Seattle City Light

2024 Demand-Side Management Potential Assessment

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December 11, 2023

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Definition of Terms

aMW	Average megawatt
AC	Air conditioning
BPA	Bonneville Power Administration
CanESM2	Second Generation Canadian Earth System Model
CBECS	Commercial Buildings Energy Consumption Survey
CBSA	Commercial Building Stock Assessment
CDD	Cooling degree days
CEIP	Clean Energy Implementation Plan
CETA	*Clean Energy Transformation Act*
CFL	Compact fluorescent lamp
Council	Northwest Power and Conservation Council
CPA	Conservation Potential Assessment
DSMPA	Demand-Side Management Potential Assessment
ECM	Energy conservation measure
EHD	Environmental Health Disparities
EISA	*Energy Independence and Security Act*
EPRI	Electric Power Research Institute
EUL	Effective useful life
EV	Electric vehicle
HDD	Heating degree days
HVAC	Heating Ventilation and Air Conditioning
I-937	Initiative 937
IRP	Integrated Resource Plan
kWh	Kilowatt-hour
LED	Light-emitting diode
MACA	Multivariate Adaptive Constructed Analogs
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
RTF	Regional Technical Forum
RUL	Remaining useful life
TRC	Total resource cost
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, Paul Nissley, Saul Villareal, Mike Hamilton, Colm Otten, Verene Martin, Emma Johnson, Matthew Hamlin, Madeline Kostic, and Kali Hollenhorst as well as Debra Lavell from Innovation InSites.

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1. Executive Summary

1.1. Overview

Seattle City Light (City Light) engaged Cadmus to complete a Demand-Side Management Potential Assessment (DSMPA) to produce rigorous estimates of the magnitude, timing, and costs of resources in its service territory over the next 22 years, beginning in 2024. This study, as part of City Light's integrated resource planning (IRP) process, is intended to identify the cost-effective potential of energy efficiency, customer-sited solar photovoltaics (PV), and demand response within City Light's major customer sectors—residential, commercial, and industrial—while accounting for the impacts of climate change and building electrification.[1] The results of this assessment will also help inform City Light's future programs. The study period aligns with the timeline for City Light's 2024 IRP and provides direct inputs into that analysis.

Table 1.1 shows the 22-year technical and achievable technical potential for each resource considered in this study.

Table 1.1. Summary of Energy Savings and Demand Reduction Potential, Cumulative 2045

	Energy (aMW)		Winter Coincident Peak Capacity (MW)	
Resource	Technical Potential	Achievable Technical Potential	Technical Potential	Achievable Technical Potential
Energy Efficiency	263	228	324	278
Solar PV	365	60[a]	N/A	N/A
Demand Response	N/A	N/A	N/A	180
Total				

[a] *This value represents the base scenario.*

This study accomplishes several objectives:

- Fulfills statutory requirements of Chapter 194-37 of the Washington Administrative Code (WAC), *Energy Independence Act*. The WAC requires that City Light identify all achievable, cost-effective conservation potential for the upcoming 10 years.[2] The WAC also specifies that 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 2024-2025 biennium.

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1 This study estimates demand response potential for managed electric vehicle (EV) charging. It does not estimate conservation potential for efficient EV chargers. It also does not include transportation electrification in its baseline forecast. Instead, City Light adds the transportation electrification forecast to the 2024 DSMPA load forecast as part of the IRP modeling process.

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

- Supports City Light's compliance of Washington State's *Clean Energy Transformation Act* (CETA), passed as Senate Bill 5116 in April 2019, to inform City Light's energy efficiency and demand response short- and long-term targets.[3] In addition, this study will inform City Light's near-term interim targets for its Clean Energy Implementation Plan (CEIP) as required by CETA. CETA sets additional requirements for City Light, such as including the social cost of carbon in avoided energy costs. This study, more broadly, supports City Light's Clean Energy Action Plan, a 10-year action plan described in the 2020 IRP Progress Report to meet CETA requirements.
- Develops up-to-date estimates of energy conservation measure (ECM) datasets for the residential, commercial, and industrial market sectors using measures consistent with the Northwest Power and Conservation Council's (Council) 2021 Power Plan, the Regional Technical Forum (RTF), and other data sources.
- Provides inputs into City Light's IRP, which is completed every two years. City Light's IRP determines the mixture of supply-side and demand-side resources required over the next 22 years to meet customer demand and looks ahead to how City Light plans to meet the 2045 100% non-emitting standard of CETA. The IRP requires a thorough analysis of potential to properly assess the reliability, cost, risk, and environmental impact of different resource portfolios for power generation as well as to assess other demand-side resources that are not part of the DSMPA.
- Informs City Light's program planning and budget setting for customer programs and City Light's load forecast.

This study also provides insights on the impacts of extreme climate change and accelerated electrification on the end-use load forecast and demand-side management potential by showing the results of an analysis for three different scenarios: extreme climate change, accelerated electrification, and extreme climate change combined with accelerated electrification. Details of these scenarios can be found in the *Baseline Forecast Scenarios* section of this report.

The study relies on City Light–specific data, compiled from City Light's oversample of the 2017 Northwest Energy Efficiency Alliance (NEEA) Residential Building Stock Assessment (RBSA),[4] NEEA's 2019 Commercial Building Stock Assessment (CBSA),[5] and other regional data sources. This study uses a methodology

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3 CETA requires proposing interim targets for meeting the standard under RCW 19.405.040(1) during the years prior to 2030 and between 2030 and 2045. This study estimates potential over 22 years, from 2024 through 2045.

4 Northwest Energy Efficiency Alliance. *2017 Residential Building Stock Assessment*.

5 Northwest Energy Efficiency Alliance. *2019 Commercial Building Stock Assessment*.

consistent with the supply curve workbooks of Council's 2021 Power Plan, published in March 2022.[6] It incorporates savings and costs for all ECMs in the Council's 2021 Power Plan workbooks and the active unit energy savings (UES) workbooks from the RTF.[7] The *Detailed Methodology* section of this report describes the sources and data used in greater detail.

This study also shows estimates of the demand response potential to align with the Council's demand response methodology and to provide City Light with the data it needs to meet Washington State's CETA requirements. The methodology and findings of the demand response potential assessment are presented in Appendix E.

Lastly, this study shows estimates of the solar PV and battery potential assessment to inform City Light's load forecasting work, 2024 IRP, and distribution planning. The methodology and findings of the solar PV and battery potential assessment are presented in Appendix F.

1.2. Scope of Analysis

For this study, Cadmus analyzed three sectors—residential, commercial, and industrial—and, where applicable, considered multiple market segments, construction vintages (new and existing), and end uses:

- Residential: Eight segments including standard-income single-family and multifamily homes (including low-rise, mid-rise, and high-rise) and highly impacted single-family and multifamily homes (including low-rise, mid-rise, and high-rise)[8]
- Commercial: 20 major commercial segments (including offices, retail, and other segments)
- Industrial: Eight segments including energy-intensive manufacturing, primarily process-driven customers, and water and wastewater treatment plants.

For each sector, Cadmus developed a baseline end-use load forecast that assumed no new future programmatic conservation and accounted for the effects of climate change,[9] building electrification, and consumption trends related to COVID-19. 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 the impact of each ECM on this baseline forecast. Therefore,

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6 The 2021 Power Plan is a regional plan that provides guidance on which resources can help ensure a reliable and economical regional power system from 2022 to 2041. The Council develops supply curves covering a variety of supply- and demand-side resources, considers how to best meet the region's power needs across a range of future scenarios (balancing cost and risk), develops a draft plan, and gathers public input before releasing the final version.

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

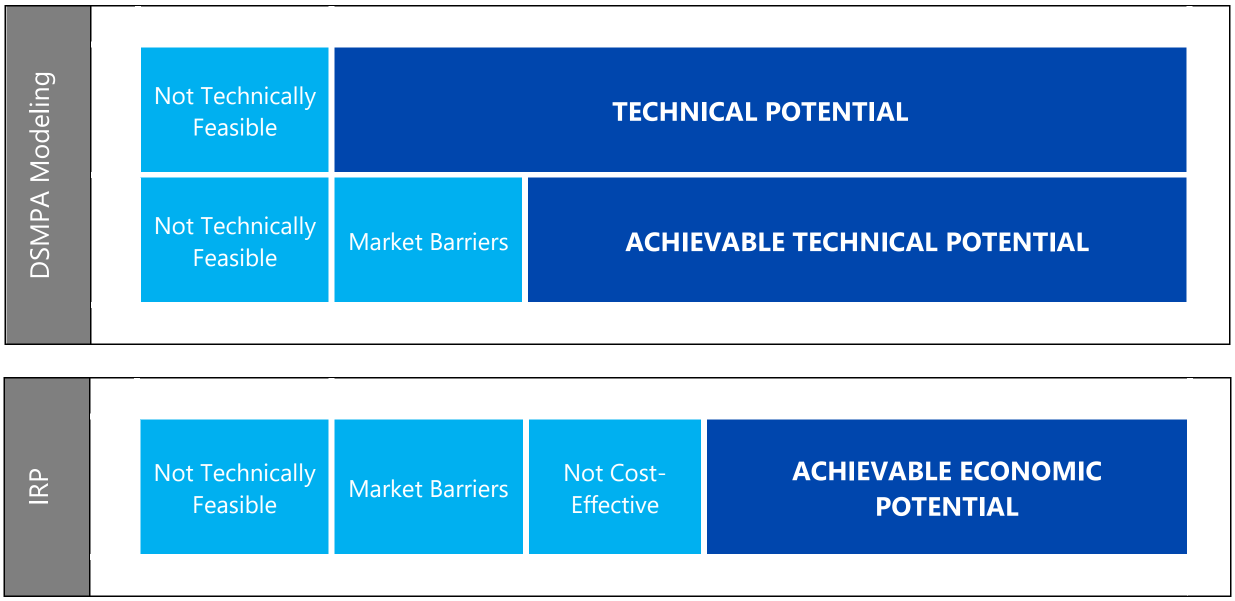
8 Cadmus disaggregated residential households into highly impacted and standard-income segments based on the data provided by City Light.

9 Cadmus did not account for the effects of climate change on the industrial sector.

conservation potential estimates presented in this report represent savings beyond codes and standards and naturally occurring savings.

Consistent with the WAC requirements, this study considers two types of energy efficiency potential, as shown in Figure 1.1. City Light determined a third potential—achievable economic—through the IRP's optimization modeling.

Figure 1.1. Types of Energy Efficiency Potential



The three types of potential are described as follows:

- **Technical potential** assumes that all technically feasible resource opportunities may be captured, regardless of their costs or other market barriers. It represents the total energy efficiency potential in City Light's service territory, after accounting for purely technical constraints.
- **Achievable technical potential** is the portion of technical potential assumed to be achievable during the study's forecast, regardless of the acquisition mechanism. For example, savings may be acquired through utility programs, improved codes and standards, and market transformation.
- **Achievable economic potential** is the portion of achievable technical portion determined to be cost-effective by the IRP's optimization modeling, in which either bundles or individual energy efficiency measures are selected based on cost and savings. The cumulative potential for these selected bundles constitutes achievable economic potential.

Cadmus provided City Light with forecasts of achievable technical potential, which City Light then entered as variables in the IRP's optimization model to determine achievable economic potential.

To be consistent with WAC requirements of relying on cost-effective energy efficiency, Cadmus bundled the resulting forecasts of achievable technical potential by levelized costs bin for City Light's IRP modeling team. The IRP modeling team then determined the amount of cost-effective energy efficiency that could be considered as a resource within the IRP. Details of the IRP process and the final selection of measures considered as part of the IRP optimization model can be found in the *6.5.Development of Conservation IRP Inputs* section of this report and in Appendix D. Measure Details.

1.3. Summary of Results

The study found 139 average megawatts (aMW) of achievable technical potential in the first 10 years (cumulative in 2033) in City Light's service territory.[10] To inform I-937 and CEIP energy efficiency targets Cadmus calculated two-year and four-year cumulative achievable technical potential. Cumulative achievable technical potential equals 30 aMW in the first two years and 57 aMW in the first four years.

Furthermore, City Light used its IRP optimization model to select measures based on the levelized total resource cost (TRC). Overall, the cumulative 22-year achievable economic potential is 132 aMW, with 79 aMW acquired in the first 10 years. The *pro rata* share (20% of 10-year achievable economic potential), which represents City Light's minimum biennial target, equals 16 aMW. All estimates of potential in this report are presented at the generator, meaning they include distribution line losses.[11]

1.3.1. Technical Potential

Table 1.2 shows the cumulative technical potential for each sector in 2045. Overall, the study identified 263 aMW of technically feasible conservation potential by 2045—the equivalent of 21% of forecasted baseline sales. Study results are presented as a percentage of forecasted baseline sales, which provides a useful benchmark for comparison against City Light's previous CPAs. The commercial, residential, and industrial sectors account for 22%, 24%, and 11% of the 22-year technical potential, respectively.

Table 1.2. Cumulative Technical Potential by Sector (2024–2045)

Sector	Baseline Sales–22-Year (aMW)	Technical Potential–22-Year (aMW)	Technical Potential as % of Baseline Sales
Residential	398	95	24%
Commercial	718	155	22%
Industrial	124	13	11%
Total	**1,240**	**263**	**21%**

1.3.2. Achievable Technical Potential

Table 1.3 shows the cumulative achievable technical potential for each sector in 2045. Overall, the study identified 228 aMW of technically feasible achievable potential by 2045—the equivalent of 18% of

10 An aMW refers to a unit of measure that represent one million watts (MW) delivered continuously 24 hours a day for each day of the year (for a total of 8,760 hours in non-Leap Years). A detailed description of MW and aMW can be found on the Council's website: https://www.nwcouncil.org/reports/columbia-river-history/megawatt

11 City Light estimates distribution line losses to be 5.5%, so the minimum biennial target at a customer site is 15 aMW.

forecasted baseline sales. The commercial, residential, and industrial sectors account for 19%, 20%, and 9% of the cumulative achievable technical potential, respectively.

Table 1.3. Cumulative Achievable Technical Potential by Sector (2024–2045)

Sector	Baseline Sales–22-Year (aMW)	Achievable Technical Potential–22-Year (aMW)	Achievable Technical Potential as % of Baseline Sales
Residential	398	79	20%
Commercial	718	138	19%
Industrial	124	11	9%
Total	**1,240**	**228**	**18%**

Table 1.4 provides two-year, four-year, 10-year, and 22-year cumulative achievable technical potential by sector. The commercial sector provides the majority of the cumulative achievable technical potential. This is due to the commercial sector's higher baseline sales compared with those of the residential and industrial sectors.

Table 1.4. Cumulative Achievable Technical Potential by Sector and Time Period

Sector	Achievable Technical Potential (aMW)				
	2-Year (2024-2025)	4-Year (2024–2027)	10-Year (2024–2033)	22-Year (2024–2045)	20% of 10-Year Potential
Residential	5	11	34	79	7
Commercial	23	42	95	138	19
Industrial	2	4	9	11	2
Total	**30**	**57**	**139**	**228**	**28**

Table 1.5 provides the winter and summer technical and achievable technical capacity savings from energy efficiency by sector in 2045 in megawatts (MW). Capacity savings represent the maximum demand reduction for each season. The commercial sector accounts for the majority of the total cumulative winter and summer capacity achievable technical potential. The residential sector accounts for nearly 46% of the winter capacity achievable technical potential but only 19% of the summer capacity achievable technical potential, which reflects the relatively higher saturation of residential electric space heating loads compared with residential cooling loads.

Table 1.5. Cumulative Winter and Summer Capacity (MW) Savings by Sector (2024–2045)

Sector	Technical Potential		Achievable Technical Potential	
	Winter MW	Summer MW	Winter MW	Summer MW
Residential	153	71	127	60
Commercial	157	270	139	240
Industrial	14	14	12	12
Total	**324**	**356**	**278**	**312**

Table 1.6 provides the two-year, four-year, and 10-year summer and winter capacity savings by sector. In the first 10 years of the study period, the cumulative winter achievable technical capacity savings are 160 MW, which is 57% of the 22-year cumulative winter achievable technical capacity savings. The cumulative summer achievable technical capacity savings are 208 MW, which is 67% of the 22-year cumulative summer achievable technical capacity savings.

Table 1.6. Cumulative Winter and Summer Capacity (MW) Savings by Sector and Time Period

Sector	Cumulative Winter Achievable Technical Potential (MW)			Cumulative Summer Achievable Technical Potential (MW)		
	2-Year (2024-2025)	4-Year (2024–2027)	10-Year (2024–2033)	2-Year (2024-2025)	4-Year (2024–2027)	10-Year (2024–2033)
Residential	8	18	56	3	7	24
Commercial	22	41	94	45	80	174
Industrial	2	5	10	2	5	10
Total	**33**	**63**	**160**	**51**	**92**	**208**

1.3.3. Technical and Achievable Technical Potential Comparison to the 2022 CPA

The 2024 DSMPA identified 263 aMW of cumulative, final year technical potential, compared with 233 aMW in the 2022 CPA, as shown in Table 1.7. The 13% increase in cumulative, final year technical potential is due to several major drivers:

- The study horizon of 2022 CPA was 20 years whereas the 2024 DSMPA produces potential estimates for 22 years.
- In the 2024 DSMPA, Cadmus incorporated the impacts of building electrification and climate change in the baseline forecast.
- Cadmus made updates to the residential baseline forecast that assume a shift in heating and cooling equipment to more efficient heat pumps over time based on City Light's assumptions about market adoption. For example, Cadmus increased new construction, single-family heat pump saturations from 3% in the base year to 31% in the final year to align with City Light's load forecasting assumptions. While the 2022 CPA also increased heat pump saturation over time, the increase was less substantial than in the 2024 DSMPA.
- Similarly, Cadmus made updates to the residential baseline forecast that assume a shift in water heating equipment from fossil fuel water heaters to heat pump water heaters over time based on City Light's assumptions about market adoption.
- The 2024 DSMPA included measures involving emerging technologies.

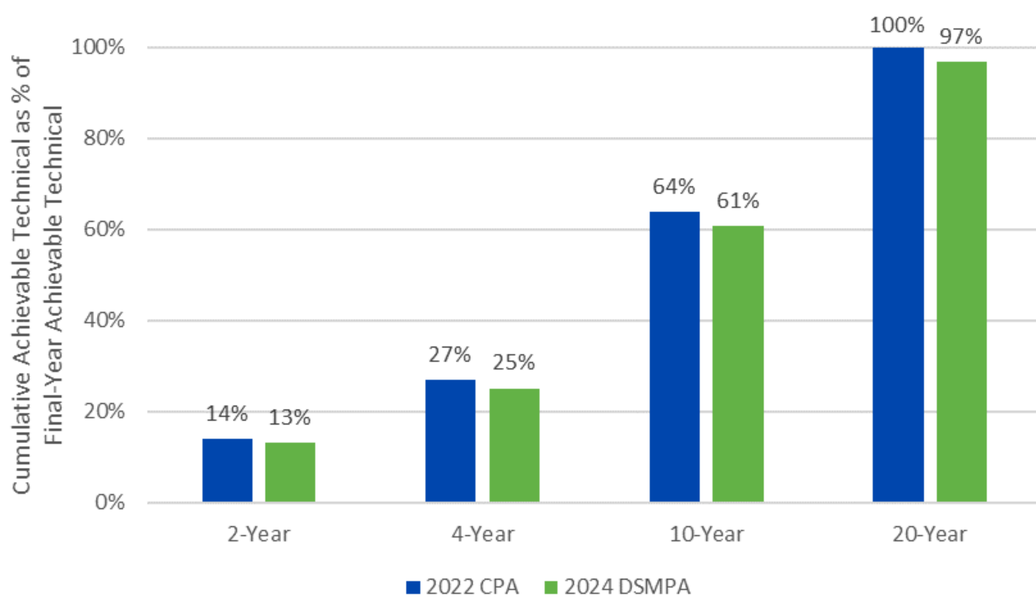
Table 1.7. Final Year Cumulative Technical Potential Comparison by Sector

Sector	2024 DSMPA			2022 CPA		
	Baseline Sales– 22 Year (aMW)	Technical Potential– 22 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	398	95	24%	422*	90	21%
Commercial	718	155	22%	667	131	20%
Industrial	124	13	11%	91	12	13%
Total	**1,240**	**263**	**21%**	**1,181***	**233**	**20%**

** This is the value after removing the sales due to electric vehicles (EVs).*

This report section discusses each factor in detail. Figure 1.2 illustrates that the 2022 CPA realized a higher proportion of total achievable technical potential in the initial years of the study. This is because the 2022 CPA has a 20-year study horizon while the 2024 DSMPA has a 22-year horizon—meaning that there is more achievable technical potential in the 2024 DSMPA because of the two additional years.

Figure 1.2. Cumulative Achievable Technical Potential as a Percentage of Total Achievable Technical Potential



The 2024 DSMPA used the ramp rates from the 2021 Power Plan supply curve workbooks, which have ramp rates for the 2022 to 2041 period (for 20 years). As the study period extends from 2024 to 2045 (for 22 years), Cadmus took the ramp rates beginning in 2022, applied them for the first 20 years of the study (from 2024 to 2043) and extrapolated them to extend from 2043 to the final year of the study (2045) following the last three years' trend (as described in more detail in the *6.4.2. Achievable Technical Potential* section). It is worth noting that, as part of this study, Cadmus worked with City Light to determine the appropriate Council ramp rates so that City Light's program measures better align with historical program acquisition as well as with local and state policies promoting energy efficiency.

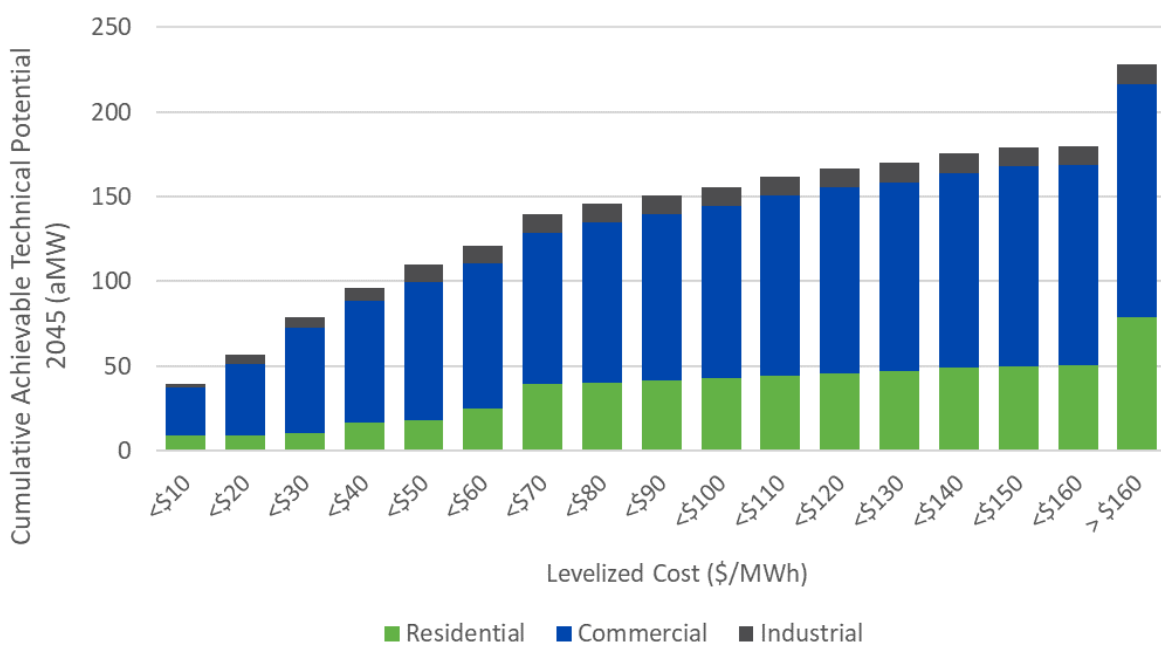
Similar to the prior CPA, this study shows the savings are front-loaded in the earlier part of the study, with the 10-year estimate representing over 60% of the 22-year achievable technical potential. Ramp rates are explained in more detail in the *6.4.2 Achievable Technical Potential* section.

The industrial sector in the 2024 DSMPA included measures and savings methodologies based on the 2021 Power Plan, such as HVAC measures, forklift battery chargers, compressors, fans, pumps, and other motor-driven systems. Aligning with 2022 CPA, Cadmus also included measures such as industrial generator block heaters, retro-commissioning, and welder system upgrades in the 2024 DSMPA. Due to following a similar methodology, the potential in the industrial sector did not change significantly compared with the 2022 CPA. Additional details can be found in the *5.1.3. Changes in Industrial Technical Potential* section.

1.3.4. Incorporating Conservation into City Light's IRP

Cadmus summarized the achievable technical potential for energy efficiency, described above, by the levelized cost groups (bins) of conserved energy by customer class for inclusion in City Light's IRP framework. We calculated these costs over a 22-year program life—the *6.5. Development of Conservation IRP Inputs* section provides additional detail on the levelized cost methodology. Figure 1.3 shows that 79 aMW, or 35% of the cumulative 2045 achievable technical potential has a levelized cost of less than or equal to $30 per megawatt-hour. Additionally, the figure shows that 21% of the total achievable technical potential has a levelized cost of greater than $160 per megawatt-hour.

Figure 1.3. Electric Supply Curve – Cumulative 22-Year Achievable Technical Potential (Levelized Cost Bins)



1.3.5. Achievable Economic Potential

After incorporating the achievable technical levelized cost of conserved energy bins, City Light's IRP model identified an optimal amount of annual conservation. Bundling resources into distinct cost groups allowed the portfolio optimization model to select the combination of conservation cost bundles by sector that provided City Light with the least-cost portfolio alongside renewable resources, while also achieving resource adequacy targets, I-937 requirements, and CETA requirements. By integrating conservation choices alongside renewable supply options into the portfolio optimization model, City Light captured the different value streams from all resources within the same analytical framework.

The resulting IRP analysis selected 132 aMW of achievable economic potential by 2045 at an optimal levelized cost for each sector, as shown in Table 1.8. Cumulative 22-year achievable economic potential accounted for 11% of the total baseline sales in 2045. The residential sector had the greatest achievable economic potential relative to baseline sales, accounting for 13% of the 2045 residential baseline sales. This was followed by the commercial sector cumulative achievable economic potential, which accounted for 10% of the 2045 commercial baseline sales. Finally, the industrial sector cumulative achievable economic potential made up 8% of the 2045 industrial baseline sales.

The IRP portfolio optimization model differentiated the levelized TRC by sector so the model can select the specific energy efficiency cost bins for each sector that best fit City Light's portfolio and minimize the overall costs. This also recognizes that the conservation supply curves for each sector have different shapes, limits, and elasticities. As shown in Table 1.8, the achievable economic potential represents a levelized TRC of $160 or less per megawatt-hour for residential, $40 or less per megawatt-hour for commercial, and $60 or less per megawatt-hour for industrial.

Table 1.8. Cumulative Achievable Economic Potential by Sector (2024–2045)

Sector	Levelized TRC ($/MWh)	Baseline Sales 22-Year (aMW)	22-Year Achievable Economic Potential (aMW)	Achievable Economic Potential as % of Baseline Sales
Residential	160	398	50	13%
Commercial	40	718	72	10%
Industrial	60	124	10	8%
Total	**N/A**	**1240**	**132**	**11%**

Table 1.9 provides the two-, four-, 10-, and 22-year cumulative achievable economic potential estimates by sector. As shown, 14% of the total 22-year achievable economic is achieved in the first two years and 60% is achieved in the first 10 years.

Table 1.9. Cumulative Achievable Economic Potential by Sector and Time Period

Sector	Achievable Economic Potential - aMW				
	2-Year (2024-2025)	4-Year (2024–2027)	10-Year (2024–2033)	22-Year (2024–2045)	20% of 10-Year Potential
Residential	4	8	22	50	4
Commercial	12	23	49	72	10
Industrial	2	4	8	10	2
Total	**18**	**35**	**79**	**132**	**16**

Table 1.10 provides achievable economic potential estimates of the two-, four-, and 10-year summer and winter capacity savings by sector.

Table 1.10. Cumulative Winter and Summer Capacity (MW) Savings by Sector and Time Period

Sector	Cumulative Winter Achievable Economic Potential (MW)			Cumulative Summer Achievable Economic Potential (MW)		
	2-Year (2024-2025)	4-Year (2024–2027)	10-Year (2024–2033)	2-Year (2024-2025)	4-Year (2024–2027)	10-Year (2024–2033)
Residential	10	20	52	5	9	24
Commercial	23	36	70	31	51	93
Industrial	3	6	11	3	6	11
Total	**36**	**62**	**133**	**39**	**66**	**128**

1.3.6. Scenarios

Table 1.11 shows the baseline sales, cumulative technical potential, cumulative achievable technical potential and cumulative achievable economic potential of all sectors for each scenario in 2045. Cumulative achievable technical potential results are also presented as a percentage of forecasted baseline sales, which provides a useful benchmark for comparison against the base case.

Table 1.11. Baseline Sales, Cumulative Technical, and Achievable Technical Potential for Each Scenario (2024–2045)

Scenario	Baseline Sales–22-Year (aMW)	Technical Potential–22-Year (aMW)	Achievable Technical Potential–22-Year (aMW)	Achievable Technical Potential as % of Baseline Sales	Achievable Economic Potential–22-Year (aMW)	Achievable Economic Potential as % of Baseline Sales
Base Case	1,240	263	228	18%	132	11%
Extreme Climate Change	1,235	264	250	20%		
Accelerated Electrification	1,252	266	231	18%		
Extreme Climate Change and Accelerated Electrification	1,248	267	252	20%		

1.3.7. Highly Impacted Communities

Cadmus estimated potential impacts for highly impacted communities within the City Light service area. We considered equity by including highly impacted communities in the study segmentation. Highly impacted communities is defined as "the census tract ranks a 9 or 10 on the Environmental Health Disparities (EHD) Map, as designated by the Washington State Department of Health". They also include the census tracts "covered or partially covered by 'Indian Country' as defined in and designated by statute."[12] The EHD contains 19 criteria, which are grouped under environmental exposures (including fossil fuel pollution and vulnerability to climate change impacts that contribute to health inequities), environmental effects, socioeconomic factors, and sensitive populations. Cadmus selected highly impacted communities as the equity metric because of the data granularity available to incorporate into the DSMPA.

The highly impacted disaggregation is done based on income qualification in the City Light Utility Discount Program[13] and Washington Environmental Health Disparities index[14] for income-qualified customers. Thus, only customers with a household income equal to or less than 70% of the state median income, by household size, and with an EHD rank of 9 and higher were considered highly impacted.

12 Washington State Department of Health. Accessed June 2023. "Instructions for Utilities to Identify Highly Impacted Communities." https://doh.wa.gov/data-statistical-reports/washington-tracking-network-wtn/climate-projections/clean-energy-transformation-act/ceta-utility-instructions

13 City of Seattle, Seattle Public Utilities. Accessed June 2023. "Utility Discount Program." https://www.seattle.gov/utilities/your-services/discounts-and-incentives/utility-discount-program

14 Washington State Department of Health. Accessed June 2023. "Washington Environmental Health Disparities Map." https://doh.wa.gov/data-and-statistical-reports/washington-tracking-network-wtn/washington-environmental-health-disparities-map

1.4. Organization of This Report

This report presents the study findings in three volumes. Volume I—this document—presents the methodologies and findings of the energy efficiency potential assessment. Volume II contains appendices and provides methodologies and detailed results of demand response and solar and battery potential assessments along with supplemental materials.

Volume I includes the following chapters:

- *Methodology Overview* provides an overview of the methodology Cadmus and City Light used to estimate technical, achievable technical, and achievable economic potential.
- *Baseline Forecast* provides detailed sector-level results for Cadmus' baseline end-use forecasts along with the scenarios.
- *Energy Efficiency Potential* provides detailed sector, segment, and end-use specific estimates of conservation potential as well as a discussion of top-saving measures in each sector. It also provides the potential estimates for the scenarios.
- *Comparison to 2022 CPA* shows how this study's results (the 2024 DSMPA) compared with City Light's prior CPA.
- *Detailed Methodology* describes Cadmus' combined top-down/bottom-up modeling approach through several sections.
    - *Developing Baseline Forecasts* provides an overview of Cadmus' approach to produce baseline end-use forecasts for each sector.
    - *Baseline Forecast Scenarios* describes the scenarios in detail.
    - *Measure Characterization* describes Cadmus' approach for developing a database of ECMs, deriving from the estimates of conservation potential. This section discusses how Cadmus adapted measure data from the 2021 Power Plan, the RTF, the RBSA, the CBSA, and other sources for this study.
    - *Estimating Conservation Potential* discusses assumptions and underlying equations used to calculate technical and achievable technical potential.
    - *Development of Conservation IRP Inputs* details the 2024 DSMPA methodology of determining cost-effective conservation supply curves as an input for City Light's IRP optimization model to identify the achievable economic potential while providing an overview of the methodology from the City Light economic screening process to determine the cost-effective conservation potential for the *Energy Independence Act* and the CEIP.

Volume II contains the appendices:

- Appendix A. Washington Initiative 937 (I-937) Compliance Documentation
- Appendix B. Baseline Data
- Appendix C. Detailed Assumptions and Energy Efficiency Potential

- Appendix D. Measure Details[15]
- Appendix E. Demand Response Potential Assessment
- Appendix F. Solar and Battery Potential Assessment

2. Methodology Overview

This chapter gives an overview of the methodology Cadmus used in 2024 DSMPA followed by an explanation of the considerations for the design of this potential study. The methodology is described in greater detail in the *6. Detailed Methodology* section.

2.1. Methodology: An Overview

Estimating conservation potential draws upon a sequential analysis of various ECMs in terms of technical feasibility (technical potential), expected market acceptance, and the normal barriers that could impede measure implementation (achievable technical potential).

For this assessment Cadmus took three primary steps:

- Developed the baseline forecast, which involved determining the 22-year future energy consumption by sector, market segment, and end use. We calibrated the base year (2023) to City Light's sector-level, corporate load forecast produced in 2022. Baseline forecasts in this report included estimated impacts of market-driven efficiency, codes and standards, and City Light's estimates of the impacts of COVID-19 on commercial and residential energy usage. They also included the impacts of building electrification and climate change. Cadmus worked with the City Light load forecast team to determine all of these impacts.
- Estimated technical potential based on the incremental difference between the baseline load forecast and an alternative forecast reflecting the technical impacts of specific energy efficiency measures.
- Estimated achievable technical potential by applying ramp rates and achievability percentages to technical potential, described in greater detail in this section.

This approach offered two advantages:

- Savings estimates were driven by a baseline forecast that is consistent with the assumptions used in City Light's adopted 2022 corporate load forecast.
- The approach had consistency among all assumptions underlying the baseline and alternative forecasts—technical and achievable technical potential. The alternative forecasts changed relevant inputs at the end-use level to reflect ECM impacts. Because estimated savings represented the difference between baseline and alternative forecasts, they could be directly attributed to specific changes made to analysis inputs.

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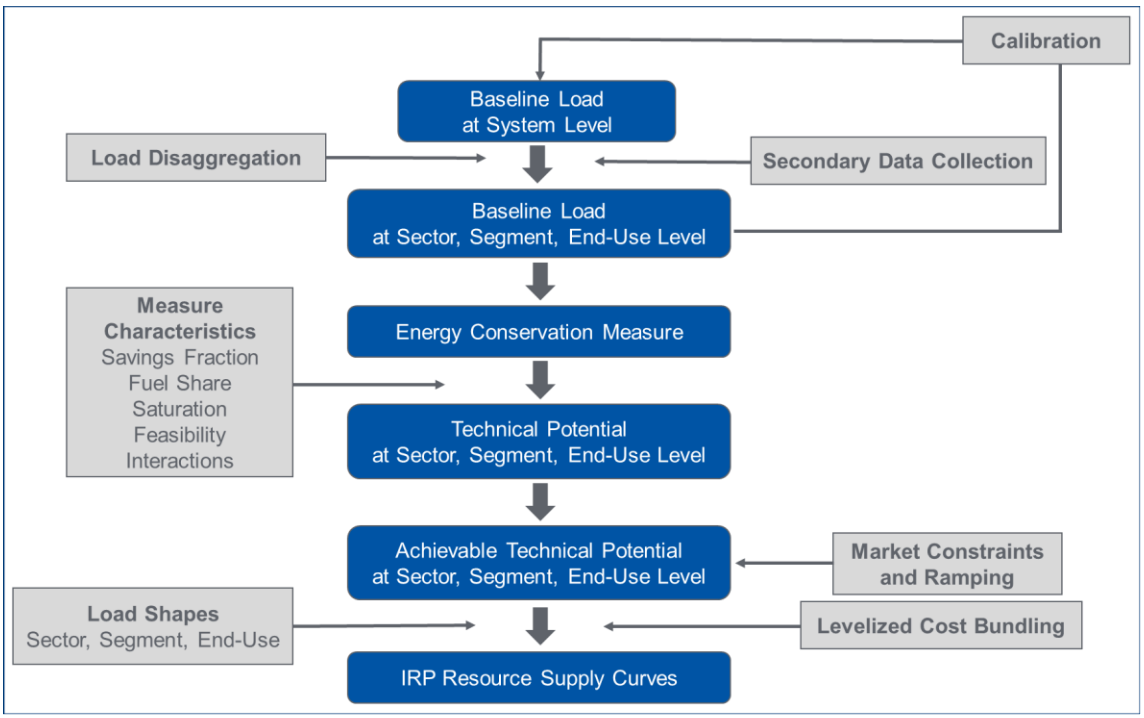
15 Appendix D includes sector, end-use group, and measure-level results by technical, achievable technical, and IRP selected potential (achievable economic potential).

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, climate change, and market trends including building electrification. Cadmus then disaggregated this load forecast into its constituent customer sectors, customer segments, and end-use components.

The bottom-up component estimates electric consumptions for each major building end-use and applies the potential technical impacts of various ECMs to each end-use. This bottom-up analysis includes assumptions of end-use equipment saturations, fuel shares, ECM technical feasibility, ECM cost, and engineering estimates of ECM unit energy consumption (UEC) and savings. A detailed description of the methodology can be found in the *6. Detailed Methodology* section.

Figure 2.1. Overall Methodology for Assessment of Demand-Side Management Potential



In the final step, Cadmus developed energy efficiency supply curves so City Light's IRP portfolio optimization model could identify the amount of cost-effective energy efficiency. The portfolio optimization model required hourly forecasts of electric energy efficiency potential. To produce these hourly forecasts, Cadmus applied hourly end-use load profiles to annual estimates of achievable technical potential for each measure. These profiles are similar to the shapes the Council used in its 2021 Power Plan supply curves and to those the RTF used in its UES measure workbooks. New to this study, Cadmus adopted a select set of commercial sector end-use load shapes from National Renewable Energy Laboratory's ComStock database.[16]

2.2. Considerations and Limitations

This study provides insights into which measures City Light could offer in future programs and is intended to inform program targets. Several other considerations about the design of this potential study may cause future program plans to differ from study results:

- The baseline forecasts are based on City Light's adopted 2022 Corporate Forecast. It includes assumptions about the impacts of COVID-19 on commercial and residential energy usage that, by default, impact the related energy efficiency potential. Due to the lack of data and knowledge about future pandemic impacts, it is possible that the near-term demand and available potential has more uncertainty than in non-pandemic times.
- This potential study uses broad assumptions about the adoption of energy efficiency measures. Program design, however, requires a more detailed examination of historical participation and incentive levels on a measure-by-measure basis. The study can inform planning for measures City Light has not historically offered or can focus the program design on areas with remaining amounts of potential identified in this study.
- This potential study does not consider program implementation barriers. Though it includes a robust, comprehensive set of efficiency measures, it does not examine whether these measures can be delivered through incentive programs or what incentive rate is appropriate. Many programs require strong trade ally networks or must overcome market barriers to succeed.
- This potential study cannot predict market changes over time. Though it accounts for changes in codes and standards as they are enacted today, the study cannot predict future changes in policies, pending codes and standards, and which new technologies may become commercially available. City Light programs are not static and have the flexibility to address changes in the marketplace, whereas the potential study estimates use information collected at a single point in time.
- This potential study does not attempt to forecast or otherwise predict future changes in energy efficiency measure costs. The study includes Council and RTF incremental energy efficiency measure costs, including equipment, labor, and operations and maintenance (O&M), but it does not attempt to forecast changes to these costs during the course of the study (except where the Council makes adjustments). For example, changes in incremental costs may impact some emerging technologies, which may then impact both the speed of adoption and the levelized cost of that measure (impacting the IRP levelized cost bundles).

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[16] Parker, Andrew, Henry Horsey, Matthew Dahlhausen, Marlena Praprost, Christopher CaraDonna, Amy LeBar, and Lauren Klun. March 2023. *ComStock Reference Documentation: Version 1*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5500-83819. https://www.nrel.gov/docs/fy23osti/83819.pdf

- This study estimated the potential for highly impacted communities separately. Because of the lack of data on program and administrative costs, Cadmus used the same program and administration costs across the DSMPA. City Light has reason to believe that these costs would be significantly higher for customers in highly impacted communities compared with customers not in highly impacted communities. City Light expects to have more data in future DSMPAs to refine these assumptions and provide the best service to highly impacted communities.
- Like the prior CPA, Commercial UEC relies on NEEA's CBSA data, which is supplemented by data from the U.S. Energy Information Administration's Commercial Buildings Energy Consumption Survey (CBECS). However, these data may not reflect the type of commercial facilities in City Light's territory and have an inherent level of uncertainty. On May 28, 2021, the Council's Conservation Resources Advisory Committee reiterated that additional research for the region is needed to develop more reliable energy use intensity data for commercial buildings. In addition, Seattle contains many large multifamily buildings with insufficient primary data (such as baseline stock characteristics). For example, this potential study assessed the impacts of the 2021 Seattle Energy Code and incorporated the code as best as possible. Data were limited on the natural gas fuel shares of equipment in multifamily construction, and therefore it was difficult to correctly estimate the impact of this 2021 code. As a result, this potential study has limited insight to inform the remaining potential in this segment and requires further research.
- This study uses City Light's nonresidential database to identify sales and the number of customers for each commercial market segment. This includes historical sales and number of customers for nonresidential buildings, as well as annual forecasts of commercial square footage for each commercial market segment.
- This study applied accelerated ramp rates to approximate the impact of the Inflation Reduction Act (IRA) and state and local initiatives. Across the base results and electrification scenarios, this study informs a range of results that can be used to indirectly infer the possible impact of the IRA, but there remains uncertainty in how IRA will impact the energy landscape in Washington state.
- This study modeled the impacts of climate change by increasing cooling load and decreasing heating load over time. The study assumes cooling loads steadily increase year after year and heating loads steadily decrease. In reality, year-to-year weather fluctuations mean that cooling loads will increase and decrease year-to-year while the overall trend is increasing cooling loads over time. In addition, this study uses a prediction of weather changes and acknowledge there is a level uncertainty in such predictions.

Though these considerations and limitations impact the DSMPA, it is worth noting that Chapter 194-37 of the WAC requires City Light to complete and update a conservation potential assessment every two years. City Light can then address some of these considerations over time and mitigate short- and mid-term uncertainties by continually revising DSMPA assumptions to reflect changes in the market.

3. Baseline Forecast

An assessment of demand-side management potential begins with developing baseline end-use load forecasts, followed by calibrating results to City Light's corporate load forecast in the base year (2023).

This chapter will briefly describe the methodology of this analysis followed by the results, presented for each sector separately.

3.1. Scope of Analysis

Cadmus started the analysis by developing separate baseline end-use load forecasts over a 22-year (2024 to 2045) planning horizon for each of the three sectors: residential, commercial, and industrial. We then calibrated these forecasts to City Light's corporate load forecast in the base year (2023). The forecasts do not include future programmatic conservation, but they do account for enacted equipment standards and building energy codes and the impacts of COVID-19, building electrification, and climate change.

For each sector, Cadmus further distinguished the results by building segments, facility types, and applicable end uses:

- Sixteen residential segments of existing and new construction:
  - Single-family, single-family highly impacted
  - Multifamily low-rise, multifamily low-rise highly impacted, multifamily mid-rise, multifamily mid-rise highly impacted, multifamily high-rise, multifamily high-rise highly impacted[17]
- Forty commercial segments, which include new and existing construction for 20 standard commercial segments
- Eight industrial segments (existing construction only), including water and wastewater treatment segments[18]

Cadmus and City Light's load forecast team worked together to develop a baseline forecast that aligned with City Light's 2022 adopted corporate load forecast. To achieve this, Cadmus modified the residential baseline forecast to include assumptions about building electrification (based on the moderate market advancement scenario of the Electric Power Research Institute's (EPRI's) "Phase 2 – Seattle City Light Electrification Assessment" study) and climate change (by changing heating and cooling UECs and cooling equipment saturations over time). These changes are detailed in the following section as well as in the *6. Detailed Methodology* section.

Figure 3.1 shows the distribution of projected sales by sector for the 2024 through 2045 period. In 2045, the commercial sector will account for roughly 58% of projected sales, while the residential and industrial sectors will account for 32% and 10%, respectively.

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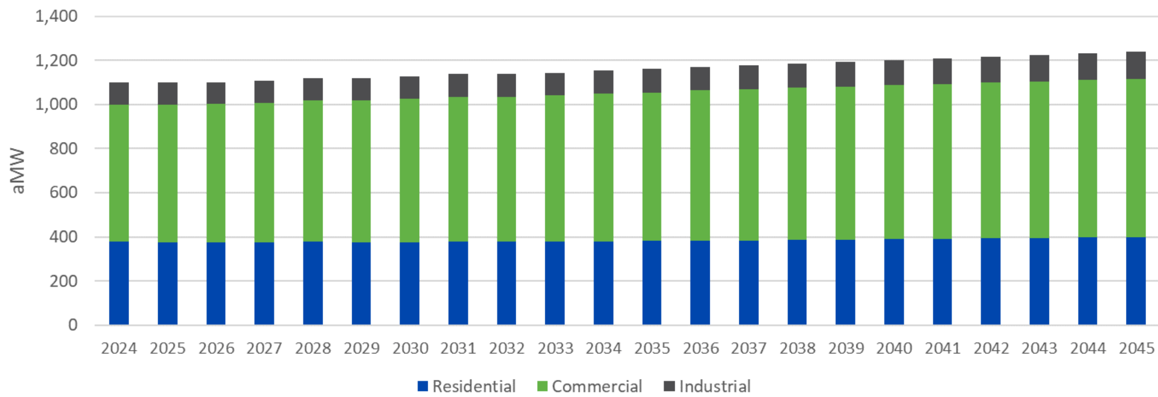
17 Multifamily low-rise is defined as multifamily buildings with one to three floors, while mid-rise is defined as buildings with four to six floors and high-rise is defined as buildings with more than six floors. The multifamily common area is treated within the commercial sector.

18 Although City Light's internal classification system considers water and wastewater treatment segments as part of the commercial sector, to align with 2021 Northwest Power Plan, Cadmus included these two segments in the industrial sector. For this purpose, Cadmus removed water and wastewater treatment plants' sales (including the sales of King County Wastewater Treatment Plant and Seattle Public Utilities) from commercial sales and added it to industrial sales.

Figure 3.1. Annual Baseline Sales by Sector (2024–2045)



3.2. Residential

Cadmus considered eight residential segments with 28 end uses. Table 3.1 lists the residential segments and end uses considered as well as the broad end-use groups used in this study. Overall, the residential sector accounted for approximately 32% of total baseline sales.

Cadmus used City Light's 2022 residential household forecast in the baseline forecast. Cadmus disaggregated these households into standard-income and highly impacted segments.

For this study, Cadmus, first, defined equity to represent the vulnerable populations and highly impacted communities within the City Light service area as described below:

- Vulnerable populations are "population groups that are more likely to be at higher risk for poor health outcomes in response to environmental harms, due to: (i) Adverse socioeconomic factors, such as unemployment, high housing and transportation costs relative to income, limited access to nutritious food and adequate health care, linguistic isolation, and other factors that negatively affect health outcomes and increase vulnerability to the effects of environmental harms; and (ii) sensitivity factors, such as low birth weight and higher rates of hospitalization."[19]
- Highly Impacted Communities is defined as "the census tract ranks a 9 or 10 on the EHD Map, as designated by the Washington State Department of Health". They also include the census tracts "covered or partially covered by 'Indian Country' as defined in and designated by statute."[20] The EHD contains 19 criteria which are grouped under environmental exposures (including fossil fuel

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19 Washington State Legislature. RCW 70A.02.010. "Revised Code of Washington. Title 70A Environmental Health and Safety" https://app.leg.wa.gov/RCW/default.aspx?cite=70A.02.010

20 Washington State Department of Health. Accessed June 2023. "Instructions for Utilities to Identify Highly Impacted Communities." https://doh.wa.gov/data-statistical-reports/washington-tracking-network-wtn/climate-projections/clean-energy-transformation-act/ceta-utility-instructions

pollution and vulnerability to climate change impacts that contribute to health inequities), environmental effects, socioeconomic factors, and sensitive populations.

Between two equity descriptions, Cadmus selected the highly impacted communities because of the data granularity available to incorporate into the DSMPA. In addition, this study assumes climate change and it aligns well with the highly impacted definition that includes environmental impacts. The highly impacted disaggregation is done based on income qualification in the City Light Utility Discount Program[21] and Washington Environmental Health Disparities index[22] for income-qualified customers. Thus, only customers with a household income of equal to or less than 70% of the state median income, by household size, and with an EHD rank of 9 and higher were considered highly impacted.

Cadmus combined the highly impacted communities' distributions by building type with residential household forecasts, estimates of end-use saturations, fuel shares, efficiency shares, and UEC to produce a sales forecast through 2045. This approach is described in the *6.1. Developing Baseline Forecasts* section.

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[21] City of Seattle, Seattle Public Utilities. Accessed June 2023. "Utility Discount Program." https://www.seattle.gov/utilities/your-services/discounts-and-incentives/utility-discount-program

[22] Washington State Department of Health. Accessed June 2023. "Washington Environmental Health Disparities Map." https://doh.wa.gov/data-and-statistical-reports/washington-tracking-network-wtn/washington-environmental-health-disparities-map

Table 3.1. Residential Segments and End Uses

Segments	End-Use Group	End Uses	
Single-Family Multifamily – High-Rise Multifamily – Mid-Rise Multifamily – Low-Rise Single-Family – Highly impacted Multifamily – High-Rise Highly impacted Multifamily – Mid-Rise Highly impacted Multifamily – Low-Rise Highly impacted	Appliances	Cooking Oven Cooking Range Dryer	Freezer Refrigerator
	Cooling	Cool Central	Cool Room
	Electronics	Computer – Desktop Computer – Laptop Copier DVD Player Home Audio System Microwave	Monitor Multifunction Device Plug Load (Other) Printer Set-Top Box Television
	Exterior Lighting	Lighting Exterior Standard	
	Heating	Air-Source Heat Pump with Back-Up Ductless Heat Pump – Central Heat Ductless Heat Pump – Central Heat with Back-Up Ductless Heat Pump – Room Heat Ductless Heat Pump – Room Heat with Back-Up	Circulation – Domestic Hot Water Circulation – Hydronic Heating Heat Central Heat Pump Heat Room Ventilation – Air
	Interior Lighting	Lighting Interior Linear Fluorescent Lighting Interior Specialty	Lighting Interior Standard Lighting Exterior Standard
	Miscellaneous	Air Purifier Other	Wastewater Pool Pump
	Water Heating	Water Heat GT 55 Gallon	Water Heat LE 55 Gallon

Figure 3.2 shows residential sales by segment for each year of the study. City Light projects that more than 60,000 new housing units will be built by 2045. New multifamily units account for about 50% of new residential construction, so both multifamily and single-family segment baseline sales are expected to increase at a similar rate, as shown in Table 3.2.

Figure 3.2. Annual Residential Baseline Sales by Segment (2024–2045)

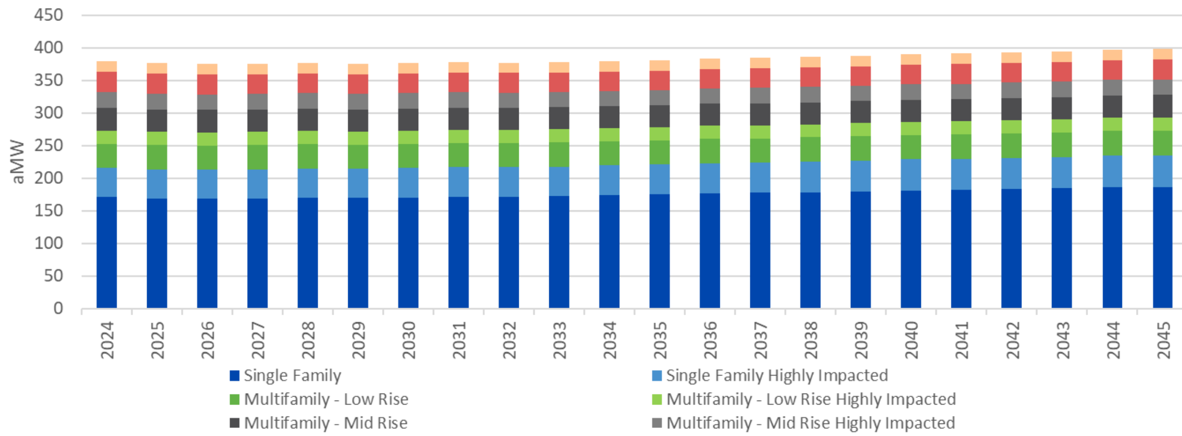


Table 3.2. Residential Baseline Sales and Housing Units by Segment

Sector	Sales (aMW)		Housing Units	
	2024	2045	2024	2045
Single-Family	171	187	169,790	194,491
Single-Family Highly Impacted	45	49	44,325	50,774
Multifamily – Low-Rise	37	38	48,533	55,593
Multifamily – Low-Rise Highly Impacted	20	20	26,360	30,195
Multifamily – Mid-Rise	35	34	47,837	54,797
Multifamily – Mid-Rise Highly Impacted	24	24	33,161	37,985
Multifamily – High-Rise	31	30	42,564	48,756
Multifamily – High-Rise Highly Impacted	17	16	22,753	26,063
Total	**380**	**398**	**435,324**	**498,654**

In the base year (2023), Cadmus calibrated baseline forecasts to City Light's load forecast, ensuring that the study's starting point aligned with the starting point of City Light's forecasts. Cadmus then produced a residential forecast.

Figure 3.3 shows the residential baseline forecast by end use. Overall, City Light's residential forecast increases by approximately 5% over the 22-year horizon. This is primarily due to assumptions for the greater saturation of electric heat pumps as a result of electrification and for the greater saturation of air conditioning (AC) units as a result of climate change. The figure also shows that heating and appliances are the top two consuming end-use groups, accounting for a combined 59% of residential consumption. The next three highest forecasted end-use groups are water heating (17.5%), electronics (15.2%), and interior lighting (3.3%).

Figure 3.3. Annual Residential Baseline Forecast by End-Use Group (2024–2045)

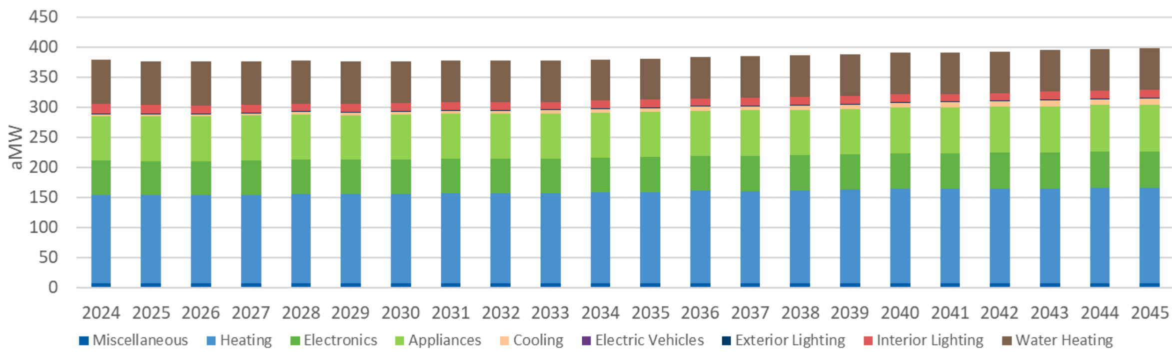


Table 3.3 shows the assumed average electric consumption per household for each residential segment in 2045. Differences in the average consumption for each segment drive either differences in UEC, saturations, fuel shares,[23] or any combination of differences. Appendix B includes detailed baseline data for the residential sector.

Table 3.3. Per Household Baseline Sales (kWh/Home) by Sector and End-Use Group – 2045

End-Use	Single-Family	Multifamily – Low-Rise	Multifamily – Mid-Rise	Multifamily – High-Rise
Miscellaneous	169	104	86	86
Heating	3,171	2,467	2,401	2,369
Electronics	1,420	756	665	717
Appliances	1,732	890	1,059	1,059
Cooling	161	203	197	197
Exterior Lighting	50	0	1	1
Interior Lighting	346	124	118	118
Water Heating	1,367	1,398	918	918
Total	**8,417**	**5,942**	**5,445**	**5,465**

Note: Highly impacted kilowatt-hour per home values are equivalent to those for non-highly impacted homes.

Table 3.4 shows the electric end-use group distributions of the baseline consumption in 2045 by building type. For each building type, heating makes up greater than 25% of the building type consumption in 2045 and is the end-use group with the largest consumption.

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

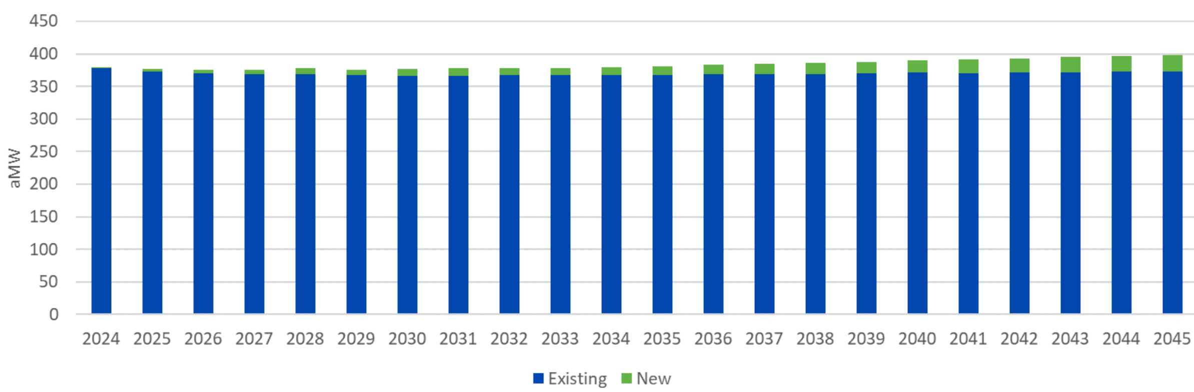
Table 3.4. Residential Consumption End-Use Group Distributions by Segment – 2045

End-Use	Single-Family	Multifamily – Low-Rise	Multifamily – Mid-Rise	Multifamily – High-Rise
Miscellaneous	2%	2%	2%	2%
Heating	38%	42%	44%	43%
Electronics	17%	13%	12%	13%
Appliances	21%	15%	19%	19%
Cooling	2%	3%	4%	4%
Exterior Lighting	1%	0.01%	0.02%	0.02%
Interior Lighting	4%	2%	2%	2%
Water Heating	16%	24%	17%	17%
Total	**100%**	**100%**	**100%**	**100%**

Note: Highly impacted end use percentage distribution values are equivalent to the non-highly impacted.

Figure 3.4 shows forecasted residential sales by construction vintage over the study horizon. Study results indicate that approximately 7% of 2045 sales will derive from new construction homes.

Figure 3.4. Annual Residential Baseline Sales by Construction Vintage (2024–2045)



3.3. Commercial

Cadmus considered 20 commercial building segments and 18 end uses. Table 3.5 shows the commercial segments and end uses considered in this study as well as the corresponding segment and end-use groups presented in this report. Cadmus chose commercial segments for consistency with the 2021 Power Plan with one exception: the multifamily common area was not a standalone segment in the 2021 Power Plan. Overall, the commercial sector accounts for 718 aMW, or 58% of total baseline sales in 2045.

Table 3.5. Commercial Segments and End Uses

Segment Group	Segment
Assembly	Assembly
Data Center	Data Center
Hospital	Hospital
Large Grocery	Supermarket
Large Office	Large Office
	Medium Office
Lodging	Lodging
Multifamily Common Area	Multifamily Common Area
Miscellaneous	Other
Other Health	Residential Care
Restaurant	Restaurant
Retail	Large Retail
	Medium Retail
	Small Retail
	Extra Large Retail
School	School K–12
Small Grocery	Mini Mart
Small Office	Small Office
University	University
Warehouse	Warehouse

End-Use Group	End-Uses
Cooking	Cooking
Cooling	Cooling Chiller
	Cooling Direct Expansion
Data Center	Data Center
	Server
Heat Pump	Heat Pump
Heating	Space Heat
Lighting	Exterior Lighting
	Interior Lighting
Miscellaneous	Computer – Desktop
	Computer – Laptop
	Other [a]
	Plug Load (Other)
	Wastewater
Refrigeration	Refrigeration
Ventilation and Circulation	Ventilation and Circulation
Water Heat	Water Heat GT 55 Gallon
	Water Heat LE 55 Gallon

[a] *Other end uses include all undefined loads such as elevators, automatic doors, and process loads.*

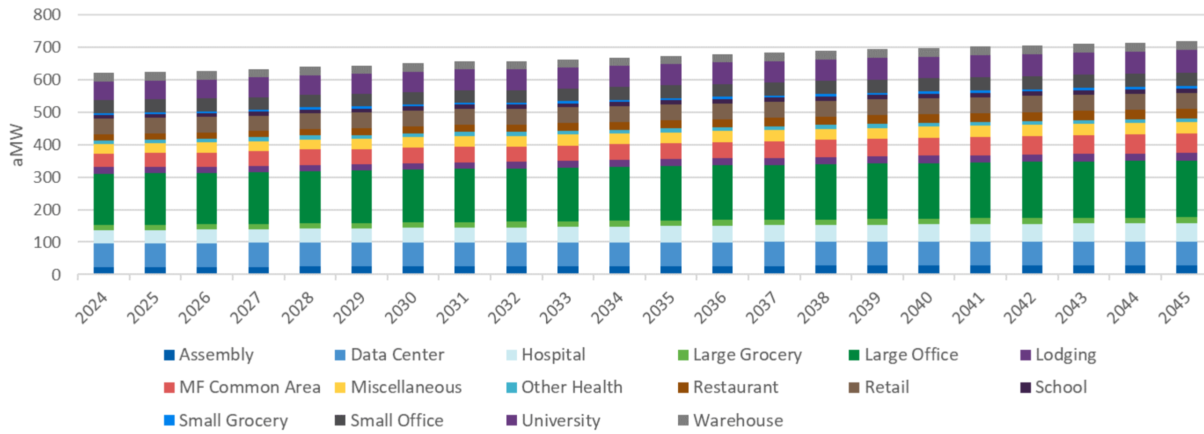
Cadmus used City Light's nonresidential database to identify sales and the number of customers for each commercial market segment. The database combined City Light's billing data with King County Assessor data, as well as with other secondary data sources, to identify the customer segment and consumption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

Cadmus also classified customers as commercial or industrial based on City Light's premise-level nonresidential customer database. Commercial customers are mapped to the segments listed in Table 3.5. (Industrial customers are mapped to the segments listed in Table 3.6, shown in the *3.4. Industrial* section.)

To align with the City Light load forecast team's commercial building square footage, Cadmus adjusted the commercial building counts per segment, based on average square footage per building type from the 2022 CPA.

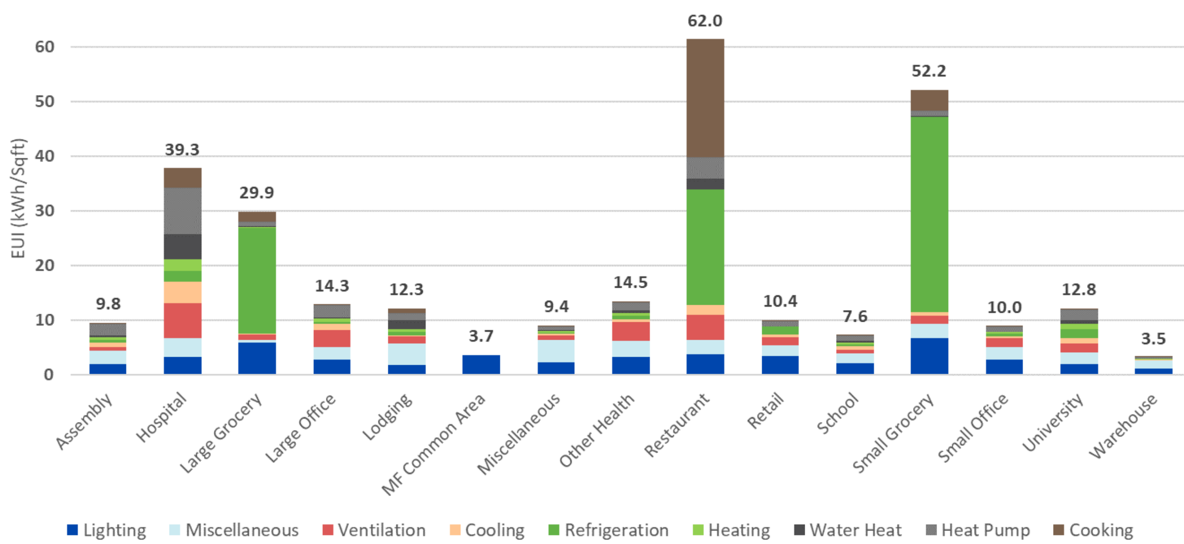
Figure 3.5 shows the distribution of baseline commercial energy consumption by segment for each year of the study. Large offices accounted for 24% of commercial baseline sales. Data center, university, and multifamily common areas accounted for 10%, 10%, and 8% of baseline sales, respectively. Together, these segments represent 53% of all commercial-sector sales.

Figure 3.5. Annual Commercial Baseline Sales by Segment (2024–2045)



Cadmus developed the whole-building electric energy intensities (total kilowatt-hours per building square feet) based on NEEA's CBSA IV. To develop the end-use intensities, Cadmus used the CBSA, the CBECS, and other Cadmus research. Further details are provided in the *6.1 Developing Baseline Forecasts* section. Figure 3.6 shows energy use intensities for each building type and end-use group.

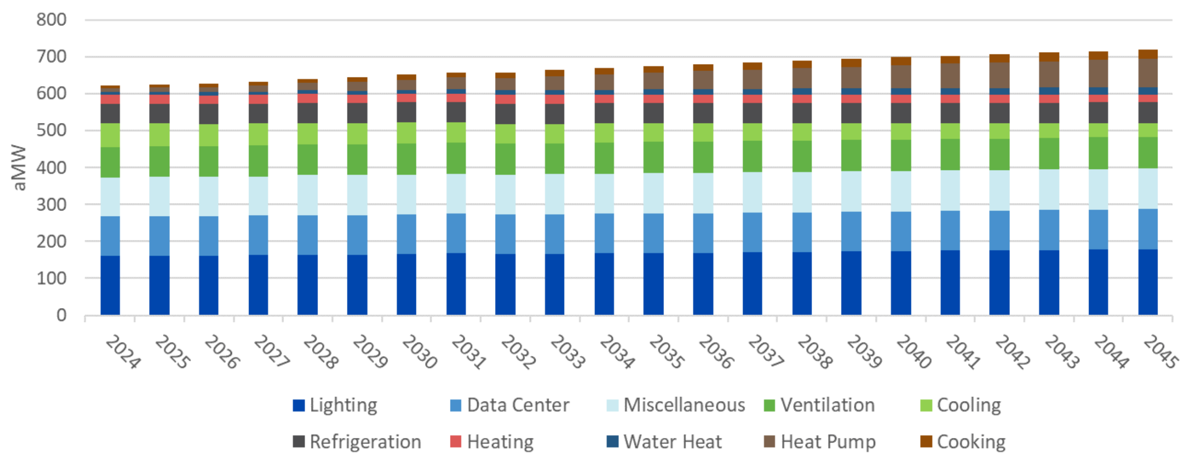
Figure 3.6. Commercial End-Use Group Intensities by Building Type – 2045



Note: The data center segment energy use intensity of 181.5 kWh per square foot is not included due to scaling. Additionally, all the consumption for the data center segment appears in the data center end-use group.

Figure 3.7 shows the commercial baseline forecast by end-use group. The forecast shows a load growth of commercial sales by roughly 0.7% on average per year over the study horizon. The highest consuming end-use group was lighting, accounting for 25% of projected commercial consumption in 2045 (approximately the same percentage of overall end use as in 2024). The miscellaneous, data center, and ventilation end-use groups also account for a large share of consumption, at 17%, 17%, and 13% of projected commercial sales in 2045, respectively. Appendix B includes detailed baseline data for the commercial sector.

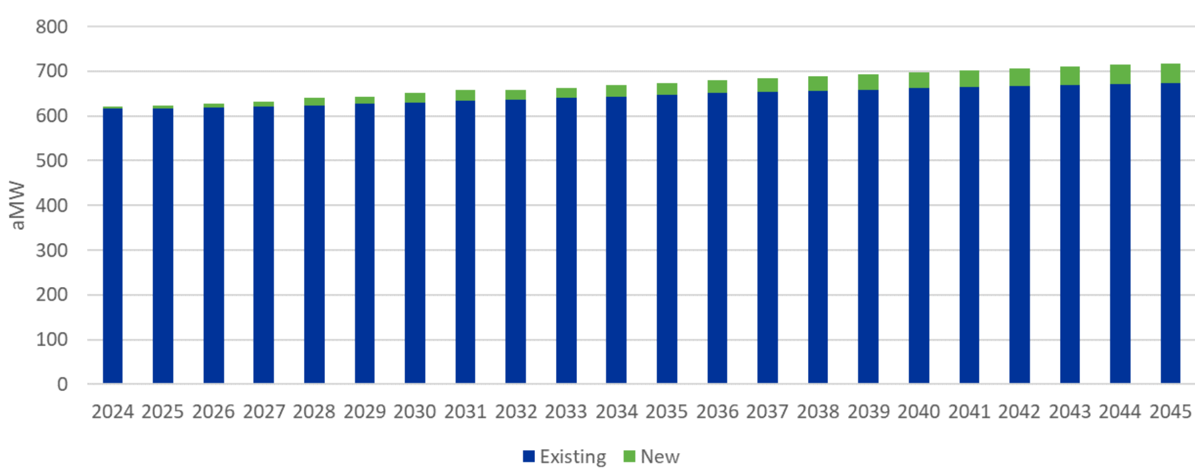
Figure 3.7. Annual Commercial Forecast by End-Use Group (2024–2045)



Note: The Miscellaneous end-use group includes laptops, desktops, and all other plug load and wastewater end uses.

New commercial floorspace is a significant contributor to load growth in the commercial sector. By 2045, 6% of the forecasted load will come from new construction. Figure 3.8 shows the commercial baseline forecast by construction vintage.

Figure 3.8. Annual Commercial Forecast by Construction Vintage (2024–2045)



3.4. Industrial

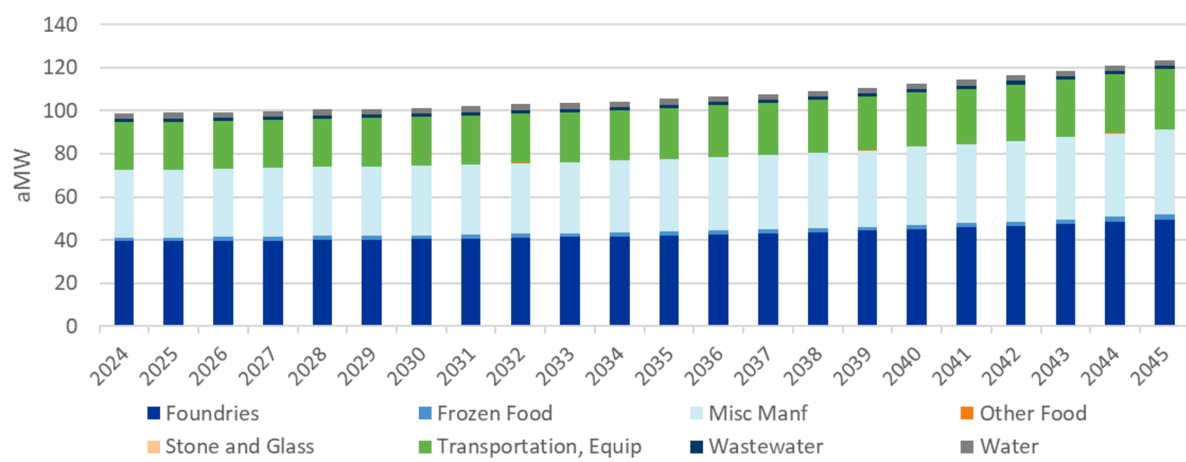
Cadmus disaggregated City Light's forecasted industrial sales into eight facility types/segments and 11 end-uses, as shown in Table 3.6. Overall, the industrial sector accounted for 124 aMW, or 10% of City Light's overall forecasted baseline sales in 2045. The sector included City Light's customers with known industrial processes in addition to customers who contribute wastewater and water treatment loads.

Table 3.6. Industrial Segments and End Uses

Segments	End Uses
	Process Air Compressor
Foundries	Lighting
Frozen Food	Fan
Miscellaneous Manufacturing	Pump
Other Food	Motors (Other)
Stone and Glass	Process (Other)
Transportation, Equipment	Process Heat
Wastewater	HVAC
Water	Other
	Process Electro Chemical
	Process Refrigeration

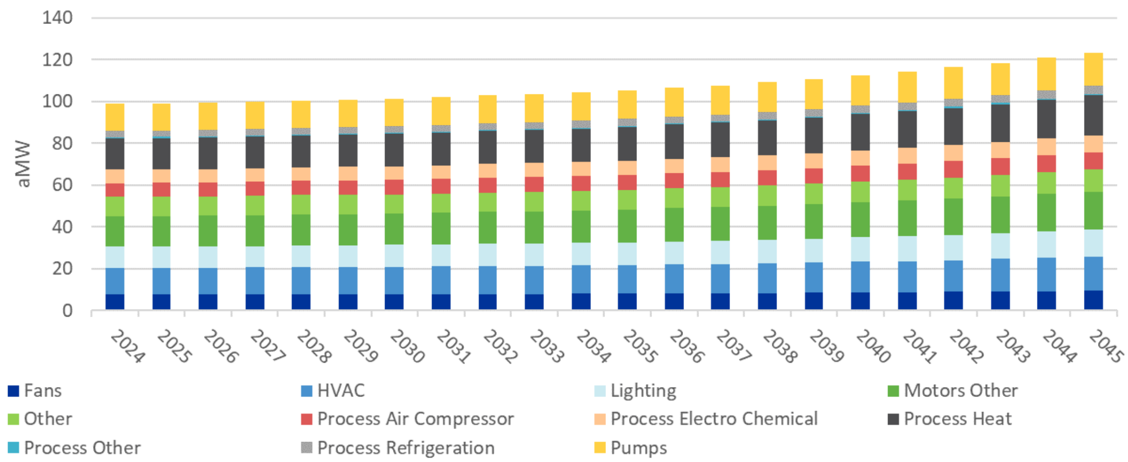
Like for the commercial sector, Cadmus relied on City Light's nonresidential customer database to determine the distribution of baseline sales by segment. Foundries account for 40% of industrial baseline sales; the next largest segments are miscellaneous manufacturing (32%) and transportation equipment (23%).

Figure 3.9. Annual Industrial Baseline Sales by Segment (2024–2045)



Cadmus relied on end-use distributions provided in the 2021 Power 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. Annual Industrial Baseline Sales by End-Use (2024–2045)



3.5. Scenarios

Cadmus worked with the City Light load forecast team to define three baseline sales forecast scenarios, listed in Table 3.7 and shown in Figure 3.11. We then updated the baseline sales to reflect the impacts of these scenarios. Details of these scenarios are provided in the *6. Detailed Methodology* chapter.

Table 3.7. Baseline Sales Forecast Scenario Descriptions

Scenario	Definition
Extreme Climate Change	Reflects the impacts of higher temperatures on the residential and commercial forecast based on cooling degree days (CDDs) and heating degree days (HDDs) associated with the CanESM2 model[24] provided by City Light. Note that because the CanESM2 model exhibited volatile year-over-year temperature patterns, this was reflected in the modeling output, creating a "zig zag" effect. Also reflects the impacts of higher AC saturations on the residential forecast by increasing the final year AC saturation to 85%.
Accelerated Electrification	Reflects higher building electrification adoption rates based on the accelerated market advancement scenario of EPRI's "Phase 2 – Seattle City Light Electrification Assessment" study.
Extreme Climate Change and Accelerated Electrification	Reflects the combined impacts of the extreme climate change and accelerated electrification scenarios.

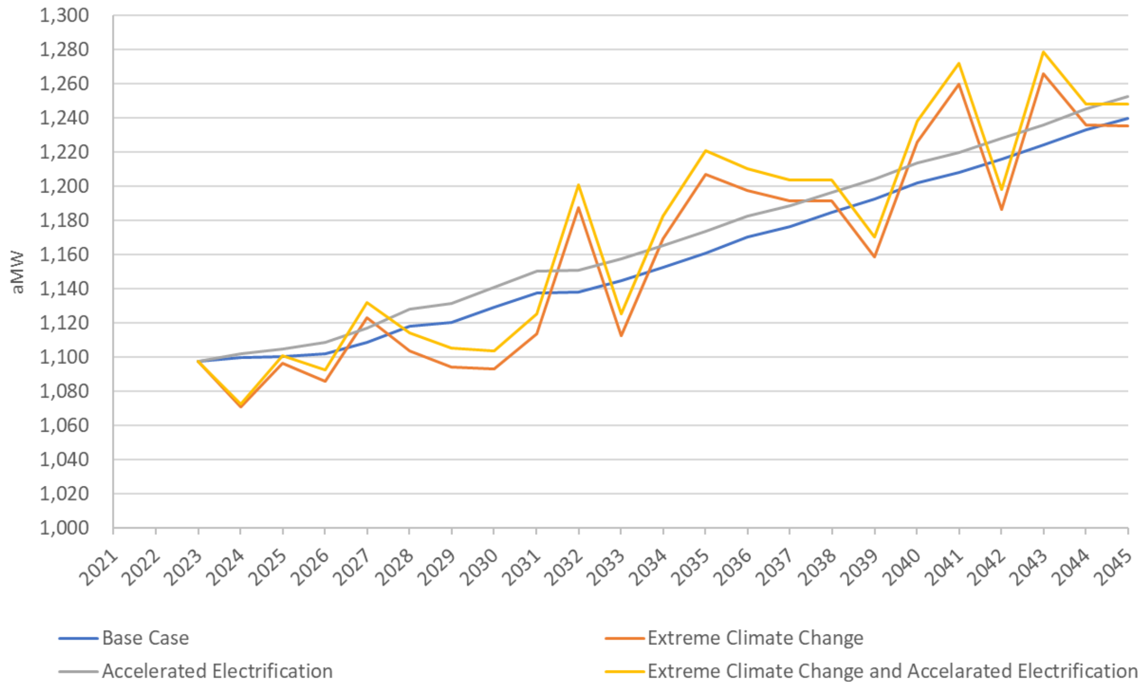
24 The second generation Canadian Earth System Model, CanESM2, is the fourth generation of the coupled global climate model, CGCM4, developed by the Canadian Centre for Climate Modelling and Analysis of Environment and Climate Change Canada. For more information, visit https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/modeling-projections-analysis/centre-modelling-analysis/models/second-generation-earth-system-model.html. City Light performed additional bias correction of this model to account for geographic resolution issues.

Figure 3.11. Baseline Sales Forecast Scenarios

	What's Included	
Scenario	Building Electrification	Climate Change
Base Case	Moderate	Moderate
Extreme Climate Change	Moderate	More Extreme
Accelerated Electrification	Accelerated	Moderate
Extreme Climate Change and Accelerated Electrification	Accelerated	More Extreme

Figure 3.12 shows baseline sales when the impacts of each scenario are considered. The following subsections present these impacts for each sector separately. Note that for the extreme climate change scenarios, the volatile year-over-year temperature patterns exhibited in the CanESM2 model were reflected in the modeling output, creating a “zig zag” effect.

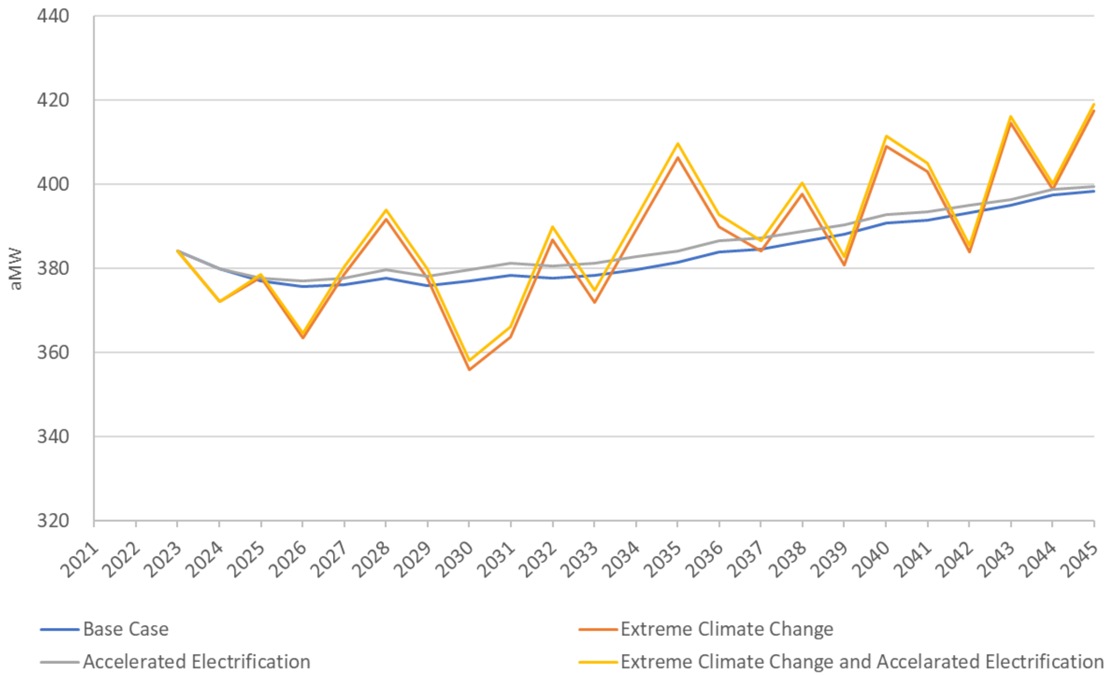
Figure 3.12. Annual Baseline Sales for All Three Sectors Combined for Each Scenario (2024–2045)



3.5.1. Residential

Figure 3.13 shows the residential baseline sales for each scenario for each year of the study.

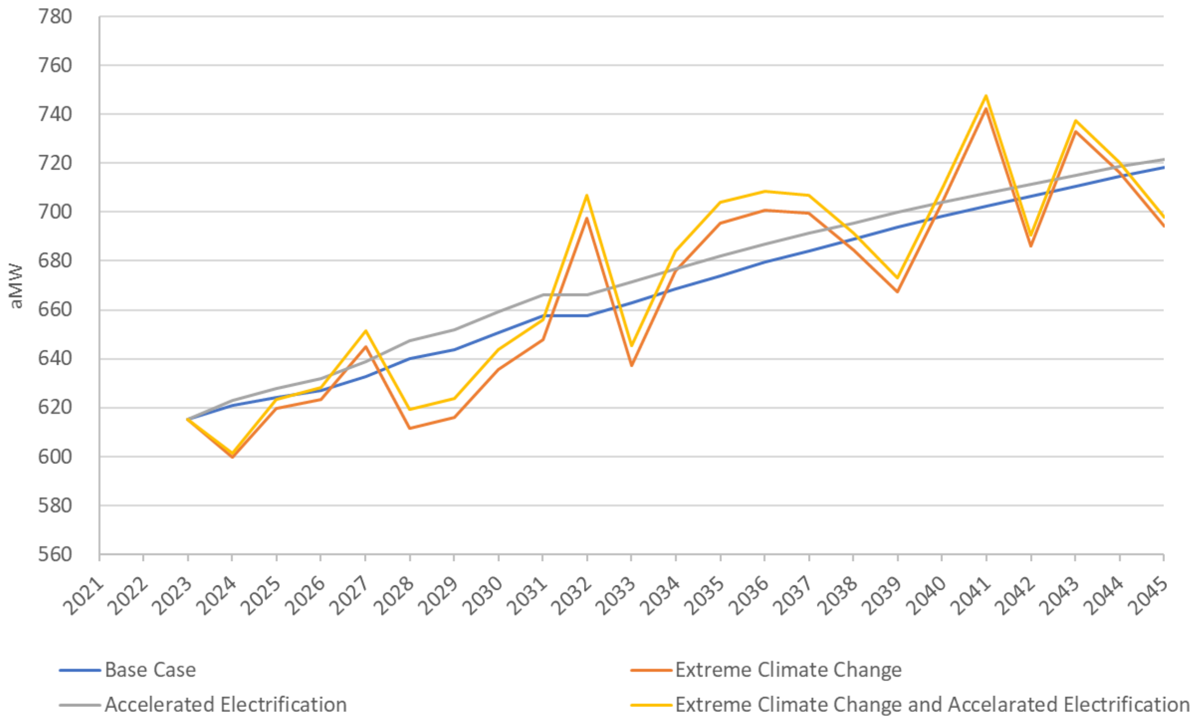
Figure 3.13. Annual Residential Baseline Sales for Each Scenario (2024–2045)



3.5.2. Commercial

Figure 3.14 shows the commercial baseline sales for each scenario for each year of the study.

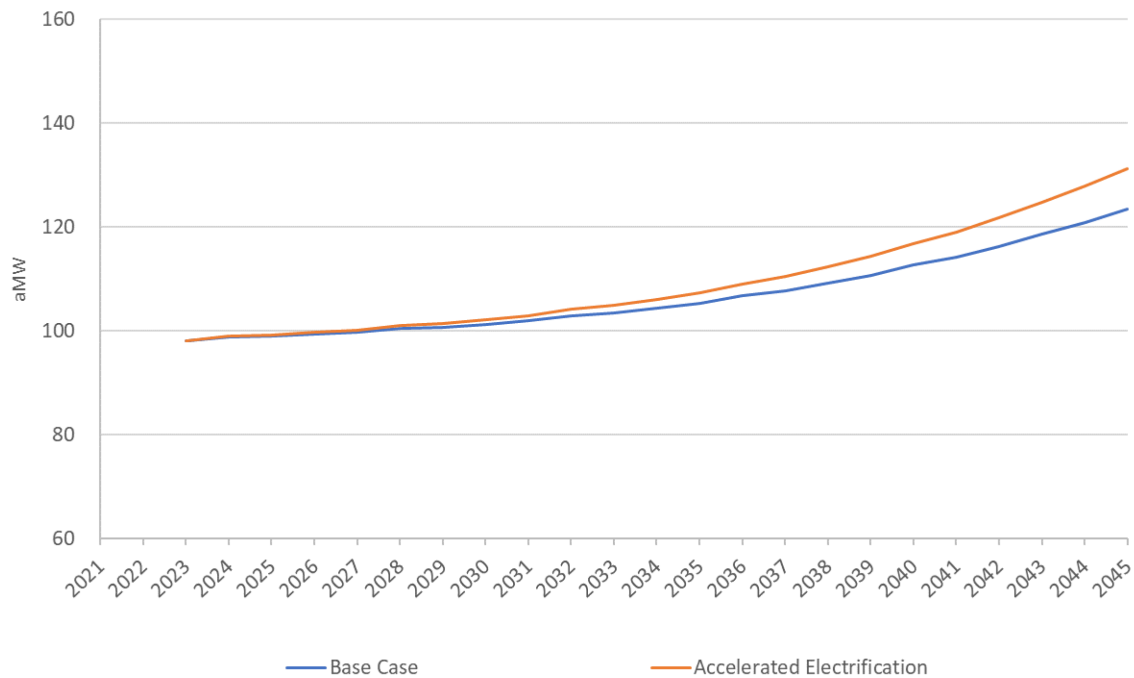
Figure 3.14. Annual Commercial Baseline Sales for Each Scenario (2024–2045)



3.5.3. Industrial

Climate change is assumed to not impact the industrial sector and only the accelerated electrification scenario was evaluated, as shown in Figure 3.15.

Figure 3.15. Annual Industrial Baseline Sales for Base Case and Accelerated Electrification Scenario (2024–2045)



4. Energy Efficiency Potential

City Light requires accurate estimates of technically achievable energy efficiency potential, which are essential for its IRP and program planning efforts. These potentials are then bundled based on levelized cost of conserved energy so that the IRP model can select the optimal amount of energy efficiency potential.

In order to support these efforts, Cadmus performed an in-depth assessment of technical potential and achievable technical potential in three sectors: residential, commercial, and industrial. This chapter presents the detailed results of this assessment.

4.1. Overview

This study included a comprehensive set of conservation measures, including those assessed by the Council in the 2021 Power Plan and by the RTF. Cadmus began its analysis by assessing the technical potential of hundreds of unique conservation measures applicable to each sector, segment, and construction vintage (as discussed in the *Baseline Forecast* section).

Cadmus considered 10,257 permutations of conservation measures representing a wide range of technologies and applications. Permutations are defined as unique measure, sector, segment, end-use, construction vintage, and baseline combinations that have technical potential (no below-standard measures were included). For example, an ENERGY STAR® air purifier for residential single-family new construction with a market average baseline is a different permutation than an ENERGY STAR® air purifier for residential single-family existing construction with a market average baseline. Table 4.1 lists the number of conservation measures and permutations by sector considered in this study.

Table 4.1. Measures and Permutations

Sector	Measures	Permutations
Residential	152	3,940
Commercial	1,063	6,135
Industrial	33	182
Total	**1,248**	**10,257**

Table 4.2 shows baseline sales and cumulative technical and achievable technical potential by sector. Study results indicate that 263 aMW of technically feasible conservation potential—21% of baseline sales—will be available by 2045, and that 87% of that amount (228 aMW) is considered achievable in 2045. The achievable technical potential corresponds to 18% of baseline sales. Technical and achievable technical potential are inclusive of future City Light–funded conservation. That is, the baseline consumption forecasts account for historically achieved and planned City Light–funded conservation prior to 2024. However, the estimated potential identified is inclusive of—not in addition to—forecasted program savings. In other words, the baseline forecast excludes future, planned energy efficiency program efforts but the savings estimates include future energy efficiency program savings.

The results in this report account for line losses and represent cumulative energy savings at the generator (unless specified).

Table 4.2. Cumulative Technical and Achievable Technical Potential by Sector (2024-2045)

Sector	Baseline Sales (aMW)	Technical Potential		Achievable Technical Potential	
		aMW	% of Baseline Sales	aMW	% of Baseline Sales
Residential	398	95	24%	79	20%
Commercial	718	155	22%	138	19%
Industrial	124	13	11%	11	9%
Total	**1,240**	**263**	**21%**	**228**	**18%**

The commercial sector, representing 58% of baseline energy use, accounts for approximately 60% of the cumulative achievable technical potential in 2045, as shown in Figure 4.1. The residential and industrial sectors account for 35% and 5% of the cumulative achievable technical potential in 2045, respectively.

Figure 4.1. 22-Year Achievable Technical Potential by Sector

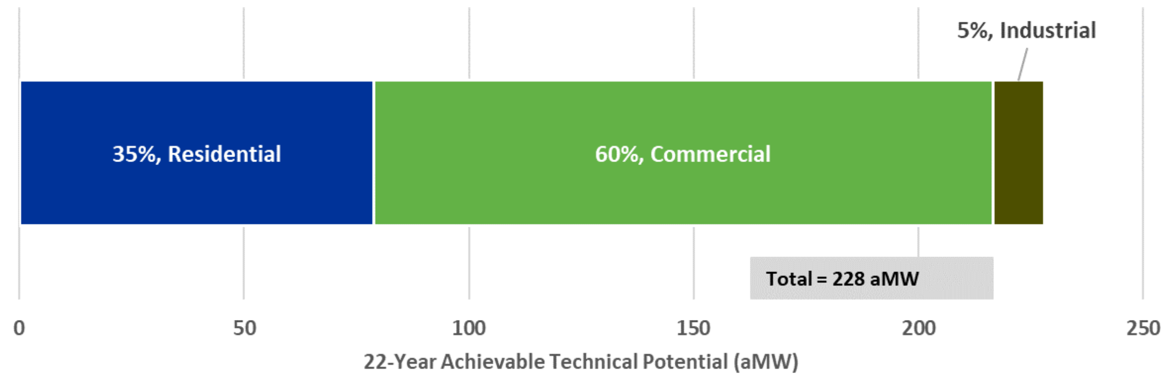


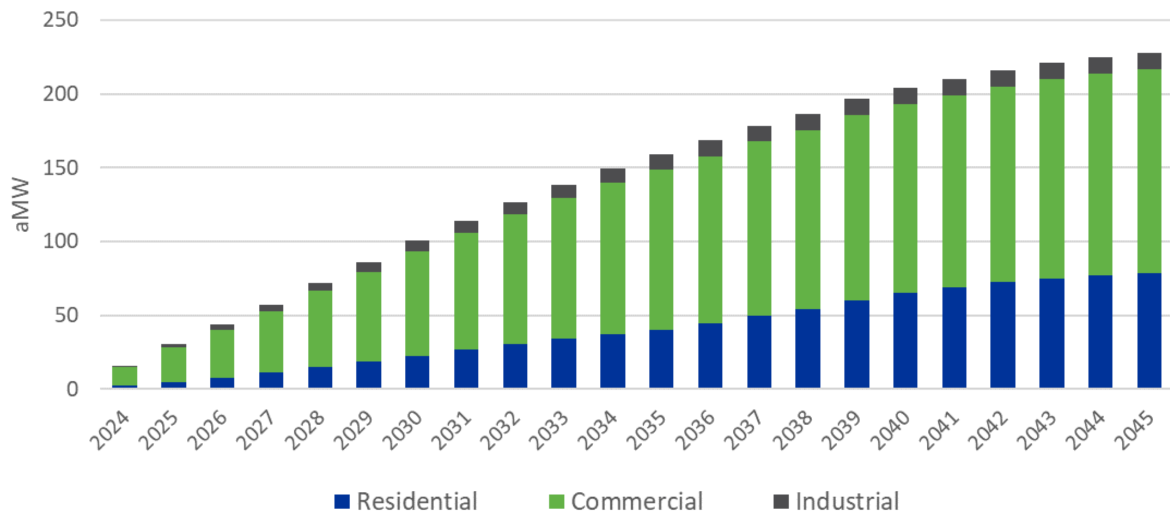
Table 4.3 shows cumulative two-year, four-year, 10-year, 20-year, and 22-year achievable technical potential by sector, as well as 20% of the 10-year achievable technical potential.

Table 4.3. Cumulative Achievable Technical Potential by Sector and Time Period

Sector	Achievable Technical Potential – aMW				
	2-Year (2024-2025)	4-Year (2024–2027)	10-Year (2024–2033)	22-Year (2024–2045)	20% of 10-Year Potential
Residential	5	11	34	79	7
Commercial	23	42	95	138	19
Industrial	2	4	9	11	2
Total	**30**	**57**	**139**	**228**	**28**

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

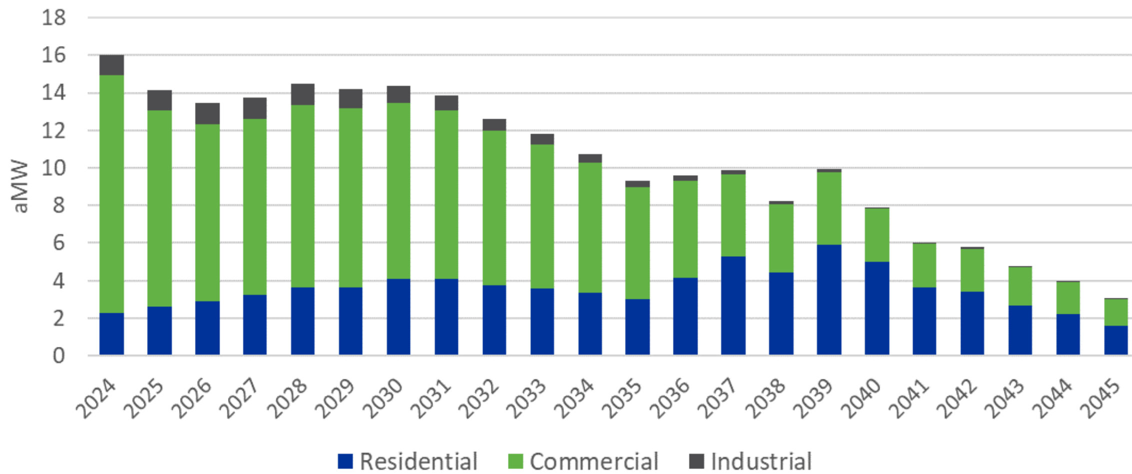
Figure 4.2. Cumulative Achievable Technical Potential by Sector (2024–2045)



Of the cumulative 22-year achievable potential, approximately 25% is acquired in the first four years and 61% is acquired in the first 10 years. This acquisition rate is based on the 2021 Power Plan along with accelerated adoption for measures that City Light has historically offered through programs to better align with local and state policies promoting energy efficiency. The *6. Detailed Methodology* section of this report provides more information on how Cadmus performed this calculation.

Cadmus determined incremental achievable technical potential in each year of the study horizon, using natural equipment turnover rates and measure-specific ramp rates. Figure 4.3 shows incremental achievable potential. The increase in savings in 2039 is the result of the ramp rates applied and the 15-year measure life for many heating measures. For example, in 2039, residential zonal heating systems that were initially installed in 2024 will need to be replaced (since the technology has a 15-year measure life). Based on the ramp rate in the year of replacement (2039), a proportion will be replaced by ductless heat pumps. Since ductless heat pumps are such a high-saving measure, there is a large increase in residential incremental achievable potential in 2039.

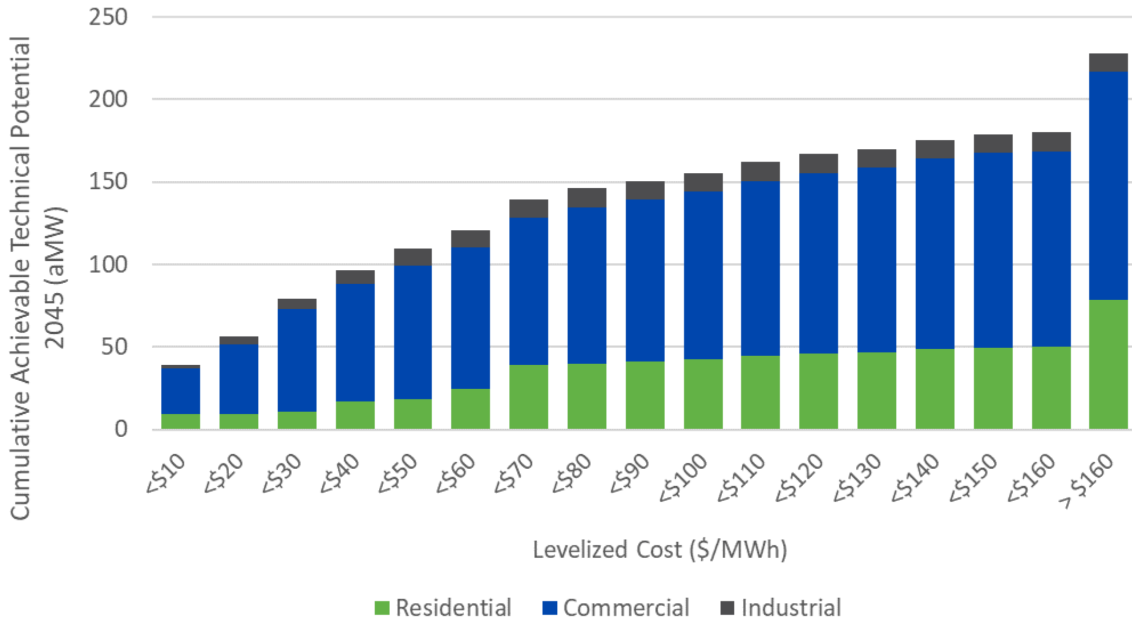
Figure 4.3. Annual Incremental Achievable Technical Potential (2024–2045)



The conservation supply curve in Figure 4.4 shows cumulative achievable potential in $10 per megawatt-hour levelized cost increments, where each bar includes all measures with levelized cost less than the listed amount. For example, the study revealed that 53% (121 aMW) of the cumulative 2045 achievable technical potential can be acquired at less than or equal to $60 per megawatt-hour.[25] The amount of available achievable technical potential levels off at less than or equal to $70 per megawatt-hour, excluding measures that cost more than $160 per megawatt-hour. The 2045 achievable technical potential with a levelized cost of greater than $160 per megawatt-hour makes up 21% of the cumulative achievable technical potential. Many of these costly measures are for emerging technology equipment, heat pumps, and weatherization in the residential and commercial sectors.

25 The levelized cost bundle of less than or equal to $60 per megawatt-hour represents an example value.

Figure 4.4. All Sectors Supply Curve – Cumulative Achievable Technical Potential in 2045 by Levelized Cost



City Light's IRP selected achievable economic potential is 132 aMW by 2045. Table 4.4 shows cumulative 22-year achievable economic potential by sector and the maximum levelized cost for measure permutations in each sector. For example, all residential achievable economic potential can be obtained at a levelized cost of less than or equal to $160 per megawatt-hour. Details of the achievable economic potential methodology can be found in the *6. Detailed Methodology* chapter.

Table 4.4. Cumulative Achievable Economic Potential by Sector (2024–2045)

Sector	Levelized TRC ($/MWh)	22-Year Achievable Economic Potential (aMW)
Residential	160	50
Commercial	40	72
Industrial	60	10
Total	**N/A**	**132**

Appendix D shows detailed measure-level results, including levelized costs and technical and achievable technical conservation potential for each measure. The remainder of this chapter provides detailed results of technical, achievable technical, and achievable economic potential by sector.

4.2. Residential

Residential customers in City Light's service territory account for 32% of 2045 total baseline sales and 35% of total achievable technical potential. This sector, made up of standard-income and highly impacted single-family and multifamily customers, has a variety of sources for potential savings, including equipment efficiency upgrades (such as water heaters and appliances) and improvements to building shells (such as windows, insulation, and air sealing).

Based on resources in this assessment, Cadmus estimated residential cumulative achievable technical potential of 79 aMW over 22 years, which corresponds to 20% of the forecasted residential load in 2045. Table 4.5 shows cumulative 22-year residential conservation potential by segment.

Table 4.5. Cumulative Residential Technical, Achievable Technical and Achievable Economic Potential by Segment in 2045

Segment	Baseline Sales (aMW)	22-Year Technical Potential		22-Year Achievable Technical Potential		22-Year Achievable Economic Potential	
		aMW	% of Baseline Sales	aMW	% of Technical Potential	aMW	% of Technical Potential
Single-Family	187	47	25%	39	83%	27	58%
Single-Family Highly Impacted	49	12	25%	10	83%	7	58%
Multifamily – Low-Rise	38	9	23%	7	84%	4	48%
Multifamily – Low-Rise Highly Impacted	20	5	23%	4	84%	2	48%
Multifamily – Mid-Rise	34	7	21%	6	84%	3	45%
Multifamily – Mid-Rise Highly Impacted	24	5	21%	4	84%	2	45%
Multifamily – High-Rise	30	6	21%	5	84%	3	42%
Multifamily – High-Rise Highly Impacted	16	3	21%	3	84%	1	42%
Total	**398**	**95**	**24%**	**79**	**83%**	**50**	**53%**

As shown in Table 4.5 and Figure 4.5, single-family homes account for 63% (49 aMW) of total achievable technical potential, followed by multifamily low-rise (11 aMW), multifamily mid-rise (10 aMW), and multifamily high-rise (8 aMW). The total achievable technical potential for highly impacted customers is 21 aMW, or 27%. Each home type's proportion of baseline sales drives this distribution, but segment-specific end-use saturations and fuel shares have an effect as well. Appendix B includes detailed data on saturations and fuel shares for each segment.[26] Appendix C includes a detailed summary of achievable technical potential by segment and end use for each segment.

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26 The scope of this study does not distinguish differences in end-use saturations and fuel shares between the highly impacted and non-highly impacted segments. Potential for these classifications is defined by customer segmentation. (Potential results by segment, including the highly impacted versus non-highly impacted classification, and end use, is available in Appendix C.)

Figure 4.5. Residential Cumulative Achievable Technical Potential by Segment (2024–2045)

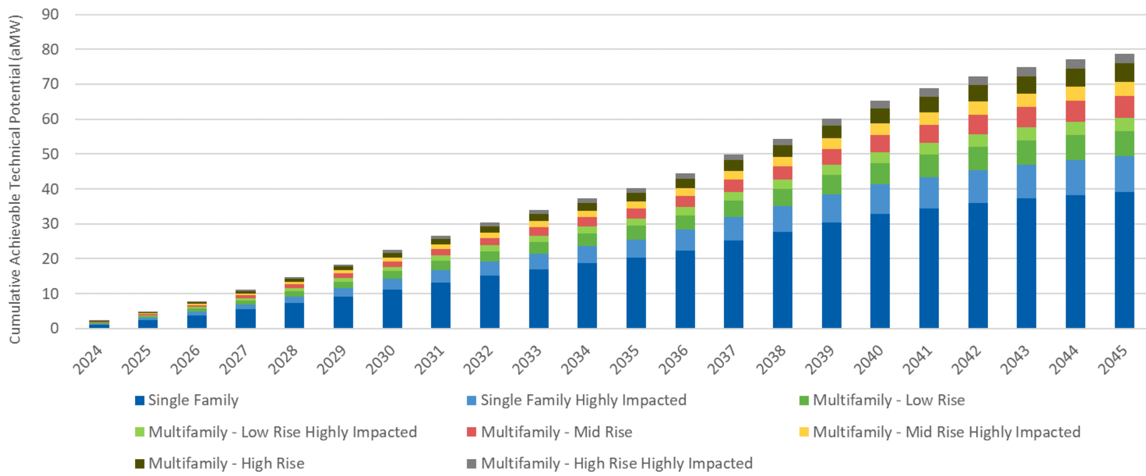


Figure 4.6 presents the cumulative achievable technical potential by construction type for the residential sector. Existing construction represents the majority of achievable technical potential, particularly in the early years of the study, accounting for 98% of the potential in the first four years (2024 through 2027). By the final year of the study period (2045), new construction accounts for 7% of the total cumulative residential achievable technical potential. This is because of the increase in new construction, from roughly 2,780 buildings in 2024 to over 66,000 buildings constructed between 2024 and 2045.

Figure 4.6. Residential Cumulative Achievable Technical Potential by Construction Type (2024–2045)

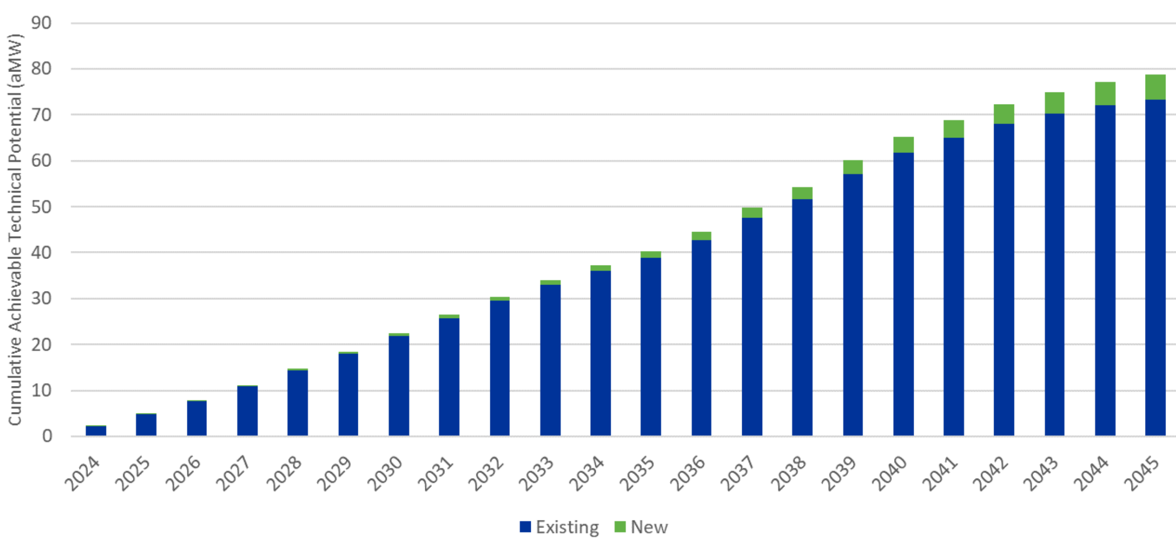


Table 4.6 shows the residential baseline sales and technical and achievable technical potential by end-use group. Heating savings make up the greatest proportion of cumulative achievable technical potential, at 39%. Water heating measures contribute 27% of the total achievable technical potential, followed by

appliance measures (24%). Overall, 83% of the technical potential is considered achievable based on adoption patterns from the 2021 Power Plan and adjusted for City Light's historical program success.

Table 4.6. Cumulative Residential Technical, Achievable Technical and Achievable Economic Potential by End-Use Group in 2045

Segment	Baseline Sales (aMW)	22-Year Technical Potential		22-Year Achievable Technical Potential		22-Year Achievable Economic Potential	
		aMW	% of Baseline Sales	aMW	% of Technical Potential	aMW	% of Technical Potential
Appliances	77	23	29%	19	83%	17.4	77%
Cooling	10	1	14%	1	83%	0.1	7%
Electronics	60	5	9%	5	92%	3.3	62%
Exterior Lighting	1	0.1	6%	0.1	85%	0	0%
Heating	159	37	24%	31	82%	9.7	26%
Interior Lighting	13	2	13%	2	90%	1	57%
Miscellaneous	7	0.4	5%	0.3	88%	0.3	87%
Water Heating	70	25	36%	21	83%	18.5	73%
Total	**398**	**95**	**24%**	**79**	**83%**	**50**	**53%**

Incremental and cumulative potential over the 22-year study horizon varies by end-use group due to the application of ramp rates. Cadmus assigned ramp rates to each measure based on factors such as availability, existing program activity, and market trends. Cadmus used the same ramp rates for each measure, as assigned by the Council in the 2021 Power Plan, with some adjustments based on City Light's historical program success, as discussed in the *5.2. Achievable Technical Potential and Ramp Rate Comparison* section. Figure 4.7 shows cumulative residential achievable potential by end use.

Figure 4.7. Residential Cumulative Achievable Technical Potential by End Use (2024–2045)

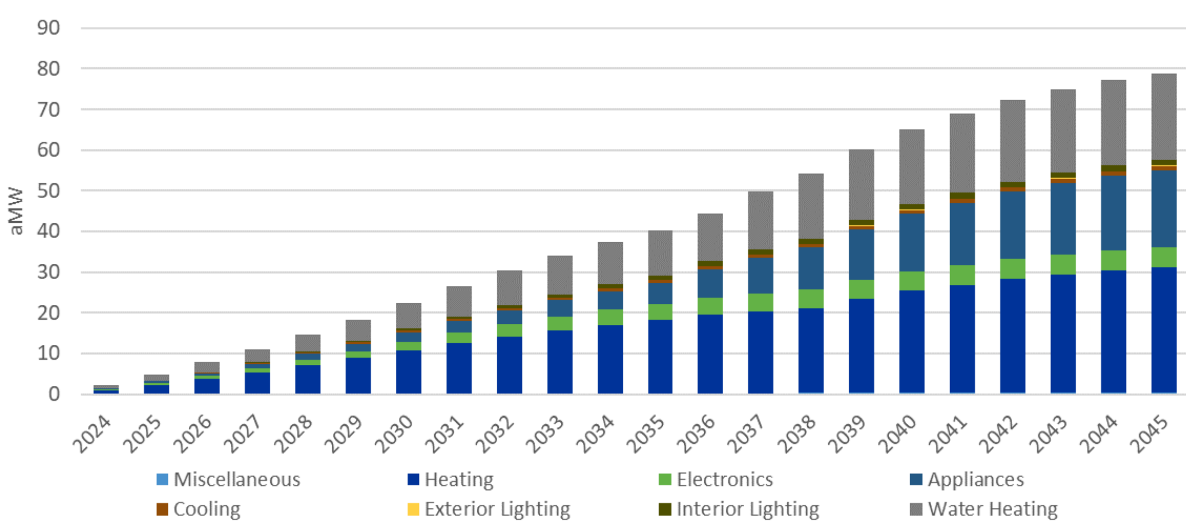


Figure 4.8 shows incremental residential achievable potential. Measure ramp rates and effective useful life (EUL) (only for equipment replacement measures) determine the timing of these savings. The increase in heating savings in 2039 is the result of replacing a high proportion of zonal heating measures with ductless heat pumps at the end of their 15-year measure life.

Figure 4.8. Residential Incremental Achievable Technical Potential by End Use (2024–2045)

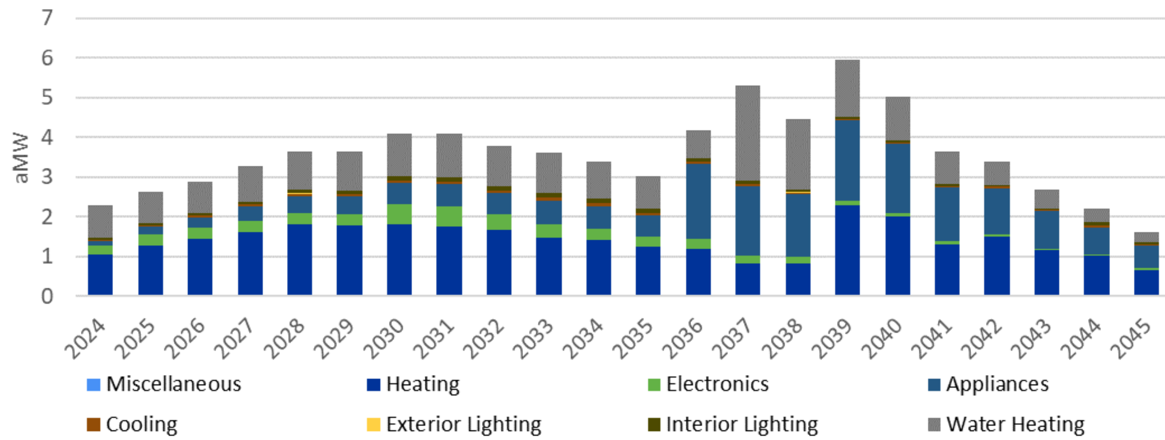


Table 4.7 lists the 15 highest-saving residential measures sorted by 22-year achievable technical potential. These measures make up 77% of the total residential achievable technical potential. The table also includes the weighted average levelized costs for these measures,[27] which represent the economic equipment and administrative costs while still accounting for energy and non-energy benefits. The measure with the highest cumulative achievable technical potential—multifamily ductless heat pumps—has a levelized cost of $302 per megawatt-hour. Other measures identified with high savings are heat pump dryers, efficient heat pump water heaters, and refrigerators and freezers of Consortium for Energy Efficiency Tier 3. Of the highest-savings measures, the least costly are front-load ENERGY STAR® washers, thermostatic shower restriction valves, and ENERGY STAR® printers.

[27] The levelized cost value represents a weighted average across all iterations, including segment and end use. As a result, some permutations of a measure may have a low levelized cost while other permutations have a high levelized cost.

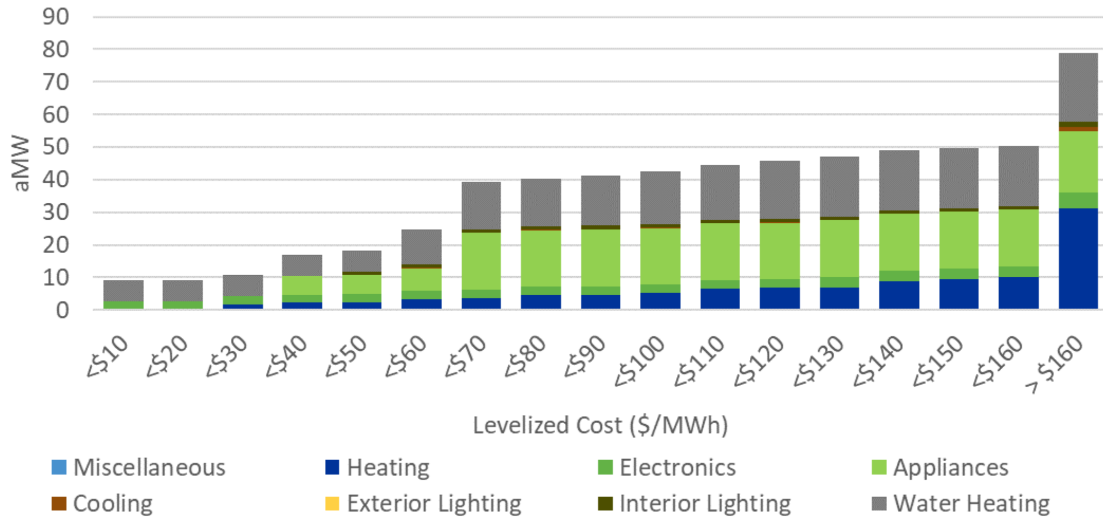
Table 4.7. Top-Saving Residential Measures

Measure Name	Cumulative Achievable Technical Potential (aMW)					Weighted Average Levelized TRC ($/MWh)
	2-Year	4-Year	10-Year	22-Year	% of Total (22-Year)	
Multifamily Ductless Heat Pump Upgrade	0.37	1.07	3.81	10.67	14%	$302.33
Heat Pump Dryer	0.03	0.09	0.70	10.39	13%	$67.09
Heat Pump Water Heater – Tier 3	0.30	0.83	2.55	6.98	9%	$49.69
Heat Pump Water Heater – Tier 4	0.24	0.68	2.12	5.90	7%	$66.75
Refrigerator and Refrigerator-Freezer – Consortium for Energy Efficiency Tier 3	0.26	0.70	2.09	5.65	7%	$39.43
Zonal to Ductless Heat Pump	0.20	0.53	1.53	3.91	5%	$168.52
Networked Automation Controls	0.04	0.18	1.69	3.21	4%	$3,362.65
Front Load ENERGY STAR Washer (w/Electric Dryer)	1.06	1.60	2.50	3.02	4%	$0.00
Single-Family Weatherization – Insulate Wall R0 to R11, Heating Zone 1	0.51	1.02	2.04	2.32	3%	$138.77
ENERGY STAR Office Printer	0.29	0.60	1.44	1.76	2%	$0.00
Convert Electric Forced Air Furnace with Central AC to Heat Pump	0.08	0.22	0.65	1.59	2%	$143.16
Residential Retail Valve, Electric Resistance Domestic Hot Water	0.02	0.08	0.73	1.35	2%	$0.00
Electric HVAC Visual + Testing NoCAC Bill Screen: NA Any HZ (Duct Sealing)	0.02	0.08	0.76	1.32	2%	$51.24
HVAC Heat Pump Upgrade to 12 HSPF/ 18 SEER + Heating Zone 1, Cooling Zone 1	0.01	0.04	0.31	1.20	2%	$1,363.50
Solar Hot Water, Zone 1	0.00	0.01	0.13	1.13	1%	$1,323.52

[a] *The net expenses (costs and benefits) were less than zero for the following measures: 'Front-Load ENERGY STAR Washer and Domestic Hot Water Dryer (Electric)', 'ENERGY STAR Office Printer', and 'Residential Retail Valve, Electric Resistance Domestic Hot Water'. The resulting levelized TRC was shown as $0.00 (per megawatt-hour) and can be considered cost-effective.*

Overall, 14% of residential conservation potential is achievable within the first four years, and 43% is achievable in the first 10 years. Figure 4.9 shows 22-year cumulative residential potential by levelized cost (in $10 per megawatt-hour increments).

Figure 4.9. Residential Supply Curve – Cumulative Achievable Technical Potential in 2045 by Levelized Cost



Thirty-six percent of the residential achievable technical potential is from measures with a levelized cost of over $160 per megawatt-hour. This is partly because the highest savings measure—multifamily ductless heat pump upgrades—has a levelized cost greater than $160 per megawatt-hour.

City Light's IRP selected an economic achievable potential of 50 aMW for the residential sector by 2045. Figure 4.10 shows the cumulative 22-year achievable economic potential for the residential sector by end-use group. The two end-use groups with the greatest achievable economic potential are water heating and appliances, which collectively represent 71% of the total residential 22-year cumulative achievable economic potential.

Figure 4.10. Residential Cumulative Achievable Economic Potential in 2045 by End-Use Group

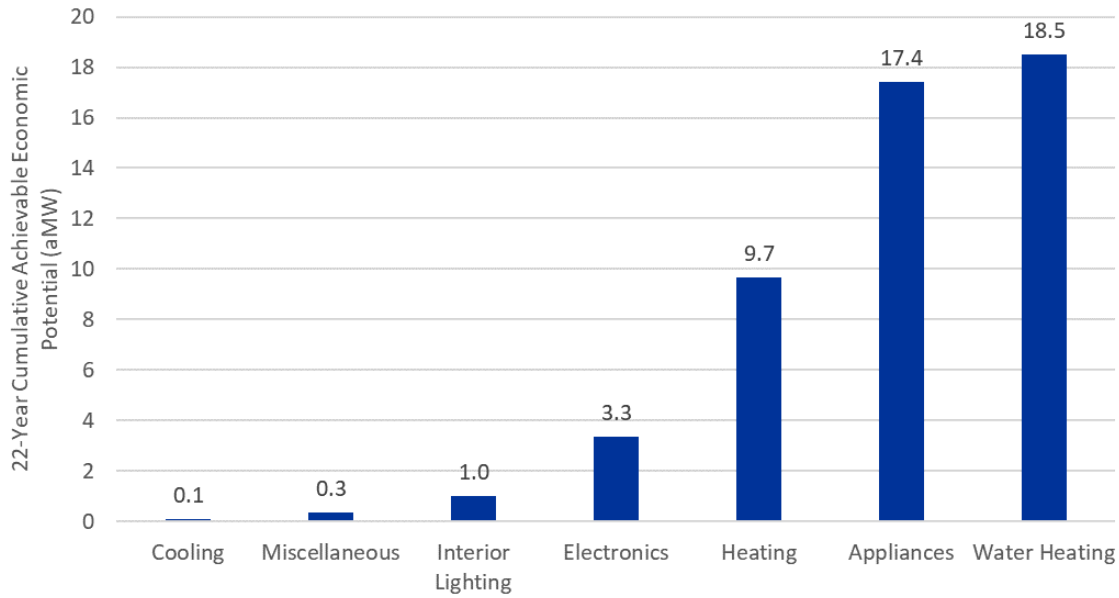


Table 4.8 lists the 15 highest-saving IRP selected residential measures. The measure permutations included in the table all have a levelized cost of less than or equal to $160 per megawatt-hour and make up 88% of the cumulative 22-year achievable economic potential for the residential sector.

Table 4.8. Top-Saving Residential Measures Selected by IRP

Measure Name	Cumulative Achievable Economic Potential (aMW) – Less than or Equal to $160/MWh				% of Cumulative 22-Year Achievable Economic Potential
	2-Year	4-Year	10-Year	22-Year	
Heat Pump Dryer	0.03	0.09	0.70	10.39	21%
Heat Pump Water Heater – Tier 3	0.30	0.83	2.55	6.98	14%
Heat Pump Water Heater – Tier 4	0.24	0.68	2.12	5.90	12%
Refrigerator and Refrigerator-Freezer – Consortium for Energy Efficiency Tier 3	0.26	0.70	2.09	5.65	11%
Front Load ENERGY STAR Washer (w/Electric Dryer)	1.06	1.60	2.50	3.02	6%
Single-Family Weatherization – Insulate Wall R0 to R11, Heating Zone 1	0.48	0.95	1.91	2.17	4%
ENERGY STAR Office Printer	0.29	0.60	1.44	1.76	3%
Convert Electric Forced Air Furnace with Central AC to Heat Pump	0.08	0.21	0.60	1.43	3%
Residential Retail Valve, Electric Resistance Domestic Hot Water	0.02	0.08	0.73	1.35	3%
Electric HVAC Visual + Testing NoCAC Bill Screen: NA Any Heating Zone (Duct Sealing)	0.02	0.08	0.76	1.32	3%
Wall Insulation R0 to R11, Heating Zone 1	0.24	0.48	0.96	1.09	2%
Clothes Dryer with Heat Recovery	0.01	0.06	0.59	1.09	2%
Linear Fluorescent Lamp - TLED	0.08	0.19	0.49	0.96	2%
Connected Thermostat Single -Family, Air Source Heat Pump, Heating Zone 1	0.14	0.28	0.57	0.71	1%
Multi Family LR Behavior	0.01	0.03	0.31	0.56	1%

4.2.1. Highly Impacted Communities

Cadmus estimated the potential for highly impacted communities which are defined as “the census tract ranks a 9 or 10 on the Environmental Health Disparities (EHD) Map, as designated by the Washington State Department of Health” and also include the census tracts “covered or partially covered by ‘Indian Country' as defined in and designated by statute.” As shown in Table 4.5, highly impacted community segments constituted 27% (21 aMW) of the total achievable technical potential. Each home type’s proportion of baseline sales drives this distribution, but segment-specific end-use saturations and fuel shares have an effect as well.

City Light’s IRP selected an economic achievable potential of 13 aMW in highly impacted communities by 2045. Figure 4.11 shows the cumulative 22-year achievable economic potential in highly impacted communities by end-use group. The two end-use groups with the greatest achievable economic potential are water heating and appliances, which collectively represent 72% of the total 22-year cumulative achievable economic potential in highly impacted communities.

Figure 4.11. Cumulative Achievable Economic Potential in Highly Impacted Communities 2045 by End-Use Group

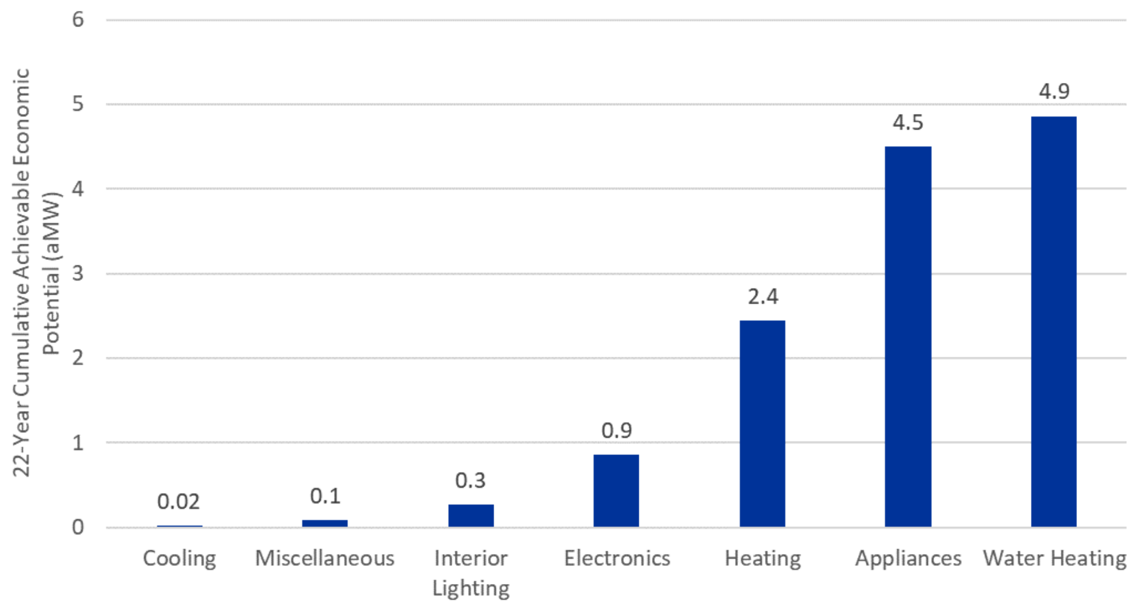


Table 4.9 lists the 15 highest-saving IRP selected measures in highly impacted communities. The measure permutations included in the table all have a levelized cost of less than or equal to $160 per megawatt-hour and make up 87% of the cumulative 22-year achievable economic potential available for highly impacted communities.

Table 4.9. Top-Saving Residential Measures in Highly Impacted Communities Selected by IRP

Measure Name	Cumulative Achievable Economic Potential (aMW) – Less than or Equal to $160/MWh				% of Cumulative 22-Year Achievable Economic Potential
	2-Year	4-Year	10-Year	22-Year	
Heat Pump Dryer	0.01	0.02	0.18	2.64	20%
Heat Pump Water Heater – Tier 3	0.07	0.21	0.63	1.73	13%
Refrigerator and Refrigerator-Freezer – Consortium for Energy Efficiency Tier 3	0.11	0.26	0.67	1.57	12%
Heat Pump Water Heater – Tier 4	0.06	0.17	0.52	1.47	11%
Front Load ENERGY STAR Washer (w/Electric Dryer)	0.30	0.46	0.72	0.86	7%
ENERGY STAR Office Printer	0.08	0.16	0.38	0.46	4%
Single-Family Weatherization – Insulate Wall R0 to R11, Heating Zone 1	0.10	0.20	0.40	0.45	3%
Residential Retail Valve, Electric Resistance Domestic Hot Water	0.01	0.02	0.22	0.40	3%
Wall Insulation R0 to R11, Heating Zone 1	0.09	0.17	0.35	0.40	3%
Convert Electric Forced Air Furnace with Central AC to Heat Pump	0.02	0.04	0.12	0.30	2%
Electric HVAC Visual + Testing NoCAC Bill Screen: NA Any Heating Zone (Duct Sealing)	0.00	0.02	0.16	0.27	2%
Linear Fluorescent Lamp - TLED	0.02	0.05	0.12	0.24	2%
Clothes Dryer with Heat Recovery	0.00	0.01	0.12	0.22	2%
Multi Family LR Behavior	0.00	0.01	0.12	0.21	2%
Connected Thermostat Single -Family, Air Source Heat Pump, Heating Zone 1	0.03	0.06	0.12	0.15	1%

4.3. Commercial

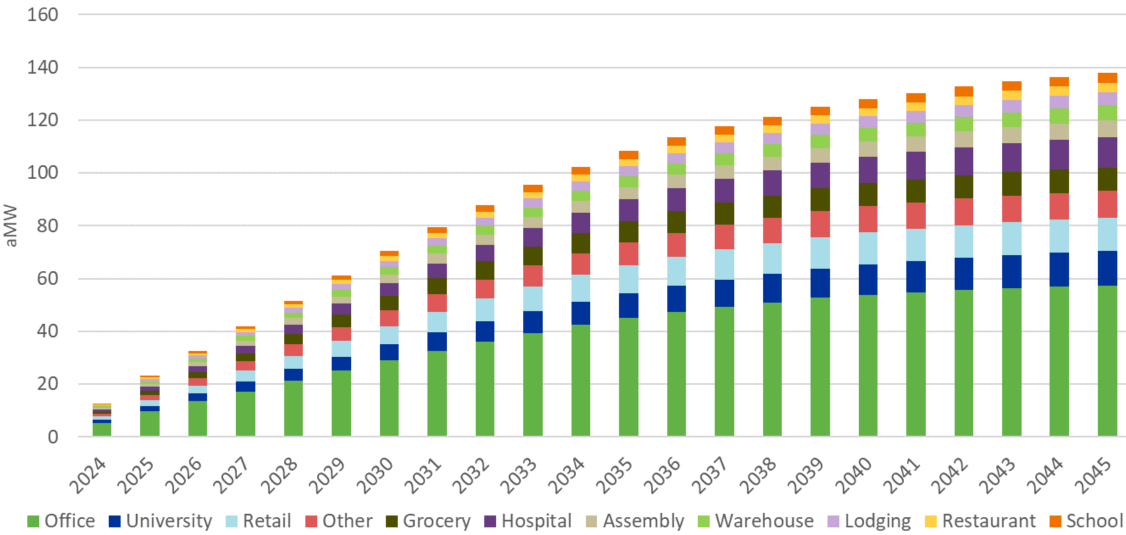
City Light's commercial sector accounts for 58% of its baseline sales in 2045 and 60% of total achievable technical potential. Cadmus estimated potential for the 20 commercial segments listed above in Table 3.5 (grouped into 16 segments for this report). Table 4.10 summarizes the 20-year cumulative technical and achievable technical potential by commercial segment.

Table 4.10. Cumulative Commercial Technical and Achievable Technical Potential by Segment in 2045

Segment	Baseline Sales (aMW)	22-Year Technical Potential		22-Year Achievable Technical Potential	
		aMW	% of Baseline Sales	aMW	% of Technical Potential
Assembly	28	7	25%	6	89%
Data Center	73	0.4	0.5%	0.3	85%
Hospital	57	14	24%	12	85%
Large Grocery	18	8	45%	7	90%
Large Office	175	48	27%	43	90%
Lodging	23	6	25%	5	86%
Multifamily Common Area	60	0	0%	0	N/A
Miscellaneous	35	8	23%	7	91%
Other Health	13	3	24%	3	89%
Restaurant	28	4	14%	3	87%
Retail	50	14	28%	13	91%
School	14	4	32%	4	87%
Small Grocery	7	2	26%	2	88%
Small Office	41	16	39%	14	90%
University	69	15	22%	13	85%
Warehouse	28	6	23%	6	90%
Total	**718**	**155**	**22%**	**138**	**89%**

Approximately 31% of the 22-year commercial achievable technical potential is from the large office segment, as shown in Figure 4.12. Together, large and small offices (shown as office in Figure 4.12) account for 42% of the 22-year commercial achievable technical potential. The large grocery segment has the highest technical potential savings relative to baseline sales due to the high potential associated with refrigeration equipment.

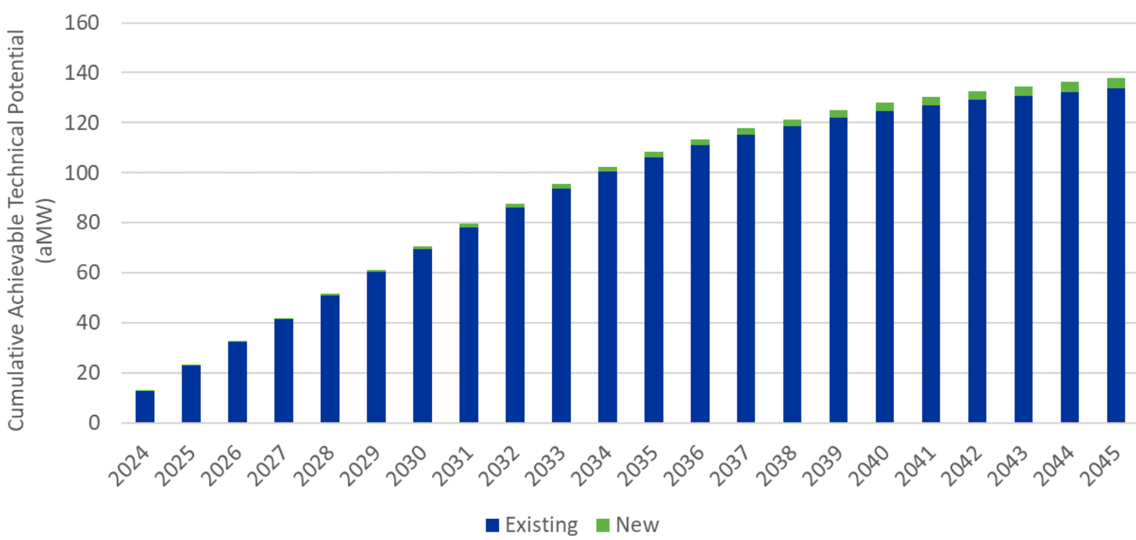
Figure 4.12. Cumulative Commercial Achievable Technical Potential by Segment (2024–2045)



Note: The "Other" segment includes data centers, miscellaneous, and other health.

Figure 4.13 presents the cumulative achievable technical potential by construction vintage for the commercial sector. Existing construction represents the majority of achievable technical potential, particularly in the early years of the study, accounting for 99.5% of the potential in the first two years (2024 and 2025).

Figure 4.13. Cumulative Commercial Achievable Technical Potential by Construction Type (2024–2045)



Across all end uses, lighting accounts for 29% of total achievable technical potential. Table 4.11 shows 22-year cumulative commercial potential by end use.

Table 4.11. Cumulative Commercial Technical, Achievable Technical and Achievable Economic Potential by End-Use Group in 2045

Segment	Baseline Sales (aMW)	22-Year Technical Potential		22-Year Achievable Technical Potential		22-Year Achievable Economic Potential	
		aMW	% of Baseline Sales	aMW	% of Technical Potential	aMW	% of Technical Potential
Cooking	23	1	6%	1	85%	0.4	25%
Cooling [a]	38	16	42%	14	85%	5	30%
Data Center	108	5	5%	4	89%	4	89%
Heat Pump [b]	77	26	34%	23	87%	7	26%
Heating [c]	21	9	41%	7	85%	4	42%
Lighting	179	44	24%	40	93%	36	82%
Miscellaneous	110	5	4%	4	88%	1	21%
Refrigeration	56	15	26%	13	91%	7	49%
Ventilation	85	25	30%	23	91%	3	13%
Water Heating	20	10	50%	8	77%	5	45%
Total	**718**	**155**	**22%**	**138**	**89%**	**72**	**46%**

[a] *The cooling end-use group refers to cooling direct expansion, chiller equipment, and related retrofit measures.*
[b] *The heat pump end-use group includes air-source heat pumps and related retrofit measures. This differs from heat pump water heaters, which are included in the water heating end-use group.*
[c] *The heating end-use group refers to non-heat pump electric space heating equipment (such as electric resistance heating).*

Almost one-third of commercial achievable potential comes from interior lighting equipment upgrades, exterior lighting equipment upgrades, and controls. The 20-year achievable technical potential for lighting is equivalent to a 22% reduction in baseline lighting consumption. Overall, 93% of lighting technical potential is considered achievable based on the maximum achievable potential assumed in the draft 2021 Power Plan.

Compared to the residential sector, a larger proportion of the achievable technical potential is realized in the first 10 years of the study, with 69% of the 22-year cumulative achievable technical potential in the first 10 years (versus 43% for residential sector) and 30% in the first four years (versus 14% for residential sector). Figure 4.14 and Figure 4.15 show cumulative and incremental achievable potential for the commercial sector by end use, respectively. There is a slight bump in incremental achievable technical potential in 2039 due to the replacement of high-savings measures that have a measure life of 15 years.

Figure 4.14. Commercial Cumulative Achievable Technical Potential by End Use (2024–2045)

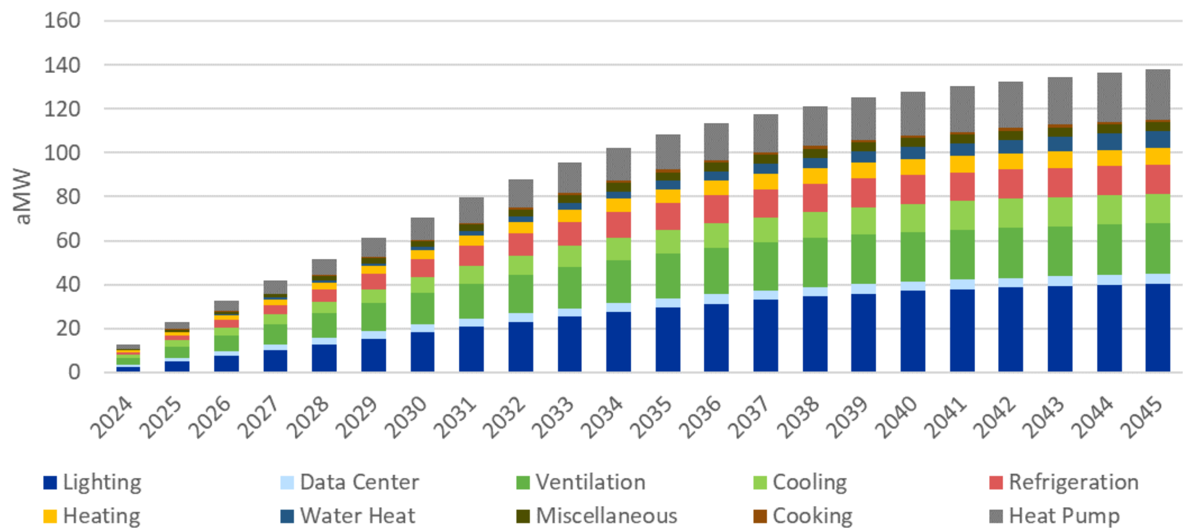


Figure 4.15. Commercial Incremental Achievable Technical Potential by End Use (2024–2045)

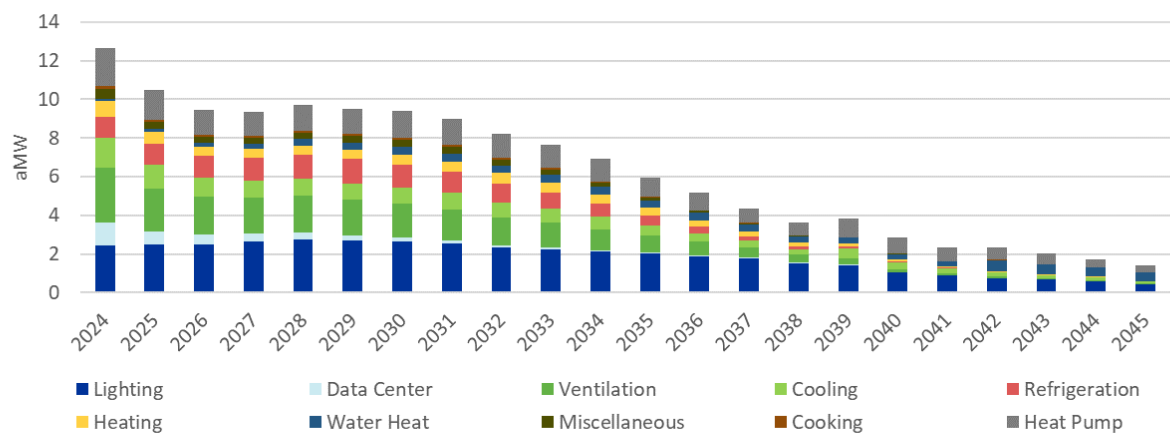


Table 4.12 shows the top 15 commercial measures and their average levelized costs,[28] sorted by 22-year achievable technical potential. Together, these measures represent 37% of the commercial cumulative 2045 achievable technical potential. The highest-saving measure is HVAC retro-commissioning with close to 7 aMW, or 5%, of achievable technical potential. Depending on the application, this measure can also be costly and may not be considered economic, with a weighted average levelized TRC of $148 per megawatt-hour.

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28 The levelized cost value represents a weighted average across all iterations, including segment and end use. As a result, some permutations of a measure may have a low levelized cost while other permutations have a high levelized cost.

Table 4.12. Top-Saving Commercial Measures

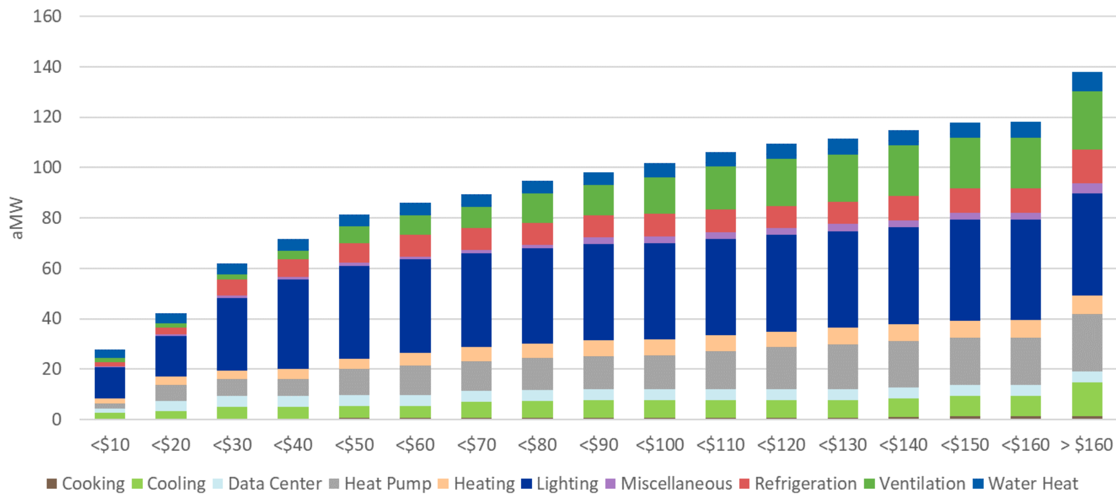
Measure Name	Cumulative Achievable Technical Potential (aMW)					Weighted Average Levelized TRC ($/MWh) [a]
	2-Year	4-Year	10-Year	22-Year	% of Total (22-Year)	
HVAC Retro-Commissioning	2.56	3.87	5.97	6.82	5%	$147.83
Building Automation System Upgrades	2.33	3.52	5.46	6.31	5%	$15.13
Strategic Energy Management	0.08	0.34	3.18	5.70	4%	$167.50
Air-Source Heat Pump ≥240,000 Btu/h and <760,000 Btu/h - Above Code	0.08	0.29	1.65	4.80	3%	$37.69
Large Office Linear Fluorescent Tube to LED Panel Fixture with Lighting Controls	0.25	0.62	1.93	3.54	3%	$22.91
New Display Case - Replacement	0.77	1.54	3.10	3.52	3%	$25.84
Air-Source Heat Pump ≥135,000 Btu/h and <240,000 Btu/h - Above Code	0.06	0.22	1.21	3.40	2%	$163.93
Fans Retrofit - All Commercial-System Upgrade	0.52	1.05	2.10	2.39	2%	$47.01
Water Heater LE 55 Gallon Heat Pump - Tier 4	0.04	0.16	0.83	2.35	2%	$277.41
Water Heater LE 55 Gallon Heat Pump - Tier 3	0.04	0.15	0.78	2.21	2%	$59.41
Server Virtualization	0.46	0.92	1.85	2.10	2%	$14.87
Thin Triple-Pane Large Office – Natural Gas	0.03	0.12	1.12	1.98	1%	$117.60
ENERGY STAR Server	1.24	1.68	1.92	1.95	1%	$0.72
Circulation Pumps - Hydronic Heating - Commercial with ECM and Advanced Speed Controls	0.71	1.08	1.66	1.90	1%	$95.75
Medium Office Linear Fluorescent Tube to LED Panel Fixture with Lighting Controls	0.13	0.33	1.03	1.90	1%	$22.72

[a] *The average levelized TRC value represents a weighted average across all iterations including segment and end use. As a result, some permutations of a measure may have a low levelized cost while other permutations have a high levelized cost.*

Approximately 69% of 22-year commercial achievable technical potential falls within the first 10 years of the study horizon. Much of the commercial retrofit potential for existing buildings occurs within the first 10 years, largely due to the ramp rates associated with these measures.

Figure 4.16 shows that the commercial levelized cost distributions for the achievable technical potential are similar to those for the residential sector. However, 14% of the achievable technical potential has costs greater than $160 per megawatt-hour. This is primarily because HVAC retro-commissioning and weatherization measures such as thin triple-pane window replacements are costly but offer large savings opportunities.

Figure 4.16. Commercial Supply Curve – Cumulative Achievable Technical Potential in 2045 by Levelized Cost



Note: The cooking end use has 0.12 aMW at ≤$10 per megawatt-hour, 0.37 aMW at ≤$20 per megawatt-hour, 0.51 aMW at ≤$50 per megawatt-hour, 0.67 aMW at ≤$80 per megawatt-hour, 0.96 aMW at ≤$140 per megawatt-hour, 1.20 aMW at ≤$150 per megawatt-hour, and 1.24 aMW at >160 per megawatt-hour.

City Light's IRP selected an achievable economic potential for the commercial sector of 72 aMW by 2045. Figure 4.17 shows the cumulative 22-year achievable economic potential for the commercial sector by end-use group. Achievable economic potential for lighting makes up 50% of the commercial achievable economic potential, followed by refrigeration (10%) and heat pump (9%).

Figure 4.17. Commercial Cumulative Achievable Economic Potential in 2045 by End-Use Group

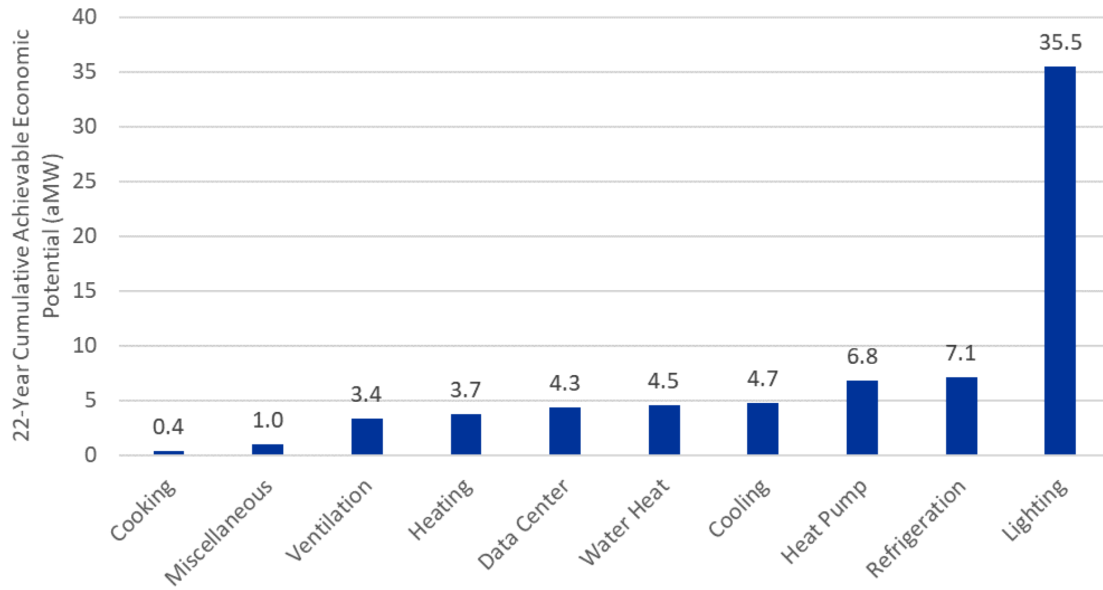


Table 4.13 lists the 15 highest-saving IRP selected commercial measures. The commercial achievable economic measure permutations included in the table have a levelized cost of less than or equal to $40 per megawatt-hour and make up 43% of the commercial cumulative 22-year achievable economic potential.

Table 4.13. Top-Saving Commercial Measures Selected by IRP

Measure Name	Cumulative Achievable Economic Potential (aMW) – Less than or Equal to $40/MWh				% of Cumulative 22-Year Achievable Economic Potential
	2-Year	4-Year	10-Year	22-Year	
Building Automation System Upgrades	1.81	2.73	4.23	4.89	7%
Large Office Linear Fluorescent Tube to LED Panel Fixture with Lighting Controls	0.25	0.62	1.93	3.54	5%
New Display Case - Replacement	0.77	1.54	3.10	3.52	5%
Server Virtualization	0.46	0.92	1.85	2.10	3%
ENERGY STAR Server	1.24	1.68	1.92	1.95	3%
Medium Office Linear Fluorescent Tube to LED Panel Fixture with Lighting Controls	0.13	0.33	1.03	1.90	3%
Outside Air Economizer	0.68	1.03	1.59	1.82	3%
Advanced Air-to-Water Heat Pump	0.03	0.11	1.01	1.76	2%
Heat Pump Water Heater Less than 55 Gallons - Tier 3	0.03	0.11	0.58	1.68	2%
Air Source Heat Pump >= 240,000 Btu/h and < 760,000 Btu/h - Above Code	0.03	0.09	0.52	1.51	2%
Strategic Energy Management	0.02	0.08	0.80	1.44	2%
Small Office Linear Fluorescent Tube to LED Panel Fixture with Lighting Controls	0.08	0.19	0.59	1.38	2%
HVAC Retro commissioning	0.46	0.69	1.06	1.22	2%
Heat Pump Water Heater Greater than 55 Gallons - Tier 3	0.02	0.07	0.40	1.14	2%
Other Linear Fluorescent Tube to LED Panel Fixture with Lighting Controls	0.09	0.23	0.71	1.13	2%

4.4. Industrial

Cadmus estimated conservation potential for the industrial sector using the Council's 2021 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 11 aMW of achievable technical potential by 2045. Table 4.14 shows the cumulative industrial potential by segment in 2045.

Table 4.14. Cumulative Industrial Technical and Achievable Technical Potential by Segment in 2045

Segment	Baseline Sales (aMW)	22-Year Technical Potential		22-Year Achievable Technical Potential	
		aMW	% of Baseline Sales	aMW	% of Technical Potential
Foundries	50	5.9	12%	5.2	87%
Frozen Food	2	0.3	14%	0.3	86%
Miscellaneous Manufacturing	40	1.5	4%	1.3	86%
Other Food	0	0.0	14%	0.0	87%
Transportation Equipment	28	4.8	17%	4.1	86%
Wastewater	2	0.4	27%	0.3	85%
Water	3	0.2	10%	0.2	85%
Total	**124**	**13.1**	**11%**	**11.4**	**86%**

Figure 4.18 shows industrial cumulative achievable technical potential by segment and year. Similar to baseline sales, the foundries segment has the largest share (46%) of 22-year industrial achievable technical potential account, with 5 aMW. It is followed by transportation equipment and miscellaneous manufacturing, which make up 4 aMW and 1 aMW of total achievable technical potential, respectively.

Figure 4.18. Cumulative Industrial Achievable Technical Potential by Segment (2024–2045)

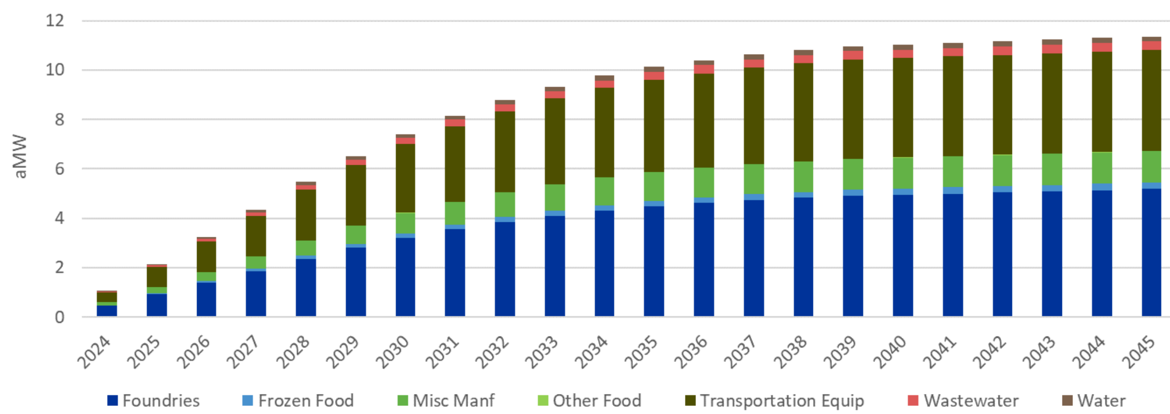


Table 4.15 shows 22-year potential by industrial end use. The four end uses with the highest industrial achievable technical potential are lighting (33%), pumps (16%), fans (15%), and process air compressor (10%).

Table 4.15. Cumulative Industrial Technical, Achievable Technical and Achievable Economic Potential by End Use in 2045

Segment	Baseline Sales (aMW)	22-Year Technical Potential		22-Year Achievable Technical Potential		22-Year Achievable Economic Potential	
		aMW	% of Baseline Sales	aMW	% of Technical Potential	aMW	% of Technical Potential
Fans	10	2.1	22%	1.8	85%	1.8	85%
HVAC	16	1.3	8%	1.1	85%	1.1	85%
Lighting	13	4.5	35%	3.8	85%	3.8	85%
Motors (Other)	18	0.8	4%	0.7	87%	0.7	87%
Other	10	0.7	6%	0.6	85%	0.6	85%
Process Air Compressor	8	1.3	15%	1.2	92%	0.4	31%
Process Electro Chemical	8	0.4	5%	0.3	87%	0.3	87%
Process Heat	19	0.0	0%	0.0	0%	0.0	0%
Process (Other)	1	0.0	0%	0.0	0%	0.0	0%
Process Refrigeration	4	0.2	4%	0.1	86%	0.1	86%
Pumps	16	2.0	12%	1.8	90%	1.5	78%
Total	**124**	**13.1**	**11%**	**11.4**	**86%**	**10.4**	**79%**

Figure 4.19 and Figure 4.20 show cumulative and incremental achievable technical potential by end use over the 22-year study horizon, respectively.

Figure 4.19. Industrial Cumulative Achievable Technical Potential by End Use (2024–2045)

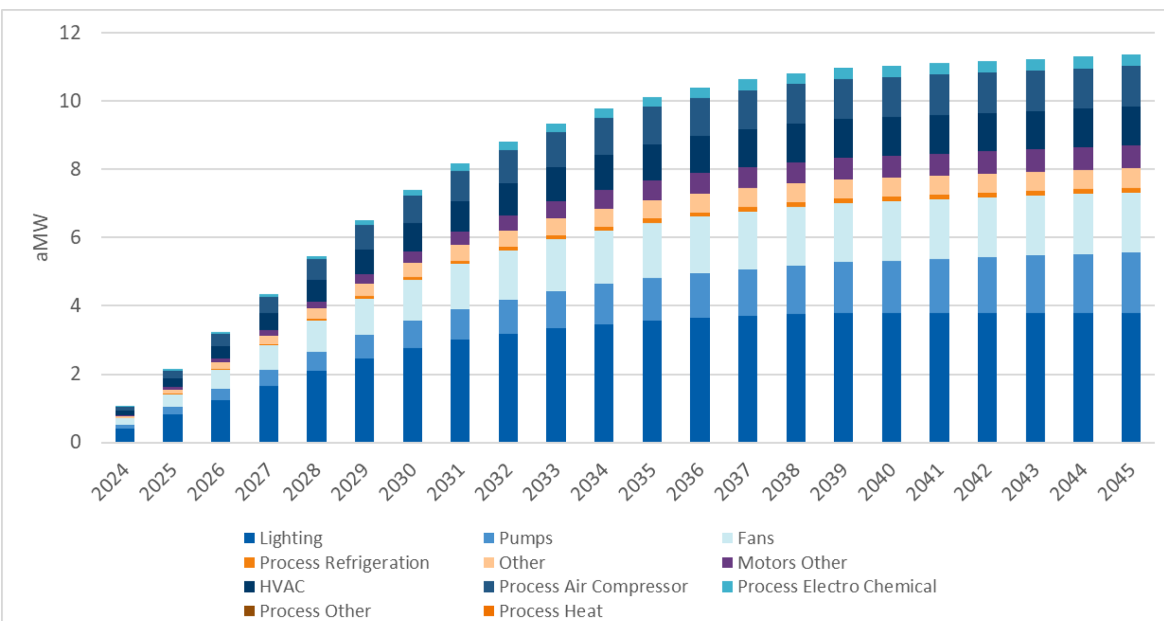


Figure 4.20. Industrial Incremental Achievable Technical Potential by End Use (2024–2045)

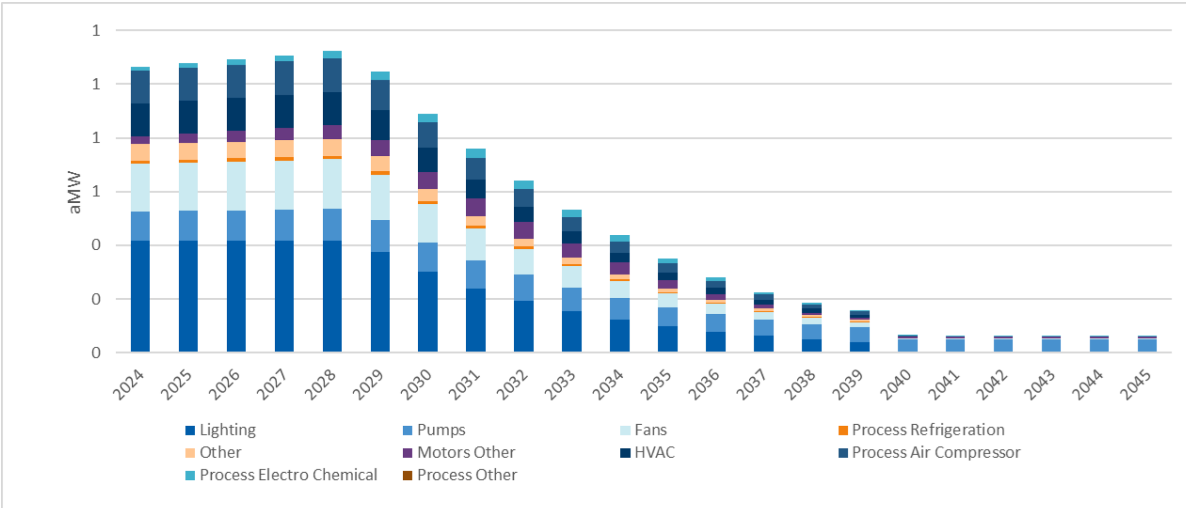


Table 4.16 shows the top-saving industrial measures and their weighted average levelized costs. Collectively, these 15 measures represent 78% of industrial 22-year cumulative achievable technical potential.

Table 4.16. Top-Saving Industrial Measures

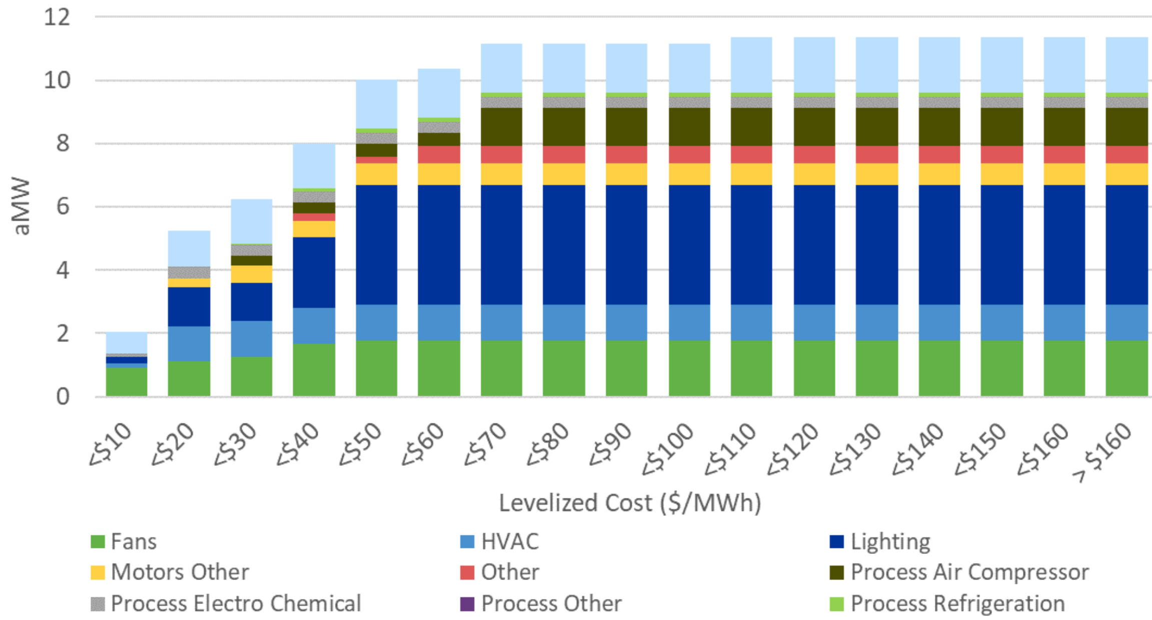
Measure Name	Cumulative Achievable Technical Potential (aMW)					Weighted Average Levelized TRC ($/MWh) [a]
	2-Year	4-Year	10-Year	22-Year	% of Total (22-Year)	
HVAC	0.22	0.43	0.87	0.99	9%	$15.98
Lighting Controls	0.21	0.42	0.85	0.96	8%	$44.84
Energy Management - Level 1 [b]	0.08	0.19	0.66	0.79	7%	$23.71
Fan Equipment Upgrade [c]	0.16	0.32	0.65	0.74	6%	$0.00
Pump Optimization	0.07	0.13	0.33	0.72	6%	$1.80
High-Bay Lighting - 2 Shift	0.16	0.31	0.63	0.71	6%	$38.05
High-Bay Lighting - 1 Shift	0.14	0.27	0.55	0.63	6%	$40.98
Efficient Lighting - 2 Shift	0.12	0.25	0.49	0.56	5%	$11.46
Air Compressor Equipment	0.12	0.23	0.46	0.53	5%	$66.84
Efficient Lighting - 1 Shift	0.10	0.21	0.41	0.47	4%	$13.00
Energy Management - Level 2 [b]	0.04	0.08	0.19	0.42	4%	$49.20
Fan Optimization	0.09	0.19	0.37	0.42	4%	$39.12
Wastewater	0.08	0.15	0.30	0.34	3%	$59.48
Advanced Motors - Material Processing	0.03	0.07	0.24	0.28	2%	$10.04
High-Bay Lighting - 3 Shift	0.06	0.12	0.25	0.28	2%	$30.44

[a] *The average levelized TRC value represents a weighted average across all iterations, including segment and end use. As a result, some permutations of a measure may have a low levelized cost while other permutations have high levelized cost.*
[b] *The Council separated the Energy Management measures into two tiers: Level 1 and Level 2. Level 1 represents the standard strategic energy management applied in mostly large industrial facilities. Level 2 represents a share of strategic energy management potential likely found in smaller facilities, which is therefore more difficult to achieve. The cost of Level 2 is twice the cost of Level 1 and has half the savings.*
[c] *The Fan Equipment Upgrade net expenses (costs and benefits) were less than zero. The resulting levelized TRC was shown as $0.00 (per megawatt-hour) and can be considered cost-effective.*

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 82% of 22-year achievable technical potential is realized within the first 10 years.

Industrial measures are generally low cost, so the industrial achievable technical potential by levelized cost distribution does not have the same peak at greater than $160 per megawatt-hour as that for the residential and commercial sectors. In fact, all 11 aMW of industrial potential can be achieved at a levelized cost of less than or equal to $110 per megawatt-hour. Figure 4.21 shows cumulative achievable economic potential in 2045 for different levelized cost thresholds.

Figure 4.21. Industrial Supply Curve — Cumulative Achievable Technical Potential in 2045 by Levelized Cost



City Light's portfolio modeling selected nearly all industrial measures for inclusion in the achievable economic potential portfolio. Therefore, the 22-year cumulative achievable economic potential for the industrial sector is 10 aMW at a levelized cost of less than or equal to $60 per megawatt-hour. For this sector, the achievable economic potential is nearly equivalent to the achievable technical potential, because almost all the achievable technical potential is considered economically feasible at the levelized cost threshold, except some measures in process air compressor and pumps end uses, as shown in Table 4.15. The 15 highest-savings IRP selected industrial measures are equal to the ones shown in Table 4.16, except that the air compressor equipment measure is not in the list due to having a levelized cost above the threshold and advanced motors - material handling measure is added as the fifteenth measure with 0.27 aMW of 22-year economic potential.

4.5. Scenarios

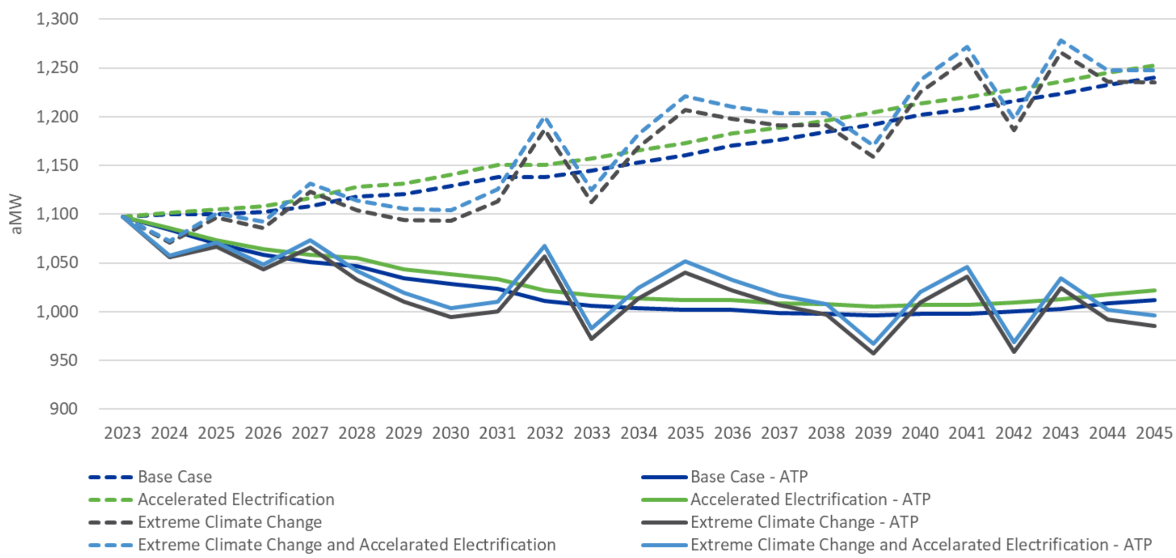
Cadmus worked with the City Light load forecast team to define three baseline sales forecast scenarios, listed in Table 3.7 of the *3.5. Scenarios* section. After updating the baseline sales to reflect the impacts of these scenarios (see the *3.5. Scenarios* section for results), Cadmus estimated the achievable technical potential based on these scenario sales forecasts considering the same 10,257 permutations of conservation measures as the base case forecast. Table 4.17 shows baseline sales and cumulative technical and achievable technical potential by sector for each scenario. The following subsections present the results by sector.

Table 4.17. Cumulative Technical and Achievable Technical Potential by Sector (2024–2045)

Sector	Baseline Sales (aMW)	Technical Potential		Achievable Technical Potential	
		aMW	% of Baseline Sales	aMW	% of Baseline Sales
Base Case					
Residential	398	95	24%	79	20%
Commercial	718	155	22%	138	19%
Industrial	124	13	11%	11	9%
Total	**1,240**	**263**	**21%**	**228**	**18%**
Accelerated Electrification					
Residential	399	95	24%	79	20%
Commercial	722	158	22%	140	19%
Industrial	131	13	10%	12	9%
Total	**1,252**	**266**	**21%**	**231**	**18%**
Extreme Climate Change					
Residential	417	100	24%	90	22%
Commercial	694	151	22%	149	21%
Industrial	124	13	11%	11	9%
Total	**1,235**	**264**	**21%**	**250**	**20%**
Extreme Climate Change and Accelerated Electrification					
Residential	419	101	24%	90	22%
Commercial	698	153	22%	150	22%
Industrial	131	13	10%	12	9%
Total	**1,248**	**267**	**21%**	**252**	**20%**

Figure 4.22 shows the combined residential, commercial, and industrial baseline sales before and after subtracting achievable technical potential for each scenario for each year of the study.

Figure 4.22. All Sectors Combined Baseline Sales Before and After Subtracting Achievable Technical Potential for Each Scenario (2024–2045)



4.5.1. Residential

Figure 4.23 shows the residential cumulative achievable technical potential over the 22-year study horizon for each scenario.

Figure 4.23. Residential Cumulative Achievable Technical Potential for Each Scenario (2024–2045)

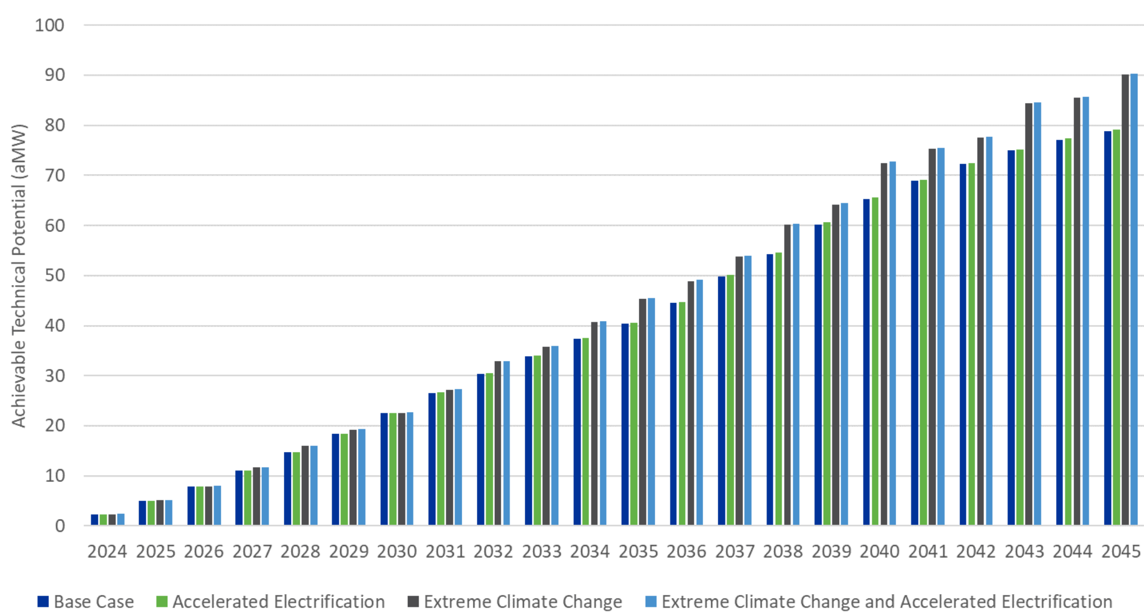
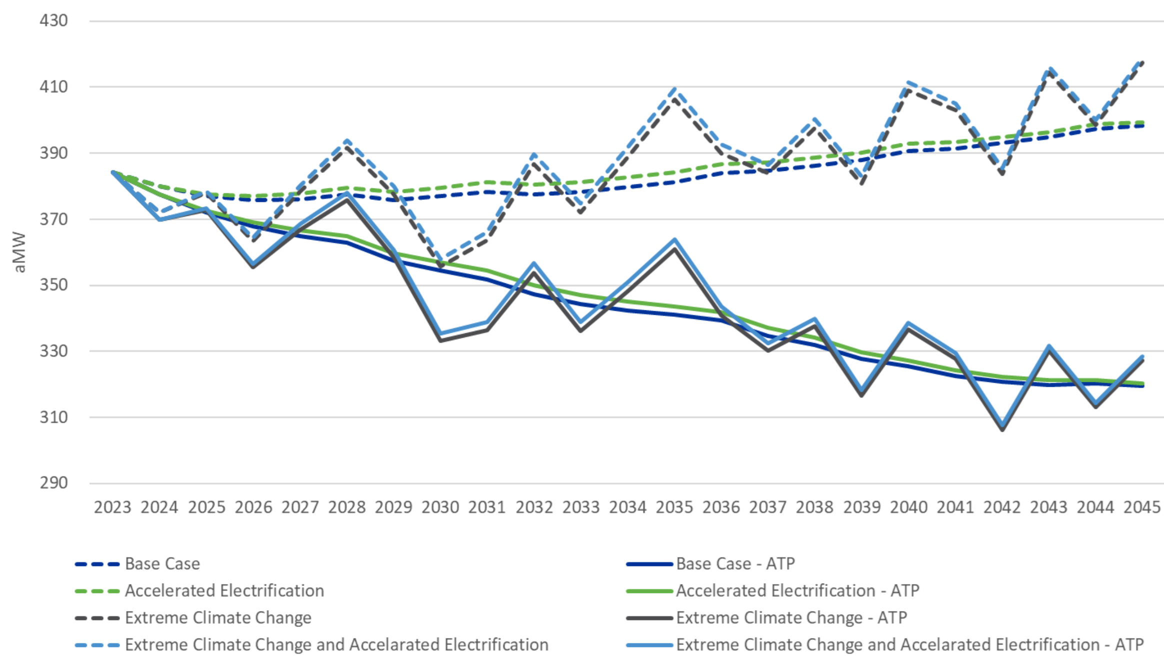


Figure 4.24 shows the residential baseline sales before and after subtracting achievable technical potential for each scenario for each year of the study.

Figure 4.24. Annual Residential Baseline Sales for Each Scenario after Subtracting Achievable Technical Potential (2024–2045)



4.5.2. Commercial

Figure 4.25 shows the commercial cumulative achievable technical potential over the 22-year study horizon for each scenario.

Figure 4.25. Commercial Cumulative Achievable Technical Potential for Each Scenario (2024–2045)

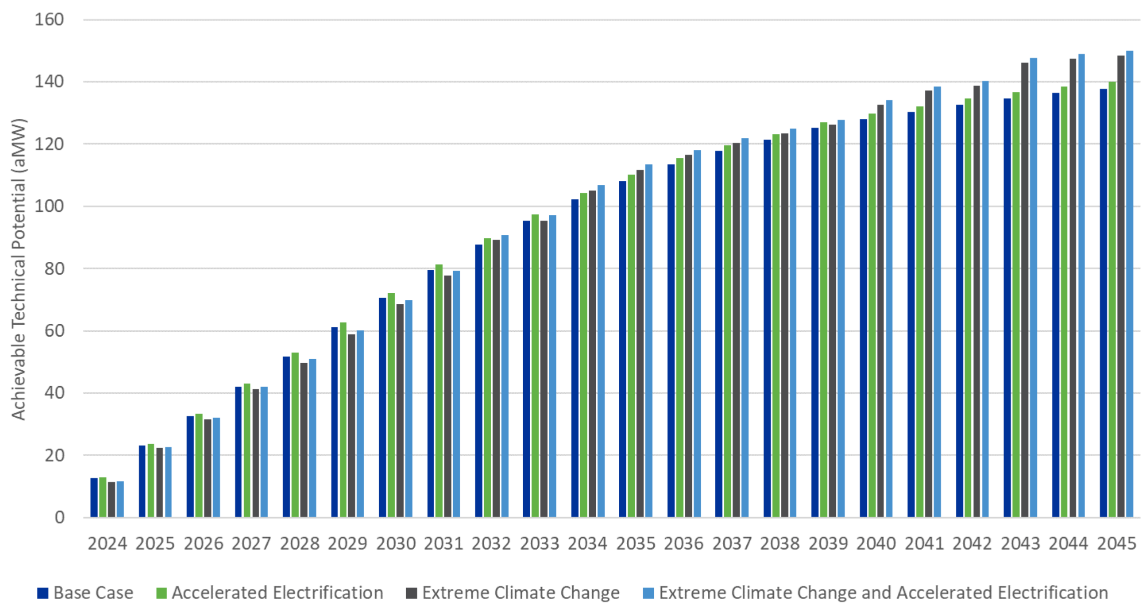
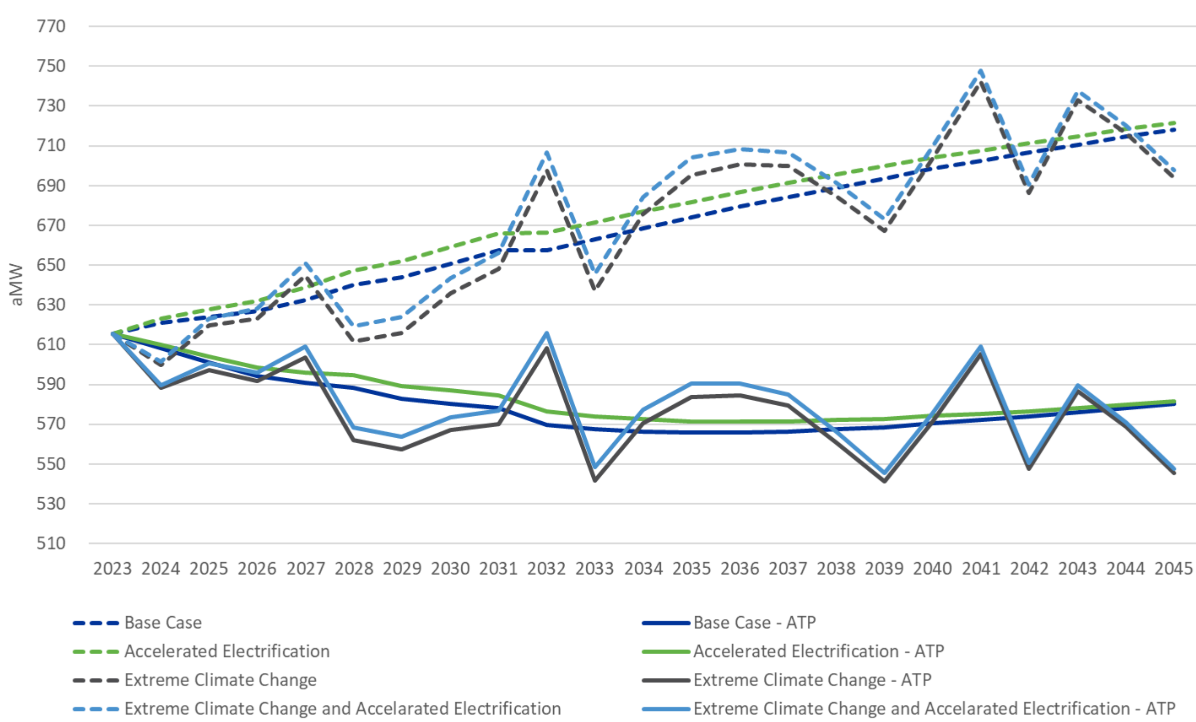


Figure 4.26 shows the commercial baseline sales before and after subtracting achievable technical potential for each scenario for each year of the study.

Figure 4.26. Annual Commercial Baseline Sales for Each Scenario after Subtracting Achievable Technical Potential (2024–2045)



4.5.3. Industrial

As climate change impacts will be negligible for the industrial sector, only the accelerated electrification scenario was considered. Figure 4.27 shows the industrial cumulative achievable technical potential over the 22-year study horizon for base case and accelerated electrification scenario.

Figure 4.27. Industrial Cumulative Achievable Technical Potential for Each Scenario (2024–2045)

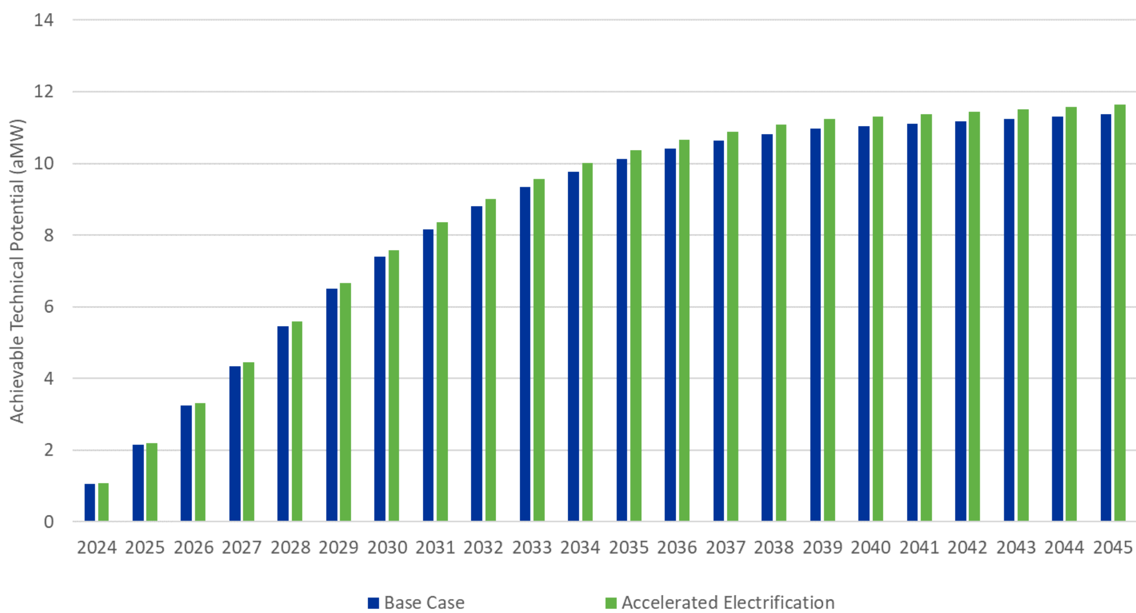
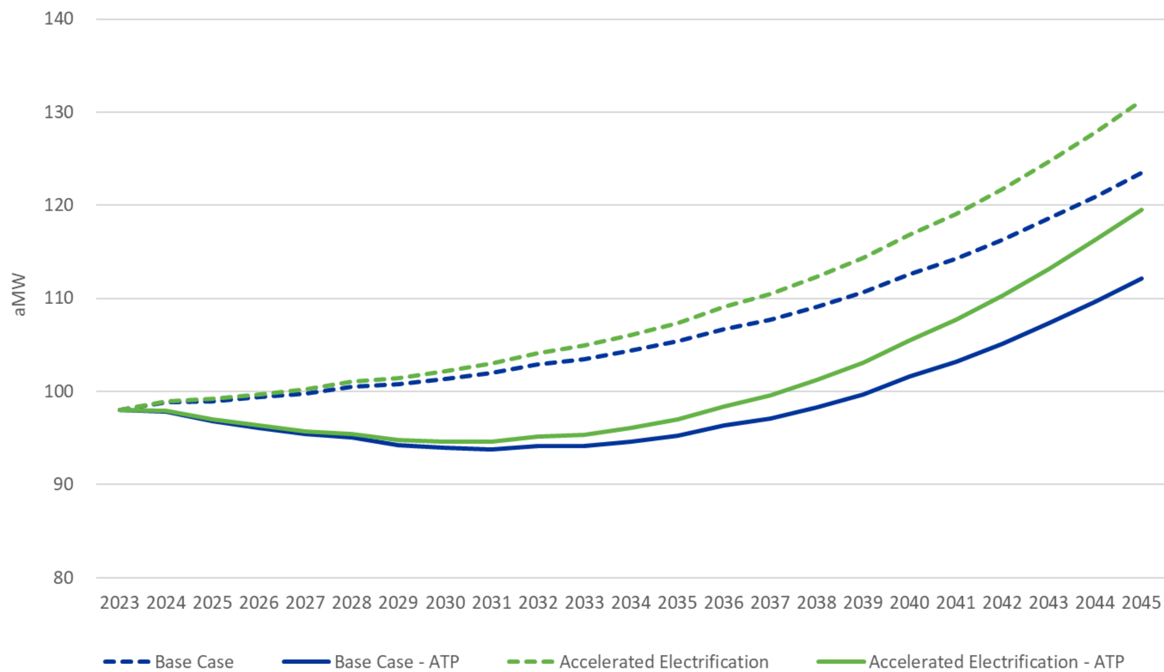


Figure 4.28 shows the industrial baseline sales before and after subtracting achievable technical potential for each scenario for each year of the study.

Figure 4.28. Annual Industrial Baseline Sales for the Base Case and Accelerated Electrification Scenario (2024–2045)



5. Comparison to 2022 CPA

The 2024 DSMPA focused on final year cumulative estimates of technical potential and incremental estimates of achievable technical potential. Cadmus defines the final year cumulative technical potential as the total average megawatt savings that are considered technically feasible to achieve over the study horizon. For the 2022 CPA, that horizon was 2022 through 2041 (20 years) while for the 2024 DSMPA, it is 2024 through 2045 (22 years). Overall, the 2024 DSMPA identified higher final year cumulative technical potential and achievable technical potential compared with the 2022 CPA. This chapter presents the comparison of technical, achievable technical, and achievable economic potential results from these two assessments by detailing the reasons for the differences in results.

5.1. Technical Potential Comparison

The 2024 DSMPA identified 263 aMW of technical potential in the final year, compared with 233 aMW in the 2022 CPA. The 13% increase in cumulative final year technical potential is heavily influenced by the longer study horizon, new load forecast with the adjustments mentioned in the *3. Baseline Forecast* chapter (building electrification, climate change, new construction codes, and impacts of COVID-19), new and updated residential and commercial measures, and the inclusion of residential and commercial measures involving emerging technologies. Table 5.1 shows a comparison of cumulative technical potential, by sector, from the 2022 CPA and 2024 DSMPA.

Table 5.1. Final Year Cumulative Technical Potential Comparison by Sector

Sector	2024 DSMPA			2022 CPA			Percentage Change in Technical Potential
	Baseline Sales—22 Year (aMW)	Technical Potential—22 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	398	95	24%	422 [a]	90	21%	5%
Commercial	718	155	22%	667	131	20%	18%
Industrial	124	13	11%	91	12	13%	8%
Total	**1,240**	**263**	**21%**	**1,181***	**233**	**19%**	**13%**

[a] *This is the value after removing the sales due to EVs.*

The following sections detail the differences between the 2024 DSMPA and the 2022 CPA by sector.

5.1.1. Changes in Residential Technical Potential

The residential sector technical potential increased from 90 aMW in the final year in the 2022 CPA to 95 aMW in the 2024 DSMPA, which is a 5% increase. In the 2024 DSMPA, several factors affected the potential in positive or negative ways and resulted in an overall increase. The factors contributing to increasing potential are an increase in heat pump and water heater saturations due to electrification, new and updated measures (mainly RTF measures), and the inclusion of measures involving emerging technologies. The factors resulting in a decrease in potential are having the new residential load forecast being 6% lower in the 2024 DSMPA than in the 2022 CPA, adjustments made for the 2022 Revised Code of Washington (RCW 19.27A.160),[29] which requires that "… residential and nonresidential construction permitted under the 2031 state energy code achieve a seventy percent reduction in annual net energy consumption, using the adopted 2006 Washington state energy code as a baseline," and an overall decrease in heating and cooling load due to climate change adjustments to the load forecast. In addition, the 2024 DSMPA excludes the EV end use and associated potential, unlike the 2022 CPA, although achievable technical potential due to EVs accounts for only 0.3% of the total achievable technical potential in 2022 CPA.

Table 5.2 provides a comparison of baseline sales and technical potential and the reasoning for the differences.

29 WA Rev Code § 19.27A.160. 2022. "RCW 19.27A.160 Residential and Nonresidential Construction—Energy Consumption Reduction—Council Report." https://app.leg.wa.gov/RCW/default.aspx?cite=19.27A.160

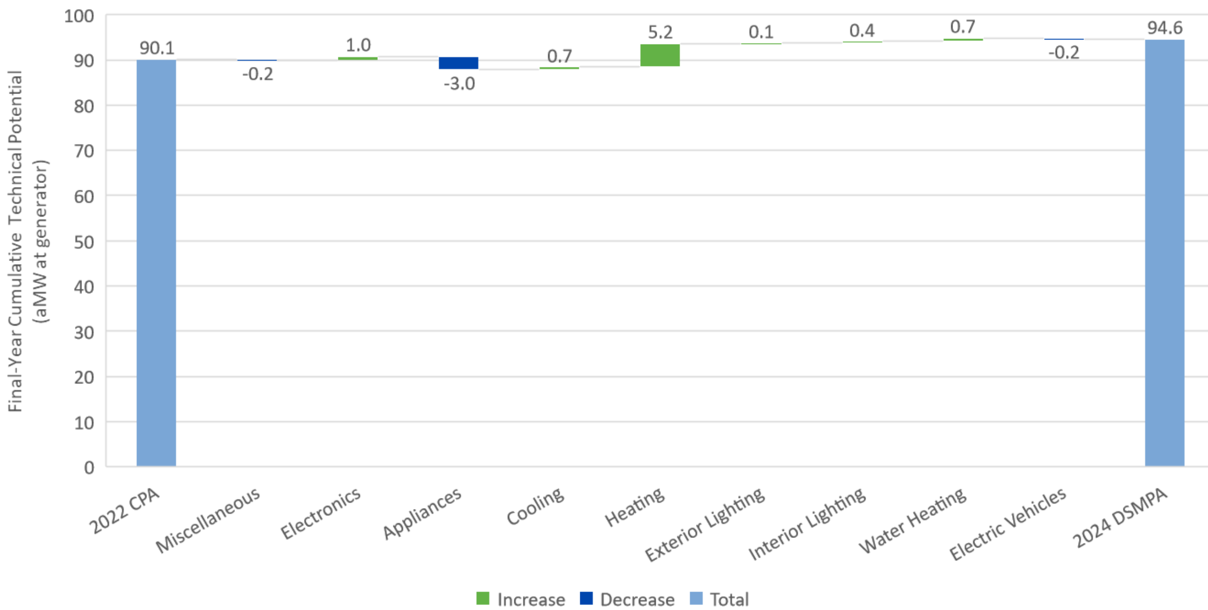
Table 5.2. Residential Cumulative Technical Potential Comparison

Component	2024 DSMPA 22-Year (aMW)	2022 CPA 20-Year (aMW)	Percentage Change	Reason for Change
Baseline Sales (aMW)	398	422 [a]	-6%	Updated sales forecast from City Light with adjustments for COVID-19, building electrification, climate change, and codes and standards.
Technical Potential (aMW)	95	90	5%	Increase in heat pump and water heater saturations due to electrification, new and updated measures, and the inclusion of emerging technology measures
Technical Potential as % of Baseline	24%	21%	N/A	

[a] *This is the value after removing the sales due to EVs.*

Figure 5.1 shows a comparison of residential technical potential at the end-use group level. The blue bars indicate all end-use groups that had a decrease in technical potential from the 2022 CPA to the 2024 DSMPA. The most significant decrease of 3 aMW comes from the appliances end use, driven by reduced savings for heat pump dryers following an update to the RTF heat pump dryers workbook. Other relatively smaller dips in potential are for EVs, due to excluding the EV end use in the 2024 DSMPA, and miscellaneous end uses due to updated pool pump savings and wastewater impacts from updated RTF measure workbooks. The green bars indicate all end-use groups that had an increase in technical potential. The most significant increase was for the heating end use (including heat pumps), at 5.2 aMW, which is due to the increase in heat pump saturations due to electrification. Similarly, the water heating end use increased by 0.7 aMW due to increasing water heater saturations because of electrification. Emerging technology measures added for 2024 DSMPA also led to increased potential in several end uses, such as cooling and heating.

Figure 5.1. Change in Cumulative Residential Technical Potential by End-Use Group



5.1.2. Changes in Commercial Technical Potential

Several factors resulted in the 2024 DSMPA identifying higher final-year cumulative technical potential than the 2022 CPA. These are the new commercial load forecast being 8% higher in the 2024 DSMPA than in the 2022 CPA, an increase in heat pump and water heater saturations due to electrification, an overall increase in heating and cooling load due to climate change adjustments, new and updated measures (mainly RTF measures), and new commercial measures involving emerging technologies. The only factor resulting in a decrease in potential is the adjustment made for the 2022 RCW 19.27A.160.[30] Table 5.3 shows a comparison of technical potential in the commercial sector for the two CPAs.

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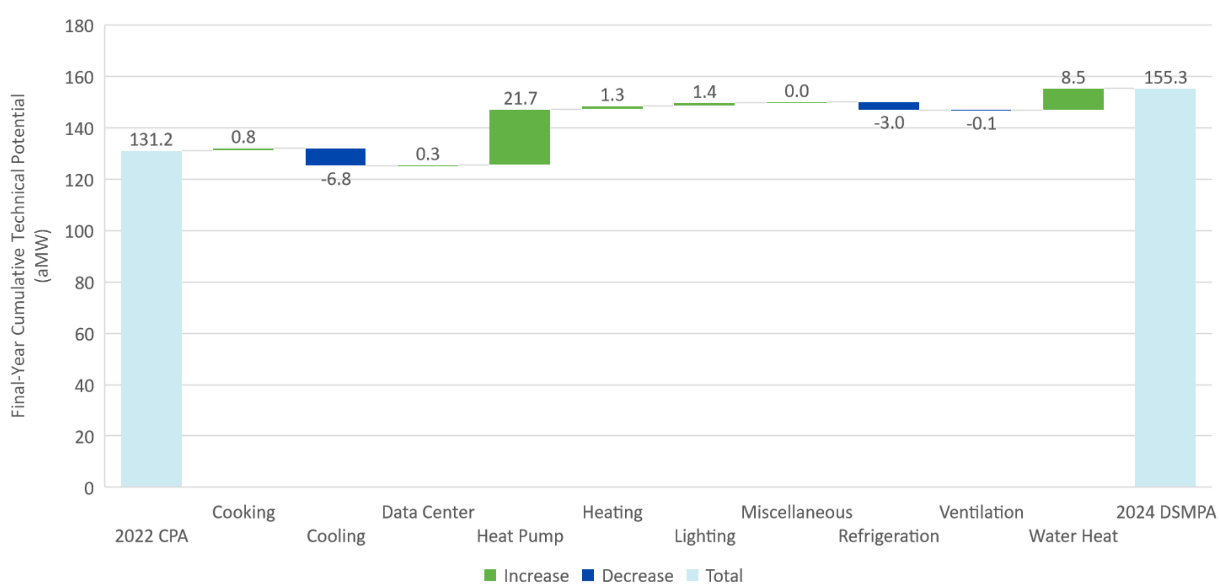
30 WA Rev Code § 19.27A.160. 2022. "RCW 19.27A.160 Residential and Nonresidential Construction—Energy Consumption Reduction—Council Report." https://app.leg.wa.gov/RCW/default.aspx?cite=19.27A.160

Table 5.3. Commercial Cumulative Technical Potential Comparison

Component	2024 DSMPA 22-Year (aMW)	2022 CPA 20-Year (aMW)	Percentage Change	Reason for Change
Baseline Sales (aMW)	718	667	8%	Updated sales forecast from City Light with adjustments for COVID 19, building electrification, climate change, and codes and standards.
Technical Potential (aMW)	155	131	18%	Increase in heat pump and water heater saturations due to electrification, increase in heating and cooling loads due to climate change adjustments, new and updated measures, and the inclusion of emerging technology measures
Technical Potential as % of Baseline	22%	20%	N/A	

Figure 5.2 illustrates the change in commercial technical potential between the 2022 CPA and 2024 DSMPA by end-use group. End-use groups exhibiting decreased technical potential include cooling and refrigeration. The decrease in technical potential for the cooling end use is due to the saturation of cooling equipment shifting to heat pumps over the study horizon. Overall, technical potential for commercial space cooling, including both the cooling end-use group (DX and chillers) and the heat pump end-use group, is higher in the 2024 DSMPA than in the 2022 CPA, primarily due to increased cooling loads from climate change adjustments. The decrease in refrigeration potential is driven by updates to RTF refrigeration measures.

Figure 5.2. Change in Commercial Cumulative Technical Potential by End-Use Group



5.1.3. Changes in Industrial Technical Potential

The industrial sector in the 2024 DSMPA did not include any new measures based on the 2021 Power Plan, which resulted in no major change in the industrial sector potential compared with the 2022 CPA. Accounting for building electrification in the 2024 DSMPA increased the base case forecast and resulted in the opportunity for additional energy efficiency potential.

5.2. Achievable Technical Potential and Ramp Rate Comparison

As with assessments of technical potential, Cadmus identified higher cumulative achievable technical potential in the 2024 DSMPA than was shown in the 2022 CPA. Because 22-year cumulative achievable technical potential is a subset of technical potential, factors contributing to higher cumulative achievable technical potential are the same as those previously discussed for technical potential.

The following figures show incremental achievable technical potential from the 2024 DSMPA (Figure 5.3) and the 2022 CPA (Figure 5.4). Incremental achievable technical potential in the first two years of the 2024 DSMPA is about 9% higher than that in the first two years of the 2022 CPA.

Figure 5.3. Incremental Achievable Technical Potential – 2024 DSMPA

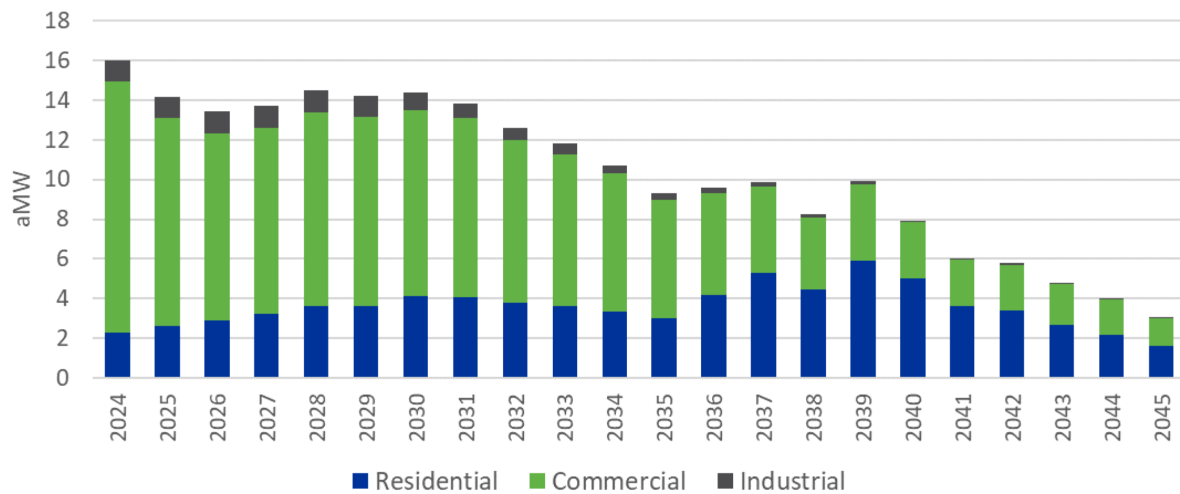


Figure 5.4. Incremental Achievable Technical Potential – 2022 CPA

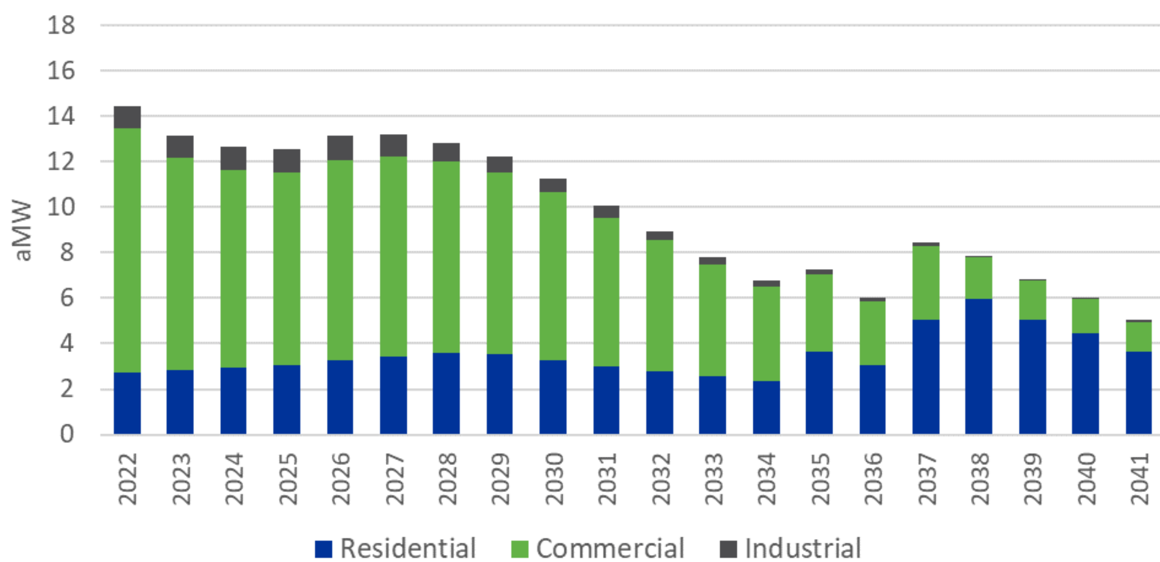


Figure 5.3 and Figure 5.4 show a pretty similar distribution of potential over the study horizons. The two-year achievable potential in the 2022 CPA is equal to approximately 14% of the total 20-year achievable technical potential, whereas the two-year achievable potential in the 2024 DSMPA is equal to approximately 13% of the total 22-year achievable technical potential. This similarity is expected as there is no major difference in ramp rate assumptions used in the 2022 CPA and 2024 DSMPA.

5.3. IRP Achievable Economic Potential Comparison

Both the 2022 CPA and 2024 DSMPA used the IRP optimization modeling to determine how much energy efficiency, as a resource, is cost-effective compared with other competing resources over the study horizon. Table 5.4 shows a comparison of the achievable (economic) potential between the two studies. The IRP optimization modeling assumptions between the two studies differ along several subject areas. For example, costs of supply resource Power Purchase Agreement contracts, the transmission delivery costs in those agreements, and any other ancillary services associated with the energy. Load forecasts are different between the two studies as well. The load forecast in the 2022 CPA did not include any climate change adjustments, had very few electrification assumptions, and included preliminary COVID-19 load adjustments. The 2024 DSMPA load forecast featured climate change, more building electrification loads, and better-understood COVID-19 adjustments. The two studies also have different demand-side potentials and associated costs.

Table 5.4. Achievable Economic Cumulative Potential Comparison

Sector	2024 DSMPA			2022 CPA		
	Baseline Sales – 22-Year (aMW)	Achievable Economic Potential – 22-Year (aMW)	Achievable Economic Potential as % of Baseline Sales	Baseline Sales – 20-Year (aMW)	Achievable Economic Potential – 20-Year (aMW)	Achievable Economic Potential as % of Baseline Sales
Residential	398	50	13	461	18	4%
Commercial	718	72	10	667	77	12%
Industrial	124	10	8	91	10	11%
Total	**1240**	**132**	**11%**	**1,219**	**105**	**9%**

The 2024 DSMPA 22-Year residential sector achievable economic potential increased by nearly 200% compared with the 2022 CPA. The 2024 DSMPA selected nearly all residential measures, mostly due to residential measures' effectiveness at reducing winter loads..

The 2024 DSMPA commercial and industrial sectors achievable economic potential is very similar to that of the 2022 CPA.

6. Detailed Methodology

Cadmus' general methodology can be best described as a combined top-down/bottom-up approach. We began the top-down component with City Light's most current 2022 load forecast. Cadmus adjusted this forecast for building energy codes, equipment efficiency standards, COVID-19 impacts, building electrification, and climate change that was not already accounted for through the forecast. Cadmus then disaggregated this load forecast into its constituent customer sectors, customer segments, and end-use components and projected the results out 22 years. We also calibrated the base year (2023) to City Light's sector-load forecasts produced in 2022.

For the bottom-up component, Cadmus considered potential technical impacts of various ECMs and practices on each end use. We then estimated impacts, based on engineering calculations, accounting for fuel shares, current market saturations, technical feasibility, and costs. The technical potential presents an alternative forecast that reflects the technical impacts of specific energy efficiency measures. Cadmus then determined the achievable technical potential by applying ramp rates and achievability percentages to technical potential. This chapter describes the CPA methodology in detail.

6.1. Developing Baseline Forecasts

City Light's sector-level sales and customer forecasts provided the basis for assessing energy efficiency potential. Prior to estimating potential, Cadmus 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 was to determine the appropriate customer segments in each sector. For designations we drew upon categories available in the study's key data sources—primarily City Light's nonresidential customer database (for the commercial and industrial sectors) and the U.S. Census Bureau's American Community Survey (for the residential sector)—then we mapped the appropriate end uses to relevant customer segments.

Upon determining appropriate customer segments and end uses for each sector, Cadmus produced the baseline end-use load forecasts by integrating current and forecasted customer counts with key market and equipment usage data.

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

$$EUSE_{ij} = \sum\nolimits_{e} ACCTS_i \times UPA_i \times SAT_{ij} \times FSH_{ij} \times ESH_{ije} \times EUI_{ije}$$

where:

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

For each sector, we determined the total annual electric consumption as the sum of $EUSE_{ij}$ across the end uses and customer segments.

Consistent with other conservation potential studies, and commensurate with industrial UEC data (which varied widely in quality), we allocated the industrial sector's loads to end uses in various segments based on data available from the U.S. Energy Information Administration.[31]

6.1.1. Derivation of End-Use Consumption

End-use electric 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, Cadmus used estimates of UEC, representing annual electric energy consumption associated with an end use and represented by a specific type of equipment (such as a central AC or heat pump). The basis for the UEC values were derived from savings in the latest RTF workbooks, the Council's 2021 Power Plan workbooks, and savings analyses to calculate accurate consumption wherever possible for all efficiency levels of an end-use technology. When Council workbooks did not exist for certain end uses, Cadmus used results from NEEA's 2017 RBSA or City Light's oversample, or we conducted other research (e.g., U.S. Department of Energy, ENERGY STAR).

For the commercial sector, Cadmus treated consumption estimates as end-use intensities that represented annual electric energy consumption per square foot served. To develop the end-use intensities, Cadmus developed electric energy intensities (total kilowatt-hours per building square foot) based on NEEA's 2019 CBSA IV. Cadmus then benchmarked these electric energy intensities against various other data sources including the CBSA III, historical forecasted and potential study data from City Light, and historical end-use intensities developed by the Council and NEEA.

To distribute the electric energy intensities to end-use intensities, Cadmus used assumptions specific to each building segment and each end use:

- Lighting. The methodology for lighting end-use consisted of analyzing CBSA IV's lighting power density (lighting wattage per square foot) multiplied by the Council's interior lighting hours of use by building type. Once we had calculated lighting end-use intensity, Cadmus subtracted this portion of load from the total CBSA electric energy intensities (e.g., to estimate non-lighting intensities).
- Non-lighting. To distribute the remaining non-lighting CBSA electric energy intensities into end uses, Cadmus used 2012 CBECS microdata to calculate percentages of end-use intensities across various end-use groups by building types as defined by the Council. Cadmus used the CBSA fuel shares and end-use saturations to adjust the distributions of CBECS end-use intensities to better represent City Light's commercial service territory. These finalized CBECS end-use intensities—adjusted with CBSA values where possible—were the basis for most of the end-use intensities in the commercial sector.

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[31] U.S. Department of Energy, Energy Information Administration. 2010. *Manufacturing Energy Consumption Survey*.

- Computers and servers. Cadmus developed energy intensities by building type for two end-uses—computers (desktops and laptops) and servers—using the CBECS number of units per square foot multiplied by unit consumption.
- University. The CBSA IV data lacked information on university building type, and the schools building type represented only K–12, as designated by the Council. Cadmus developed a more accurate electric energy intensity specific to universities by calculating a ratio of the CBECS's university and school K–12 building types. Cadmus then used the CBSA school K–12 lighting power density and applied the Council's university lighting hours of use. Cadmus determined that the result was reasonable by benchmarking the university lighting end-use intensity developed for City Light against the ratio of CBECS university and school K–12 lighting loads.
- Retail. Low CBSA respondent counts and matching varying definitions of building type in Council and CBECS data caused concern, especially for the large and extra-large retail building types, so Cadmus combined large and extra-large retail building types for the CBSA electric energy intensities and lighting power density. Similarly, Cadmus combined small and medium retail building types because the counts and definitions were insufficient.

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

6.1.2. City Light Forecast Adjustments

Cadmus worked with the City Light load forecast team to adjust the baseline forecast to account for the impacts of COVID-19, climate change, equipment standards, building energy codes, and building electrification.

We accounted for the impacts of COVID-19 based on the adjustment factors provided by City Light for the residential and commercial sectors. We did not consider COVID-19 impacts for the industrial sector.

To account for the impacts of climate change, Cadmus used Multivariate Adaptive Constructed Analogs (MACA) scalar-adjusted HDD and CDD data provided by City Light. Cadmus applied annual HDD and CDD adjustment ratios (called climate change adjustment factors) to cooling, heating, and heat pump UECs for the residential and commercial sectors. Table 6.1 presents the climate change adjustment factors for the heating, cooling, and heat pump end uses for each year.

Table 6.1. Climate Change Adjustment Factors for Residential and Commercial Heating, Cooling, and Heat Pump End Uses for Each Year

Year	Residential and Commercial Heating End-Use Multiplier	Residential and Commercial Cooling End-Use Multiplier	Residential Heat Pump End-Use Multiplier	Average Commercial Heat Pump End-Use Multiplier [a]
2023	1.00	1.00	1.00	1.00
2024	1.00	1.02	1.00	1.01
2025	0.99	1.04	0.99	1.01
2026	0.98	1.06	0.99	1.02
2027	0.98	1.08	0.98	1.02
2028	0.98	1.10	0.98	1.04
2029	0.97	1.13	0.97	1.04
2030	0.96	1.15	0.97	1.05
2031	0.96	1.17	0.97	1.06
2032	0.96	1.20	0.97	1.07
2033	0.95	1.22	0.96	1.07
2034	0.94	1.25	0.95	1.08
2035	0.94	1.27	0.95	1.09
2036	0.94	1.30	0.95	1.10
2037	0.93	1.32	0.94	1.10
2038	0.92	1.35	0.94	1.11
2039	0.92	1.37	0.93	1.12
2040	0.92	1.40	0.94	1.13
2041	0.91	1.42	0.93	1.14
2042	0.90	1.44	0.92	1.14
2043	0.90	1.47	0.92	1.15
2044	0.90	1.49	0.92	1.16
2045	0.89	1.52	0.91	1.17

[a] Since the heat pump heating/cooling ratio of heat pumps varies by the type of the commercial building, commercial heat pump consumptions vary by building type. The numbers presented in this table are average multipliers.

For each end uses, Cadmus multiplied the base year (2023) UEC by the multipliers shown in the table above to calculate the climate change adjusted UEC. For example, for cooling, the climate adjustment factor was 1.52 in 2045, and therefore we multiplied the base year (2023) cooling consumption by 152% in 2045.

For the commercial sector, heat pump consumptions vary by building type because the heat pump heating/cooling ratio of heat pumps varies by the type of commercial building. On average, we multiplied the base year commercial heat pump consumptions by 117% in 2045. For the residential sector, based on observed increases in the adoption of heat pumps and air conditioning spurred by the 2021 heat dome, Cadmus assumed that future cooling saturation (heat pump plus air conditioning) would reach 70% by

2045. Cadmus implemented this assumption by linearly interpolating between base year (2023) saturation and final year (2045) saturation.

Cadmus further tailored the load forecast embedded with climate change adjustments for the impacts of city and state codes and federal standards that were on the books as of January 2023. We describe treatment of codes and standards in the 2024 DSMPA in the *Incorporating Federal Standards and State and Local Codes and Policies* section.

Furthermore, Cadmus made adjustments for building electrification based on a 2022 EPRI study.[32] For this 2024 DSMPA, Cadmus applied the EPRI study's moderate market advancement scenario data to account for the impacts of electrification. The moderate market advancement scenario is the closest to a "business as usual" scenario where electric transportation adoption continues to grow based on past trajectories and includes any incentives that may have been offered prior to 2020, and where the electrification of buildings and industry are driven by customer choice as well as relative economics.[33] The building stock and end-use saturation assumptions of the moderate market advancement scenario is generally consistent with City Light's 2022 load forecast and the 2022 CPA.

Based on moderate market advancement scenario data, Cadmus increased the fuel shares and equipment saturations such that for the residential sector, we converted cooking, dryer, and water heater fuel to electric: this meant that heat pump equipment saturations increased as non-electric space heating equipment is converted to heat pumps. Figure 6.1 presents the change in saturation of electric equipment for cooking, water heating, and HVAC heat pumps with and without fossil fuel backup over the study horizon for single-family houses (existing construction).

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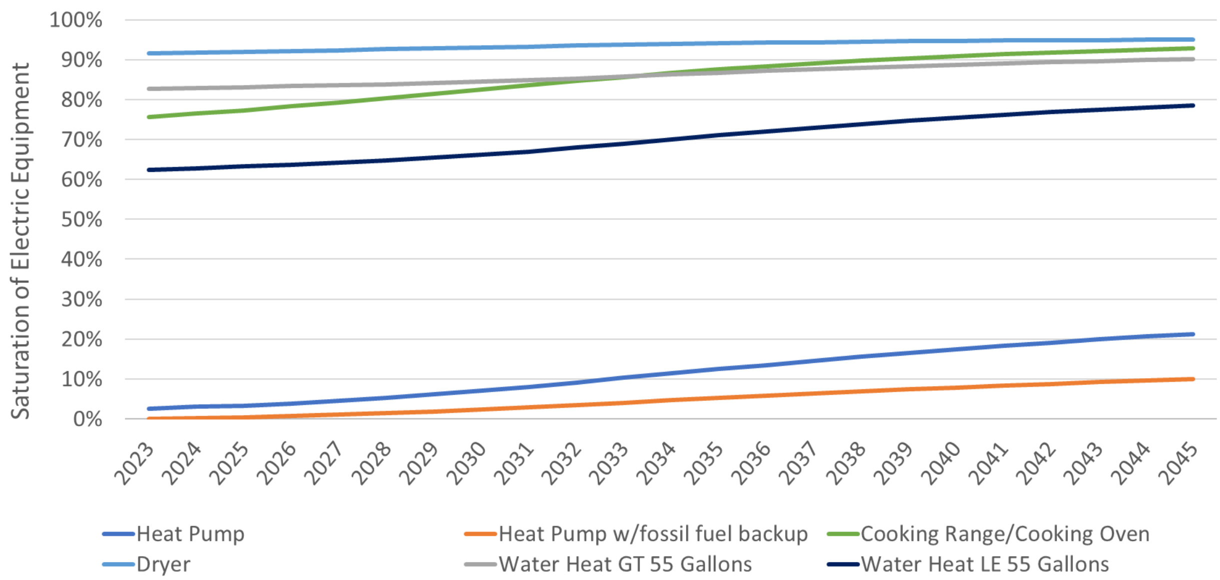
[32] Electric Power Research Institute. January 2022. *Seattle City Light Electrification Assessment, Final Report*.

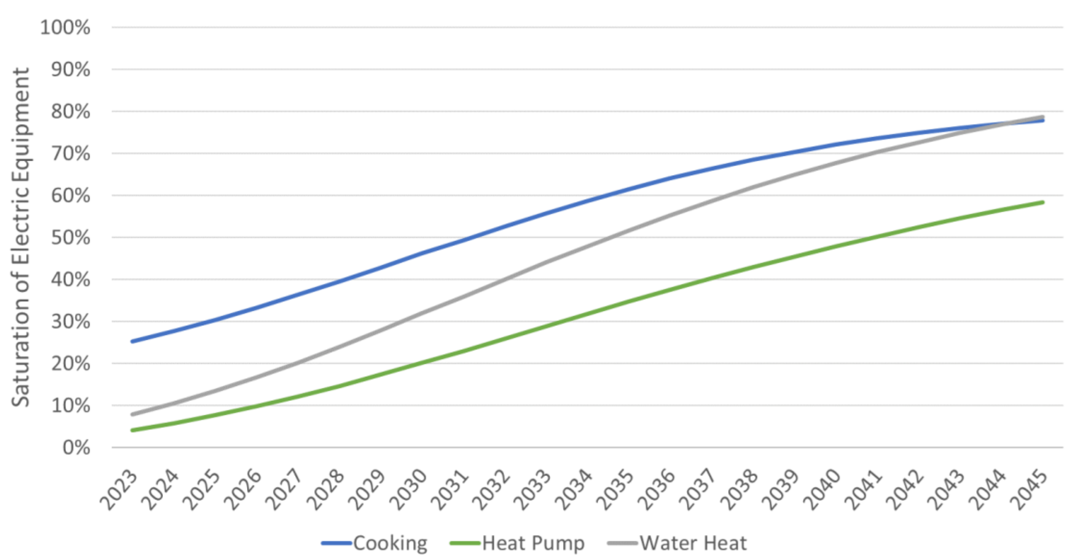
[33] This is a description of the EPRI study scenario used by City Light in the IRP process. The 2024 DSMPA estimates demand response potential for managed EV charging. It does not estimate conservation potential for efficient EV chargers. It also does not include transportation electrification in its baseline forecast. Instead, City Light adds the transportation electrification forecast to the 2024 DSMPA load forecast as part of the IRP modeling process.

Figure 6.1. Cooking, Water Heating, Heat Pump, and Heat Pump with Fossil Fuel Backup Saturations in Single-Family Houses (Existing Construction)



Similarly, for the commercial sector, cooking, water heater, and HVAC heat pump electric equipment saturations increased. As an example, Figure 6.2 presents the change in cooking, water heating, and heat pump saturation of electric equipment over the study horizon for restaurants (existing construction).

Figure 6.2. Cooking, Water Heating, and Heat Pump Saturations in Restaurants (Existing Construction)



In this study, all these adjustments are naturally occurring rather than having energy efficiency potential.

6.2. Baseline Forecast Scenarios

Cadmus worked with the City Light load forecast team to define three baseline forecast scenarios that represent different conditions that could occur in the future. We then updated the baseline forecast to show the effects of these conditions on the load forecast:

- **Scenario 1: Extreme Climate Change.** This scenario reflects the impact of higher temperatures on the residential and commercial forecast compared with the moderate climate change conditions incorporated in the baseline forecast. It also demonstrates the impact of higher AC saturations on the residential forecast. We modeled the temperature increase based on CDDs and HDDs associated with the CanESM2 model provided by City Light, which resulted in increased cooling and decreased heating load. The impacts of this scenario effected the residential sector as an increase in AC saturation from 70% by 2045 in the baseline forecast to 85% in this scenario forecast.
- **Scenario 2: Accelerated Electrification.** This scenario reflects the accelerated market advancement scenario of the "Phase 2 - Seattle City Light Electrification Assessment" conducted by EPRI in 2022. This accelerated market advancement scenario is a middle ground between the moderate and rapid market advancement scenarios of City Light's Electrification Assessment, where the rapid market advancement scenario was defined to be consistent with the goals and policies outlined in the Seattle Climate Action Plan[34] while also covering the Seattle Office of Sustainability proposal to set carbon-based benchmarking requirements for commercial and multifamily buildings over 20,000 square feet.[35]
- **Scenario 3: Extreme Climate Change and Accelerated Electrification.** This was the most extreme of all three scenarios and represents a condition of both extreme climate change and the accelerated electrification scenario.

6.3. Measure Characterization

Because technical potential draws upon an alternative forecast, reflecting installations of all technically feasible measures, Cadmus chose the most robust set of appropriate ECMs and developed a comprehensive database of technical and market data for these ECMs that applied to all end uses in various market segments.

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34 Seattle Office of Sustainability and Environment. June 2013. *City of Seattle 2013 Climate Action Plan.* https://www.seattle.gov/Documents/Departments/Environment/ClimateChange/2013_CAP_20130612.pdf

35 Brown K. March 10, 2022. Exploring Building Performance Standards: A New Policy to Reduce Building Sector Emissions. https://greenspace.seattle.gov/2022/03/exploring-building-performance-standards-a-new-policy-to-reduce-building-sector-emissions/#sthash.lCi0WGc5.inrTWtUd.dpbs

The database included the following measures:

- All measures in the Council's 2021 Power Plan conservation supply curve workbooks
- Active UES measures in the RTF
- Commercial technologies that were of interest to City Light and included in the 2022 CPA, such as airflow management (data center), building automation system upgrades, computer room AC, cooling towers, economizer (outside air), economizer (water side), freezer (lab grade), heat pump (water source), heat recovery improvements, HVAC retro-commissioning, LED sign lighting, server (virtualization), and water heater controls.
- Emerging technology measures that are near commercialization or that may become cost-effective within the next five years and can help bridge the gap in declining potential from current technologies. These measures included the following for the residential and commercial sectors:

  Residential sector:

  - Induction cooktop, 2-element
  - Induction cooktop, 4-element
  - Vinyl siding, insulated
  - Structural Insulated Panels panel framing
  - Networked automation controls
  - Smart electrical panel
  - Smart outlets
  - Indirect evaporative cooler, 2.5 tons
  - Indirect evaporative cooler, 1.0 tons
  - Clothes dryer with heat recovery
  - Advanced air-to-water heat pump

  Commercial sector:

  - Induction cooktop
  - Commercial/industrial carbon dioxide heat pumps
  - Central heat pump water heater with load controls
  - Aerofoil outfitted shelving
  - Advanced air-to-water heat pump
  - Web-enabled power monitoring for small and medium-sized businesses
  - Food truck, efficient electric cooking
  - Low global warming potential freezers and refrigerator cases

Cadmus included only the Council and RTF measures applicable to sectors and market segments in City Light's service territory. For example, we did not characterize measures for the agriculture sector or the residential manufactured home segment, as these sectors are a small fraction of City Light's customer mix. Cadmus added measures if the RTF workbooks were not included in the Council's 2021 Power Plan or if the RTF workbooks have been updated since the Council's 2021 Power Plan workbooks.

Cadmus classified the electric energy efficiency measures applicable to City Light's service territories into two categories:

- **High-efficiency equipment (lost opportunity) measures** directly affecting end-use equipment (such as high-efficiency domestic water heaters), which follow normal replacement patterns based on expected lifetimes.
- **Non-equipment (retrofit) measures** affecting UEC without replacing end-use equipment (such as 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 had several relevant inputs:

- **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 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:**
  - 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 (for example, a decrease in lighting power density causing heating loads to increase)

Among various sources, Cadmus primarily derived these inputs from four resources:

- NEEA CBSA IV, including Puget Sound Energy's oversample, where applicable[36]
- NEEA RBSA II with City Light's oversample
- The Northwest Power and Conservation Council's 2021 Power Plan conservation supply curve workbooks
- The RTF 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 a hierarchy for costs and savings (also shown in Table 6.2):

1. The Council's 2021 Power Plan conservation supply curve workbooks, except in cases where a more recent version of RTF UES measure workbooks was submitted and not used in the Council's 2021 Power Plan

[36] City Light did not have an oversample conducted as part of CBSA IV. To better represent the Seattle area (compared with regional values), Cadmus incorporated Puget Sound Energy's CBSA oversample data.

2. RTF UES measure workbooks
3. 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.

RBSA Methodology

For residential estimates, Cadmus relied on City Light's oversample in NEEA's RBSA II (2017). If City Light's subset did not have a sufficient sample to achieve 90% confidence with ±10% precision for a given estimate, we derived estimates from the sample of Puget Sound–area customers (of City Light, Puget Sound Energy, the Snohomish County Public Utility District, and Tacoma Power) or for the broader Northwest, as found in the RBSA. If Cadmus could not calculate applicability factors from NEEA's RBSA, we used applicability factors from the Council's 2021 Power Plan conservation supply curve workbooks. The resulting estimates reflect averages for the Northwest region and were not necessarily specific to City Light's service territory.

CBSA Methodology

For the commercial sector, Cadmus first used the subset of City Light's customers, including Puget Sound Energy's oversample, in NEEA's CBSA IV (2019).

The original CBSA IV weights were constructed to represent the Council's regional building counts. To represent City Light's building counts, Cadmus reanalyzed the CBSA weights based on City Light's totals of building square footage for specific building types. Cadmus included only the CBSA data and the Puget Sound Energy's oversample in the Council's defined climate heating zone 1. While reviewing whether to only include urban sites in these analyses, Cadmus found that, for the heating zone 1 subset, 92% of the buildings were urban and 95% of building square footage was urban. Due to the limited impact of rural for all sites in the heating zone 1 subset, Cadmus did not make any further adjustments in the overall analysis.

Once Cadmus finalized City Light's CBSA weights to match City Light's total building square footage by building type, we used these weights for all CBSA analysis in this study. Where respondent counts were sufficient for specific CBSA analyses, Cadmus used building type names as defined by the Council to produce more granular results.

If NEEA's CBSA did not have sufficient data to estimate a particular value (for example, applicability factors) for a given measure, Cadmus relied on factors from the Council's 2021 Power Plan conservation supply curve workbooks.

Measure Data Sources

Table 6.2 lists the primary sources referenced in the study by data input.

Table 6.2. Key Measure Data Sources

Data	Residential Source	Commercial Source	Industrial Source
Energy Savings	2021 Power Plan supply curve workbooks; RTF; Cadmus research	2021 Power Plan supply curve workbooks; RTF; Cadmus research	2021 Power Plan supply curve workbooks; Cadmus research
Equipment and Labor Costs	2021 Power Plan supply curve workbooks; RTF; Cadmus research	2021 Power Plan supply curve workbooks; RTF; Cadmus research	2021 Power Plan supply curve workbooks; Cadmus research
Measure Life	2021 Power Plan supply curve workbooks; RTF; Cadmus research	2021 Power Plan supply curve workbooks; RTF; Cadmus research	2021 Power Plan supply curve workbooks; Cadmus research
Technical Feasibility	NEEA RBSA; Cadmus research	NEEA CBSA; Cadmus research	Cadmus research; Council industrial data
Percentage Incomplete	NEEA RBSA; City Lights program accomplishments; Cadmus research	NEEA CBSA; City Lights program accomplishments; Cadmus research	Cadmus research; Council industrial data
Measure Interaction	2021 Power Plan supply curve workbooks; RTF; Cadmus research	2021 Power Plan supply curve workbooks; RTF; Cadmus research	Cadmus research

6.3.1. Incorporating Federal Standards and State and Local Codes and Policies

Cadmus' assessment accounted for changes in codes, standards, and policies over the planning horizon. These changes not only affected customers' energy-consumption patterns and behaviors, they also revealed 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 reviewed all local and state codes, federal standards, and local and state policy initiatives that could impact this potential study and that were on the books as of January 2023. For the residential and commercial sectors, the potential study considered the local energy codes (2021 Seattle Energy Code with amendments, 2021 Washington State Energy Code, and 2021 RCW) as well as current and pending federal standards. Cadmus also assessed if, how, and when Washington State and Seattle City legislation impacted the potential study. This legislation included Seattle's Energy Benchmarking Program (SMC 22.920), Washington's Clean Buildings bill (E3S House Bill 1257), and the CETA (194-40-330).

Cadmus reviewed many codes, standards, and policy initiatives:

- **Federal standards.** All technology standards for heating and cooling equipment, lighting, water heating, motors, and other appliances not covered in or superseded by state and local codes.[37]
- **2021 Seattle Energy Code.** The code requires all new commercial buildings and large multifamily buildings above three stories to use the most-efficient technologies for space and

37 Office of Energy Efficiency & Renewable Energy. Accessed June 2021. "Standards and Test Procedures." https://www.energy.gov/eere/buildings/standards-and-test-procedures

water heating, which are *de facto* electric heat pumps in most cases. These latest updates to the Energy Code also apply to HVAC and water heating equipment replacements in existing buildings; however, there are several exemptions such that the impact of this provision on load forecasts is projected to be negligible (regarding existing buildings). All other code provisions took effect on March 15, 2021.[38]

- **2021 Washington State Energy Code.** The code provides requirements for residential and commercial new construction buildings, except in cases where the 2021 Seattle Energy Code supersedes the Washington code. The effective date was July 1, 2023.[39]
- **Seattle's Energy Benchmarking Program (SMC 22.920).** This program requires owners of commercial and multifamily buildings (20,000 square feet or larger) to track and report energy performance and annually to the City of Seattle. Though in effect since 2016, full enforcement of the program began on January 1, 2021.[40]
- **2021 RCW 19.260.040.** These codes set minimum efficiency standards for specific types of products including computers, monitors, showerheads, faucets, residential ventilation fans, general service lamps, air compressors, uninterruptible power supplies, water coolers, portable ACs, high color rendering index fluorescent lamps, commercial dishwashers, steam cookers, hot food holding cabinets, and fryers. The effective dates varied by product with the 2021 RCW signed on July 28, 2019.[41]
- **Clean Buildings Bill (E3S House Bill 1257).** The law requires the Washington State Department of Commerce to develop and implement an energy performance standard for the state's existing buildings, especially large commercial buildings (based on building square feet) and provide incentives to encourage efficiency improvements. The effective date was July 28, 2019, with the

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38 City of Seattle, Office of the City Clerk. February 1, 2021. "Council Bill No: CB 119993. An Ordinance Relating to Seattle's Construction Codes." http://seattle.legistar.com/LegislationDetail.aspx?ID=4763161&GUID=A4B94487-56DE-4EBD-9BBA-C332F6E0EE5D

39 Washington State Building Code Council. Accessed June 2021. https://sbcc.wa.gov/

40 City of Seattle, Office of Sustainability and Environment. Accessed June 2021. "Energy Benchmarking." https://www.seattle.gov/environment/climate-change/buildings-and-energy/energy-benchmarking#:~:text=Seattle's%20Energy%20Benchmarking%20Program%20(SMC,to%20the%20City%20of%20Seattle.&text=Compare%20your%20building's%20energy%20performance,started%20saving%20energy%20and%20money.

41 Washington State Legislature. Revised Code of Washington. December 7, 2020. "RCW 19.260.050 Limit on Sale or Installation of Products Required to Meet or Exceed Standards in RCW 19.260.040." https://app.leg.wa.gov/rcw/default.aspx?cite=19.260.050

building compliance schedule set to begin on June 1, 2026. Early adopter incentive applications began in July 2021.[42]

- **CETA (194-40-330).** This act applies to all electric utilities serving retail customers in Washington and sets specific milestones to reach the required 100% clean electricity supply. The first milestone was in 2022, when each utility was required to have prepared and published a Clean Energy Implementation Plan with its own four-year targets for energy efficiency, demand response, and renewable energy.[43]
- **Shoreline's Ordinance No. 948.** [44] This ordinance promotes energy efficiency and the decarbonization of commercial and large multifamily buildings like the Seattle Building Energy Code.

Applying Federal Standards

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 6.3 provides a comprehensive list of equipment standards considered in the study. Bars indicate the year in which a new equipment standard was or will be enacted. However, Cadmus did not attempt to predict how energy standards might change in the future. At the time Cadmus finalized the measure list for this study, there were no federal appliance standards pending after 2023.

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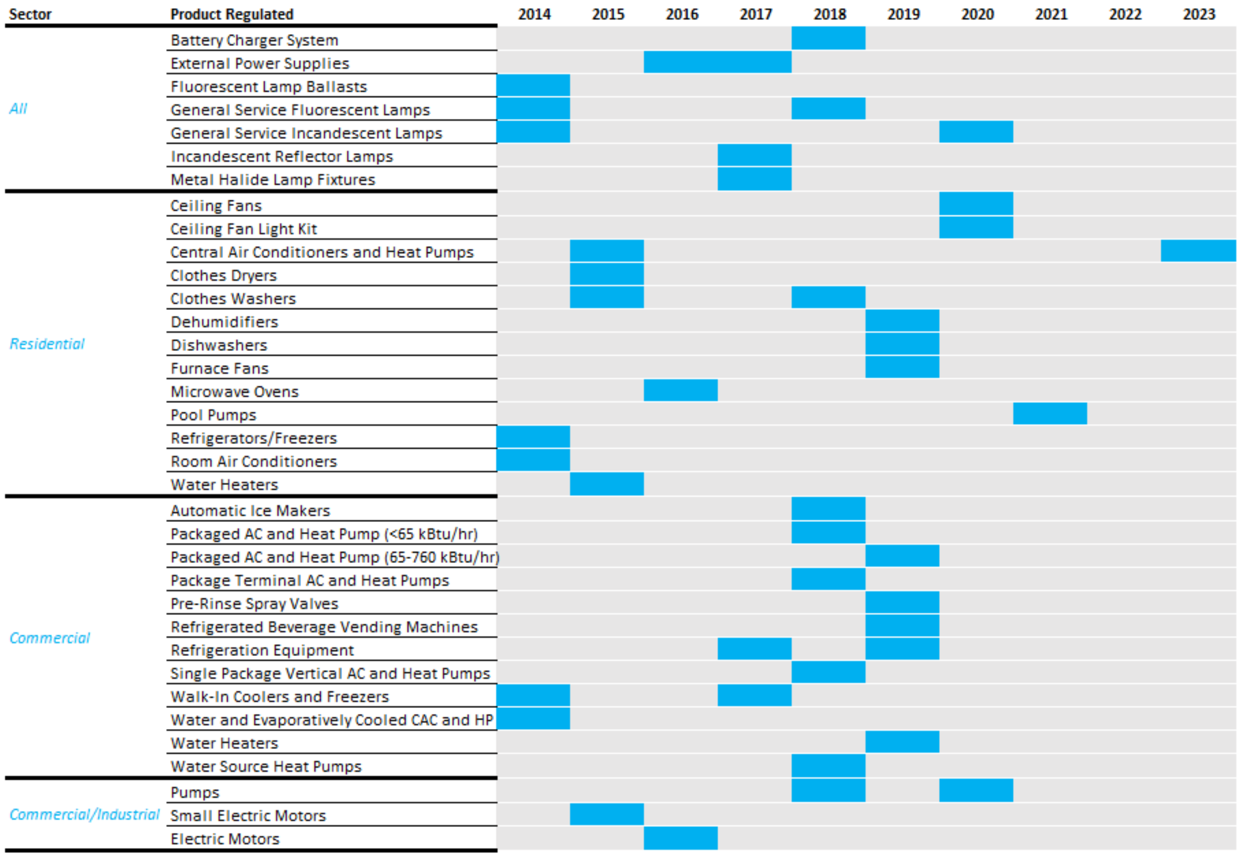
42 Washington State Department of Commerce. Accessed June 2023. "Clean Buildings." https://www.commerce.wa.gov/growing-the-economy/energy/buildings/

43 Washington State Department of Commerce. Accessed June 2023. "*Clean Energy Transformation Act* (CETA)." https://www.commerce.wa.gov/growing-the-economy/energy/ceta/

44 Ordinance No. 948 "Ordinance of the City of Shoreline, Washington Amending Chapter 15.05, Construction and Building Codes, of the Shoreline Municipal Code, to Provide Amendments to the Washington State Energy Code – Commercial, as Adopted by the State of Washington" took effect on July 1, 2022.

Figure 6.3. Equipment Standards Considered



Treatment of State and Local Codes and Initiatives

Cadmus identified each type of code (local or state) and/or initiative (local and state) that would impact measures in the DSMPA. Cadmus sorted each impact into four main categories.

- **Measure applicability or savings adjustment.** Cadmus adjusted measure characterization inputs to account for local and state energy codes (2021 Washington State Energy Code and 2021 RCW). Where appropriate, Cadmus revised measure applicability, savings, and/or costs to reflect the impact of the code. For example, we removed measures entirely or over time (applicability set to zero) if code baselines were more efficient than the baseline data found in the RTF or Council workbooks (such as for showerheads, fryers, steam cookers, and new construction homes).
  Notably, the Washington State Energy Code (RCW 19.27A.160) states "…residential and nonresidential construction permitted under the 2031 state energy code must achieve a 70% reduction in annual net energy consumption, using the adopted 2006 Washington state energy code as a baseline." For this purpose, Cadmus adjusted the new construction load forecast periodically so that by 2031 the new construction load meets the requirement. RCW 19.27A.160 also mandates that the Council report its progress every three years, so Cadmus incremented the code adjustment every three years until 2031 to account for future state codes that meet

the requirement of RCW 19.27A.160. Cadmus did not predict exactly how each end use will be impacted, rather we opted for a general reduction to building energy use for new construction across all end uses. Much of the net energy reduction is expected to be achieved through electrification of thermal end uses, an expectation which this study does not fully reflect. That said, we partially capture this expectation by modeling increasing heat pump saturation (and decreasing fossil fuel saturations) in accordance with the moderate electrification scenario from the 2022 EPRI study.

We also accounted for these adjustments in the baseline forecast, as mentioned in the *City Light Forecast Adjustments* section.

- **Equipment saturation adjustment.** Cadmus adjusted equipment saturations by year to account for the 2021 Seattle Energy Code. In addition, Cadmus adjusted new construction commercial and large multifamily buildings space heating equipment saturations to align with this code (such as for ductless heat pumps and air-source heat pumps). We also accounted for these adjustments for in the baseline forecast, as mentioned in the *City Light Forecast Adjustments* section.
- **Adoption ramp rate adjustment.** Cadmus accounted for initiatives and legislation that promote energy efficiency through customer incentives, penalties, or feedback on energy use (Seattle's Energy Benchmarking Program and the Clean Buildings Bill). This also includes CETA in setting statewide goals that require City Light to set performance targets. These initiatives do not mandate an energy code or baseline for specific measures, rather they inherently speed up the rate of the adoption of energy efficiency through energy reduction requirements. City Light can also claim energy impacts through these initiatives; therefore, removing measures or adjusting baselines may not be appropriate within the context of the DSMPA. Cadmus reviewed and adjusted the prescribed ramp rates in the Council's draft 2021 Power Plan, where necessary, to address groups of measures that will be impacted. Changing the ramp rates (in most cases) will not impact the cumulative potential; rather it changes the timing of when the potential occurs. Cadmus adjusted ramp rates to measures currently in City Light's programs by increasing the allocated Council ramp rates up to the next tier (for example, moving a slow speed ramp to a medium speed ramp).
- **No adjustment (already accounted for in the existing data).** Measures impacted by federal standards and in some cases by the 2021 RCW, the Council's draft 2021 Power Plan workbooks, and Cadmus' equipment characterization are already accounted for as part of the initial development of the measure data.

Additional Codes and Standards Considerations

Cadmus identified three considerations around codes and standards that impact the characterization of this potential study.

First, starting with residential lighting, Cadmus reviewed the codes and standards as well as assessed the current situation related to LED lighting. The Council's 2021 Power Plan and RTF residential lighting workbooks account for the Washington State Code requirement (House Bill 1444) of the *Energy Independence and Security Act* (EISA) backstop provision. Originally adopted from the federal standard, the EISA backstop provision requires higher-efficiency technologies (45 lumens per watt or better). The savings in the most recent RTF lighting workbook use an LED baseline (for Washington only).

After reviewing the Council and RTF workbooks, Cadmus concluded that the DSMPA should use an LED baseline. Currently, there are no lighting technologies on the market that meet the 45 lumens per watt requirement other than CFLs or LEDs. Furthermore, major manufacturers have phased out the production of CFLs. The market is rapidly adopting LEDs (according to the RBSA saturations and Council and RTF projections), which are becoming the *de facto* baseline. Considering that LEDs are the only viable technology that meets Washington code, Cadmus used LEDs as the baseline for all standard-income applications but assessed potential for highly impacted homes. This adjustment to the lighting loads is effectively accounted for in City Light's baseline forecast and the DSMPA. The lighting impact by end-use can be found in Table 3.3 and Table 4.6.

Secondly, the 2021 Washington State Energy Code includes both residential and commercial new construction prescriptive and performance path requirement options. The DSMPA characterizes efficiency improvements on a measure basis that align with the prescriptive path. The performance path includes the HVAC total system performance ratio requirement, defined as the ratio of the sum of a building's annual heating and cooling load compared with the sum of the annual carbon emissions from the energy consumption of the building's HVAC systems. The variability in the HVAC total system performance ratio from building to building cannot be easily captured in the DSMPA. For this study, Cadmus followed the prescriptive requirements in the 2021 Washington State Energy Code.

Finally, in 2024, City Light expects to receive an Ecotope study that sets estimates for energy savings for city code enhancement activities. City Light may choose to apply this study to claim energy impacts for savings attributable to Seattle codes and policies in the 2022–2023 biennium. If City Light chooses to go down this path removing measures or adjusting baselines for these codes may not be appropriate within the context of the DSMPA.. In light of this, City Light should continue to consider how best to incorporate Seattle codes and policies in future DSMPAs.

6.3.2. Adapting Measures from the RTF and 2021 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 two principles:

- **Deemed ECM savings in RTF or Council workbooks must be preserved:** City Light relies on deemed savings estimates provided by the Bonneville Power Administration (BPA) that largely remain consistent with savings in RTF workbooks in demonstrating compliance with I937 targets. Therefore, Cadmus sought to preserve these deemed savings in the potential study to avoid possible inconsistencies among 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 the RBSA and CBSA. Cadmus updated regional inputs with estimates calculated 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's and RTF's workbooks varied by sector, as described in the following sections.

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 Light's program accomplishments. If Cadmus could not develop a City Light–specific applicability factor from the 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. There are two key distinctions between these two types of measures:

- Equipment replacement (i.e., lost opportunity): We calculated savings for equipment replacement measures as the difference between measure consumption and baseline consumption. For instance, for the heat pump water heater measure, Cadmus estimated the baseline consumption of an average market water heater and used the Council's deemed savings to calculate the consumption for a heat pump water heater. This approach preserved the deemed savings in Council workbooks.
- Retrofit (i.e., discretionary): We calculated savings for retrofit measures in percentage terms relative to the baseline UEC but reflected the Council's and RTF's deemed values. For instance, if the Council's deemed savings were 1,000 kWh per home for a given retrofit measure and Cadmus estimated the baseline consumption for the applicable end use as 10,000 kWh, relative savings for the measure were 10%. Cadmus did not apply relative savings from the Council's workbooks to baseline UEC because doing so would lead to per-unit estimates that differed from Council and RTF values.

Cadmus also accounted for interactive effects presented 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 represents a single installation, Cadmus employed a stock accounting model, which combined interactive and primary end-use effects into one savings estimate. Though Cadmus recognizes that this approach could lead to overstating or understating savings in an end use, in aggregate—across end-uses—savings matched the Council's deemed values.

Cadmus generally followed the same approach with the commercial sector; however, because of the mixture of lighting measures considered in the Council's 2021 Power Plan, Cadmus chose to model all commercial lighting measures as retrofits and none as equipment replacements. Savings and costs for these measures reflected this decision.

Industrial

Cadmus adapted measures from the Council's Industrial_Tool_2021P_v08 and IND_AllMeasures_2021P_V8 workbooks for inclusion in this study for four key industrial measure inputs:

- Measure savings (expressed as end-use percentage savings)
- Measure costs (expressed in dollar per kilowatt-hour 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 UEC in each industry. Table 6.3 shows the distribution of end-use consumption and the list of industries considered in this study.

Table 6.3. Distribution of End Use Consumption by Segment

Segment	Process Air Compressor	Lighting	Fans	Pumps	Motors Other	Process Other	Process Heat	HVAC	Other	Process Electro-Chemical	Process Refrigeration
Foundries	7%	9%	10%	18%	15%	0%	21%	9%	5%	6%	0%
Frozen Food	4%	8%	4%	4%	12%	0%	4%	7%	1%	3%	53%
Misc. Manufacturing	7%	11%	7%	10%	16%	0%	11%	17%	9%	6%	6%
Other Food	12%	4%	2%	8%	11%	0%	0%	9%	8%	2%	44%
Transportation Equipment	6%	20%	6%	8%	11%	0%	0%	28%	7%	14%	0%
Wastewater	0%	5%	30%	44%	15%	0%	0%	0%	6%	0%	0%
Water	12%	4%	0%	71%	0%	0%	0%	7%	6%	0%	0%
Stone and Glass	8%	5%	7%	13%	20%	2%	25%	6%	3%	2%	7%

To incorporate broader secondary data, Cadmus aggregated some Council end uses into broader end uses. Table 6.4 shows the mapping of Council end uses to Cadmus end uses.

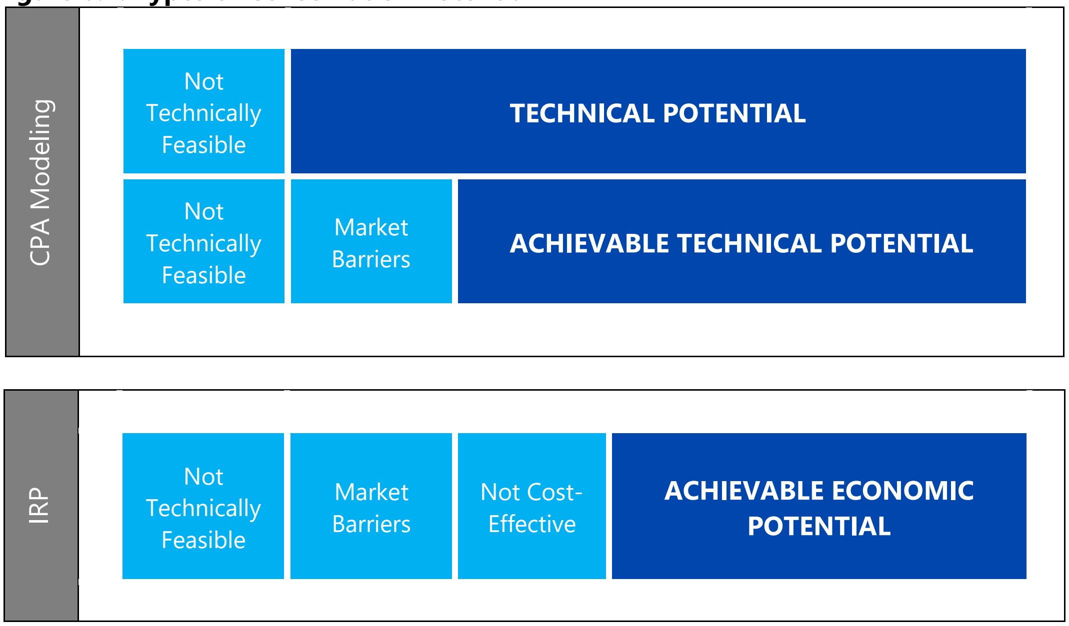
Table 6.4. Council and Cadmus End Uses

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
Med 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

6.4. Estimating Conservation Potential

As discussed, Cadmus estimated two types of conservation potential, and City Light determined a third potential—achievable economic—through the IRP's optimization modeling, as shown in Figure 6.4.

Figure 6.4. Types of Conservation Potential



Technical potential assumes that all technically feasible resource opportunities may be captured, regardless of their costs or other market barriers. It represents the total energy efficiency potential in City Light's service territory, after accounting for purely technical constraints.

Achievable technical potential is the portion of technical potential assumed to be achievable during the study forecast, regardless of the acquisition mechanism. For example, savings may be acquired through utility programs, improved codes and standards, and market transformation.

Achievable economic potential is the portion of achievable technical determined to be cost-effective by the IRP's optimization modeling, in which either bundles or individual energy efficiency measures are selected based on cost and savings. The cumulative potential for these selected bundles constitutes achievable economic potential.

The following sections describe Cadmus' approach to estimating technical and achievable technical potential as well as to developing the conservation IRP inputs. The last section of this chapter explains the approach City Light used to estimate achievable economic potential.

6.4.1. 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 is commercially available. For example, this study examined central air conditioners of varying efficiencies in residential applications, including SEER 20 and SEER 18 air conditioners. In assessing technical potential, Cadmus assumed that, as equipment fails or new homes are built, customers will install SEER 20 air conditioners wherever technically feasible, regardless of cost.

Where applicable, we assumed SEER 18 would be installed in homes where the SEER 20 equipment was not feasible. Cadmus 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 less 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 the equipment had 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 showerhead does not affect savings realized from installing a faucet aerator. Insulating hot water pipes, however, causes the water heater to operate more efficiently, thus reducing savings from the water heater. Cadmus 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, Cadmus assumed that these opportunities would be realized in equal annual amounts over the 22-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.

For this study's technical potential estimates, Cadmus 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 by the Council in developing regional energy efficiency potential) and remained consistent with methods used in City Light's previous CPAs.

6.4.2. Achievable Technical Potential

The achievable technical potential summarized in this report is a subset of the technical potential that accounts for market barriers. To subset the technical potential, Cadmus followed the Council's approach and employed two factors:

- **Maximum achievability factors** represent the maximum proportion of technical potential that can be acquired over the study horizon.
- **Ramp rates** are annual percentage values representing the proportion of cumulative 20-year technical potential that can be acquired in a given year (discretionary measures) or the proportion of technical annual potential that can be acquired in a given year (lost opportunity measures).

Achievable technical potential is the product of technical potential and both the maximum achievability factor and the ramp rate percentage. Cadmus assigned maximum achievability factors to measures based on the Council's 2021 Power Plan supply curves. Ramp rates are measure-specific and were based on the ramp rates developed for the Council's 2021 Power Plan supply curves but were accelerated based on the program accomplishments of City Light.

Cadmus applied measure ramp rates to lost opportunity and discretionary resources, although the interpretation and application of these rates differed for each class, as described below. We based measure ramp rates on the Council's 2021 Power Plan. As described above in *Treatment of State and Local Codes and Initiatives* section, Cadmus accounted for initiatives and legislation that promote energy efficiency through customer incentives or penalties (Seattle's Energy Benchmarking Program and Clean Buildings Bill, as well as the federal Inflation Reduction Act) by accelerating ramp rates for measures that are offered by City Light programs. These initiatives and legislation (including CETA) are viewed as mechanisms to speed up the rate of the adoption for energy efficiency.

For measures not specified in the 2021 Power Plan, Cadmus assigned a ramp rate considered appropriate for that technology, such as using the same ramp rate as that for a similar measure in 2021 Power Plan.

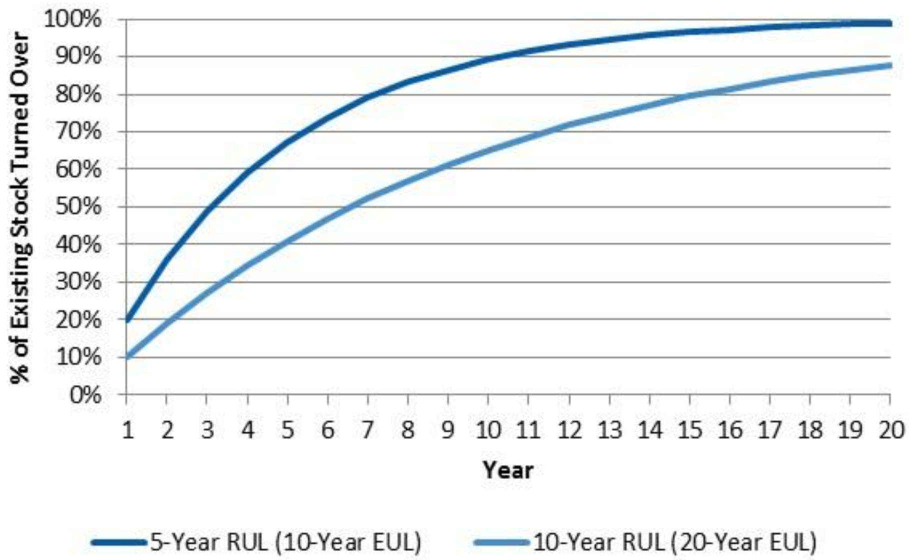
Lost Opportunity Resources

Quantifying achievable technical potential for lost opportunity resources in each year required determining potential technically available through new construction and natural equipment turnover. New construction rates drew directly from City Light's customer forecast. Cadmus 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 timeline.

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, technical potential for lost opportunity measures would have an annual shape before applying ramp rates, as shown in Figure 6.5. The same concept applied to new construction, where opportunities became available only during home or building construction. In addition to showing an annual shape, Figure 6.5

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 6.5. Existing Equipment Turnover for Two Remaining Useful Life Scenarios



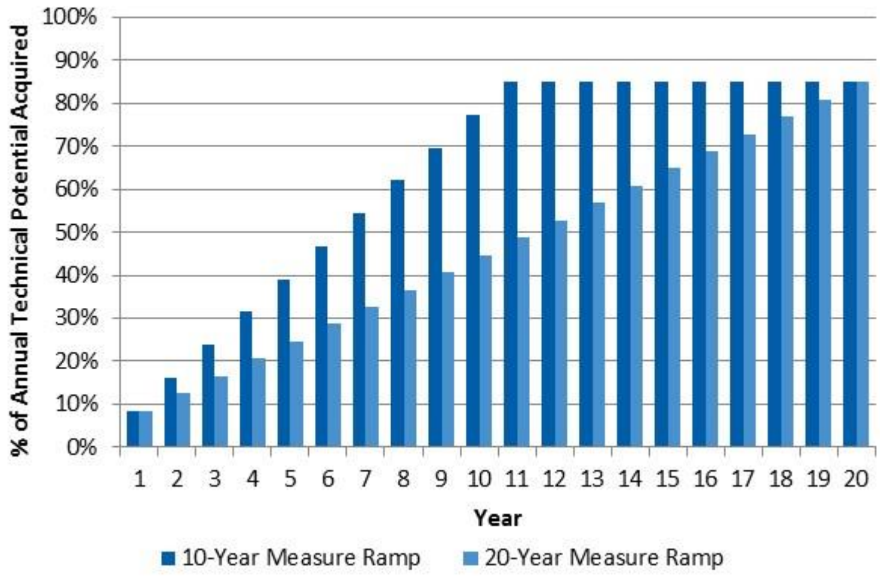
In addition to natural timing constraints of equipment turnover and new construction rates, Cadmus applied measure ramp rates to reflect other resource acquisition limitations (such as market availability over the study's horizon). For lost opportunity measures, Cadmus used the same ramp rates as those developed by the Council for its 2021 Power Plan supply curves. However, since the 2021 Power Plan ramp rates cover the 2022 to 2041 timeline (20 years), Cadmus first took these ramp rates beginning in 2022, applied them for the first 20 years of the study (from 2024 to 2043) and extrapolated them to extend from 2043 to the final year of the study (2045) following the last three years' trend. Table 6.5 presents two examples of how Cadmus converted 2021 Power Plan ramp rates for this study.

Table 6.5. 2021 Power Plan Ramp Rate Conversion for 2024 DSMPA

Year	LO12Med (Lost Opportunity 12 Medium)		LO5Med (Lost Opportunity 5 Medium)	
	2021 Power Plan	2024 DSMPA	2021 Power Plan	2024 DSMPA
2022	10.9%	N/A	4.3%	N/A
2023	21.9%	N/A	9.6%	N/A
2024	32.8%	10.9%	16.0%	4.3%
2025	43.7%	21.9%	23.5%	9.6%
2026	54.7%	32.8%	32.1%	16.0%
2027	64.5%	43.7%	42.1%	23.5%
2028	72.4%	54.7%	53.1%	32.1%
2029	78.7%	64.5%	64.3%	42.1%
2030	83.7%	72.4%	74.8%	53.1%
2031	87.8%	78.7%	83.9%	64.3%
2032	91.0%	83.7%	90.9%	74.8%
2033	93.6%	87.8%	95.8%	83.9%
2034	95.6%	91.0%	98.7%	90.9%
2035	97.3%	93.6%	100.0%	95.8%
2036	98.6%	95.6%	100.0%	98.7%
2037	99.7%	97.3%	100.0%	100.0%
2038	99.7%	98.6%	100.0%	100.0%
2039	99.7%	99.7%	100.0%	100.0%
2040	99.7%	99.7%	100.0%	100.0%
2041	99.7%	99.7%	100.0%	100.0%
2042	N/A	99.7%	N/A	100.0%
2043	N/A	99.7%	N/A	100.0%
2044	N/A	99.7%	N/A	100.0%
2045	N/A	99.7%	N/A	100.0%

Figure 6.6 shows a measure with a maximum achievability of 85% that ramps up over 10 years. This measure would reach full market maturity—85% 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 20 years in this study included some newer technologies, such as heat pump dryers, dedicated outside air systems, and emerging technology measures as listed in the *6.3. Measure Characterization* section. On the other hand, measures that were ramped over a shorter time period included more mature and accepted technologies, such as various LED lighting technologies, ENERGY STAR computers and laptops, and ENERGY STAR office equipment.

Figure 6.6. Examples of Lost Opportunity Ramp Rates



To calculate annual achievable technical potential for each lost opportunity measure, Cadmus multiplied technical resource availability and measure ramping effects together, consistent with the Council's methodology. In the early years of the study horizon, a gap occurs between assumed acquisition and the 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 twenty-second year, and the total lost opportunity achievable economic potential may be less than the maximum achievable percentage of the technical potential.

Figure 6.7 shows a case for a measure with a five-year RUL and 10-year EUL. The spike in achievable technical potential starting in Year 11—after the measure's EUL—results from the acquisition of opportunities missed at the beginning of the study period.

Figure 6.7. Example of Combined Effects of Resource Availability and Measure Ramping Based on 10-Year EUL

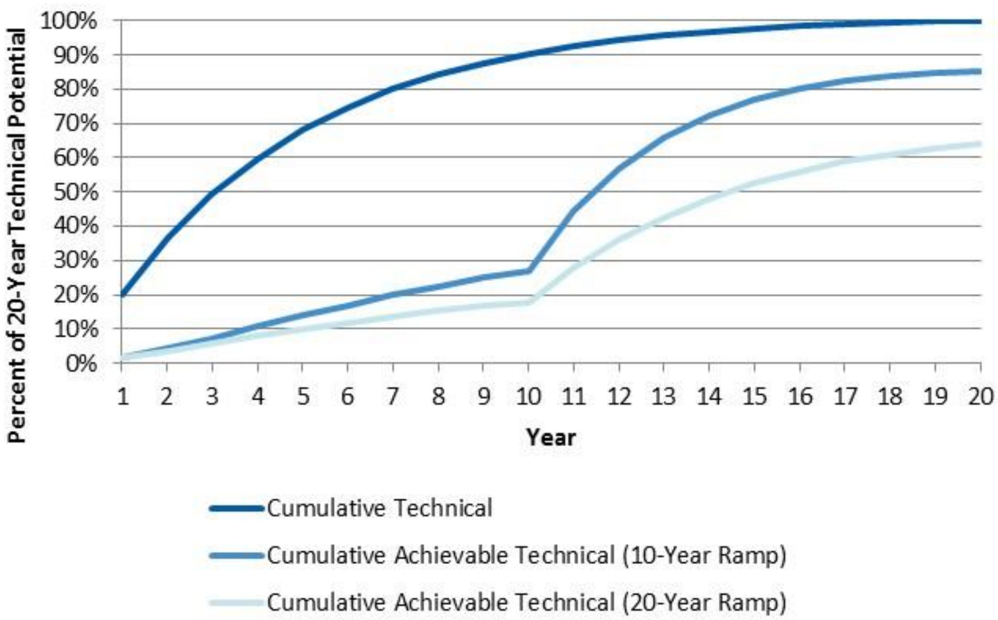


Table 6.6 illustrates this method, based on the same five-year RUL and 10-year EUL measures, with a 10-year ramp rate (the light blue line in Figure 6.7), assuming that 1,000 inefficient units would be in place by Year 1. In the first 10 years, lost opportunities would accumulate as the measure ramp-up rate caps the availability of high-efficiency equipment. Starting in the eleventh year, the opportunities lost during the previous 10 years become available again. Table 6.6 also shows that this EUL and measure ramp rate combination results in 85% of technical potential being achieved by the end of the study period.

As described, amounts of achievable potential are a function of the EUL and measure ramp rate. The same 10-year EUL measure, on a slower 20-year ramp rate, would achieve less of its 20-year technical potential—also shown in Table 6.6. Across all lost opportunity measures in this study, approximately 77% of technical potential appears achievable over the 22-year study period.

Table 6.6. Example of Lost Opportunity Treatment: 10-Year EUL Measure on a 10-Year Ramp

Study 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 Percentage 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 technical 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 (for example, a high-efficiency heat pump would save less energy in a fully weatherized home).

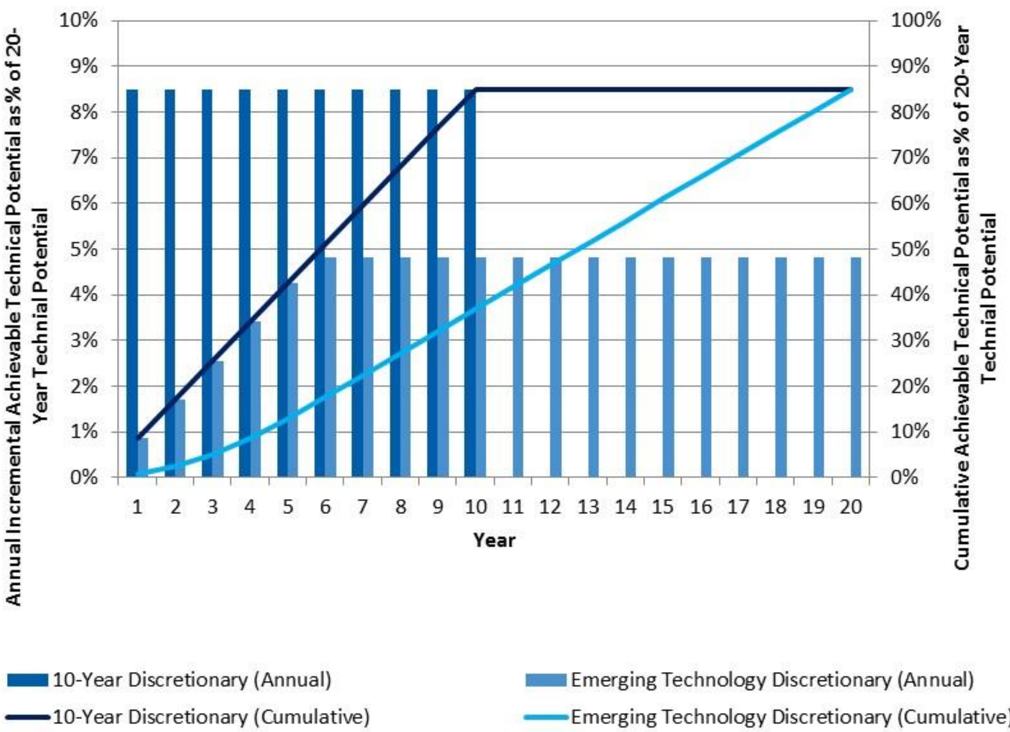
Consequently, Cadmus addressed discretionary resources via two steps:

- Developed a 22-year estimate of discretionary resource technical potential, assuming that technically feasible measure installations would occur equally (at 4.5% of the total available) for each year of the study, avoiding the distortion of interactions between discretionary and lost opportunity resources previously described.
- Overlaying a measure ramp rate to specify the timing of achievable discretionary resource potential, thus transforming a 22-year cumulative technical value into annual, incremental achievable technical values.

The discretionary measure ramp rates specify only the timing of resource acquisition and do not affect the portion of the 22-year technical potential achievable over the study period.

Figure 6.8 shows incremental (bars) and cumulative (lines) acquisitions for two different discretionary ramp rates. A measure with an 85% maximum achievability on the 10-year discretionary ramp rate reaches full maturity in 10 years, with market penetration increasing in equal increments each year. A measure with an 85% maximum achievability on the emerging technology discretionary ramp rate would take longer to reach full maturity, though also gaining 85% of the total technical potential. Ultimately, it would arrive at the same cumulative savings as the measure on the 10-year ramp rate.

Figure 6.8. Examples of Discretionary Measure Ramp Rates



6.5. Development of Conservation IRP Inputs

Cadmus worked with City Light to determine the format for inputs into the IRP model. Cadmus compiled energy efficiency potential into the levelized costs bundles shown in Table 6.7. Cadmus spread the annual savings estimates over 8,760-hour load shapes to produce hourly bundles. The number and delineating values of the levelized cost bundles remain unchanged from the 2022 CPA.

Table 6.7. Levelized Cost Bundles

Bundle	$/MWh
1	($9,999,999) to $10
2	$10 to $20
3	$20 to $30
4	$30 to $40
5	$40 to $50
6	$50 to $60
7	$60 to $70
8	$70 to $80
9	$80 to $90
10	$90 to $100
11	$100 to $110
12	$110 to $120
13	$120 to $130
14	$130 to $140
15	$140 to $150
16	$150 to $160
17	$160 to $9,999,999

Cadmus derived the levelized cost of energy for each measure using the following formula.

$$\mathrm{LCOE} = \frac{\sum_{t=0}^{n} \frac{\mathrm{Expenses}_t}{(1+\mathrm{i})^t}}{\sum_{t=0}^{n} \frac{\mathrm{E}_t}{(1+\mathrm{i})^t}}$$

where:

LCOE	=	levelized cost of conserved energy for a measure
E_t	=	energy conserved in year t
n	=	lifetime of the analysis (22 years)
$\mathrm{Expenses}_t$	=	all net expenses in the year t for a measure using the costs and benefits outlined in Table 6.8
i	=	discount rate

Cadmus grouped the achievable technical potential by levelized cost over the 22-year study horizon, allowing City Light's IRP model to select the optimal amount of energy efficiency potential, given various assumptions regarding future resource requirements and costs. The 22-year total resource levelized cost calculation incorporates numerous factors, which are consistent with the expense components shown in Table 6.8.

Table 6.8. Levelized Cost Components

Type	Component
Costs	Incremental Measure Equipment and Labor Cost
	Incremental O&M Cost
	Administrative Adder
Benefits	Present Value of Non-Energy Benefits
	Present Value of Transmission and Distribution Deferrals
	Secondary Energy Benefits
	10% Conservation Credit

The levelized cost calculation incorporates several factors:

- **Incremental measure cost:** Cadmus considered costs required to sustain savings over a 22-year horizon, including reinstallation costs for measures with useful lives less than 22 years. If a measure's useful life extended beyond the end of the 22-year study period, Cadmus incorporated an end effect that treated the measure's cost over its EUL,[45] considered to be an annual reinstallation cost for the remainder of the 22-year period.[46]

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45 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.

46 Cadmus applied this method to measures with a useful life of greater than 22 years and to those with a useful life extending beyond the twenty-second year at the time of reinstallation.

- **Incremental O&M costs or benefits:** As with incremental measure costs, Cadmus considered O&M costs annually over the 22-year horizon. We 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 16% of incremental measure costs in the residential sector and 22% of incremental measure costs in the commercial and industrial sectors.
- **Non-energy benefits:** Cadmus reduced 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 showerhead would reduce that measure's levelized cost. Council and RTF workbooks provide measure-level non-energy benefit assumptions.
- **10% conservation credit and transmission and distribution deferrals:** Cadmus treated these factors as reductions in the 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 with other resources.[47]
- **Secondary energy benefits:** Cadmus reduced levelized costs for measures that save energy on secondary fuels. This treatment was necessitated by Cadmus' end-use approach to estimating technical potential. An example is R-60 ceiling insulation costs for a home with an electric central cooling system and a natural gas furnace. For the central cooling end use, Cadmus classified energy savings the R-60 insulation produced for natural gas furnace, conditioned on the presence of electric central cooling, as a secondary benefit that reduced the measure's levelized cost. This adjustment affected only the measure's levelized costs; the insulation's magnitude of energy savings on the electric supply curve was not affected by considering secondary energy benefits.

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 22-year study horizon (including reinstallation costs for measures with useful lives less than 22 years). If a measure's useful life extended beyond the end of the 22-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 22-year period.

For example, Figure 6.9 illustrates the timing of initial and reinstallation costs for a resource with an EUL of eight years in the context of a 22-year study. This resource's lifetime ends after the study horizon, so the final six years (Year 17 through Year 22) are treated differently, with resource costs levelized over the resource's eight-year life and treated as annual reinstallation costs. This approach is consistent with what City Light has employed in its previous IRPs.

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47 Northwest Power and Conservation Council. January 1, 2010. *Northwest Power Act*. https://www.nwcouncil.org/reports/northwest-power-act

Figure 6.9. Illustration of Capital and Reinstallation Cost Treatment

	Year																					
Component	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Initial Capital Cost																						
Re-installation Cost																	End Effect					

As with incremental measure costs, Cadmus considered O&M costs annually over the 22-year horizon. We 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.

6.5.1. Achievable 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 reflect all costs for City Light to meet future resource needs. Therefore, in the 2022 CPA and the 2024 DSMPA, City Light used its IRP optimization modeling framework to assess the value of conservation and develop the economic potential.[48] The IRP methodology evaluates conservation potential alongside power supply and other demand-side resource choices to better target the conservation attributes that meet City Light's resource needs. This methodology also creates a more equivalent way of looking at supply- and demand-side resources.

The IRP framework supports development of cost-effective targets for meeting CETA and the Climate Commitment Act, as well as preparation of a CEIP every four years. City Light also included different scenarios (see the *Portfolio Optimization Modeling* section) to test the robustness of the conservation targets and based on feedback from its IRP External Advisory Panel in setting the targets.

6.5.2. City Light's IRP Portfolio Framework

The IRP framework is a decision support system that develops an optimal resource strategy, given the current forecasts of supply-side and demand-side resource costs and future load and market conditions. By using this framework for the DSMPA, the benefit of the conservation path is determined by establishing an optimal portfolio with conservation alongside resources that minimize the net present value of City Light's total incremental portfolio cost. For the 2024 DSMPA, resources of all types were set up for analysis on an equivalent basis between 2024 and 2045. Each portfolio meets City Light's resource needs and compliance obligations. Figure 6.10 is a high-level overview of City Light's IRP framework.

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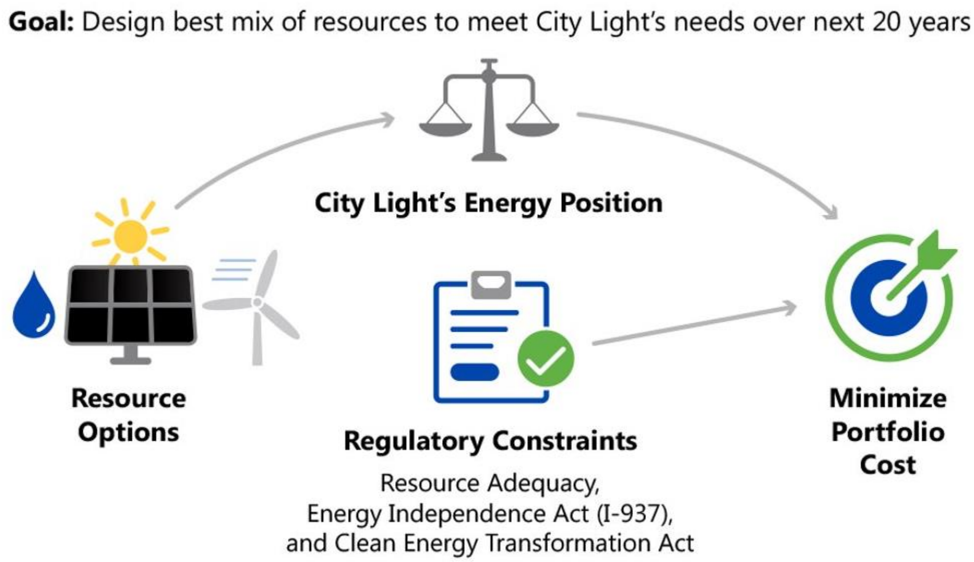
48 City Light. *2022 Integrated Resources Plan Report.* https://www.seattle.gov/Documents/Departments/CityLight/2022IntegratedResourcePlan.pdf

Figure 6.10. High-Level IRP Framework



The IRP framework captures several factors in selecting a resource strategy by methodically evaluating several interactions between different options and policies:

- **City Light's Energy Position.** This is City Light's load resource balance, which is the difference between all of City Light's energy resources and load.
- **City Light's Monthly Energy Resource Adequacy.** Resource adequacy is having sufficient generation, energy efficiency, storage, and demand-side resources to serve loads across a wide range of conditions.
- **Washington *Energy Independence Act* (I-937) compliance.**[49] In 2006, Washington voters approved Initiative 937 (I-937), which requires that major utilities invest in all cost-effective energy efficiency measures and sets targets for adding Northwest renewable energy as a percentage of load. Eligible renewable resources include water, wind, solar energy, geothermal energy, landfill gas, wave, ocean or tidal power, gas for sewage treatment plants, bio-diesel fuel, and biomass energy. In 2020, the renewable energy target increased to 15% of load, and this target does not increase beyond the current level. The law also includes provisions to keep costs affordable for utilities. Today, City Light can comply under the "no load growth" option.

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49 Washington State Legislature. RCW 19.285. "*Energy Independence Act*." https://apps.leg.wa.gov/rcw/default.aspx?cite=19.285

- **CETA clean electricity compliance.**[50] Approved by the Washington Legislature in 2019, CETA provides electric utilities in Washington with a clear mandate to phase out greenhouse gas emissions. CETA requires that utilities eliminate the use of coal-fired resources after December 31, 2025. Additionally, all electricity sold to customers must be greenhouse gas neutral starting on January 1, 2030, and greenhouse gas free by 2045. To be greenhouse gas neutral, a utility must supply at least 80% of its load with a combination of renewable and non-emitting resources. Utilities may use alternative compliance options during the greenhouse gas neutral period for no more than 20% of load.
- **Greenhouse gases.** City Light applies the social cost of greenhouse gases when evaluating conservation programs, developing IRPs, and evaluating mid- to long-term resource options during resource acquisition.
    - **City Light's greenhouse gas neutrality policy.** Since 2005, City Light has accounted for the greenhouse gas emissions used to serve retail load and purchased offsets for those emissions to be greenhouse gas neutral.[51]
    - **CETA's social cost of greenhouse gases requirement.** CETA establishes that a utility must incorporate a social cost of greenhouse gases in making resource decisions. CETA also sets a minimum cost that a utility must use from a technical study, *Social Cost of Greenhouse Gases*, published in August 2016 by the Interagency Working Group. CETA also stipulates that if a utility can establish a reasonable basis, it may use a higher cost. City Light has accounted for the social cost of greenhouse gases in the levelized cost of energy for DSM resources.
- **BPA contract impacts.** Load and energy efficiency programs impact City Light's BPA power contract deliveries. As load declines, City Light receives less BPA power. The ability to add energy efficiency creates a choice for City Light and gives the utility some control over how much BPA power it receives. When a conservation path reduces City Light's BPA power deliveries, City Light's BPA power costs are reduced. Similarly, City Light accounts for the change in BPA's contribution to resource adequacy.
- **Hourly energy sales and energy purchases.** The conservation impact on hourly demand and City Light's ability to reshape its existing hydropower resources to this change in load shape is accounted for in the IRP modeling framework. The model accounts for the hours when conservation makes City Light more surplus and when it sells more power, and it also accounts for when conservation reduces City Light's market purchases.
- **Third-party system transmission costs.** For City Light, new supply resources may interconnect with another utility's transmission system. In the IRP framework, these transmission costs (as well as Power Purchase Agreement energy costs) include the cost of moving power across BPA's (or

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50 Washington State Legislature. RCW 19.405. "*Washington Clean Energy Transformation Act.*" https://app.leg.wa.gov/RCW/default.aspx?cite=19.405

51 The Climate Registry summary of City Light's utility-specific emission factors is available online: https://www.theclimateregistry.org/our-members/cris-public-reports/

other utilities') transmission systems. City Light also accounts for current limitations on moving power from specific locations of the transmission system.

6.5.3. Conservation Resource Inputs into the IRP Framework

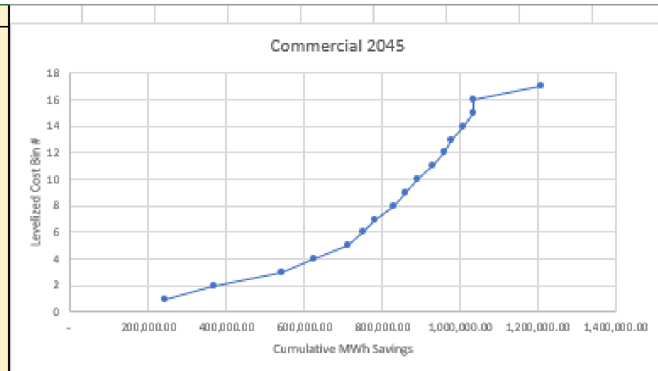
A main input into the IRP modeling framework is the levelized costs bundles shown in Table 6.7. City Light created these bundles to minimize the modeling run time. Evaluating all possible combinations of 17 levelized cost bundles for each of the three customer classes would have required optimization of the portfolio for approximately 5,000 combinations of conservation bundles. City Light further reduced the number of combinations to evaluate by combining cost bundles where the achievements did not significantly increase, even at higher levelized cost bundles.

Figure 6.11 illustrates where City Light combined original cost bundles into IRP framework bundles. For example, City Light combined the residential levelized cost bundle of less than $10 per megawatt-hour and the $10 per megawatt-hour to $20 per megawatt-hour bundle because the additional achievement with the higher cost bundle was negligible. This led to eight residential, seven industrial, and 11 commercial cost bundles, for a total of 616 bundles, which included a no-conservation savings option (for example, an IRP bundle with 0 MWhs for $0) for each customer class. This bundling led to shorter run times without sacrificing precision.

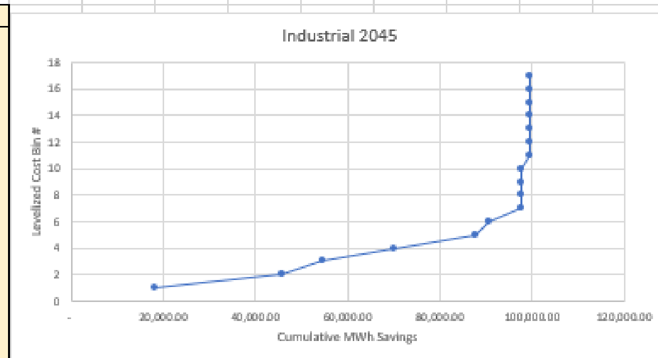
Figure 6.11 also shows the elasticity of the conservation supply curves by customer class. For example, the industrial supply curve becomes inelastic at the $60 per megawatt-hour to $70 per megawatt-hour bundle, while the residential supply curve becomes largely inelastic above $110 per megawatt-hour. The inelasticity of conservation places a limit to the amount of conservation potential that can be relied upon to contribute to the portfolio.

Figure 6.11. Conservation Supply Curves – 2045 Cumulative Savings

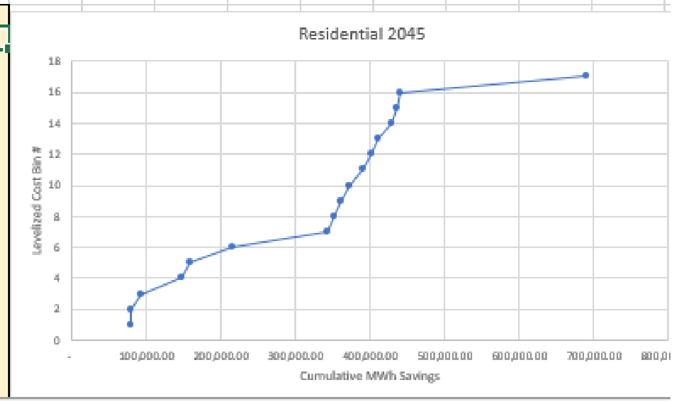
Commercial	LevCost	costBundle	IRPComBundle
1	<$10	01. Under $10/MWh	1
2	<$20	02. $10/MWh to $20/Mwh	2
3	<$30	03. $20/MWh to $30/Mwh	3
4	<$40	04. $30/MWh to $40/Mwh	4
5	<$50	05. $40/MWh to $50/Mwh	5
6	<$60	06. $50/MWh to $60/Mwh	6
7	<$70	07. $60/MWh to $70/Mwh	6
8	<$80	08. $70/MWh to $80/Mwh	7
9	<$90	09. $80/MWh to $90/Mwh	7
10	<$100	10. $90/MWh to $100/Mwh	7
11	<$110	11. $100/MWh to $110/Mwh	8
12	<$120	12. $110/MWh to $120/Mwh	8
13	<$130	13. $120/MWh to $130/Mwh	8
14	<$140	14. $130/MWh to $140/Mwh	9
15	<$150	15. $140/MWh to $150/Mwh	9
16	<$160	16. $150/MWh to $160/Mwh	9
17	>$160	17. Over $160/MWh	10



Industrial	LevCost	costBundle	IRPIndBundle
1	<$10	01. Under $10/MWh	1
2	<$20	02. $10/MWh to $20/Mwh	2
3	<$30	03. $20/MWh to $30/Mwh	3
4	<$40	04. $30/MWh to $40/Mwh	4
5	<$50	05. $40/MWh to $50/Mwh	4
6	<$60	06. $50/MWh to $60/Mwh	5
7	<$70	07. $60/MWh to $70/Mwh	6
8	<$80	08. $70/MWh to $80/Mwh	6
9	<$90	09. $80/MWh to $90/Mwh	6
10	<$100	10. $90/MWh to $100/Mwh	6
11	<$110	11. $100/MWh to $110/Mwh	6
12	<$120	12. $110/MWh to $120/Mwh	6
13	<$130	13. $120/MWh to $130/Mwh	6
14	<$140	14. $130/MWh to $140/Mwh	6
15	<$150	15. $140/MWh to $150/Mwh	6
16	<$160	16. $150/MWh to $160/Mwh	6
17	>$160	17. Over $160/MWh	6



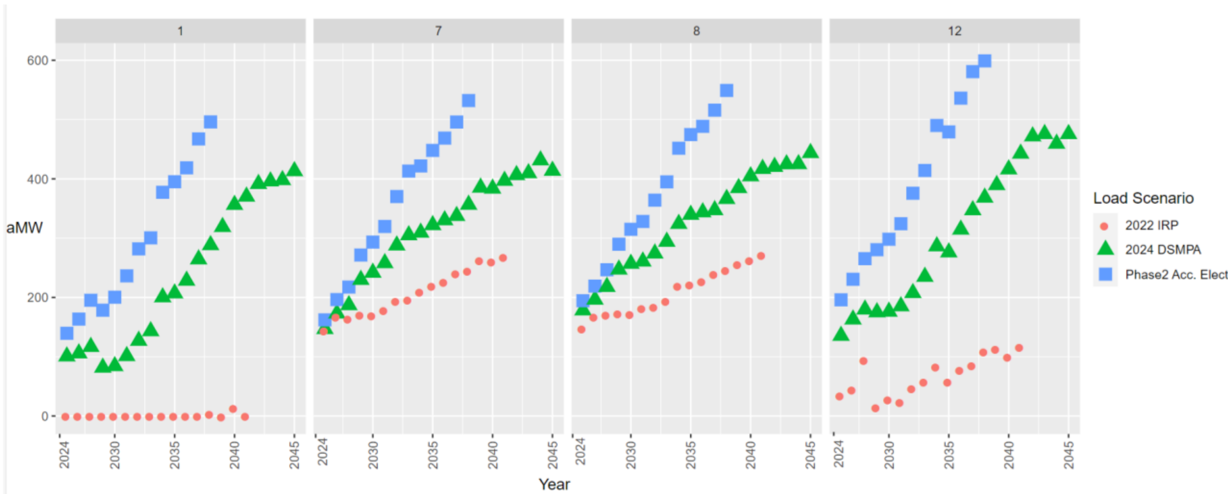
Residential	LevCost	costBundle	IRPResBundle
1	<$10	01. Under $10/MWh	1
2	<$20	02. $10/MWh to $20/Mwh	1
3	<$30	03. $20/MWh to $30/Mwh	2
4	<$40	04. $30/MWh to $40/Mwh	3
5	<$50	05. $40/MWh to $50/Mwh	3
6	<$60	06. $50/MWh to $60/Mwh	4
7	<$70	07. $60/MWh to $70/Mwh	4
8	<$80	08. $70/MWh to $80/Mwh	5
9	<$90	09. $80/MWh to $90/Mwh	5
10	<$100	10. $90/MWh to $100/Mwh	5
11	<$110	11. $100/MWh to $110/Mwh	5
12	<$120	12. $110/MWh to $120/Mwh	6
13	<$130	13. $120/MWh to $130/Mwh	6
14	<$140	14. $130/MWh to $140/Mwh	6
15	<$150	15. $140/MWh to $150/Mwh	6
16	<$160	16. $150/MWh to $160/Mwh	6
17	>$160	17. Over $160/MWh	7



The adjusted cost bundles and energy savings are the starting point for input into the IRP framework. The hourly conservation inputs allow City Light to reflect the seasonal and hourly economic benefits of conservation to the hydro system and to the overall generation portfolio. For each conservation sector being evaluated (residential, commercial, and industrial), City Light's IRP framework develops an energy resource adequacy contribution for meeting its resource adequacy needs.[52] Once this contribution is established, City Light conducts its portfolio optimization modeling.

Figure 6.12 shows that City Light has winter and summer energy resource adequacy needs that must be met.[53]

Figure 6.12. Resource Adequacy Needs



There are three main reasons City Light identified more resource adequacy needs in the 2024 DSMPA than in the 2022 IRP, as shown in Figure 6.12:

- The updated load forecast used in the 2024 DSMPA includes climate change assumptions and more electrification.
- The 2024 DSMPA reflects an updated Skagit hydrology model that better captures electricity generation based on improved river inflow forecasting, fish flow constraints, and flood control/recreation Ross Lake levels.
- The updated water year distribution sampling window that the 2024 DSMPA uses is shorter than the previous window (30 years *versus* 39 years) and therefore includes fewer high-water years and more volatility.

52 City Light's Hydro Risk and Reliability Analyzer (HydRRA) is the tool that calculates energy resources adequacy needs and contributions.

53 Resource adequacy needs are established using simulations of loads and resources in City Light's HydRRA, assuming no new supply and conservation resources, a market reliance of 200 aMW, and an achievement of an adequacy target of loss of load events no greater than two every 10 years.

Once these resource adequacy needs were identified, City Light developed seasonal resource adequacy contributions of conservation by sector for every year of the study.[54] Figure 6.13 shows the December and August Effective Load Carrying Capability (ELCC) for conservation.

These multipliers indicate the energy contribution to resource adequacy relative to the monthly energy savings of each conservation bundle.[55] For context, in 2030, the potential estimates for the three sectors are as follows: 70 aMW for Commercial, 7 aMW for Industrial, and 23 aMW for Residential, for a total of approximately 100 aMW for all sectors combined. Conservation can reduce power deliveries more in the winter than in the summer mainly because of how the power deliveries are defined in the BPA contract.[56]

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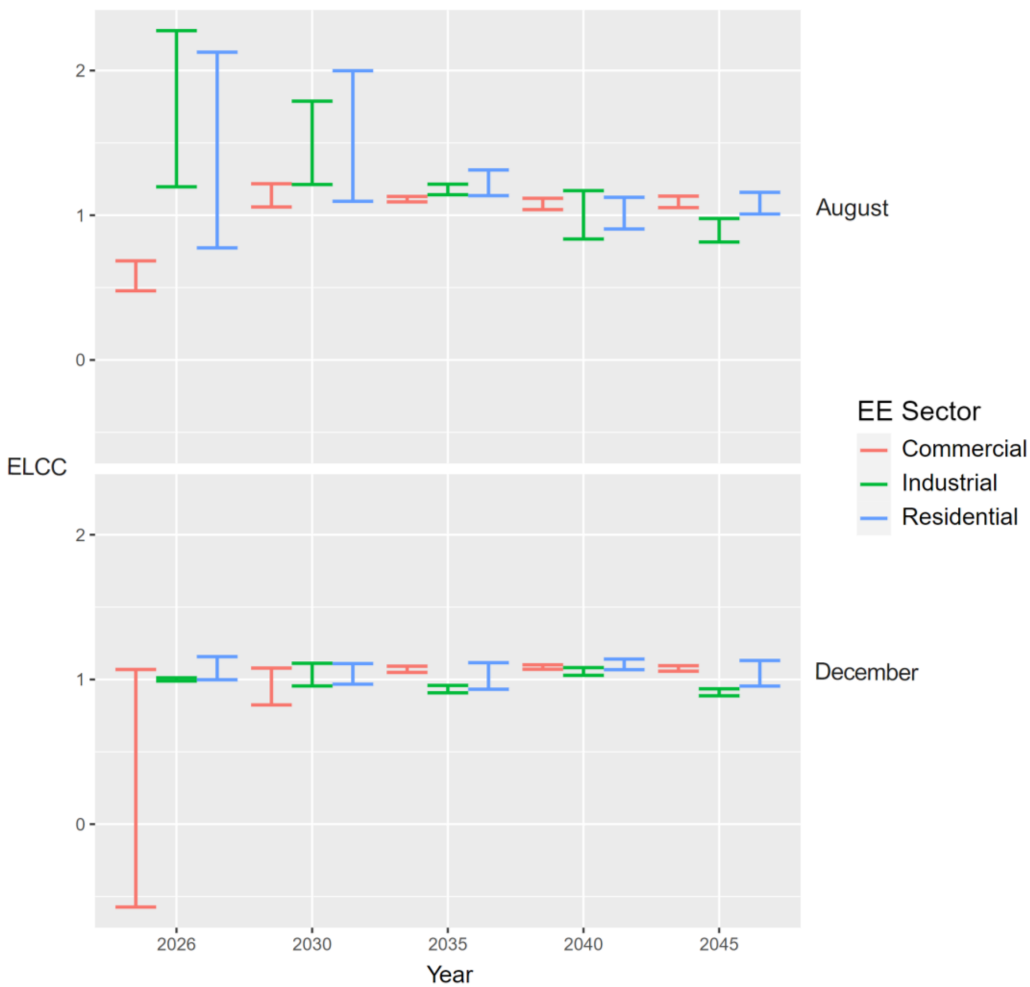
54 HydRRA is used to develop the seasonal and annual resource adequacy contributions of conservation by sector.

55 The resource adequacy contribution is applied across all conservation measures within a particular bundle and sector.

56 As an example, the resource adequacy contribution of conservation in the winter before 2035 is negative for two primary reasons. First, City Light's annual energy entitlement in the BPA contract is below the maximum annual contractual energy entitlement. Second, because existing power deliveries are shaped more toward the winter, a load reduction means a bigger power delivery reduction in the winter compared with the summer. Once loads begin to increase in 2035, the difference between the annual entitlement and the maximum annual contractual energy entitlement becomes smaller, leading to an increase in the resource adequacy contribution of conservation.

Figure 6.13. August and December Effective Load Carrying Capability for Energy Efficiency



6.5.4. Portfolio Optimization Modeling

The 2024 DSMPA demand side resource selections are driven by a BPA Transmission Sensitivity, which City Light created to model insufficient firm supply transmission to meet resource adequacy needs.

City Light created these BPA Sensitivities with three goals in mind:

- Assess the magnitude of capacity (MW) that is required to fulfill the resource adequacy needs
- Assess the possible costs that this additional capacity would incur
- Determine the most robust demand side choices of those identified through the different sensitivities

City Light created BPA Transmission Sensitivities by multiplying current BPA transmission costs by an integer from two to twenty. The goal was to investigate and understand trade-offs that could help explain what happens with City Light portfolio selections as supply side transmission costs increase.

Table 6.9 shows the amount of unavailable supply resource needed to fulfill resource adequacy needs with both looking at the magnitude and cost.

The analysis in this section uses zero-market reliance. There is a market reliance sensitivity on the top two feasible portfolios toward the end of this appendix in order to show the impacts on portfolio resource selections.

Table 6.9. BPA Transmission Cost Sensitivities

BPA Transmission Cost Sensitivities	Unavailable BPA Transmission Needed for Resource Adequacy (MW)	Unavailable BPA Transmission ($/MWh)
BPATrans_2X	1175	51.9
BPATrans_4X	1175	61.4
BPATrans_6X	1125	70.7
BPATrans_8X	1175	79.8
BPATrans_10X	1125	86.6
BPATrans_12X	1050	92.6
BPATrans_14X	1025	99.6
BPATrans_16X	950	104.4
BPATrans_18X	925	112.4
BPATrans_20X	925	120

Table 6.10 shows the lowest cost portfolios across the different BPA Transmission Sensitivities along with the resource choices that have trade-offs.

The resource choices are the demand and supply side options that are available for selection as part of the 2024 DSMPA; the selections together makeup a portfolio that will meet City Light's portfolio needs from 2024–2045.

Transmission Sensitivity Portfolio Resource Trade-offs

Table 6.10. Transmission Sensitivity Portfolio Resource Trade-offs

Resource Choices	2TX	4TX	6TX	8TX	10TX	12TX	14TX	16TX	18TX	20TX
Levelized $/MWh Cost of New Additions	$53.07	$59.67	$67.05	$73.97	$78.69	$85.33	$89.71	$92.35	$97.33	$103.16
Unavailable Transmission Additions (MW)	1175	1175	1150	1150	1100	1025	1000	925	925	925
Commercial Energy Efficiency (aMW)	102	102	111	111	89	71	62	71	71	71
Customer Solar (aMW)	49	27	27	27	27	49	49	49	27	49
Standalone Storage (MW)	100	100	100	100	100	200	200	200	200	200
EWA Solar (MW)	0	0	0	0	100	100	200	300	300	300
Demand Response (MW)	61	78	39	39	38	38	76	38	61	54
Industrial Energy Efficiency (aMW)	10	11	11	11	11	11	11	11	11	10
Residential Energy Efficiency (aMW)	50	50	50	50	50	50	50	50	50	50
EORSolar (aMW)	22	22	22	22	22	22	22	30	30	30
Gorge Wind (aMW)	94	94	94	94	94	94	94	94	94	94
MT Wind (aMW)	19	19	19	19	19	19	19	19	19	19
Offshore Wind (aMW)	219	219	219	219	219	219	219	219	219	219

Table 6.10 shows that as the BPA Transmission Costs increase, the main trade-off is the reduction of commercial energy efficiency which is replaced mainly by the more expensive Eastern Washington solar (MW), more standalone storage (MW), and more customer solar (aMW).

6.5.5. Scenarios

As part of the 2024 DSMPA, City Light considered two scenarios:

- The 2024 DSMPA Baseline (i.e., 2022 City Light corporate load forecast) with 30 years of historical water supply and 30 years of historical temperature including EPRI's Moderate electrification scenario and a climate change MACA scalar
- EPRI's Accelerated Electrification load forecast with similar characteristics.

City Light initially considered and tested more than 40 different portfolios. That portfolio number was reduced to seven after determining lowest cost cutoff points in portfolios as the BPA Transmission Sensitivities increased. The only exception to this was the sixth portfolio (P6), which City Light initially selected because of its favorable number of customer options. The top seven portfolio choices are shown in Table 6.11 **Error! Reference source not found.**.

- All seven portfolios are built to meet resource adequacy needs under the 2024 DSMPA baseline load scenario with the metric of 0.2 monthly loss of load event, which is equivalent to two 'bad events' every 10 years for each of the months of January, July, August, and December. These months represent traditionally challenging load coverage time periods for City Light. A 'bad event' is a situation in which City Light's energy resources (i.e., contracts + owned generation + 200 MW market reliance), are not able to meet load for at least one hour.
- All seven portfolios meet I-937 policy requirements and *Clean Energy Transformation Act* requirements under 20-year average hydro conditions.
- Six of the seven portfolios are within 7% of the lowest cost portfolio in terms of $/MWh.
- None of the portfolios adequately achieves the resource adequacy metric of 0.2 monthly loss of load event under the accelerated electrification scenario for the month of December.
- All seven top portfolios' energy are more than 90% greenhouse gas free under 20-year average hydro conditions.
- Customer options such as demand response, energy efficiency, and behind the meter solar are a meaningful factor in differentiating portfolios.

Table 6.11 presents the top seven portfolios for the 2024 DSMPA.

Table 6.11 2024 DSMPA Top Seven Portfolio Names

Portfolio	Transmission	Customer Solar
P1: Lowest Customer Solar, Low Cost, High Demand Response	4TX	Business As Usual
P2: Lowest Customer Solar, High Energy Efficiency	8TX	Business As Usual
P3: Lowest Demand Response, Lowest Customer Solar	10TX	Business As Usual
P4: More Customer Solar, Lowest Demand Response	12TX	Base
P5: More Customer Solar, Low Energy Efficiency	14TX	Base
P6: High Customer Solar, High Cost	14TX	Moderate
P7: More Customer Solar, Least Transmission Risk	20TX	Base

These portfolios bring incremental utility scale firm transmission supply resources in MW as shown in Table 6.12.

Table 6.12 2024 DSMPA Top Seven Portfolio Firm Transmission Supply Additions (MW)

Portfolio	2026–2030	2031–2040	2041–2045	Total Firm Transmission
P1: Lowest Customer Solar, Low Cost, High Demand Response	550	250	250	1050
P2: Lowest Customer Solar, High Energy Efficiency	550	250	250	1050
P3: Lowest Demand Response, Lowest Customer Solar	650	250	250	1150
P4: More Customer Solar, Lowest Demand Response	750	250	250	1250
P5: More Customer Solar, Low Energy Efficiency	750	350	250	1350
P6: High Customer Solar, High Cost	775	250	250	1275
P7: More Customer Solar, Least Transmission Risk	975	250	250	1475

These portfolios bring incremental utility scale unavailable transmission supply resources in MW as shown in Table 6.13.

Table 6.13 2024 DSMPA Top Seven Portfolio Unavailable Transmission Supply Additions (MW)

Portfolio	2026–2030	2031–2040	2041–2045	Total Unavailable Transmission
P1: Lowest Customer Solar, Low Cost, High Demand Response	1175	0	0	1175
P2: Lowest Customer Solar, High Energy Efficiency	1150	0	0	1150
P3: Lowest Demand Response, Lowest Customer Solar	1100	0	0	1100
P4: More Customer Solar, Lowest Demand Response	1025	0	0	1025
P5: More Customer Solar, Low Energy Efficiency	1000	0	0	1000
P6: High Customer Solar, High Cost	1025	0	0	1025
P7: More Customer Solar, Least Transmission Risk	925	0	0	925

The top seven portfolios have greater energy efficiency forecasts than the 2022 Conservation Potential Assessment and the 2022 Clean Energy Implementation Plan. Table 6.14 provides each portfolio's cumulative energy conservation resources in aMW.

Table 6.14 2024 DSMPA Top Seven Portfolio Energy Efficiency Incremental Additions (aMW)

Portfolio	2025	2027	2033	2045
P1: Lowest Customer Solar, Low Cost, High Demand Response	25	46	103	163
P2: Lowest Customer Solar, High Energy Efficiency	25	48	109	173
P3: Lowest Demand Response, Lowest Customer Solar	22	41	93	151
P4: More Customer Solar, Lowest Demand Response	18	35	80	133
P5: More Customer Solar, Low Energy Efficiency	17	33	75	124
P6: High Customer Solar, High Cost	24	45	102	162
P7: More Customer Solar, Least Transmission Risk	18	34	80	132

Table 6.14 provides each portfolio's levelized cost bins for energy efficiency. The levelized cost groups (bins) of conserved energy by customer class is part of City Light's IRP framework. These costs have been calculated over a 22-year program life—the *6.5. Development of Conservation IRP Inputs* section provides additional detail on the levelized cost methodology.

Table 6.15 2024 DSMPA Top Seven Portfolio Levelized Cost Bins

Portfolio	Commercial Cost Bin	Industrial Cost Bin	Residential Cost Bin
P1: Lowest Customer Solar, Low Cost, High Demand Response	$90/MWh to $100/MWh	Over $160/MWh	$150/MWh to $160/MWh
P2: Lowest Customer Solar, High Energy Efficiency	$120/MWh to $130/MWh	Over $160/MWh	$150/MWh to $160/MWh
P3: Lowest Demand Response, Lowest Customer Solar	$60/MWh to $70/MWh	Over $160/MWh	$150/MWh to $160/MWh
P4: More Customer Solar, Lowest Demand Response	$30/MWh to $40/MWh	Over $160/MWh	$150/MWh to $160/MWh
P5: More Customer Solar, Low Energy Efficiency	$20/MWh to $30/MWh	Over $160/MWh	$150/MWh to $160/MWh
P6: High Customer Solar, High Cost	$90/MWh to $100/MWh	$50/MWh to $60/MWh	$150/MWh to $160/MWh
P7: More Customer Solar, Least Transmission Risk	$30/MWh to $40/MWh	$50/MWh to $60/MWh	$150/MWh to $160/MWh
2022 CPA	$60/MWh to $70/MWh	Over $160/MWh	$40/MWh to $50/MWh

An energy efficiency cost bin is defined as all measures leading up to the maximum cost bin. As an example, P7 includes all commercial energy efficiency measures up to $40/MWh. The top seven portfolios have cumulative customer solar resources in aMW as shown in Table 6.16

Table 6.16 2024 DSMPA Top Seven Portfolio Customer Solar Incremental Additions (aMW)

Portfolio	Adoption Incentive	2025	2033	2045
P1, P2, P3	No Incentives	1	9	28
P4, P5, P7	25% Incentive	1	16	49
P6	50% Incentive	2	30	92

The assumed customer solar resources for portfolios P1, P2, and P3 would constitute a 'Business As Usual' solar adoption rate in which City Light continues to *not* directly incentivize customer solar installations within its service territory. The remaining portfolios would involve new City Light incentives for installation of customer solar, with incremental additions up to 92 aMW by 2045 for the 'Moderate' solar adoption rate in P6. A new program with a goal of rapid incremental growth in customer solar capacity would likely target a variety of customer types and center on equitable access to renewables; it might also require new city or state legislation to provide the legal permissions for City Light to offer incentives. Synergies and complementary benefits may be found with programs incorporating storage solutions, demand response, and ongoing transportation electrification efforts. These portfolios have cumulative demand response potential in MW as indicated in Table 6.17.

Table 6.17 2024 DSMPA Top Seven Portfolio Demand Response Incremental Additions (MW)

Portfolio	Demand Response	2033	2045
P1: Lowest Customer Solar, Low Cost, High Demand Response	Commercial CPP Commercial EVTOU Residential BYOT Residential ConHP	35	78
P2: Lowest Customer Solar, High Energy Efficiency	Commercial CPP Residential ConHP	19	39
P3: Lowest Demand Response, Lowest Customer Solar	Commercial CPP Residential BYOT	25	38
P4: More Customer Solar, Lowest Demand Response	Commercial CPP Residential BYOT	25	38
P5: More Customer Solar, Low Energy Efficiency	Commercial CPP Commercial Curtail Residential BYOT Residential ConHP	43	76
P6: High Customer Solar, High Cost	Commercial CPP Commercial Curtail Residential BYOT	39	53
P7: More Customer Solar, Least Transmission Risk	Commercial CPP Commercial Curtail Residential ConHP	33	54

6.5.6. Introduction to Portfolio Metrics

Seattle City Light evaluated the portfolios with five different metrics. These metrics are part of the 2024 DSMPA process to account for costs ($/MWh portfolio levelized cost), portfolio unspecified purchases (social cost of greenhouse gas), diversity of customer options (expanded customer options opportunity), unavailable transmission required to meet resource adequacy needs, and the electrification scenario resource adequacy metric. All of these metrics are equally weighted.

Levelized Cost of Energy in Portfolios: The levelized cost of energy (LCOE) of the portfolios is reported in nominal dollars per megawatt hour ($/MWh). This number contains the levelized sum of all changing portfolio costs: BPA block costs, energy efficiency costs, demand response costs, REC costs, customer solar costs, new supply resource costs, and social cost of greenhouse gas) divided by the levelized sum of all the MWhs of energy from BPA and the new resources from 2024 to 2045. City Light’s owned generation and contracts are not part of this metric calculation as those are considered constant across all portfolios.

Hourly Emissions: The hourly emissions metric calculates the portfolio's total Social Cost of Greenhouse Gas (SCGHG[57][58]) metric. This metric simply adds up (for every hour of every year from 2024 to 2045) the total number of unspecified MWhs and multiplies that number by an emissions rate and by the social cost of greenhouse gas. Sources of unspecified MWhs that change across the different portfolios are from the BPA block contract and any market purchases needed to meet load.

Customer Options: A customer program metric was created to measure each portfolio's ability to carry out City Light's values[59] of providing customers with more flexibility in how they can meet their energy needs and further advancing equitable community connections. Furthermore, CETA specifically emphasizes equitable customer involvement in a clean energy future. The customer program metric considers the number of customer options available in each of the seven top portfolios. The number of demand response, energy efficiency, and customer solar options are factored into this metric.

Unavailable Transmission: The transmission metric looks at the total estimated reliance of a portfolio's unavailable transmission required to meet City Light's resource adequacy needs because of uncertainty in future transmission networks, this metric can be viewed as a transmission risk level for each of the portfolios.

Electrification Resource Adequacy: The electrification resource adequacy metric looks at how well the portfolio performs in an accelerated electrification load scenario in the year 2045 in the month of December. Recent electrification studies show building and vehicle electrification will increase City Light's future loads, especially in the winter, and most significantly in December.

6.5.7. Conclusions

A summary of the performance of the seven top portfolios across all the metrics is shown in Table 6.18**Error! Reference source not found.**. The heat map coloring is used to indicate the relative performance of different portfolios for each metric; green is better performing than yellow, and yellow is better performing than red.

[57]https://www.utc.wa.gov/regulated-industries/utilities/energy/conservation-and-renewable-energy-overview/clean-energy-transformation-act/social-cost-carbon

[58]Revised code of Washington related to IRPs that governs SCGHG methodology is 3a under 19.280.030

[59] https://www.seattle.gov/city-light/about-us/what-we-do/mission-vision-values

Table 6.18 2024 DSMPA Top Seven Portfolio Metric Performance Heat Map

Portfolio	Portfolio $/MWh	Hourly Emissions $	Customer	Non-Firm TX MW	Elect_DecRA
P1	$ 48.15	$ 595,997,205.00	0.50	1175	0.4
P2	$ 49.15	$ 602,682,056.83	0.40	1150	0.4
P3	$ 48.47	$ 610,895,398.46	0.37	1100	0.6
P4	$ 51.52	$ 611,859,089.22	0.45	1025	0.7
P5	$ 51.02	$ 576,083,787.43	0.55	1000	0.8
P6	$ 54.61	$ 445,876,684.52	0.65	1025	0.4
P7	$ 51.45	$ 533,272,440.99	0.50	925	0.7

A more in-depth look at the strengths and weaknesses of these top seven portfolios is outlined in Table 6.19.

Table 6.19 2024 DSMPA Top Seven Portfolio Strengths and Weaknesses

Portfolio Name	Strengths	Weaknesses
P1: Lowest Customer Solar, Low Cost, High Demand Response	Lowest cost portfolio Top electrification resource adequacy metric performance	Largest unavailable transmission reliance High energy efficiency target operationally difficult to achieve in current business climate
P2: Lowest Customer Solar, High Energy Efficiency	Top electrification resource adequacy metric	High energy efficiency target operationally difficult to achieve in current business climate
P3: Lowest Demand Response, Lowest Customer Solar	Second-lowest cost Middle of the road	Fewest customer options
P4: More Customer Solar, Lowest Demand Response	Not many	Highest emissions Second-highest cost Second worst in electrification resource adequacy
P5: More Customer Solar, Low Energy Efficiency	Most likely to operationally meet energy efficiency targets Second-lowest transmission risk	Worst performing under higher electrification loads
P6: High Customer Solar, High Cost	Top electrification resource adequacy metric performance Lowest emissions Most customer options	Most expensive City Light 50% discount solar incentive program High energy efficiency target operationally difficult to achieve in current business climate
P7: More Customer Solar, Least Transmission Risk	Least transmission risk	Second worst in electrification resource adequacy

Table 6.20 contains the top seven portfolios and their resource composition by the year 2045.

Table 6.20 2024 DSMPA Top Seven Portfolio Forecasted Firm Resources By 2045

Portfolio	Wind (MW)	Solar (MW)	Energy Efficiency (aMW)	Demand Response (MW)	Customer Solar (aMW)	Standalone Battery (MW)
P1	875	75	163	78	28	100
P2	875	75	173	39	28	100
P3	875	175	151	38	28	100
P4	875	175	133	38	49	200
P5	875	275	124	76	49	200
P6	875	200	162	53	92	200
P7	875	400	132	54	49	200

6.5.8. Recommendations

In the face of growing electrification, the 2024 DSMPA analysis has demonstrated more supply and demand resources will be needed to meet future resource adequacy needs than the 2022 IRP and 2022 CPA.

To help address winter resource adequacy needs, residential energy efficiency will be rising significantly compared to the 2022 IRP and 2022 CPA. In the 2024 DSMPA, all top seven portfolios include a residential cost bin of $150-160 MWh (~22 aMW over 10 years). In the 2022 IRP and 2022 CPA it was a $40-50 MWh cost bin (~11 aMW over 10 years). It will take considerable effort to scale up residential energy efficiency, but there are likely going to be significant synergies with federal and state funding opportunities (i.e., federal Inflation Reduction Act funding).

On the commercial energy efficiency side, four of the seven top 2024 DSMPA portfolios feature commercial cost bins equal to, or greater than the 2022 CPA. As of September 2023, City Light is not on track to meet its two-year 2022 CPA targets, in large part due to the reduced activity in office building upgrades due to the ongoing changes in that sector following the COVID pandemic. Therefore, it is reasonable to assume, in the short term, that the demand side commercial energy efficiency potentials in portfolios P1, P2, P3, and P6 are not available. Given this, utility solar is a feasible and recommended replacement for the identified additional need for commercial energy efficiency.

Since portfolios P1, P2, P3, and P6 are not feasible, this leaves portfolios P4, P5, and P7. P4 performs the worst in all of the metrics of these remaining three, leaving P5 and P7. Table 6.21 shows the top two portfolios P5 and P7 under three different hourly flat market reliance conditions: 0 aMW, 100 aMW, and 200 aMW.

Table 6.21 2024 DSMPA Top Two Portfolio Market Reliance (MR) Sensitivity

Portfolio	Wind (MW)	Solar (MW)	Energy Efficiency (aMW)	Demand Response (MW)	Customer Solar (aMW)	Battery Only (MW)	Unavailable Transmission (MW)
P5_MR0	875	275	124	76	49	200	1000
P5_MR100	875	150	124	76	49	200	525
P5_MR200	875	425	124	76	49	0	75
P7_MR0	875	400	132	54	49	200	925
P7_MR100	875	350	132	76	49	200	450
P7_MR200	875	450	132	32	49	100	50

In Table 6.22 P7 performs better in the December electrification resource adequacy metric, has less reliance on unavailable transmission, and has fewer emissions.

City Light finds the portfolio attributes of P7, with market reliance of 200 aMW, to be the best fit for the utility because this portfolio mitigates supply transmission risk, energy efficiency achievability risk, and electrification resource adequacy risk.

City Light recognizes that individual resources (supply or demand) are subject to deliverability uncertainty. Given the highlighted uncertainties and challenges, there currently is no perfect solution to City Light's resource adequacy challenge. The recommendation is based on minimizing identified risks while acknowledging that circumstances will change, and City Light will reevaluate resources adequacy needs and resourcing options every two years.

Table 6.22 2024 DSMPA Top Portfolio (P7) Resources

Resource	Capacity by Year 2028 (MW)	Capacity by Year 2045 (MW)
Battery	100	100
EOR Solar	75	75
EOR Solar+Battery	0	25
EWA Solar	275	300
EWA Solar+Battery	0	50
Gorge Wind	275	275
Montana Wind	100	100
Offshore Wind	0	500
Total Firm Supply	**825**	**1425**
Total Unavailable Transmission Supply	**50**	**50**
Commercial CPP	15	15
Commercial EVTOU	2	17
Total Demand Response	**17**	**32**
Commercial Energy Efficiency (aMW)	28	72
Industrial Energy Efficiency (aMW)	5	10
Residential Energy Efficiency (aMW)	10	50
Total Energy Efficiency (aMW)	**43**	**132**
Customer Solar (aMW)	**9**	**49**

Table 6.23 provides the 2024 DSMPA two-, four-, ten-, and 22-year cumulative achievable economic potential estimates by sector.

Table 6.23 2024 DSMPA Achievable Economic Potential

	Achievable Economic Potential - aMW				
Sector	2-Year (2024–2025)	4-Year (2024–2027)	10-Year (2024–2033)	22-Year (2024–2045)	20% of 10-Year
Residential	4	8	22	50	4
Commercial	12	23	49	72	10
Industrial	2	4	8	10	2
Total	**18**	**35**	**79**	**132**	**16**
Customer Solar	2	4	16	49	3

As a comparison, Table 6.24 provides the 2022 CPA two-, four-, ten-, and 20-year cumulative achievable economic potential estimates by sector.

Table 6.24 2022 CPA Achievable Economic Potential

	Achievable Economic Potential - aMW				
Sector	**2-Year (2022–2023)**	**4-Year (2022–2025)**	**10-Year (2022–2031)**	**20-Year (2022–2041)**	**20% of 10-Year**
Residential	2.90	5.22	11.16	17.91	2.23
Commercial	13.85	25.98	57.08	77.48	11.42
Industrial	1.99	4.03	8.65	10.44	1.73
Total	**18.74**	**35.23**	**76.89**	**105.83**	**15.38**

Figure 6.14 provides the 2024 DSMPA 22-year cumulative achievable economic potential targets compared with the maximum potential by sector.

Figure 6.14.2024 DSMPA Energy Efficiency Targets Compared with Maximum Potential

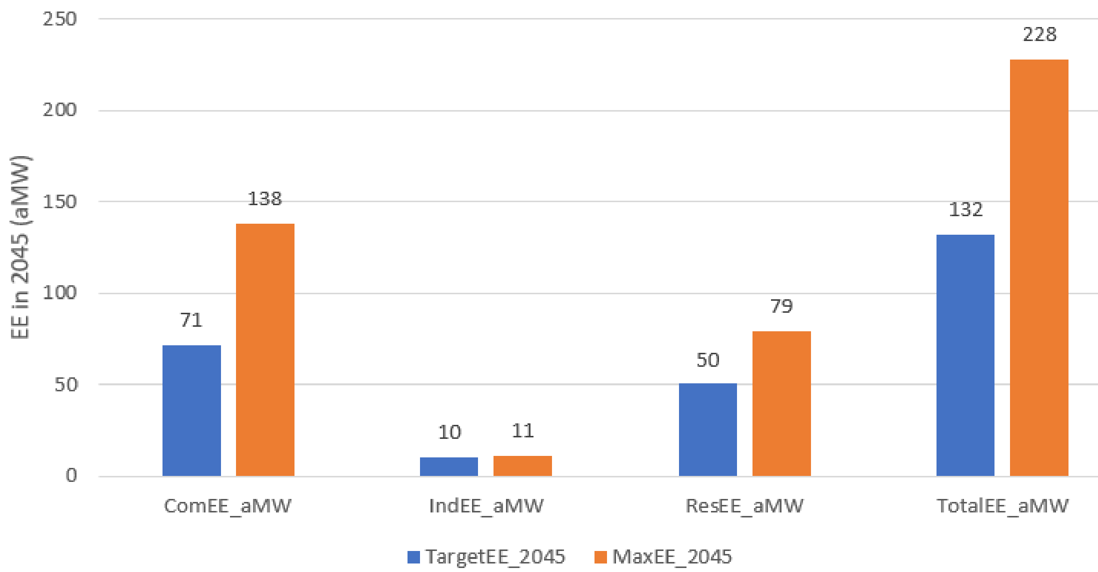


Table 6.25 provides the 2024 DSMPA 22-year top portfolio new resource additions.

Table 6.25 2024 DSMPA Top Portfolio New Resource Additions

New Resource Additions	**2024–2031**	**2032–2045**	**Total**
Solar (MW)	350	100	450
Wind (MW)	375	500	875
Energy Efficiency (aMW)	67	65	132
Customer Solar (aMW)	15	34	49
Summer Demand Response (MW)	19	7	26
Winter Demand Response (MW)	20	11	31
Standalone Battery (MW)	100	0	100
Unavailable Transmission Supply Resources (MW)	50	0	50

As a comparison, Table 6.26 provides the 2022 IRP 20-year top portfolio new resource additions.

Table 6.26 2022 IRP Top Portfolio New Resource Additions

New Resource Additions	2022–2031	2032–2041	Total
Solar (MW)	175	0	175
Wind (MW)	225	50	275
Energy Efficiency (aMW)	85	31	116
Customer Solar Programs (MW)	24	28	52
Summer Demand Response (MW)	47	31	78
Winter Demand Response (MW)	79	43	122

7. 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*.[60]

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

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 implementing 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 with conventional supply-side energy resources.

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

End-use consumption: Used for the residential sector, this represents per-UEC consumption for a given end use, expressed in annual kilowatt-hours per unit. (Also called unit energy consumption.)

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

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

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% 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).

Lost opportunity: Refers to an efficiency measure or efficiency program seeking to encourage the 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 the 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 (such as increased insulation, lighting occupancy controls, or economizer ventilation systems).

Resource adequacy*:* Having sufficient resources, generation, energy efficiency, storage, and demand-side resources to serve loads across a wide range of conditions.

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 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 with the present value of benefits, including avoided energy supply and demand costs.