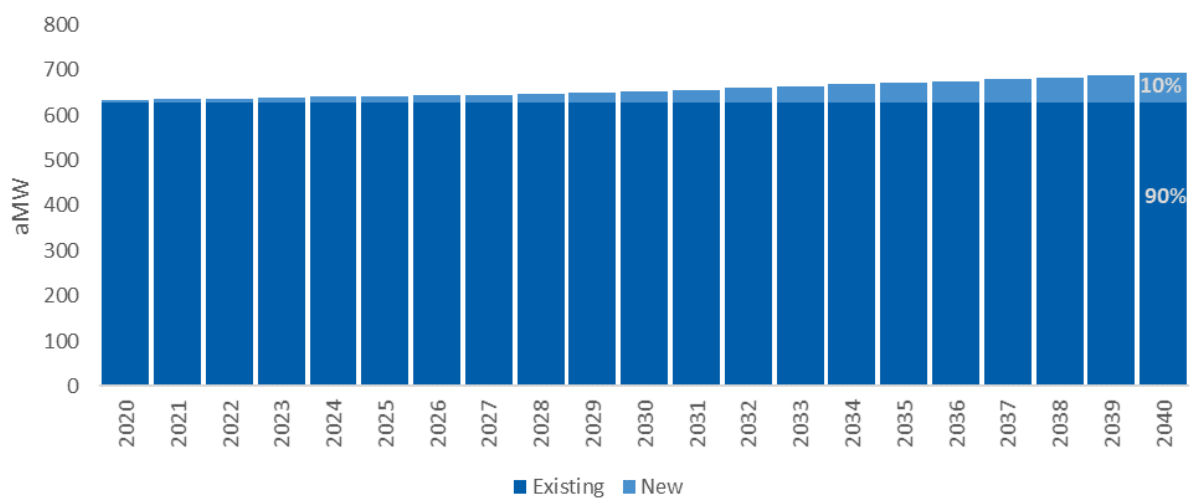

Figure 3.7 shows the commercial baseline forecast by end use. Cadmus' commercial baseline forecast includes moderate load growth; commercial sales increase by roughly 0.5 percent per year over the study's horizon. The highest-consuming end use was lighting, accounting for 41 percent of projected commercial consumption in 2040. The miscellaneous, ventilation, and cooling end uses also account for a large share of consumption, representing 11 percent, 13 percent, and 14 percent of projected commercial sales, respectively.

**Figure 3.7. Commercial Forecast by End Use**




New Commercial floorspace is a significant contributor to load growth in the commercial sector. By 2040, 10 percent of the forecasted load will come from buildings constructed after 2019. Figure 3.8 shows the commercial baseline forecast by construction vintage.

**Figure 3.8. Commercial Forecast by Construction Vintage**



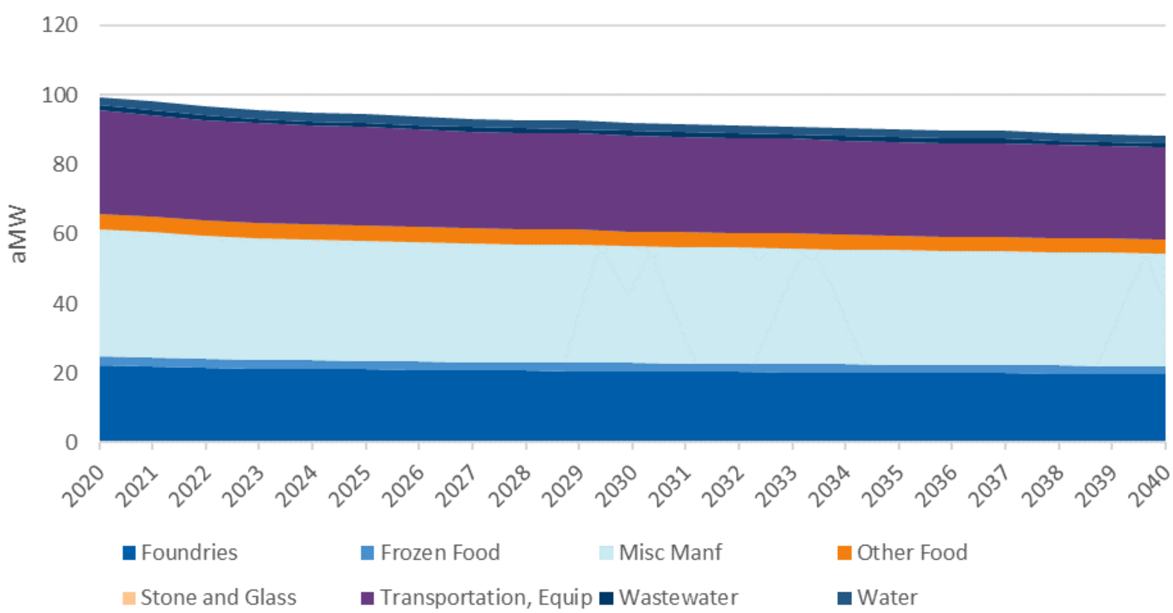

## 3.4. Industrial

Cadmus disaggregated City Light's forecasted industrial sales into eight facility types/segments and 10 end uses, as shown in Table 3.4. Overall, the industrial sector accounted for 88 aMW, or 7 percent of City Light's overall forecasted baseline sales in 2040. The industrial sector included about ten of City Light's largest customers with known Industrial processes in addition to wastewater and water treatment loads.

| TABLE 3.2. INDUSTRIAL SEGMENTS AND END USES | |
|---|---|
| **Segments** | **End Uses** |
| 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 |

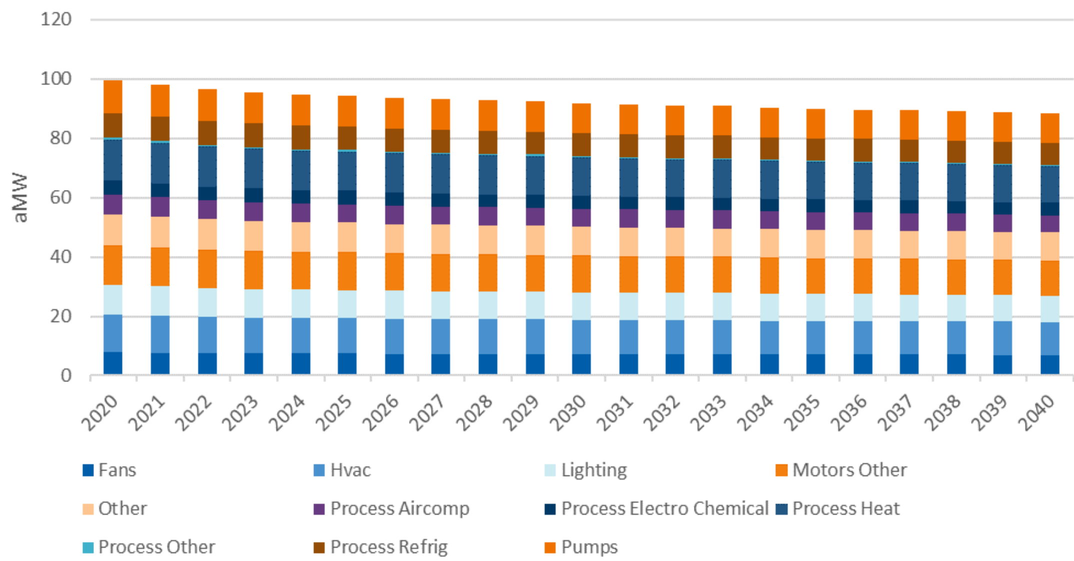
Like the commercial sector, Cadmus relied on City Light's nonresidential customer database to determine the distribution of baseline sales by segment. Figure 3.9 shows the distribution of industrial sales by segment in 2040. Miscellaneous manufacturing accounts for 37 percent of industrial baseline sales; the next largest segments are foundries (22 percent) and transportation equipment (30 percent).

**Figure 3.9. Industrial Baseline Sales by Segment**



Cadmus relied on end-use distributions provided in the Seventh Plan's industrial tool to disaggregate segment-specific consumption into end uses. Figure 3.10 shows industrial baseline sales forecast by end use.

**Figure 3.10. Industrial Baseline Sales by End Use**



# 4. Energy Efficiency Potential

## 4.1. Overview

### 4.1.1. Scope of the Analysis

This study included a comprehensive set of conservation measures, incorporating measures assessed by the Council in the 7th Power Plan and the RTF. Analysis began by assessing the technical potential of hundreds of unique conservation measures, considering these measures for each applicable sector, segment, and construction vintage discussed in the Baseline Forecast section. In total, Cadmus considered over 6399 permutations of conservation measures including, for example, a total of 969 lighting measures across 19 segments representing a wide range of technologies and applications within the commercial sector. Table 4.1 lists counts and numbers of permutations of conservation measures considered in this study.

**TABLE 4.1. MEASURE AND PERMUTATIONS**

| Sector | Measures | Permutations |
|---|---:|---:|
| Residential | 249 | 1050 |
| Commercial | 2109 | 4944 |
| Industrial | 38 | 405 |
| **Total** | 2396 | 6399 |

### 4.1.2. Summary of Results

Table 4.2 shows baseline sales and cumulative potential by sector.[17] Study results indicate 282 aMW of technically feasible conservation potential—23 percent of baseline sales—will be available by 2040, the end of the 21-year study horizon, with an estimated 142 aMW—12 percent of baseline sales—both cost-effective and technically feasible; this is economic potential. Cumulative achievable economic potential equals 111 aMW in 2040—9 percent of baseline sales. These results account for line losses and represent cumulative energy savings at generator.

These savings draw upon future sales forecasts, absent future City Light conservation program activities. Although these consumption forecasts accounted for past City Light-funded conservation, the estimated potential identified is inclusive of—not in addition to—forecasted program savings. In other words, the forecast excludes future, planned energy efficiency program efforts but the savings estimates include energy efficiency program savings.

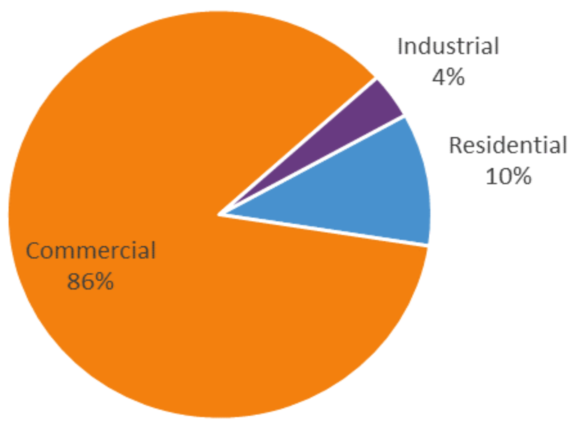
17 Economic potential and achievable economics potential reflect the IRP avoided-cost scenario.

| TABLE 4.2. TECHNICAL, ECONOMIC, AND ACHIEVABLE POTENTIAL BY SECTOR - 2040 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sector** | **Baseline Sales** | **Technical Potential** | | **Economic Potential—IRP** | | **Achievable Potential** | |
| | | **aMW** | **Percent of Baseline** | **aMW** | **Percent of Baseline** | **aMW** | **Percent of Baseline** |
| Residential | 440 | 100 | 23% | 23 | 5% | 12 | 3% |
| Commercial | 693 | 173 | 25% | 115 | 17% | 96 | 14% |
| Industrial | 88 | 9 | 10% | 5 | 5% | 4 | 5% |
| Street Lighting | 5 | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,226** | **282** | **23%** | **142** | **12%** | **111** | **9%** |

The commercial sector, representing 57 percent of baseline energy use, accounts for approximately 86 percent of achievable economic conservation potential. The commercial sector represents a much higher proportion of total achievable economic potential relative to its baseline sales because, compared with the residential sector, commercial measures are more cost effective and the percent of total commercial technical potential that is cost effective is also a lot higher.

The residential and industrial sectors account for 10 percent and 4 percent, respectively, as shown in Figure 4.1. 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 (4 percent) is much lower than its share of baseline energy consumption (7 percent). The 2020 CPA did not estimate potential for streetlighting.

**Figure 4.1. Achievable Economic Potential by Sector—2040**



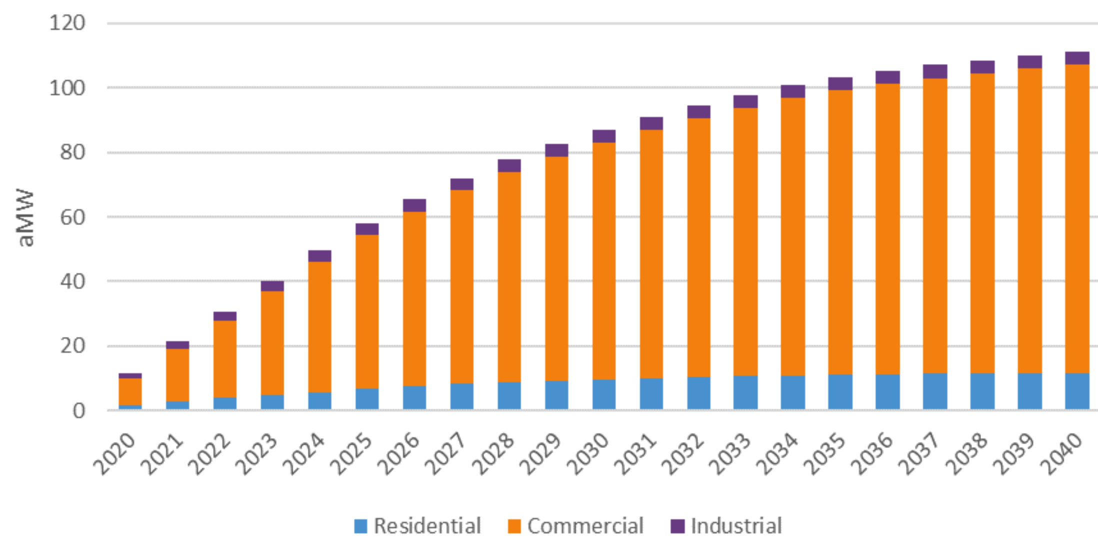

Cadmus determined incremental achievable potential in each year of the study horizon, using the rate at which equipment naturally turns over and measure-specific ramp rates (as discussed in the About Measure Ramp Rates section of this report). Table 4.3 shows cumulative 2-year, 10-year, and 21-year achievable potential by sector, as well as 20 percent of the 10-year achievable potential—the equivalent of City Light's *pro rata* share of 10-year potential for the 2020-2021 biennium.

**TABLE 4.3. ACHIEVABLE POTENTIAL BY SECTOR**

| Sector | Achievable Economic Potential - aMW | | | |
|---|---|---|---|---|
| | 2 Year (2020-2021) | 10 Year (2020-2029) | 21 Year (2020-2040) | 20% of 10-Year Potential |
| Residential | 2.77 | 9.27 | 11.70 | 1.85 |
| Commercial | 16.10 | 69.43 | 95.54 | 13.89 |
| Industrial | 2.40 | 3.96 | 4.04 | 0.79 |
| Street Lighting | 0 | 0 | 0 | 0 |
| **Total** | **21.27** | **82.67** | **111.28** | **16.53** |

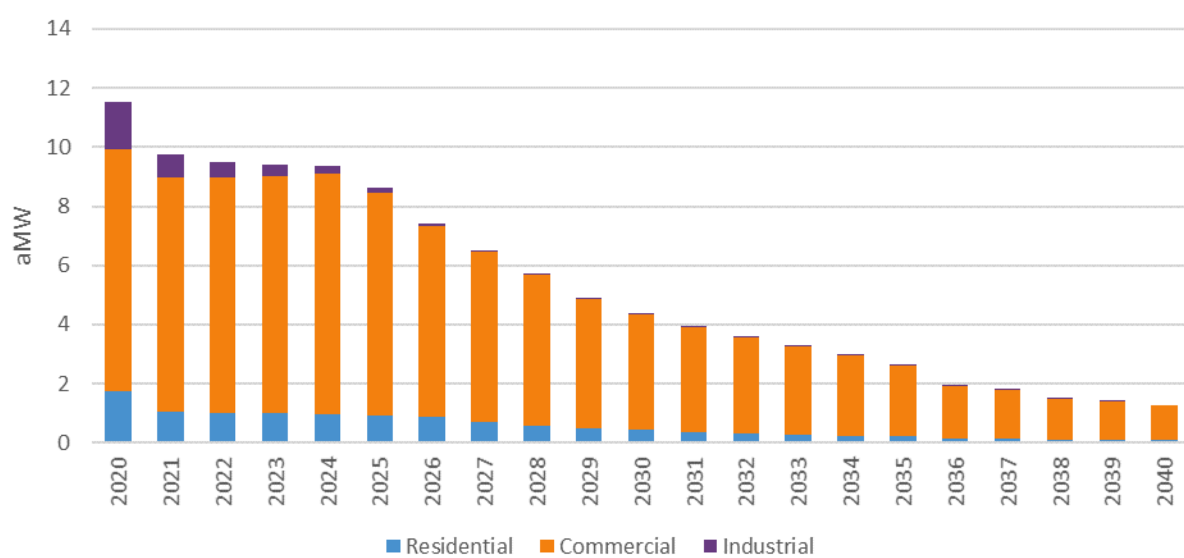
Figure 4.2 presents the cumulative achievable economic potential across the study horizon.

**Figure 4.2. Cumulative Achievable Economic Potential**



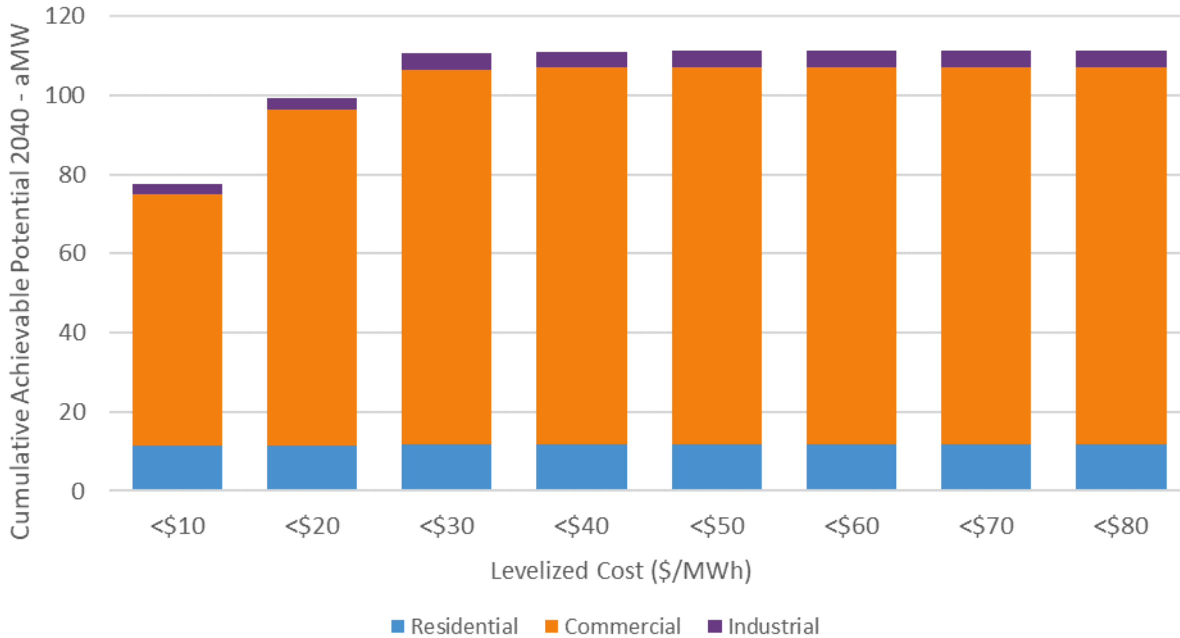

Approximately 45 percent of 21-year achievable potential is acquired in the first five years, and 74 percent of 21-year achievable potential is acquired in the first 10 years. This acquisition rate reflects the measure mixture offering high savings potential and aligning with City Light's prior program accomplishments. The About Measure Ramp Rates section of this report provides more information on how Cadmus performed this calculation.

**Figure 4.3. Incremental Achievable Economic Potential**




Study results indicate that conservation serves as a low-cost resource, with roughly 99 aMW of achievable economic potential at a cost of less than $20/MWh levelized, representing 89 percent of total cumulative 21-year achievable potential. The conservation supply curve in Figure 4.4 shows cumulative achievable potential in $10/MWh levelized cost increments. Cadmus identified cost-effective potential up to $30/MWh.

**Figure 4.4. Supply Curve – Achievable Economic Potential (All Sectors)**




Appendix F shows detailed measure-level results, including levelized costs and 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 36 percent of 2040 total baseline sales. The sector, divided into single-family, multifamily low-rise, multifamily mid-rise, and multifamily high-rise homes, present 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 11.7 aMW over 21 years, corresponding to nearly a 3 percent reduction in the residential baseline sales forecast by 2040, or approximately 15% of the forecast residential load growth. Table 4.4 shows cumulative 21-year residential conservation potential by segment.

| TABLE 4.4. RESIDENTIAL POTENTIAL BY SEGMENT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Cumulative 2040 - aMW | | | | | | |
| **Segment** | **Baseline Sales** | **Technical Potential (TP)** | **TP % of Baseline** | **Economic Potential (EP)** | **EP % of Baseline** | **EP % of TP** | **Achievable Potential (AP)** | **AP % of EP** |
| Single-Family | 237.6 | 57.9 | 24.4% | 17.5 | 7.3% | 30.1% | 8.7 | 49.6% |
| Multifamily – High-Rise | 55.5 | 7.0 | 12.6% | 1.5 | 2.8% | 22.1% | 0.8 | 50.1% |
| Multifamily – Mid-Rise | 50.6 | 11.8 | 23.3% | 1.4 | 2.8% | 12.0% | 0.7 | 50.1% |
| Multifamily – Low-Rise | 96.1 | 23.6 | 24.6% | 2.4 | 2.5% | 10.3% | 1.6 | 63.9% |
| **Total** | **439.8** | **100.3** | **22.8%** | **22.8** | **5.2%** | **22.8%** | **11.7** | **51.2%** |

As shown in Table 4.4 and Figure 4.5, single-family homes account for 74 percent (9 aMW) of total achievable economic potential, followed by multifamily low-rise (2 aMW), multifamily high-rise (1 aMW), and multifamily mid-rise (1 aMW). Each home type's proportion of baseline sales drive 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 4.5. Residential Cumulative Achievable Economic Potential by Segment**

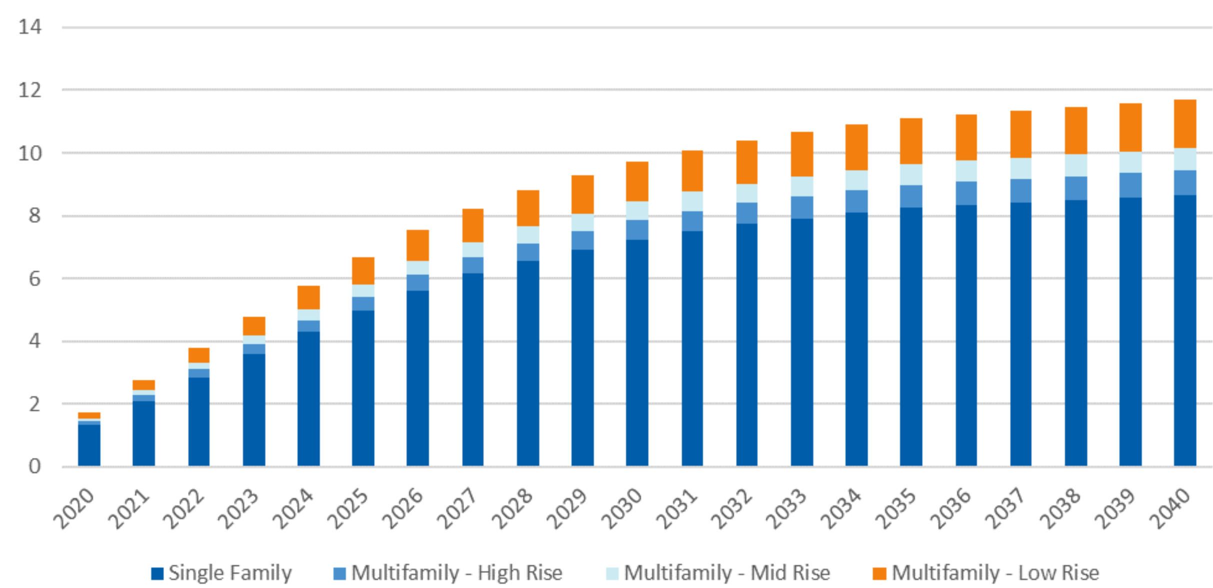
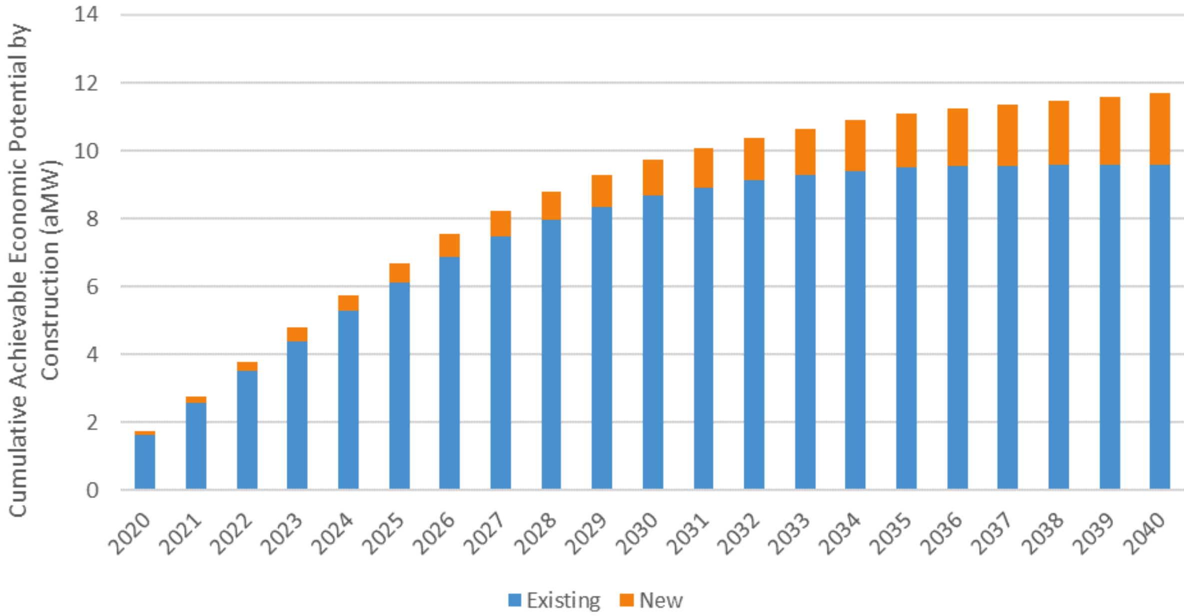


Figure 4.6 presents the cumulative achievable economic potential by construction type for the residential sector. Existing construction represents the majority of achievable economic potential, particularly in the early years of the study, as it accounts for 92.5% of the potential in the first two years of the study (2020-2021). However, by the final year of the study period (2040), new construction accounts for 22% of the total cumulative residential achievable economic potential.

**Figure 4.6. Residential Cumulative Achievable Economic Potential by Construction Type**




Lighting accounts for approximately 6 percent of total cumulative achievable economic potential by end use (as shown in Table 4.5); these savings almost entirely derive from installations of LED lighting in fixtures. Efficient upgrades to linear fluorescent fixtures in homes account for a small portion of total residential lighting savings. Cadmus modeled the residential lighting potential using the following assumptions:

- The baseline for general service lamp potential in the first year of the study (2020) is equivalent to the EISA 2020 backstop standard and the Washington State standard passed by the legislature in 2019.
- Inefficient lamps will sell through retail locations on one year.
- Achievable economic potential in 2020 is reduced by one-half to reflect City Light's plans to discontinue savings claims for residential lighting.

Weatherization savings appear primarily within the heating end use group but also within the cooling group as well. Savings from weatherization – the installation of which reduces both heating and cooling loads – represent only a small fraction (i.e. < 1%) of total residential achievable economic potential. The study determined that behavioral savings, such as home energy reports, were not cost effective and, therefore, these measures do not have any achievable economic potential.

| TABLE 4.5. RESIDENTIAL POTENTIAL BY END USE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| End Use | Baseline Sales | Cumulative 2040 - aMW | | | | | | |
| | | Technical Potential (TP) | TP % of Baseline | Economic Potential (EP) | EP % of Baseline | EP % of TP | Achievable Potential (AP) | AP % of EP |
| Miscellaneous | 8.5 | 0.6 | 7.4% | 0.5 | 5.5% | 74.6% | 0.4 | 85.0% |
| Electronics | 97.5 | 8.1 | 8.3% | 3.0 | 3.1% | 37.1% | 2.5 | 85.0% |
| Appliances | 67.6 | 11.6 | 17.2% | 0.0 | 0.0% | 0.0% | 0.0 | 0% |
| Cooling | 3.7 | 0.7 | 19.4% | 0.0 | 0.1% | 0.3% | 0.0 | 85.0% |
| Electric Vehicles | 38.2 | 1.0 | 2.7% | 0.0 | 0.0% | 0.0% | 0.0 | 0% |
| Heating | 140.3 | 36.4 | 25.9% | 0.1 | 0.1% | 0.2% | 0.1 | 84.9% |
| Exterior Lighting | 2.1 | 0.8 | 37.2% | 0.8 | 37.2% | 100.0% | 0.1 | 17.9% |
| Interior Lighting | 18.4 | 9.8 | 53.3% | 9.1 | 49.6% | 93.0% | 0.6 | 6.0% |
| Water Heating | 63.5 | 31.3 | 49.2% | 9.4 | 14.8% | 30.1% | 8.0 | 84.9% |
| **Total** | **439.8** | **100.3** | **22.8%** | **22.8** | **5.2%** | **22.8%** | **11.7** | **51.2%** |

Incremental and cumulative potential over the 21-year study horizon varies by end use due to the application of ramp rates, which 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, with some adjustments as discussed in the Achievable Potential and Ramping in section 5 of this report. Figure 4.7 and Figure 4.8 show cumulative and incremental residential achievable potential, respectively.

**Figure 4.7. Residential Cumulative Achievable Economic Potential**

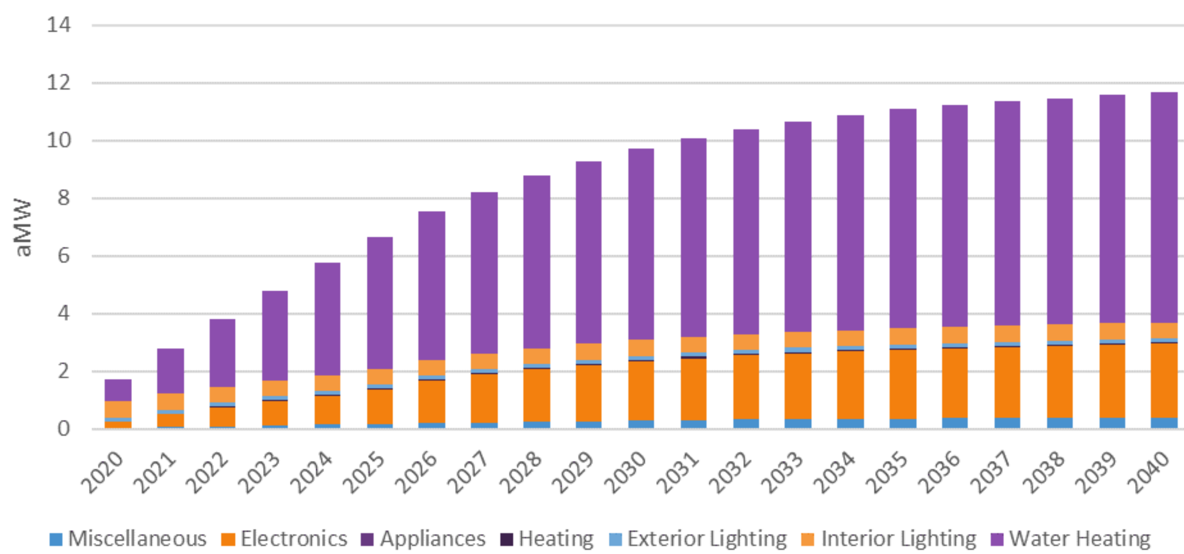
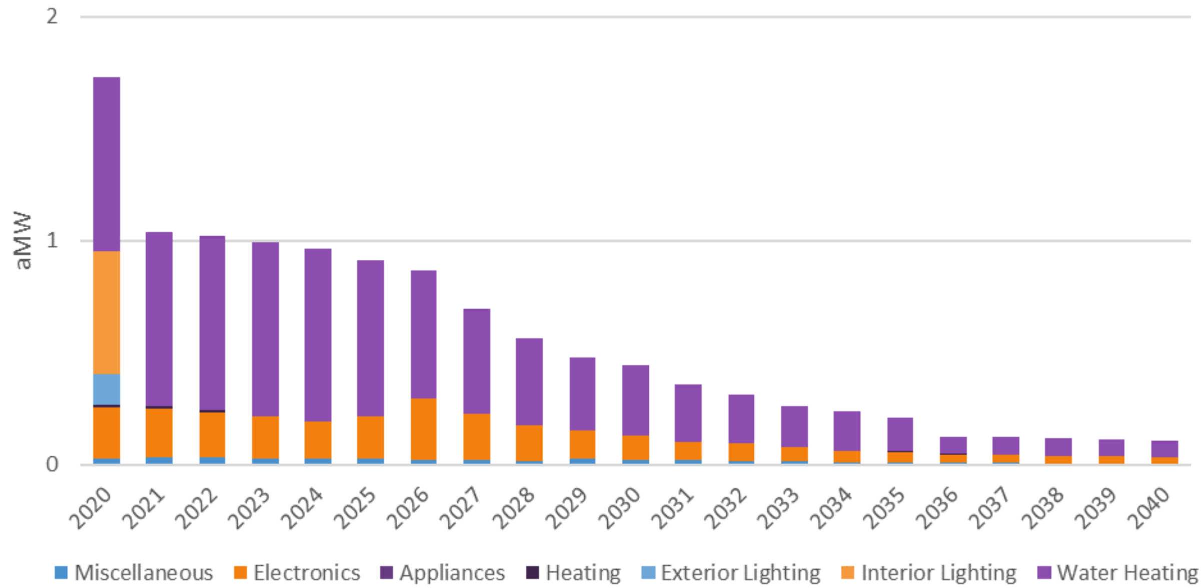


**Figure 4.8. Residential Cumulative Achievable Economic Potential**

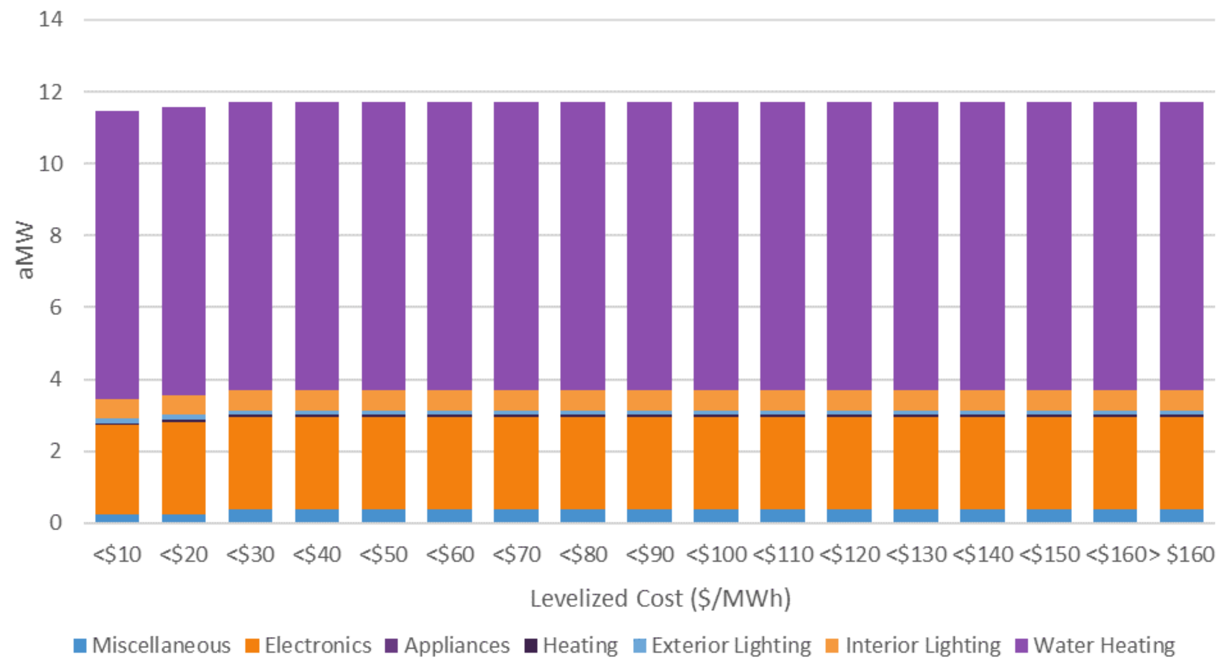



Measure ramp rates and effective useful lives (only for equipment replacement measures) determine the timing of savings shown in Figure 4.8. The spike in 2020 lighting savings results from interactions between lighting ramp rates and relatively short baseline measure lives for standard and specialty lighting measures (two years).

Overall, most (79 percent) of residential conservation potential is achievable within the first 10 years. Approximately 49 percent of 21-year residential achievable economic potential comes in the first five years, and 10 percent of this five-year potential comes from interior lighting.

Figure 4.9 shows 21-year cumulative residential potential by levelized cost (in $10/MWh increments).

**Figure 4.9. Residential Supply Curve**




Nearly 98 percent of total residential achievable economic potential comes from measures with a levelized cost of conserved energy of $10/MWh or less. Few cost-effective measures have levelized costs above $10/MWh. Clothes washers and SF showerheads are the top two saving residential measures, respectively. Table 4.6 lists the 15 top-saving residential measures.

**TABLE 4.6. TOP-SAVING RESIDENTIAL MEASURES**

| Measure Name | Achievable Economic Potential - aMW | | | Percent of Total (21-Year) |
|---|---|---|---|---|
| | 2-Year | 10-Year | 21-Year | |
| Clothes Washer | 0.59 | 2.39 | 2.99 | 26% |
| SF Showerhead | 0.53 | 2.15 | 2.74 | 23% |
| LED | 0.36 | 0.36 | 0.36 | 3% |
| LED - Specialty | 0.33 | 0.33 | 0.33 | 3% |
| TV LCD - ENERGY STAR | 0.31 | 1.39 | 1.84 | 16% |
| MF Showerhead | 0.28 | 1.15 | 1.48 | 13% |
| Set Top Box | 0.12 | 0.51 | 0.64 | 5% |
| SF Aerator | 0.12 | 0.47 | 0.58 | 5% |
| MF Aerator | 0.07 | 0.27 | 0.34 | 3% |
| ENERGY STAR Air Purifier | 0.03 | 0.16 | 0.26 | 2% |
| Heat Pump - Federal Standard 2023 | 0.02 | 0.02 | 0.04 | 0% |
| Engine Block Heater Controls | 0.01 | 0.05 | 0.06 | 1% |
| Wall Insulation | <0.01 | 0.02 | 0.02 | <1% |
| Attic Insulation | <0.01 | <0.01 | <0.01 | <1% |
| Multifunction Device | <0.01 | <0.01 | <0.01 | <1% |

Note that Table 4.6 *only* includes measures that pass the benefit-cost screen. Multifamily ductless heat pump (DHP) upgrades, for example, have the highest technical potential of any residential measure, but they are not cost-effective from a TRC perspective, as the present value of the TRC costs outweigh the TRC benefits for this measure by a factor of almost five-to-one. Additional residential measures with high technical potential savings that did not pass the benefit-cost test include tier 3 heat pump water heaters, single family zonal-to-DHP measures, and high efficiency class-22 window replacements.

## 4.3. Commercial

City Light's commercial sector accounts for 57 percent of City Light's baseline sales in 2040 and 86 percent of total achievable economic potential. The commercial sector makes up a higher proportion of potential compared to its share of baseline sales as commercial measures generally prove more cost-effective and offer more savings potential than measures found in other sectors. Cadmus estimated potential for the 22 commercial segments included in Table 3. (grouped into 15 segments for this report). Table 4.7 summarizes 21-year cumulative technical, economic, and achievable economic potential by commercial segment.

**TABLE 4.7. COMMERCIAL POTENTIAL BY SEGMENT**

| Segment | Baseline Sales | Cumulative 2040 - aMW | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Technical Potential (TP) | TP % of Baseline | Economic Potential (EP) | EP % of Baseline | EP % of TP | Achievable Potential (AP) | AP % of EP |
| Assembly | 37 | 8 | 22% | 5 | 14% | 64% | 4 | 82% |
| Hospital | 46 | 9 | 19% | 6 | 14% | 74% | 5 | 85% |
| Large Grocery | 30 | 7 | 25% | 5 | 18% | 73% | 5 | 85% |
| Large Office | 248 | 64 | 26% | 40 | 16% | 63% | 34 | 84% |
| Lodging | 37 | 8 | 22% | 5 | 14% | 63% | 4 | 84% |
| MF Common Area | 22 | 9 | 40% | 8 | 36% | 91% | 7 | 83% |
| Miscellaneous | 16 | 8 | 48% | 5 | 32% | 67% | 4 | 84% |
| Other Health | 19 | 5 | 26% | 4 | 19% | 74% | 3 | 85% |
| Restaurant | 28 | 6 | 21% | 3 | 11% | 53% | 3 | 85% |
| Retail | 73 | 16 | 21% | 10 | 14% | 67% | 9 | 83% |
| School | 20 | 8 | 39% | 6 | 28% | 71% | 5 | 82% |
| Small Grocery | 6 | 2 | 25% | 1 | 18% | 73% | 1 | 85% |
| Small Office | 57 | 15 | 26% | 8 | 14% | 55% | 7 | 81% |
| University | 20 | 4 | 20% | 3 | 14% | 71% | 2 | 84% |
| Warehouse | 34 | 6 | 16% | 4 | 12% | 75% | 3 | 80% |
| **Total** | **693** | **173** | **25%** | **115** | **17%** | **66%** | **96** | **83%** |

Approximately 36 percent of 21-year commercial achievable potential arises within the large office segment, as shown in Figure 4.8. Collectively, large and small offices account for 44 percent of commercial achievable economic potential. The miscellaneous segment has the highest technical potential savings relative to baseline sales. The Multifamily Common Area segment has the highest economic potential relative to baseline sales due to high savings potential for interior, exterior, and parking lighting upgrades.

**Figure 4.8. Cumulative Commercial Achievable Economic Potential by Segment**

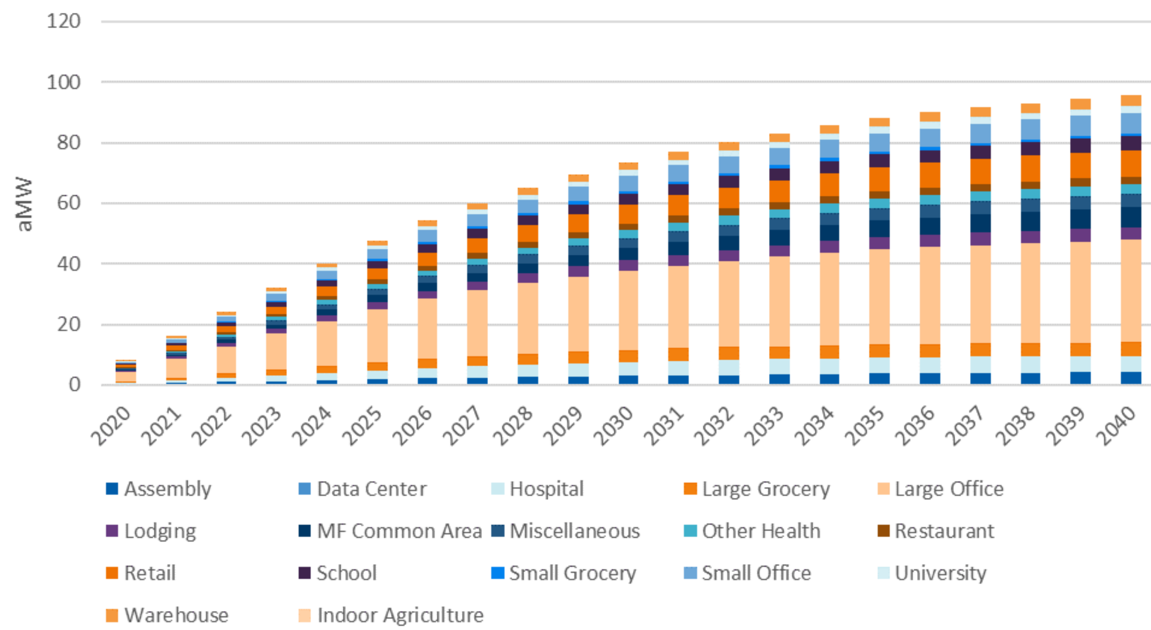
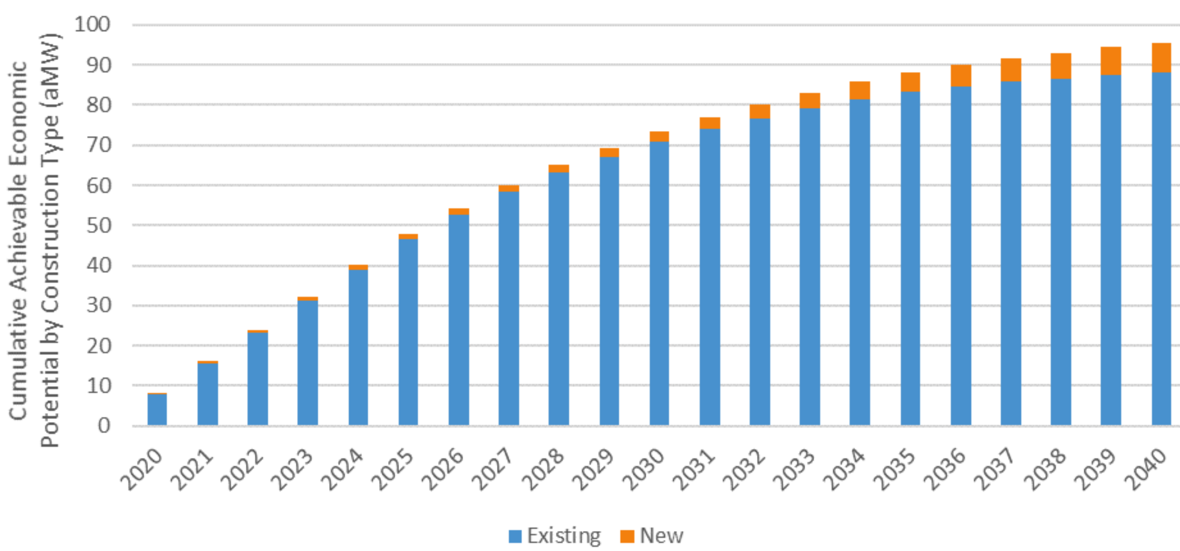



Figure 4.11 presents the cumulative achievable economic potential by construction type for the commercial sector. Existing construction represents the majority of achievable economic potential, particularly in the early years of the study, as it accounts for 96.7% of the potential in the first two years of the study (2020-2021). However, by the final year of the study period (2040), new construction accounts for 9.5% of the total cumulative commercial achievable economic potential.

**Figure 4.11. Cumulative Commercial Achievable Economic Potential by Segment**




Across each of these segments, lighting accounts for a high portion of total achievable economic potential. Table 4.8 shows 21-year cumulative commercial potential by end use.

**TABLE 4.8. COMMERCIAL POTENTIAL BY END USE**

| End Use | Baseline Sales | Cumulative 2040 - 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 | 29% | 0 | 20% | 67% | 0 | 85% |
| Cooling | 96 | 22 | 22% | 7 | 8% | 34% | 6 | 85% |
| Data Center | 51 | 20 | 39% | 18 | 35% | 91% | 15 | 85% |
| Heat Pump | 20 | 5 | 22% | 2 | 8% | 35% | 1 | 85% |
| Heating | 25 | 8 | 31% | 4 | 14% | 46% | 3 | 85% |
| Lighting | 285 | 89 | 31% | 74 | 26% | 83% | 61 | 83% |
| Miscellaneous | 76 | 6 | 8% | 2 | 3% | 41% | 2 | 85% |
| Refrigeration | 32 | 5 | 15% | 3 | 9% | 61% | 3 | 85% |
| Ventilation | 89 | 19 | 21% | 4 | 5% | 24% | 4 | 85% |
| Water Heat | 16 | 1 | 5% | 0 | 3% | 61% | 0 | 85% |
| **Total** | **693** | **173** | **25%** | **115** | **17%** | **66%** | **96** | **83%** |

Over one-half (63 percent) of commercial achievable potential comes from interior lighting equipment upgrades, exterior lighting equipment upgrades, and controls. Lighting's 21-year technical potential is equivalent to a 31 percent reduction in baseline lighting consumption. Overall, 83 percent of lighting technical potential proves cost-effective. Only 83 percent of lighting potential is achievable over the study's horizon as a high portion of the end-use savings comes from natural replacement measures, which do not always reach 85 percent achievability, depending on the measure's lifetime and the ramp rate.

As with the residential sector, a large portion commercial potential is achieved within the first 10 years of the study horizon. Figure 4.9 and Figure 4.10 show cumulative and incremental achievable potential for the commercial sector, respectively.

**Figure 4.9. Commercial Cumulative Achievable Economic Potential**

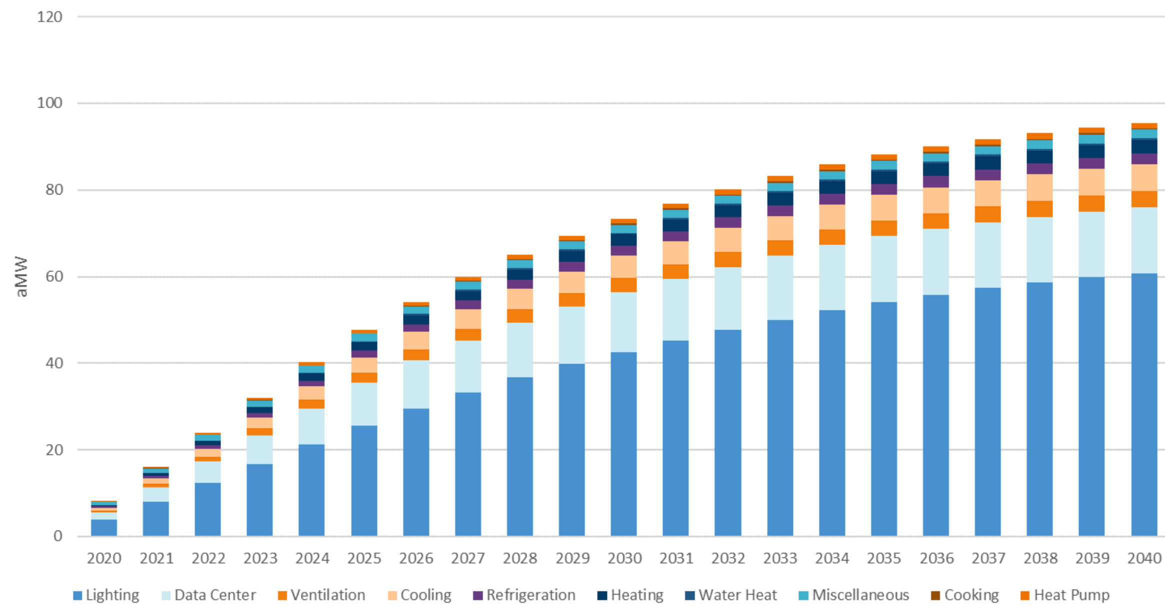
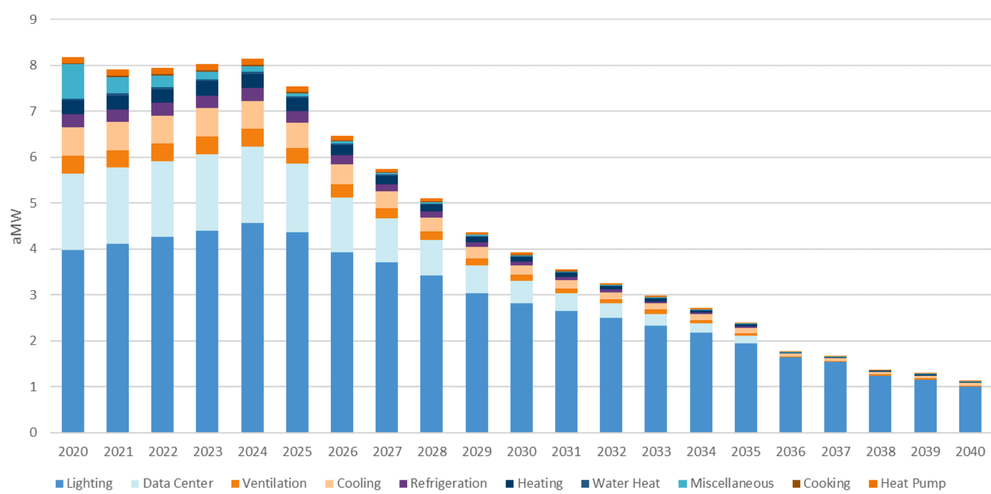


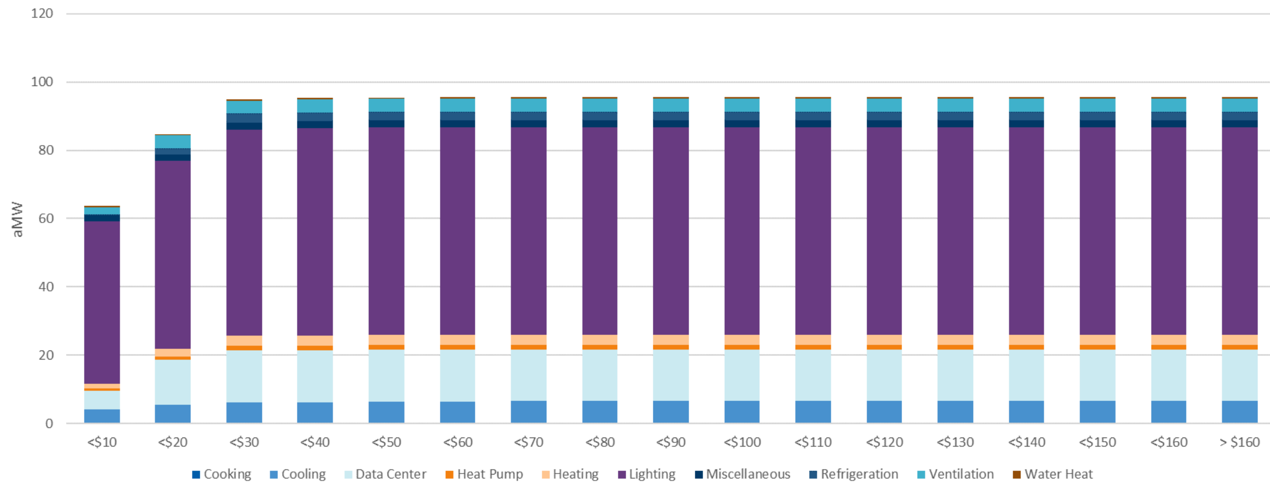

**Figure 4.10. Commercial Incremental Achievable Economic Potential**




Approximately 73 percent of 21-year commercial achievable economic potential falls within the first 10 years of the study horizon. Much commercial retrofit potential for existing buildings becomes exhausted within the first 10 years. Most savings within the last 10 years of the study's horizon come from natural turnover and replacement of inefficient lighting fixtures with LEDs.

Commercial savings are not only abundant—they are inexpensive. Figure 4.11 shows cumulative 2040 achievable economic for the commercial sector by end use and levelized cost.

**Figure 4.11. Commercial Supply Curve by End Use**




Most cumulative achievable economic potential by 2040 costs less than $10/MWh from a TRC perspective; 75 percent of these savings come from lighting measures. Although LED technologies remain more expensive than their incandescent, halogen, and fluorescent counterparts, the technology often has a much longer measure life, meaning that installing it defers future replacements of the baseline technology. For some measures, these deferred replacement costs exceed the incremental measure cost, producing negative levelized costs.

Lighting, server virtualization, and direct digital controls have significant conservation potential. Table 4.9 shows the top 15 commercial measures, sorted by 20-year achievable economic potential.

**TABLE 4.9. TOP-SAVING COMMERCIAL MEASURES**

| Measure Name | Achievable Economic Potential - aMW | | | Percent of Total (21-Year) |
|---|---|---|---|---|
| | 2-Year | 10-Year | 21-Year | |
| LED - Linear Fluorescent | 2.79 | 16.75 | 30.13 | 32% |
| Server virtualization/consolidation | 1.63 | 6.54 | 7.43 | 8% |
| Direct Digital Controls Energy Management | 0.86 | 3.44 | 4.21 | 4% |
| LED - Other | 0.71 | 2.86 | 3.25 | 3% |
| LED - Recessed Can | 0.64 | 3.61 | 5.90 | 6% |
| ENERGY STAR Desktop | 0.64 | 0.99 | 1.05 | 1% |
| Commercial HVAC and DHW Pump | 0.63 | 2.53 | 3.07 | 3% |
| Exterior Lighting: Parking Lot - HPS 250W - NR | 0.59 | 2.36 | 2.68 | 3% |
| LED Parking Garage Lighting | 0.52 | 2.08 | 2.37 | 2% |

| TABLE 4.9. TOP-SAVING COMMERCIAL MEASURES | | | | |
|---|---|---|---|---|
| Commercial Strategic Energy Management | 0.50 | 2.06 | 2.85 | 3% |
| Market Average HP Low Power T8 Shift | 0.44 | 1.79 | 2.16 | 2% |
| Decommissioning of unused servers | 0.41 | 1.63 | 1.85 | 2% |
| Economizer | 0.38 | 1.54 | 1.75 | 2% |
| ENERGY STAR Display | 0.38 | 0.58 | 0.62 | 1% |
| LED - Display or Track | 0.37 | 1.59 | 2.04 | 2% |

The highest savings measure is LED tube replacements of linear fluorescent lighting, accounting for 30.1 aMW by 2040—32 percent of total commercial potential.

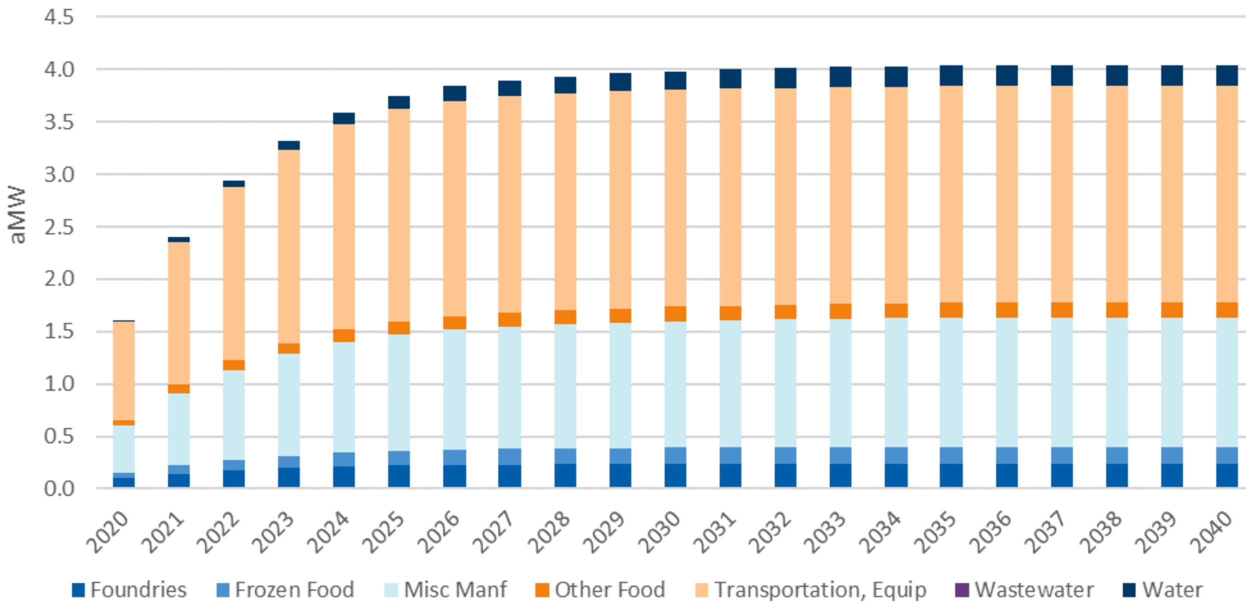
## 4.4. Industrial

Cadmus estimated conservation potential for the industrial sector using the Council's Seventh Power Plan analysis tool. The conservation potential addressed eight industrial segments in City Light's service territory, based on allocations developed from City Light's nonresidential database. The assessment identified approximately 4 aMW of achievable economic potential by 2040. Table 4.10 shows cumulative industrial potential by segment in 2040, and Figure 4.12 shows industrial achievable economic potential by segment.

**TABLE 4.10. INDUSTRIAL POTENTIAL BY SEGMENT**

| Segment | Baseline Sales | Cumulative 2040 - aMW | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Technical Potential (TP) | TP % of Baseline | Economic Potential (EP) | EP % of Baseline | EP % of TP | Achievable Potential (AP) | AP % of EP |
| Foundries | 19.7 | 0.8 | 4% | 0.3 | 1% | 36% | 0.2 | 85% |
| Frozen Food | 2.3 | 0.6 | 28% | 0.2 | 8% | 30% | 0.2 | 85% |
| Miscellaneous Manufacturing | 32.4 | 2.3 | 7% | 1.4 | 4% | 64% | 1.2 | 85% |
| Other Food | 4.0 | 0.9 | 22% | 0.2 | 4% | 18% | 0.1 | 85% |
| Transportation, Equipment | 26.4 | 3.1 | 12% | 2.4 | 9% | 78% | 2.1 | 85% |
| Wastewater | 1.3 | 0.6 | 47% | 0.0 | 0% | 0% | 0.0 | 85% |
| Water | 2.2 | 0.2 | 11% | 0.2 | 11% | 100% | 0.2 | 85% |
| **Total** | **88.4** | **8.5** | **10%** | **4.8** | **5%** | **56%** | **4.0** | **85%** |

**Figure 4.12. Industrial Achievable Economic Potential by Segment**




The distribution of industrial achievable economic potential by segment is very similar to the distribution of baseline sales. Transportation equipment manufacturing accounts for 51 percent of 21-year industrial achievable economic potential—2.1 aMW. Table 4.11 shows 21-year potential by industrial end use.

**TABLE 4.11. INDUSTRIAL POTENTIAL BY END USE**

| End Use | Baseline Sales | Cumulative 2040 - aMW | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Technical Potential (TP) | TP % of Baseline | Economic Potential (EP) | EP % of Baseline | EP % of TP | Achievable Potential (AP) | AP % of EP |
| Fans | 7.0 | 1.1 | 16% | 0.0 | 0% | 0% | 0.0 | 0% |
| HVAC | 11.1 | 0.3 | 3% | 0.3 | 3% | 100% | 0.3 | 85% |
| Lighting | 8.9 | 4.0 | 45% | 4.0 | 45% | 100% | 3.4 | 85% |
| Motors Other | 11.9 | 0.4 | 4% | 0.0 | 0% | 0% | 0.0 | 0% |
| Other | 9.4 | 0.8 | 9% | 0.2 | 2% | 27% | 0.2 | 85% |
| Process Air Compressor | 5.9 | 0.5 | 9% | 0.0 | 0% | 0% | 0.0 | 0% |
| Process Electro Chemical | 4.2 | 0.1 | 1% | 0.1 | 1% | 100% | 0.0 | 85% |
| Process Heat | 12.4 | 0.0 | 0% | 0.0 | 0% | 0% | 0.0 | 0% |
| Process Other | 0.5 | 0.0 | 0% | 0.0 | 0% | 0% | 0.0 | 0% |
| Process Refrigeration | 7.4 | 0.6 | 8% | 0.1 | 2% | 20% | 0.1 | 85% |
| Pumps | 9.8 | 0.6 | 6% | 0.0 | 0% | 0% | 0.0 | 0% |
| **Total** | **88.4** | **8.5** | **10%** | **4.8** | **5%** | **0%** | **4.0** | **85%** |

Over three-fourths (85 percent) of industrial, achievable, economic potential comes from lighting measures, followed by HVAC (7 percent) and other (5 percent).

Figure 4.13 and Figure 4.14 show cumulative and incremental, achievable, economic potential over the 21-year study horizon, respectively.

**Figure 4.13. Industrial Cumulative Achievable Economic Potential**

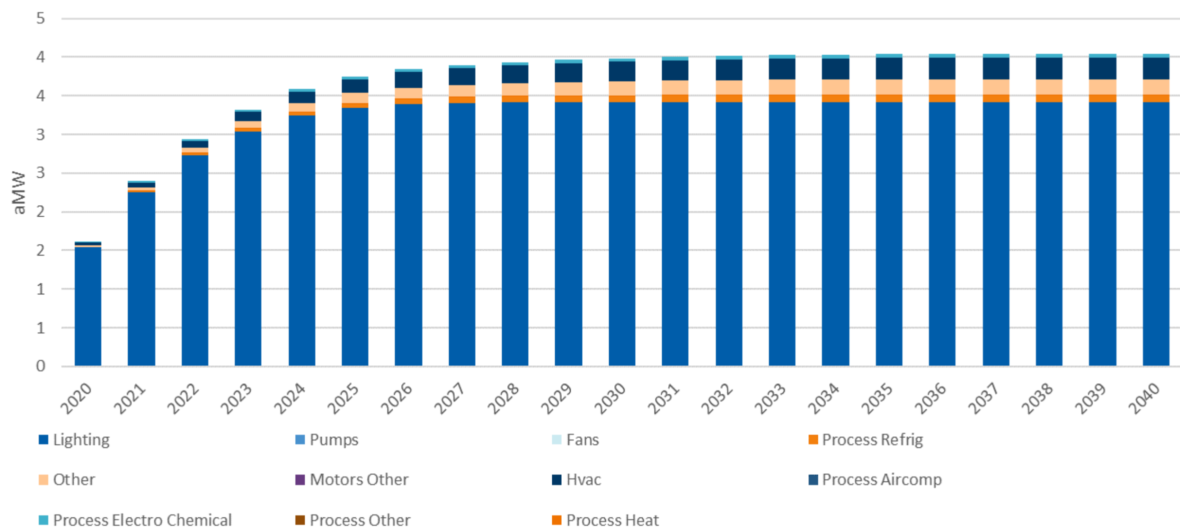
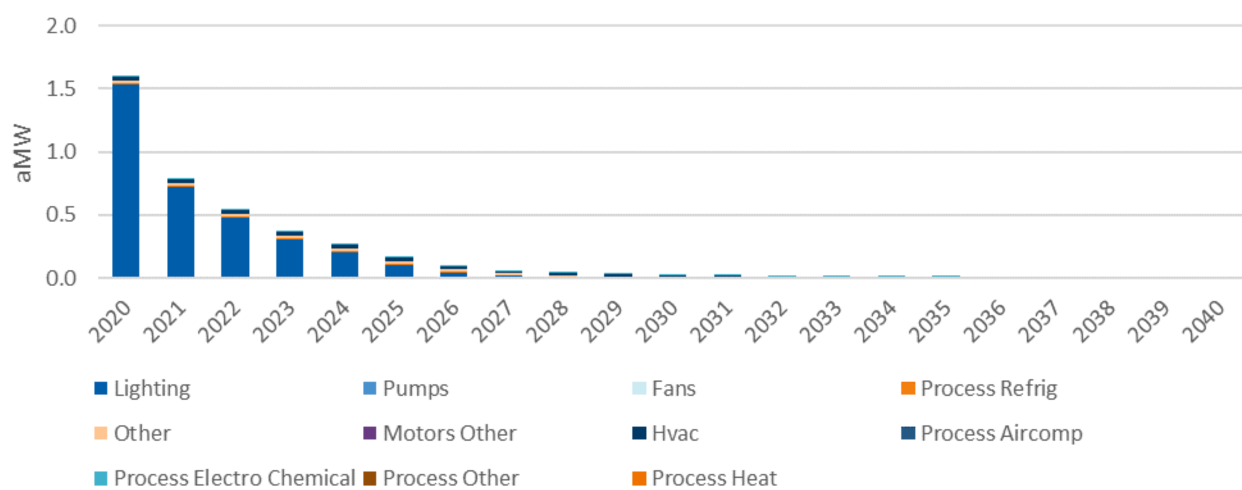



**Figure 4.14. Industrial Incremental Achievable Economic Potential**




Consistent with the Council's approach to the industrial sector, Cadmus modeled all industrial measures as retrofits and did not distinguish between new and existing construction. After applying ramp rates, approximately 98 percent of 21-year achievable economic potential is realized within the first 10 years.

Industrial measures are generally low cost; however, the 2020 CPA's lower avoided cost forecast resulted in estimates of economic potential equivalent to 56% of technical potential, compared with 97 percent in the 2018 CPA. Figure 4.15 shows cumulative achievable economic potential in 2040 for different levelized cost thresholds.

**Figure 4.15. Industrial Supply Curve—Cumulative Achievable Economic Potential in 2040 by Levelized Cost**

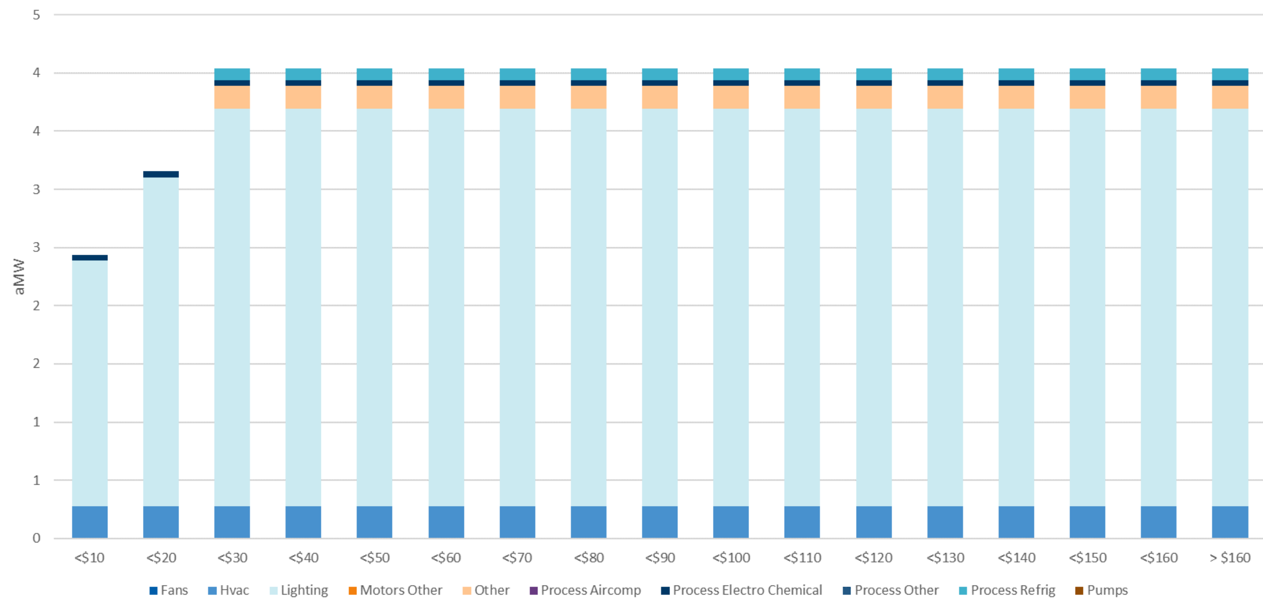



Table 4.12 shows the top saving industrial measures; collectively, these represent 90 percent of 21-year cumulative, achievable, economic potential.

**TABLE 4.12. TOP-SAVING INDUSTRIAL MEASURES**

| Measure Name | Achievable Economic Potential - aMW | | | Percent of Total (21-Year) |
|---|---|---|---|---|
| | 2-Year | 10-Year | 21-Year | |
| High Bay Lighting 2 Shift | 0.57 | 0.86 | 0.86 | 21% |
| High Bay Lighting 1 Shift | 0.47 | 0.72 | 0.72 | 18% |
| Lighting Controls | 0.40 | 0.61 | 0.61 | 15% |
| High Bay Lighting 3 Shift | 0.30 | 0.45 | 0.45 | 11% |
| Efficient Lighting 2 Shift | 0.22 | 0.33 | 0.33 | 8% |
| Efficient Lighting 1 Shift | 0.17 | 0.26 | 0.26 | 6% |
| Efficient Lighting 3 Shift | 0.12 | 0.19 | 0.19 | 5% |
| Municipal Water Supply-Retro | 0.04 | 0.17 | 0.20 | 5% |
| Fan Equipment Upgrade | <0.01 | <0.01 | <0.01 | <1% |

# 5. Comparison to 2018 CPA

## 5.1. Overview

Overall, the 2020 CPA identified higher technical potential and lower economic and achievable potential than the 2018 CPA. This section compares results from the two assessments and identifies reasons for the change in potential. The study focused on 21-year cumulative estimates of technical and economic potential and incremental estimates of achievable economic potential.

Table 5.1 compares cumulative technical potential, by sector, from the 2018 and 2020 CPAs.

**TABLE 5.1. TECHNICAL POTENTIAL COMPARISON**

| Sector | 2020 CPA | | | 2018 CPA | | |
|---|---|---|---|---|---|---|
| | Baseline Sales – 21 Year (aMW) | Technical Potential – 21 Year (aMW) | Technical Potential as % of Baseline Sales | Baseline Sales – 21 Year (aMW) | Technical Potential – 20 Year (aMW) | Technical Potential as % of Baseline Sales |
| Residential | 440 | 100 | 23% | 336 | 85 | 25% |
| Commercial | 693 | 173 | 25% | 747 | 180 | 24% |
| Industrial | 88 | 9 | 10% | 150 | 13 | 9% |
| Street Lighting | 5 | 0 | 0% | 10 | 1 | 12% |
| **Total** | **1,226** | **282** | **23%** | **1,242** | **279** | **22%** |

### 5.1.1. Technical Potential

The 2020 CPA identified 282 aMW of technical potential, compared to 279 aMW in the 2018 CPA. This slight increase is due to changes in the residential and commercial sectors. Changes that contribute to higher technical potential include:

- Higher residential baseline load forecasts
- New residential measures not previously considered in the 2018 CPA
- Additional commercial measures not previously included in the 2018 CPA
- Lower industrial baseline load forecasts due to the re-classification of some industrial customer premise loads in the commercial sector

Each of these factors are discussed in following sections.

### 5.1.2. Economic Potential and Avoided Costs

Table 5.2 compares economic potential for IRP-preferred, avoided cost scenario in the 2018 CPA and the market, avoided cost scenario in the 2020 CPA.

**TABLE 5.2. ECONOMIC POTENTIAL COMPARISON**

| Sector | 2020 CPA (Market Avoided Costs) | | | 2018 CPA (IRP Avoided Costs) | | |
|---|---|---|---|---|---|---|
| | Economic Potential – 21 Year (aMW) | Economic Potential as % of Baseline Sales | Economic as a % of Technical Potential | Economic Potential – 20 Year (aMW) | Economic Potential as % of Baseline Sales | Economic as a % of Technical Potential |
| Residential | 23 | 5% | 23% | 21 | 6% | 25% |
| Commercial | 115 | 17% | 66% | 131 | 17% | 72% |
| Industrial | 5 | 5% | 56% | 10 | 7% | 77% |
| Street Lighting | 0 | 0% | 0% | 1 | 12% | 100% |
| **Total** | **142** | **12%** | **50%** | **163** | **13%** | **58%** |

The 2020 CPA identified 142 aMW of economic potential, compared to 163 aMW in the 2018 CPA. Lower avoided energy and capacity costs contributed to a decrease in economic potential in the residential, commercial, and industrial sectors, in addition to factors contributing to lower technical potential. In the 2020 CPA, levelized avoided costs for the 2020 to 2040 period are approximately $38/MWh, compared to $52/MWh in the 2018 CPA, or nearly 27 percent lower.[18]

In addition to lower avoided energy costs, the 2020 CPA also updated assumptions regarding deferred transmission and distribution costs. Cadmus used forecast values from the Council's presentation in March of 2019, which reflected values of $3.08/kW-year and $6.85/kW-year for transmission and distribution, respectively, which were converted from 2016 to 2018 dollars.[19]

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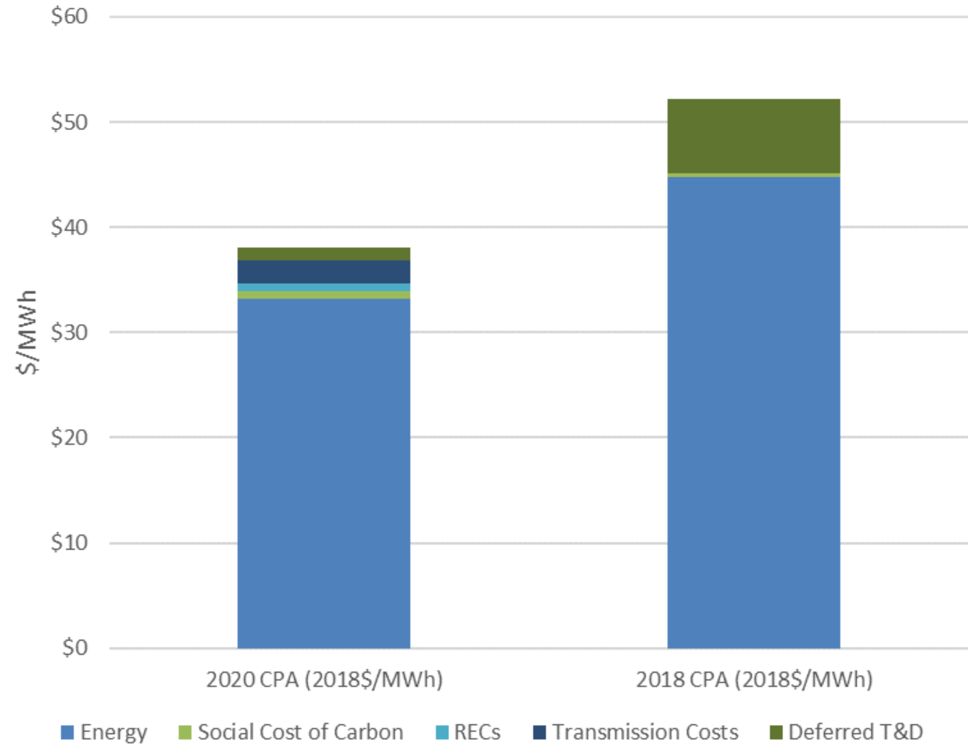
18 Both the 2018 CPA and 2020 CPA levelized cost values are expressed in 2018 dollars for comparison purposes

19 The Council's values were presented in its March 2019 meeting and reflect weighted average values from several regional utilities and are expressed in $2016, levelized. https://www.nwcouncil.org/sites/default/files/2019_0312_p3.pdf

**Figure 5.1. Change in Residential Economic Potential by End Use**




The lower avoided costs in the 2020 CPA contribute to the lower economic potential in each sector. The industrial sector had the most pronounced decline in economic potential, as illustrated in Table 5.3, which shows economic potential expressed as a fraction of technical potential. The industrial sector experienced a decline in the percent of technical potential that is economic due to the lower avoided energy and deferred T&D costs, as several large savings measures that were marginally cost effective in the 2018 CPA were not cost effective in the 2020 CPA, including plant energy management. The residential and commercial sectors also exhibited declines in the economic potential as a percent of technical.

**TABLE 5.3. COMPARISON OF CUMULATIVE ECONOMIC POTENTIAL AS A PERCENT OF TECHNICAL POTENTIAL**

| Sector | 2020 CPA | 2018 CPA |
|---|---:|---:|
| Residential | 23% | 25% |
| Commercial | 66% | 72% |
| Industrial | 56% | 77% |
| Street Lighting | 0% | 100% |
| **Total** | 50% | 58% |

## 5.2. Residential Sector Changes

The residential sector had increased technical and economic potential and a slight decline in achievable potential. These changes were driven by factors including a higher customer forecast, higher potential in three key end uses, but lower avoided energy and T&D capacity costs. Table 5.4 compares technical and economic potential in the 2018 and 2020 CPA and identifies key reasons for the changes.

**TABLE 5.4. RESIDENTIAL TECHNICAL AND ECONOMIC POTENTIAL COMPARISON**

| Component | 2020 CPA | 2018 CPA | Reason for Change |
|---|---|---|---|
| Baseline Sales | 440 | 336 | Higher customer forecast; baseline forecast calibrated to base year (2019) |
| Technical Potential | 100 | 85 | Higher load forecast; new MF DHP measures |
| Technical Potential as % of Baseline | 23% | 25% | |
| Economic Potential | 23 | 21 | Lower avoided energy and T&D capacity cost forecasts |
| Economic Potential as % of Baseline | 5% | 5% | |
| Economic Potential as % of Technical | 23% | 21% | |

### 5.2.1. Higher Residential Forecast Sales

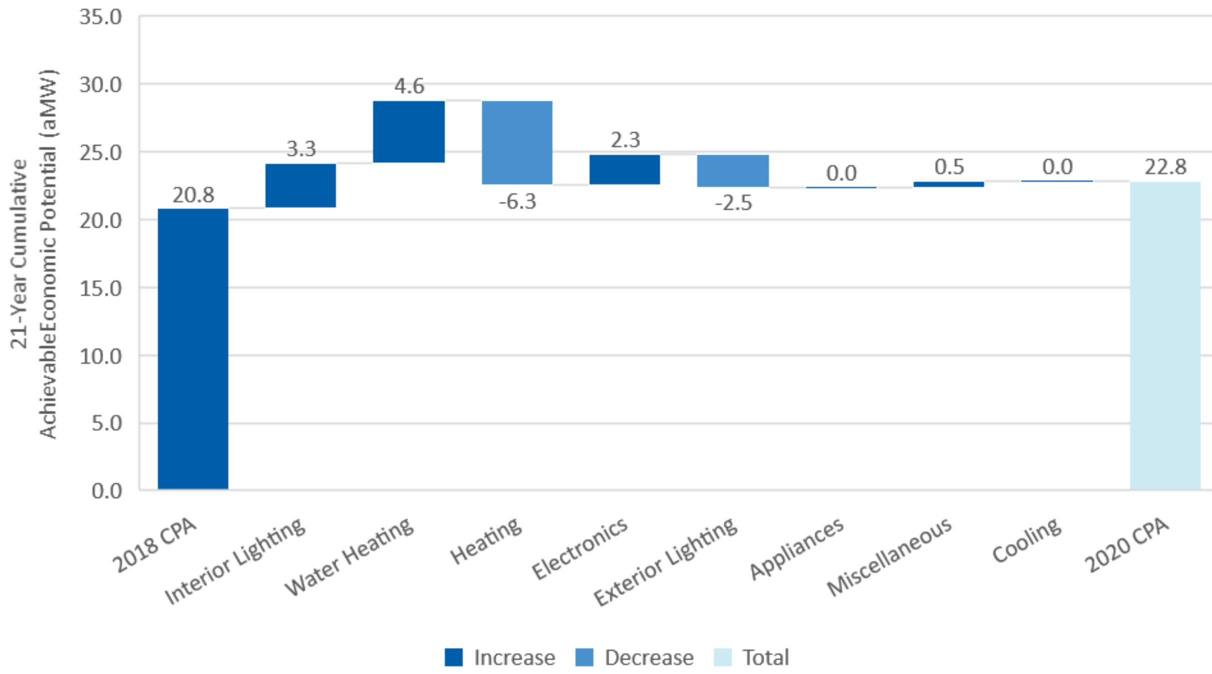
City Light's forecasted residential final study year (2040) sales were approximately 31 percent higher than the 2018 CPA final year (2037). Several key factors contributed to the increased residential sales forecast:

- City Light's underlying residential customer forecast increased from approximately 410,000 residential customers to over 508,000 in 2040. The residential customer forecast used in the 2018 showed residential customer growth from 385,000 in 2017 to 427,000 in 2037.
- The 2020 CPA baseline sales forecast includes additional load from City Light's internal EV forecast; this forecast shows an additional 38 aMW of residential customer EV load in 2040. The 2018 CPA baseline forecast did not explicitly account for EVs.
- The 2020 CPA adjusted end-use equipment saturations and fuel shares for several residential HVAC end uses (central air conditioning, room cooling, and heat pumps) based on discussion and agreement with City Light's load forecast technical team.
- Cadmus calibrated the residential bottom-up forecast in the base year (2019) to City Light's sales forecast but did not otherwise adjust or calibrate any other years. The 2018 CPA calibrated the baseline forecast to City Light's energy sales forecast.
- Furthermore, unlike the 2018 CPA, Cadmus calibrated the baseline sales forecast only in the base year (2019) to City Light's retail sales forecast, rather than for every year of the study.

### 5.2.2. Higher Interior Lighting and Water Heating Potential and Lower Heating and Exterior Lighting

Figure 5.2 illustrates the change in residential economic potential. Rises in economic potential for the interior lighting, water heating, electronics, and miscellaneous end uses contributed to the overall rise in residential economic potential; on the other hand, the heating and exterior lighting end uses both experienced declines in economic potential.

**Figure 5.2. Change in Residential Economic Potential by End Use**




Compared with the 2018 CPA, the heating and exterior lighting end uses experienced significantly lower economic potential of approximately 7.9 aMW combined. The following heating measures exhibited economic potential in the 2018 CPA but not the 2020 CPA:

- Motor – ECM. This measure became federal standard in 2019.
- DHP in existing single family with forced air furnace.
- Floor, wall, and attic insulation.

Conversely, the interior lighting, water heating, electronics, and miscellaneous end uses showed increased economic potential compared with the 2018 CPA. Examples of these measures include clothes washers, showerheads, aerators (not previously considered in the 2018 CPA), and engine block heater controls.

## 5.3. Commercial Sector Changes

The 2020 CPA identified lower 21-year cumulative technical and economic potential than the 2018 CPA, with the decrease in technical potential due to a lower commercial baseline energy forecast as City Light expects lower load growth for enterprise data centers compared with the previous CPA. However, the potential technical potential as a percent of baseline sales actually increased, due primarily to the incorporation of additional advanced rooftop controls measures approved by the RTF since the 2018 CPA. Table 5.5 compares technical and economic potential in the commercial sector for the two CPAs.

| TABLE 5.5. COMMERCIAL TECHNICAL AND ECONOMIC POTENTIAL COMPARISON | | | |
|---|---|---|---|
| **Component** | **2020 CPA** | **2018 CPA** | **Reason for Change** |
| Baseline Sales | 693 | 747 | Lower data center loads; Lower baseline sales forecast; Additional advanced rooftop controller measures |
| Technical Potential | 173 | 180 | |
| Technical Potential as % of Baseline | 25% | 24% | |
| Economic Potential | 115 | 131 | Lower avoided capacity and energy costs |
| Economic Potential as % of Baseline | 17% | 17% | |
| Economic Potential as % of Technical | 66% | 72% | |

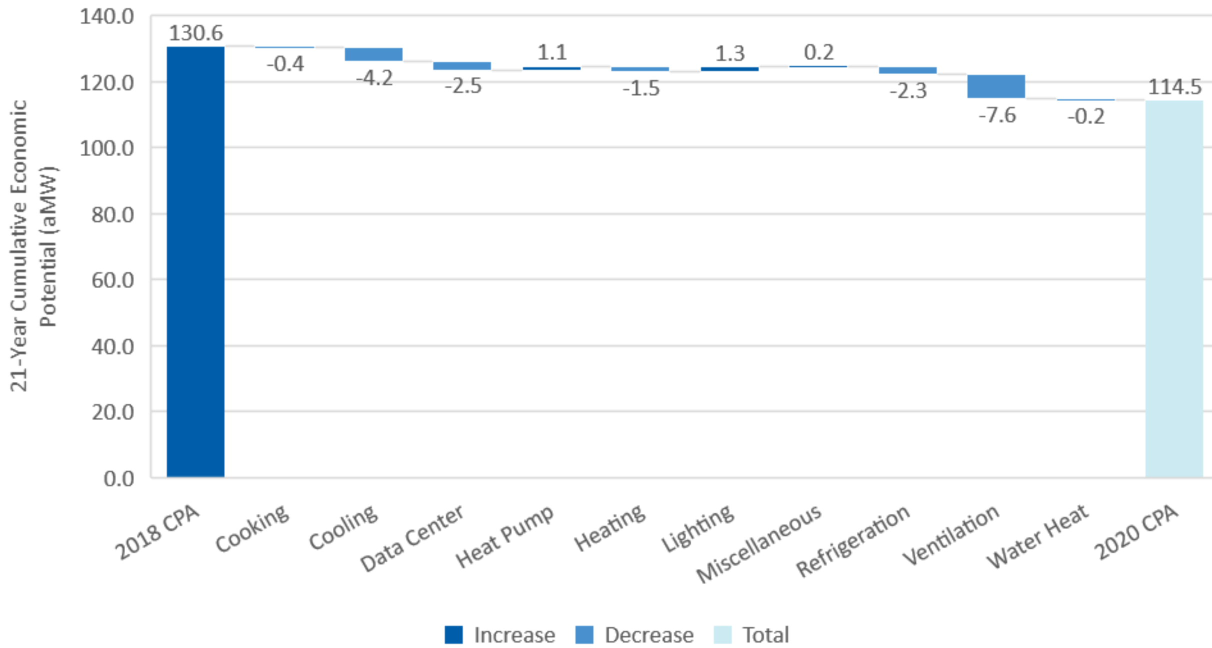
Although the 2018 CPA included an advanced rooftop controller measure from the Seventh Power Plan, the three additional measures in the 2020 CPA from the RTF's recent work include the following:[20]

- Gas Rooftop Unit (RTU) Advanced Rooftop Controls (12.3 aMW technical potential)
- Heat Pump RTU Advanced Rooftop Controls (3.6 aMW)
- Gas RTU Supply Fan VFD and Controller (3.3 aMW)

Despite the increase in technical potential from these measures, the economic potential remains relatively consistent with the 2018 CPA, at least in terms of economic potential as a percent of baseline sales. Figure 5.3 illustrates the change in commercial economic potential between the 2018 and 2020 CPAs by end use. End uses exhibiting decreased economic include cooling, data center, heating, refrigeration, and ventilation.

[20] https://rtf.nwcouncil.org/measure/advanced-rooftop-controls

**Figure 5.3. Change in Commercial Economic Potential by End Use**




## 5.4. Achievable Potential and Ramping

As with assessments of economic potential, Cadmus identified lower, cumulative, achievable economic potential. As 20-year cumulative achievable potential is a subset of economic potential, factors contributing to lower cumulative achievable potential are the same as those previously discussed for economic potential. Incremental achievable potential in the first two years of the 2020 CPA is about 13% lower than the first two years of the 2018 CPA . Figure 5.4 shows incremental achievable economic potential from the 2020 CPA, and Figure 5.5 shows incremental achievable economic potential from the 2018 CPA.

**Figure 5.4. Incremental Achievable Potential—2020 CPA**

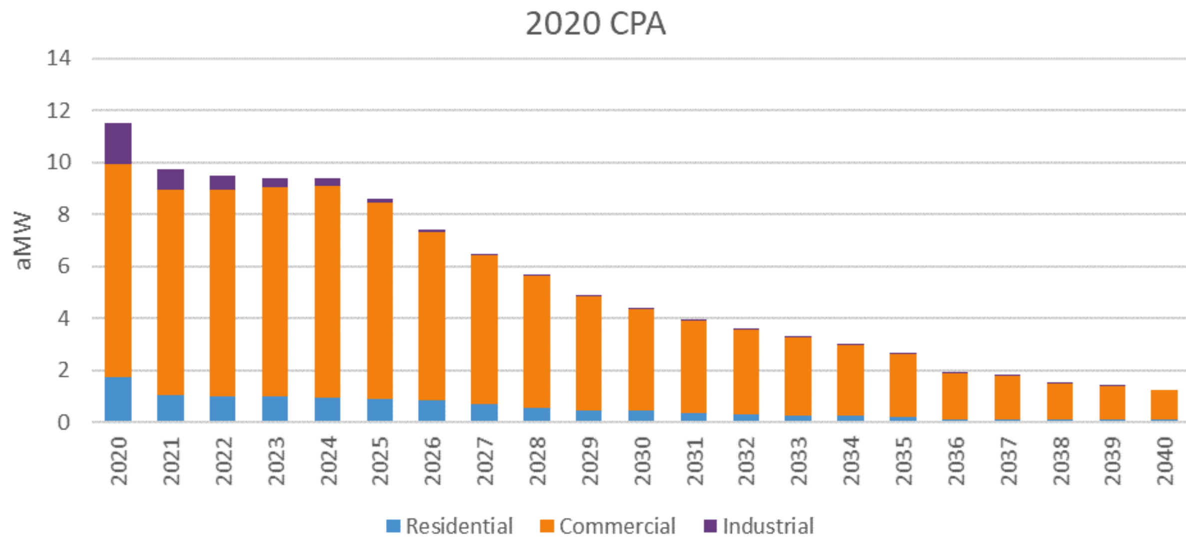



**Figure 5.5. Incremental Achievable Potential—2018 CPA**

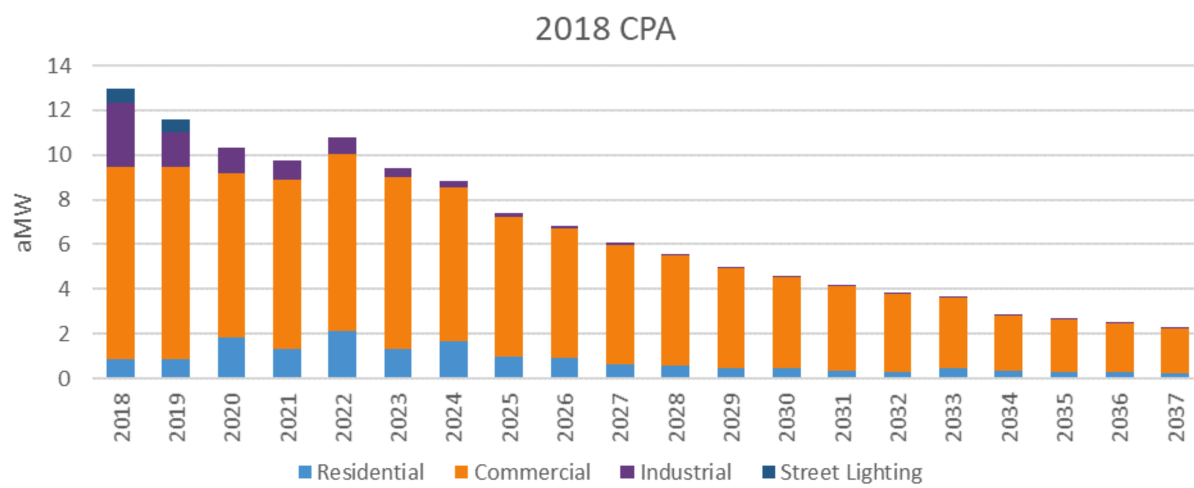



Figure 5.4 shows that the 2020 CPA determines that a higher proportion of total available potential will be realized in the study's early years. The two-year achievable potential is equal to approximately 19% of the total 21-year achievable economic potential, which is relatively consistent with the 2018 CPA, despite the lower total available achievable potential in the 2020 CPA. This change results from one key factor: the shift in the timing of lost opportunity ramp rates. For lost opportunity measures, we used the same ramp rates as those used in the Seventh Power Plan; however, we aligned the first year of this study (2020) with the fifth year of the Seventh Plan (2020) for each lost opportunity ramp rate. The result is that a greater percentage of each lost opportunity measure's potential is achieved.

# 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.[21]

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

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

**Conservation Potential Assessment:** A quantitative analysis of the amount of energy savings that exists, proves cost-effective, or could potentially be realized through implementation of energy-efficient programs and policies.

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

**Economic potential:** Refers to the subset of technical potential that is economically cost-effective 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).

**End Use Consumption:** Used for the residential sector, this represents per-UEC consumption for a given end use, expressed in annual kWh per unit. (Also called unit energy consumption [UEC]).

**End-use intensities:** Used in the commercial and institution sectors, 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 service level to an 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 the median number of years that energy efficiency measures installed under a program remain in place and operable. EUL also is sometimes defined as the date at which 50 percent of installed units remain 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 (MWhs).

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21 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

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

**Measure:** Installation of equipment, subsystems, or systems, or modifications of equipment, subsystems, systems, or operations on the customer side of the meter, designed 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.

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

**Retrofit:** An efficiency measure or efficiency program intended to encourage replacement of functional equipment before the end of its operating life with higher-efficiency units (also called "early-retirement"), or the installation of additional controls, equipment, or materials in existing facilities for 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 or 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 efficiency costs 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 impacts of efficiency initiatives on an administrator or an energy system. It compares administrator costs (e.g., incentives paid, staff labor, marketing, printing, data tracking, reporting) to accrued benefits, including avoided energy and demand supply costs. Also called the Program Administrator Cost Test (PACT).