CONSERVATION POTENTIAL ASSESSMENT

Project #1368

EnerNOC Utility Solutions Consulting
500 Ygnacio Valley Road
Suite 450
Walnut Creek, CA 94596
925.482.2000
www.enernoc.com

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Seattle City Light

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This report was prepared by

EnerNOC Utility Solutions Consulting
500 Ygnacio Valley Blvd., Suite 450
Walnut Creek, CA 94596

Project Director: I. Rohmund
Project Manager: D. Costenaro
J. Borstein
C. Carrera
S. Kananizadeh
F. Nguyen
K. Walter
S. Yoshida

Subcontractor:
Data Marketing Incorporated (DMI)

EXECUTIVE SUMMARY

Seattle City Light (City Light) has contracted with EnerNOC Utility Solutions (EnerNOC) to conduct a conservation potential assessment (CPA) to quantify the amount, the timing, and the cost of electric conservation resources available within the City Light service territory. The study's purpose is to establish cost-effective and achievable energy conservation targets for 2014–2015 to meet the legal requirements associated with Washington Administrative Code 194-371 (Initiative 937 or I-937), as well as to support City Light's Integrated Resource Plan (IRP). In accordance with I-937, this CPA is informed by and uses methodology consistent with the Northwest Power and Planning Council (NPCC) Sixth Power Plan. This study updates City Light's last CPA, which EnerNOC performed for the 2013-2014 biennium.

Report Organization

The report is organized as follows:

- Chapter 1 — Introduction
- Chapter 2 — Analysis Approach and Data Development
- Chapter 3 — Market Characterization and Market Profiles
- Chapter 4 — Baseline Projection
- Chapter 5 — Conservation Potential

Definitions

Before launching into the discussion of results, a few key terms are defined:

- **Technical potential** is defined as the theoretical upper limit of conservation potential. It assumes that customers adopt all feasible measures regardless of their cost. At the time of existing equipment failure, customers replace their equipment with the most efficient option available.
- **Economic potential** represents the adoption of all ***cost-effective*** conservation measures. In this analysis, cost-effectiveness is measured by the total resource cost (TRC) test as defined by the NPCC. This is a subset of technical potential.
- **Achievable potential** establishes a realistic target for the conservation savings that a utility can hope to achieve through its programs. It takes into account market maturity, customer preferences for energy-efficient technologies, and expected program participation, and is determined by applying a series of annual market adoption factors to the economic potential for each conservation measure. These factors represent the ramp rates at which technologies will penetrate the market. To develop these factors, the project team reviewed City Light's past conservation program achievements and program history over the last five years, as well as the NPCC ramp rates used in the Sixth Plan.
- **Baseline projection** is a reference end-use forecast developed specifically for this study. This estimates what would happen in the absence of any conservation programs. Consistent with the NPCC methodology, the baseline projection uses a frozen efficiency case in which the market purchase shares for efficient equipment do not change during the study period, unless equipment standards remove a technology option from the market. This methodology, removes from the baseline any effects of naturally occurring conservation or future conservation programs. Thus the CPA's resulting projections of potential compared to this baseline are gross, because naturally occurring conservation effects have been removed.

Overall Conservation Potential

Table ES-1 and Figure ES-1 summarizes the achievable potential across all sectors. **Based on the total achievable potential of 118.4 aMW in 2023, City Light is establishing a conservation target for the 2014–2015 biennium of 23.7 aMW**, which is 20% of the ten-year cumulative potential (118.4 aMW in 2023).

Table ES-1 Cumulative Achievable Potential by Sector (MWh)

	2014	2015	2018	2023	2028	2033
Achievable Cumulative Savings (MWh)						
Residential	28,500	59,974	127,865	249,900	398,666	548,450
Commercial	47,025	95,335	234,290	680,625	1,172,913	1,503,855
Industrial	14,509	22,765	37,031	69,591	90,627	106,463
Street Lighting	9,950	19,901	34,185	36,861	36,876	36,876
Total	**99,985**	**197,975**	**433,371**	**1,036,977**	**1,699,082**	**2,195,644**
Achievable Cumulative Savings (aMW)						
Residential	3.3	6.8	14.6	28.5	45.5	62.6
Commercial	5.4	10.9	26.7	77.7	133.9	171.7
Industrial	1.7	2.6	4.2	7.9	10.3	12.2
Street Lighting	1.1	2.3	3.9	4.2	4.2	4.24
Total	**11.4**	**22.6**	**49.5**	**118.4**	**194.0**	**250.6**

Figure ES-1 Cumulative Achievable Potential by Sector (MWh)

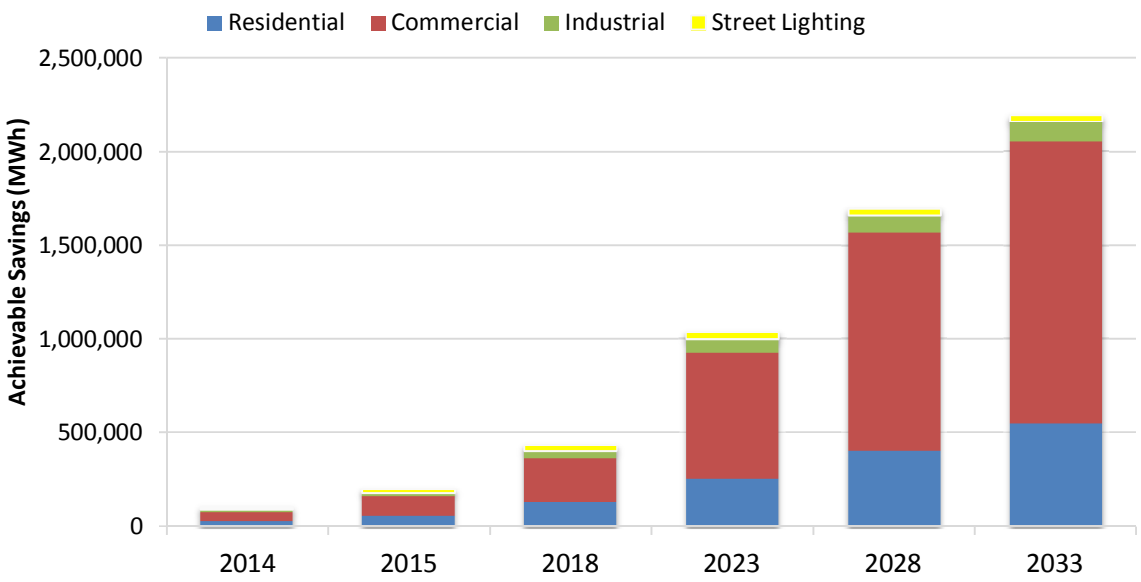


Table ES-2 presents the baseline projections of energy consumption, as well as the three levels of conservation potential for the residential, commercial, industrial, and street lighting sectors combined. As discussed in detail in Chapter 4, the baseline projection across all sectors increases over the 20-year time period. This is due largely to the growth in the commercial sector, which is tempered somewhat due to appliance and equipment standards, building codes, and a sluggish economy in the initial years. Key findings related to measure-level potentials are summarized as follows:

- **Achievable potential** across the four sectors is 197,975 MWh (22.6 aMW) in 2015 or 2.0% of the projected baseline. Cumulative achievable potential grows to 1,036,977 MWh or 118.4 aMW in 2023. This level of savings is consistent with other EnerNOC potential studies for utilities with mature conservation programs.
- **Economic potential**, which reflects the savings when all cost-effective measures are taken, is 57.5 aMW in 2015. Cumulative economic potential is 179.8 aMW in 2023.
- **Technical potential,** which reflects the adoption of all conservation measures regardless of cost-effectiveness, is a theoretical upper bound on savings. In 2013, technical potential is 74.9 aMW. In 2023, cumulative technical potential savings are 249.4 aMW.

Table ES-2 Summary of Achievable, Economic, and Technical Conservation Potential, All Sectors

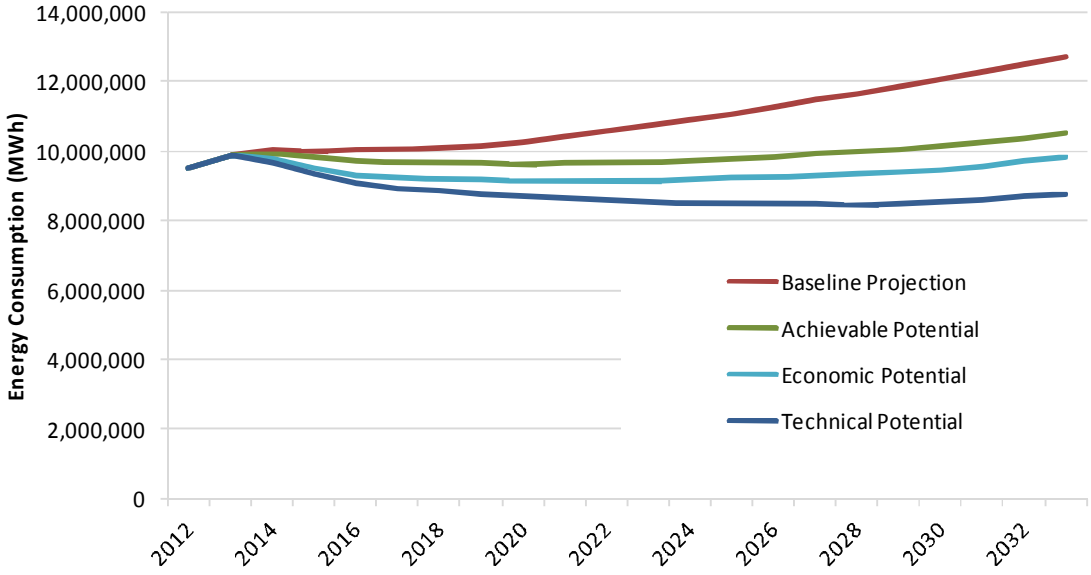
	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	10,049,821	10,005,208	10,085,063	10,728,599	11,667,344	12,706,161
Cumulative Savings (MWh)						
Achievable Potential	99,985	197,975	433,371	1,036,977	1,699,082	2,195,644
Economic Potential	285,794	504,001	911,503	1,574,823	2,342,961	2,893,157
Technical Potential	376,456	656,464	1,243,763	2,185,003	3,209,910	3,938,790
Cumulative Savings (aMW)						
Achievable Potential	11.4	22.6	49.5	118.4	194.0	250.6
Economic Potential	32.6	57.5	104.1	179.8	267.5	330.3
Technical Potential	43.0	74.9	142.0	249.4	366.4	449.6

Per WAC 194-37-070 (6), the NPCC methodology yields a maximum penetration rate after 20 years of 85% for non-lost opportunity measures and 65% for lost opportunity measures achieved through a mix of utility programs and local, state and federal codes and standards. For 10-year potential, the penetration rates are 64% for non-lost opportunity measures and 23% for lost opportunity measures with a weighted average of 46% for both.1 The results of this CPA analysis show 10-year achievable potential for the residential, commercial, and industrial sectors combined that is 65% of the economic (cost-effective) potential, greater than the 46% weighted average cited in WAC 194-37-070. Note that the CPA projected achievable savings could be achieved either through utility programs or market transformation efforts (such as NEEA activities supported by City Light and other regional utilities) and excludes savings due to codes and standards, which are incorporated in the baseline projection. The CPA projection of achievable 20-year potential for lost and non-lost opportunities combined is 76% of economic potential.

Figure ES-2 displays the baseline and conservation potential projections.

[1] http://apps.leg.wa.gov/WAC/default.aspx?cite=194-37&full=true#194-37-070, 194-37-070, (6) (a) (xii).

Figure ES-2 Baseline and Conservation Potential Energy Projections (MWh)



Study Approach

To perform the conservation potential analysis, EnerNOC used a bottom-up analysis approach as follows:

1. Performed a market characterization to describe sector-level electricity use for the residential and non-residential (commercial and industrial) sectors for the base year, 2012. This step drew upon the market characterization from the 2011 CPA, but updated the characterization to incorporate new information from the NPCC, the Regional Technical Forum (RTF), the Northwest Energy Efficiency Alliance (NEEA) 2011 Residential Building Stock Assessment (RBSA), EnerNOC's own data, and the Energy Information Administration (EIA).
2. Developed a baseline electricity use projection by sector, segment, and end use for 2013 through 2033.
3. Identified and characterized conservation measures.
4. Estimated measure-level conservation potential for three cases: *Technical, Economic, and Achievable*.

We used EnerNOC's Load Management Analysis and Planning tool (LoadMAP™) version 3.0 to develop both the baseline projection and the estimates of conservation potential. EnerNOC developed LoadMAP in 2007 and has enhanced it over time, using it for the Electric Power Research Institute (EPRI) National Potential Study and numerous utility-specific potential studies.

The analysis approach and the data sources used are described in detail in Chapter 2.

Market Characterization

The market characterization provides an understanding of how City Light customers use energy by end use and technology. Total electricity use for the residential, non-residential, and outdoor lighting sectors for City Light in 2012, the study base year, was 9,494,297 MWh.[2] As shown in Table ES-3, the largest sector is non-residential, accounting for 66% of use, followed by residential, with 33% of sales. Street lighting represents only about 1% of sales.

[2] Based on EIA Form 861. Energy usage as measured "at-the-meter," i.e., does not include line losses.

Table ES-3 Customer Counts and Energy Sales by Sector, 2012

Sector / Rate Class	Number of meters (customers)	2012 Electricity sales (MWh)
Residential	362,524	3,146,951
Commercial	40,084	4,961,098
Industrial		1,294,369
Street Lighting	3,301	91,879
Total	**405,909**	**9,494,297**

To divide non-residential usage between the Commercial and Industrial sectors as shown in Table ES-3, the project team used a database developed by Data Marketing Incorporated (DMI). This database matched City Light's non-residential billing data with information from the King County Assessor to characterize City Light's customers by building or industry type. The resulting division between Commercial and Industrial differs slightly from that reported on City Light's EIA Form 861 because for the CPA, we assign facilities to the commercial or industrial sectors based on the facility's use and whether the primary end uses are lighting and HVAC, which is the case for commercial facilities, or whether the primary end uses are motors and process uses, which is the case for industrial facilities. Doing so enables us to model the efficiency measures that are most appropriate for the dominant end uses. See Chapter 4 for additional details.

Total residential electricity use in 2012 was 3,146,951 MWh, for an average use per home of 8,681 kWh/year. Figure ES-3 presents the shares of residential electrify use for each housing segment. The single family segment includes a very small percentage of mobile homes. Multiplex comprises 2–4 attached units or townhomes. Low-Rise Multifamily is defined as 5 or more units in buildings 6 or fewer stories in height, while High-Rise Multifamily consists of 5 or more units in buildings 7 or more stories in height. The single family segment consumed 60% of total residential sector electricity in 2012 as a result of having the largest number of customers and the highest intensity.

Figure ES-3 Residential Electricity Use by Customer Segment, 2012

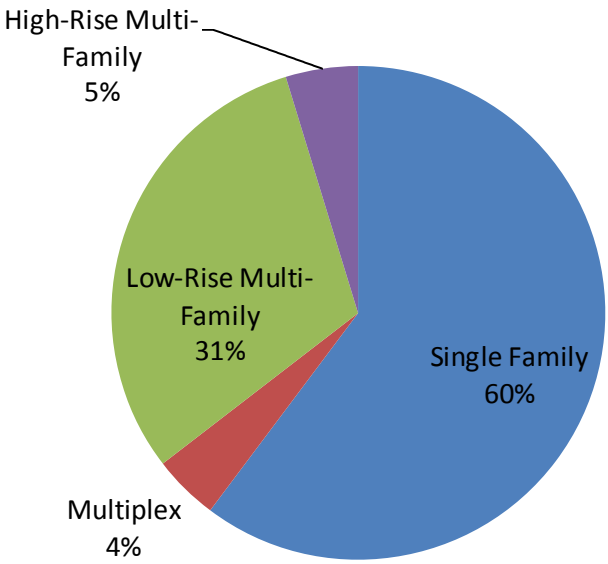


Figure ES-4 shows the breakdown of annual use per household by end use for each segment. Compared with the other housing types, single family homes allocate a smaller portion of their electricity use to space heating, due mainly to a higher saturation of gas heat in single family homes. Note that high-rise units use about 82% of the electricity that low-rise units do, despite the fact that they are slightly larger. We attribute this difference to three factors: high-rise buildings are generally newer and have better thermal shells as well as more efficient equipment overall, the high-rise units have a smaller ratio of exterior surfaces to total

unit space, and heating and cooling in high-rise buildings is more often provided by central building systems.

Due to Seattle's relatively mild climate, across all housing types, space conditioning accounts for only 23% of annual use. Appliances represent 28% of usage, water heating 17%, and interior lighting 13%. Electronics, which includes personal computers, TVs, set top boxes, home audio, etc., represent 11% of use, while the miscellaneous end use, which encompasses such devices as furnace fans, pool pumps, hot tubs, and other "plug" loads (hair dryers, power tools, coffee makers, etc.), consumes about 7%.

Figure ES-4 Residential Intensity by End Use and Segment (kWh/household, 2012)

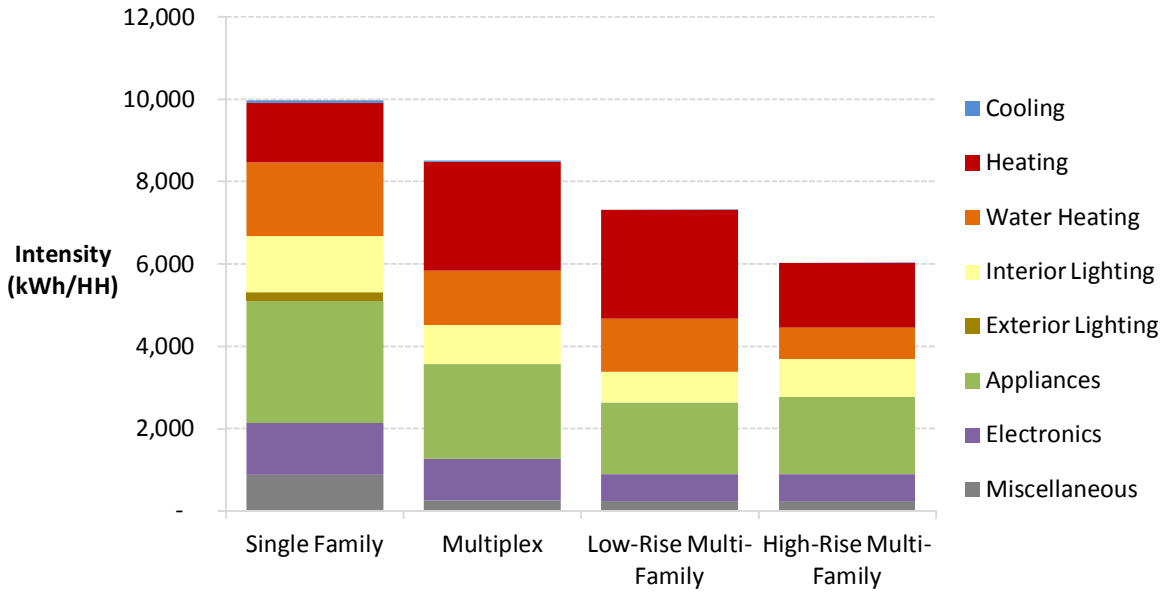


Figure ES-5 shows the percentage of the 2012 commercial sector energy use, 4,961,098 MWh, by each of the 16 segments analyzed for the CPA. The four largest segments are large office, college, data center, and retail, which together make up about 50% of sales in the commercial sector. The remaining segments individually constitute less than 6% of sales.

Figure ES-5 Share of Commercial Sector Electricity Use by Building Type, 2012

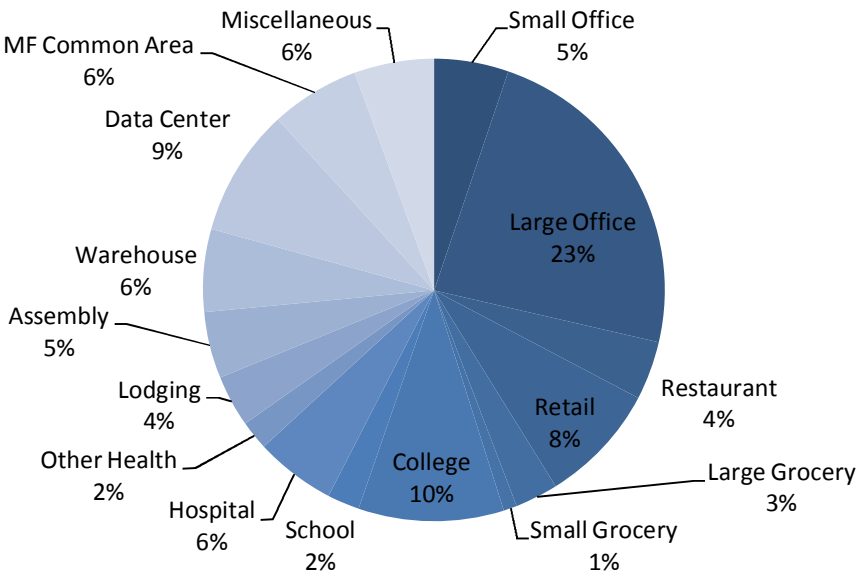
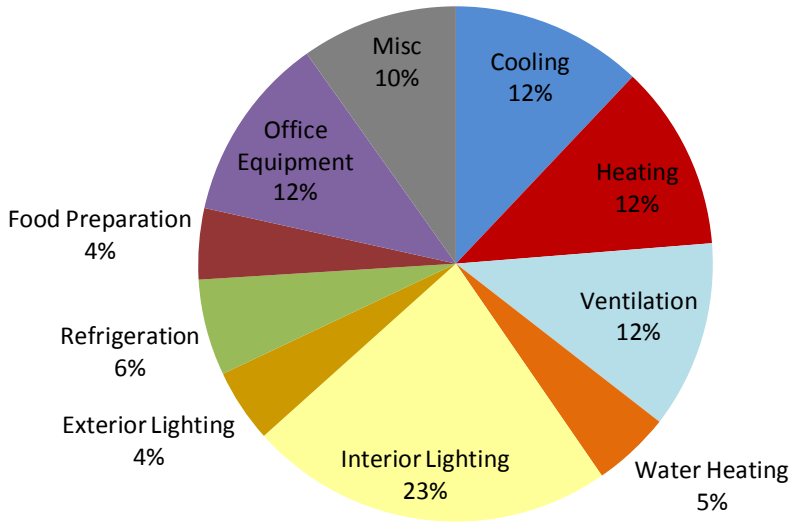


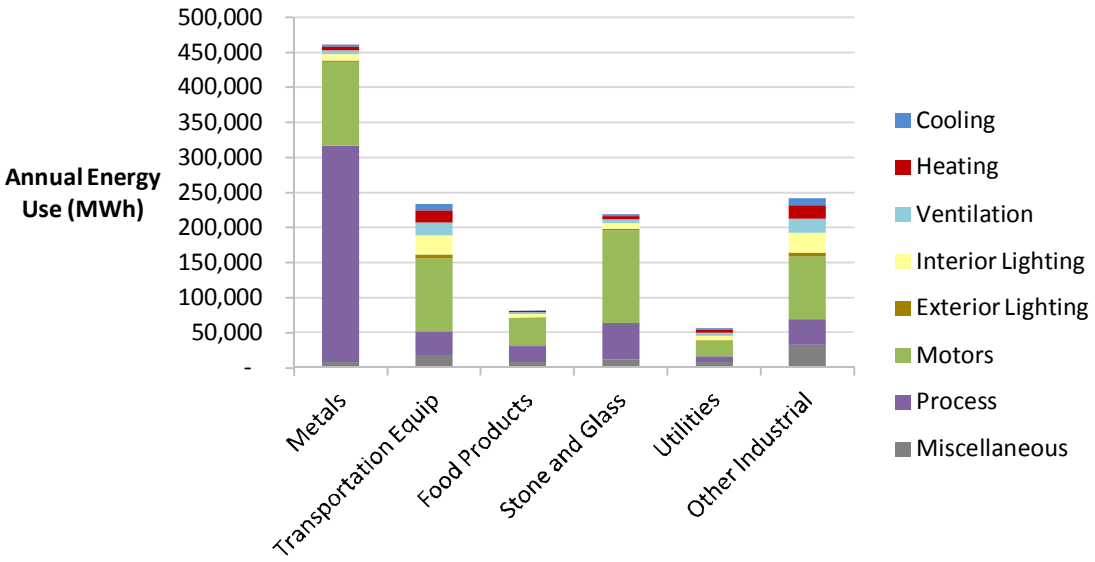
Figure ES-6 shows the breakdown of annual commercial electricity usage by end use for the commercial sector as a whole. Heating, ventilation, and cooling collectively account for 36% of energy use. Interior and exterior lighting combined represent 27% of consumption. Office equipment is significant as well, due to the large presence of data centers in the service territory. The relatively high consumption for the miscellaneous end use category, 10%, is due to the increasing use of various plug load equipment across all commercial building types. The remaining end uses — water heating, refrigeration, and food preparation — comprise 6% or less of total usage.

Figure ES-6 Commercial Electricity Consumption by End Use, 2012



The industrial sector used 1,294,369 MWh in 2012, representing about 13.6% of total City Light electricity sales. The five major industrial segments and their percentage of industrial use were identified as Metals (36%); Transportation Equipment (18%); Food Products (6%); Stone and Glass, including cement (17%); and Utilities including water and wastewater (4%). We combined the remaining industries into the Other Industrial category, which accounts for 19% of industrial use. Figure ES-7 shows each end use as a percentage of the segment's total use.

Figure ES-7 Industrial Electricity Use by End Use and Segment (MWh, 2012)



City Light reported street lighting usage of 91,879 MWh from its inventory of approximately 90,000 fixtures. The great majority of the street lighting fixtures, approximately 86%, are cobra head street lighting fixtures that traditionally use high-pressure sodium lamps. Beginning in 2010, City Light began replacing the cobra head street lighting fixtures with LED fixtures. Phase 1 of this project is expected to convert 40,763 fixtures by the end of 2013. Phase 2 of the project will begin in 2014.

Additional details of the Market Characterization appear in Chapter 3.

Baseline Projection

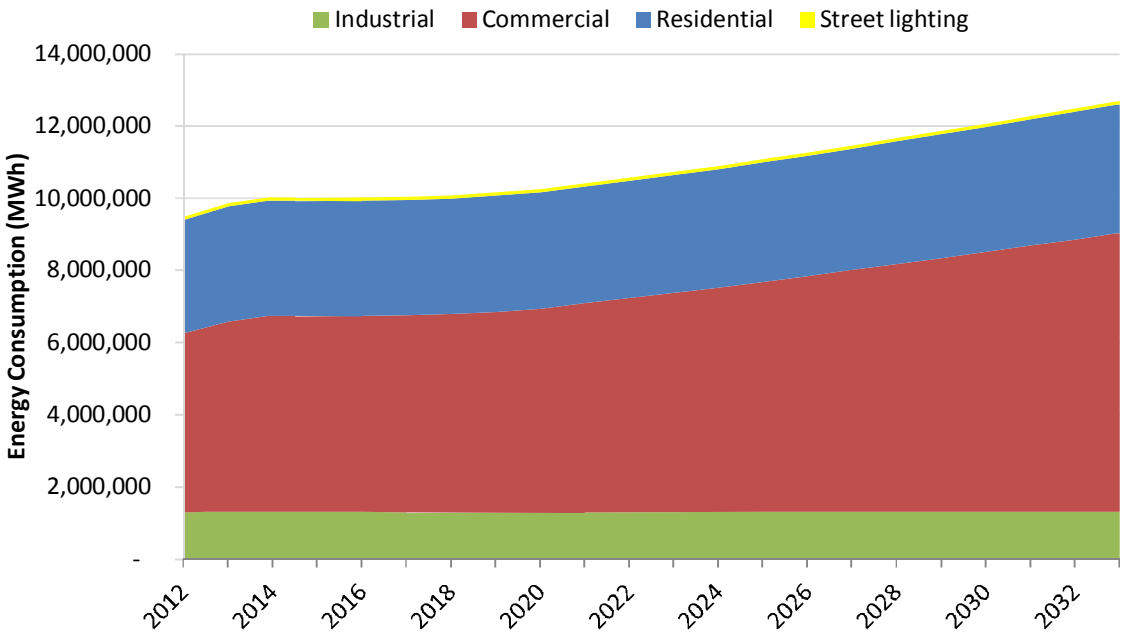
Prior to developing estimates of conservation potential, a baseline end-use projection was developed to quantify how electricity is used by end use in the base year and what the consumption is likely to be in the future in absence of new utility programs and naturally occurring conservation. The baseline projection serves as the metric against which conservation potentials are measured. The baseline projection we developed for City Light was within 5% of the City Light load forecasting group's forecast.

Table ES-4 and Figure ES-8 provide an overall summary of the baseline projection by sector and for City Light as a whole. Overall, the projection for the next 20 years grows steadily, with overall average annual growth of 1.4% per year, dominated by growth in the commercial sector.

Table ES-4 Baseline Projection Summary, All Sectors (MWh)

Sector	2012	2014	2015	2018	2023	2033	Avg. Growth Rate ('12-'33)
Residential	3,146,951	3,205,277	3,193,660	3,206,854	3,256,520	3,577,236	0.6%
Commercial	4,961,114	5,435,096	5,402,226	5,501,409	6,082,292	7,713,040	2.1%
Industrial	1,294,369	1,320,856	1,320,729	1,288,208	1,301,196	1,327,294	0.1%
Street Lighting	91,879	88,592	88,592	88,592	88,592	88,592	-0.2%
Total	9,494,313	10,049,821	10,005,208	10,085,063	10,728,599	12,706,161	1.4%

Figure ES-8 Baseline Projection Summary, All Sectors (MWh)



Additional details regarding the Baseline Projection by sector and end use appear in Chapter 4.

Conservation Potential

Conservation potential for all sectors combined appears above in Table ES-1 and Figure ES-1. Table ES-5 through Table ES-8 provide the various levels of potential for each of the individual sectors.

Table ES-5 Conservation Potential for the Residential Sector

	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	3,205,277	3,193,660	3,206,854	3,256,520	3,395,213	3,577,236
Cumulative Savings (MWh)						
Achievable Potential	28,500	59,974	127,865	249,900	398,666	548,450
Economic Potential	130,668	247,102	415,827	504,274	662,997	833,258
Technical Potential	173,554	327,293	604,761	845,762	1,136,914	1,375,499
Cumulative Savings (aMW)						
Achievable Potential	3.3	6.8	14.6	28.5	45.5	62.6
Economic Potential	14.9	28.2	47.5	57.6	75.7	95.1
Technical Potential	19.8	37.4	69.0	96.5	129.8	157.0

Residential cumulative achievable potential by end use in 2015 is illustrated in Figure ES-9. Key insights are:

- **Interior lighting** provides the greatest achievable potential, with savings from both standard screw-in and specialty lighting.
- **Home electronics** offers the second largest achievable potential due primarily to televisions. Savings also come from efficient set-top boxes and digital video recorders.
- **Heating** savings are due mainly to the adoption of ductless heat pumps in single family and multiplex homes.
- **Interior lighting** provides the greatest achievable potential, with savings from both standard screw-in and specialty lighting. The study assumes that LED costs will continue to drop rapidly, and that they will be accepted by consumers.
- **Home electronics** offers the second largest achievable potential in the near term. A large portion of the savings is due to televisions. As noted above, the baseline for televisions was adjusted to more closely correspond to that used by NEEA for calculating savings. However, the market has transformed significantly, such that almost all TVs now sold are ENERGY STAR labeled. Savings also come from efficient set-top boxes and digital video recorders.
- **Heating** offers the third largest achievable potential, due mainly to the adoption of ductless heat pumps in single family and multiplex homes. Insulation measures are a small contributor to savings because City Light's long running programs have already achieved much of that potential.
- **Appliances** offer the next highest near-term savings. However, appliances' contribution to potential in future years diminishes as equipment standards move the market to efficient units.
- **Water Heating** achievable potential is limited in the near term because HPWH, which are the cost-effective option, still face significant market barriers. Therefore, most of the near-term water heating savings are due to low-flow showerheads and faucet aerators.
- **Behavioral measure,** assumed to be a comparative feedback program, provides savings across all end uses.

Figure ES-9 Residential Cumulative Achievable Potential by End Use in 2015

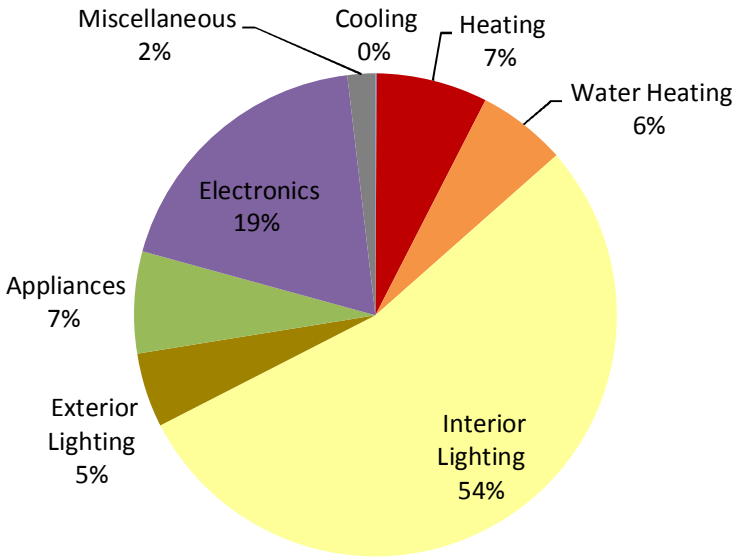


Table ES-6 Conservation Potential for the Commercial Sector

	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	5,435,096	5,402,226	5,501,409	6,082,292	6,869,417	7,713,040
Cumulative Savings (MWh)						
Achievable Potential	47,025	95,335	234,290	680,625	1,172,913	1,503,855
Economic Potential	116,007	201,851	410,776	946,480	1,530,031	1,889,671
Technical Potential	157,533	265,915	541,388	1,186,159	1,878,483	2,346,823
Cumulative Savings (aMW)						
Achievable Potential	5.4	10.9	26.7	77.7	133.9	171.7
Economic Potential	13.2	23.0	46.9	108.0	174.7	215.7
Technical Potential	18.0	30.4	61.8	135.4	214.4	267.9

Figure ES-10 illustrates how the commercial cumulative achievable potential of 95,335 MWh in 2015 is distributed among the end uses. We note the following:

- Interior and exterior lighting combined represent nearly two-thirds of all potential, consistent with lighting's preponderance in technical and economic potential. Given that these are mature technologies, they have relatively high market acceptance.
- Ventilation provides 11% of achievable savings, while HVAC overall represents 16% of potential
- Office Equipment constitutes 13% of achievable potential, which reflects that efficient technologies in this area are both cost-effective and widely accepted in the market
- Water heating savings are modest at 2% of total achievable potential, despite significant technical and achievable potential. This reflects ongoing market barriers to widespread adoption of HPWH.

Figure ES-10 Commercial Cumulative Achievable Potential by End Use in 2015

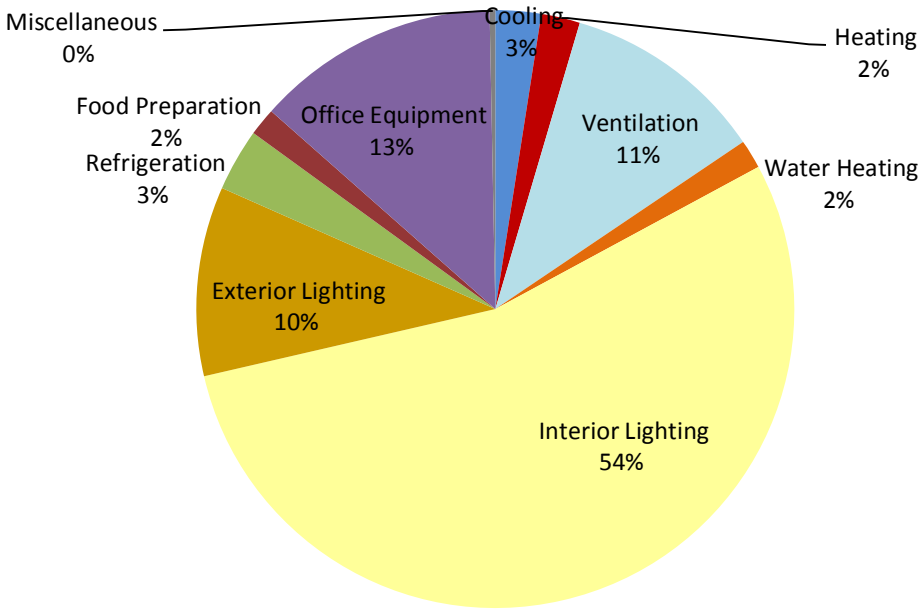


Table ES-7 Conservation Potential for the Industrial Sector

	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	1,320,856	1,320,729	1,288,208	1,301,196	1,314,122	1,327,294
Cumulative Savings (MWh)						
Achievable Potential	14,509	22,765	37,031	69,591	90,627	106,463
Economic Potential	29,168	35,148	50,715	87,208	113,056	133,352
Technical Potential	34,913	42,346	61,822	114,501	155,932	177,887
Cumulative Savings (aMW)						
Achievable Potential	1.7	2.6	4.2	7.9	10.3	12.2
Economic Potential	3.3	4.0	5.8	10.0	12.9	15.2
Technical Potential	4.0	4.8	7.1	13.1	17.8	20.3

Figure ES-11 shows industrial cumulative achievable potential by end use in 2015. Motor end uses, which are 36% of achievable potential in 2015, also offer the greatest opportunity for energy savings across the all three levels of potential and all years. Because of motor standards, much of the cost-effective and achievable savings are not due to more efficient motors, but rather to controls and system optimization strategies. Process loads and lighting are the next greatest sources of savings, followed by ventilation.

Figure ES-11 Industrial Cumulative Achievable Potential by End Use in 2015

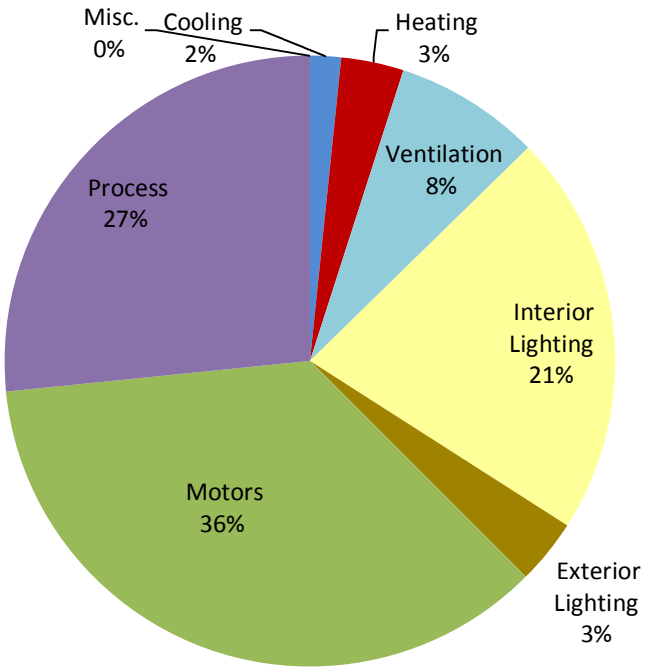


Table ES-8 Conservation Potential for the Street Lighting Sector

	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	**88,592**	**88,592**	**88,592**	**88,592**	**88,592**	**88,592**
Cumulative Savings (MWh)						
Achievable Potential	9,950	19,901	34,185	36,861	36,876	36,876
Economic Potential	9,950	19,901	34,185	36,861	36,876	36,876
Technical Potential	10,455	20,910	35,793	38,581	38,581	38,581
Cumulative Savings (aMW)						
Achievable Potential	1.1	2.3	3.9	4.2	4.2	4.2
Economic Potential	1.1	2.3	3.9	4.2	4.2	4.2
Technical Potential	1.2	2.4	4.1	4.4	4.4	4.4

Additional details regarding potential by segment and the primary end uses and measures that contribute to potential appear in Chapter 5.

Avoided Cost Sensitivity Analysis

To assist City Light in evaluating variations in potential due to changes in avoided costs, EnerNOC also evaluated conservation potential, for the residential, commercial, and industrial sectors, based on an alternate stream of avoided costs. Street lighting measures were mainly cost-effective under the reference case, and thus were not modeled under the avoided costs alternative case.

- In the reference case, for which results are presented above, and referred to here as Market + CCT (combined cycle turbine), the avoided costs are based on market costs and assume that the marginal generation unit is a conventional combined cycle turbine. In addition, avoided costs include adders for

renewable energy credits, carbon dioxide offsets, transmission and distribution costs, and a 10% credit for the Regional Act Bonus, consistent with the Sixth Power Plan methodology. Note that City Light has sufficient capacity for the study period and thus did not provide an avoided cost of capacity.

- The second scenario, referred to here as the IRP Preferred Portfolio, assumed higher avoided energy costs starting in 2021 based on City Light's Integrated Resource Plan (IRP). City Light does not expect to acquire generation resources before roughly 2021. At this point, all new resources will be from a renewable source. As with the reference case, it also includes transmission and distribution costs and a 10% credit for the Regional Act Bonus. The changes in avoided costs affect economic potential directly and flow through to achievable potential. As avoided costs increase, the benefits of savings from conservation increase, causing the benefit-cost ratio to increase. If higher avoided costs result in measure B/C ratios rising to a value of 1.0 or above, then the measures are included in economic potential.

Figure ES-12 shows the two avoided costs streams used in the analyses. Table ES-9 compares the cumulative achievable and economic potential in 2023 under the two cases. Note that baseline and technical projections, which are independent of avoided costs, are the same in both cases. In 2023, achievable potential under the IRP Preferred Portfolio case is 1,077,688 MWh, or 104% of the 1,036,977 MWh reference case.

Figure ES-12 Avoided Costs of Energy Projections

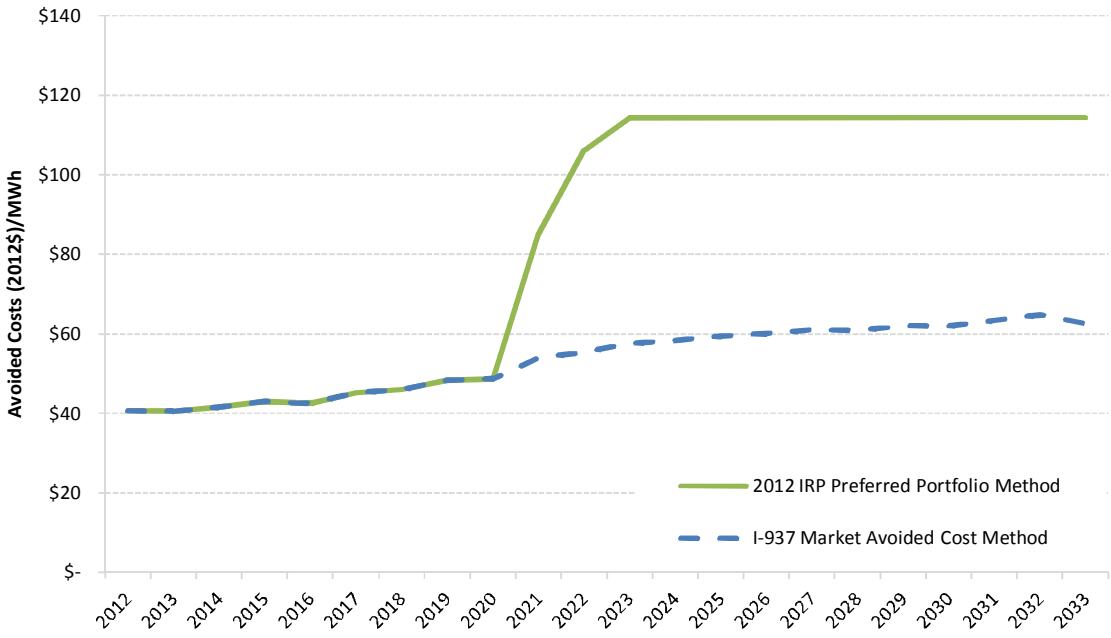


Table ES-9 Comparison of Potentials by Avoided Costs, 2023

Avoided Cost Case	Cumulative Achievable Potential	Change in Achievable Relative to I-937 Case	Cumulative Economic Potential	Change in Economic Relative to I-937 Case
I-937 Market Avoided Cost	1,036,977	n/a	1,574,823	n/a
2012 IRP Preferred Portfolio	1,077,688	104%	1,687,860	107%

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CHAPTER | 1

INTRODUCTION

Background

Seattle City Light (City Light or City Light) has contracted with EnerNOC Utility Solutions (EnerNOC) to conduct a conservation potential assessment (CPA) to quantify the amount, the timing, and the cost of electric conservation resources available within the City Light service territory. The study's purpose is to establish cost-effective and achievable energy conservation targets for 2014–2015 to meet the legal requirements associated with Washington Administrative Code 194-371 (Initiative 937 or I-937), as well as to support City Light's Integrated Resource Plan (IRP). In accordance with I-937, this CPA is informed by and uses methodology consistent with the Northwest Power and Planning Council (NPCC) Sixth Power Plan. This study updates City Light's last CPA, which EnerNOC performed for the 2013-2014 biennium.

Report Organization

The remainder of this report contains the following sections.

- Chapter 2 — Analysis Approach and Data Development
- Chapter 3 — Market Characterization and Market Profiles
- Chapter 4 — Baseline Projection
- Chapter 5 — Conservation Potential

Definition of Potential

In this study, we estimate the potential for conservation savings. The savings estimates represent gross savings developed into three levels of potential: technical potential, economic potential, and achievable potential. Technical and economic potential are both theoretical limits to conservation savings. Achievable potential embodies a set of assumptions about the decisions consumers make regarding the efficiency of the equipment they purchase, the maintenance activities they undertake, the controls they use for energy-consuming equipment, and the elements of building construction. The various levels are described below.

- **Technical potential** is defined as the theoretical upper limit of conservation potential. It assumes that customers adopt all feasible measures regardless of their cost. At the time of existing equipment failure, customers replace their equipment with the most efficient option available. In new construction, customers and developers also choose the most efficient equipment option. Technical potential also assumes the adoption of every other available measure, where applicable. For example, it includes installation of high-efficiency windows in all new construction opportunities and furnace maintenance in all existing buildings with furnace systems. These retrofit measures are phased in over a number of years, which is longer for higher-cost and complex measures.
- **Economic potential** represents the adoption of all ***cost-effective*** conservation measures. In this analysis, cost-effectiveness is measured by the total resource cost (TRC) test, which compares lifetime energy and capacity benefits to the incremental cost of the measure. If the benefits outweigh the costs (that is, if the TRC ratio is greater than 1.0), a given measure is included in the economic potential. Customers are then assumed to purchase the most cost-effective option applicable to them at any decision juncture.
- **Achievable potential** establishes a realistic target for the conservation savings that a utility can hope to achieve through its programs. It takes into account market maturity, customer preferences for energy-efficient technologies, and expected program participation, and is determined by applying a series of annual market adoption factors to the economic potential for each conservation measure. These factors represent the ramp rates at which technologies will penetrate the market. To develop these factors, the project team reviewed City Light's past conservation program achievements and

program history over the last five years, as well as the NPCC ramp rates used in the Sixth Plan. Details regarding the market adoption factors appear in Appendix E.

Abbreviations and Acronyms

Table 1-1 shows abbreviations or acronyms used in this report.

Table 1-1 Explanation of Abbreviations and Acronyms

Acronym	Explanation
ACS	American Community Survey
AEO	Annual Energy Outlook forecast developed annual by the Energy Information Administration of the DOE
B/C Ratio	Benefit to cost ratio
BEST	EnerNOC's Building Energy Simulation Tool
BPA	Bonneville Power Authority
C&I	Commercial and Industrial
CBECS	Commercial Building Energy Consumption Survey (prepared by EIA)
CBSA	NEAA Commercial Building Stock Assessment
CCT	Combined cycle turbine
CFL	Compact fluorescent lamp
CEUS	California Commercial End Use Survey
COMMEND	EPRI COMMercial END-use planning system
CPA	Conservation Potential Assessment
DEEM	EnerNOC's Database of Energy Efficiency Measures
DEER	State of California Database for Energy-Efficient Resources
DMI	Data Marketing Incorporated
DSM	Demand side management
EE	Energy efficiency
EER	Energy Efficiency Rating
EIA	Energy Information Administration
EISA	Energy Efficiency and Security Act of 2007
EPRI	Electric Power Research Institute
EUI	Energy-use index
EUL	Effective useful life
HH	Household
HID	High intensity discharge lamps
HPWH	Heat pump water heater
HVAC	Heating, ventilation, and air conditioning
I-937	Washington Initiative 937
IRP	Integrated Resource Plan

Acronym	Explanation
LED	Light emitting diode lamp
LoadMAP	EnerNOC's Load Management Analysis and PlanningTM tool
MECS	Manufacturing Energy Consumption Survey (prepared by EIA)
NEEA	Northwest Energy Efficiency Alliance
NPCC	Northwest Power and Conservation Council
RASS	California Residential Appliance Saturation Survey
RBSA	Residential Building Stock Assessment
RTF	Regional Technical Forum
REEPS	EPRI Residential End-use Energy Planning System
RBSA	NEAA Residential Building Stock Assessment
RCCS	City Light 2009 Residential Customer Characteristics Survey
RECS	Residential Energy Consumption Survey (prepared by EIA)
RTU	Roof top unit
SEEM	Simple Energy Enthalpy Model
SEER	Seasonal Energy Efficiency Rating
SCL	Seattle City Light
SIC	Standard Industrial Classification
Sq. ft.	Square feet
TRC	Total resource cost
UEC	Unit energy consumption
UES	Unit energy savings (as defined in RTF measure workbooks)

CHAPTER | 2

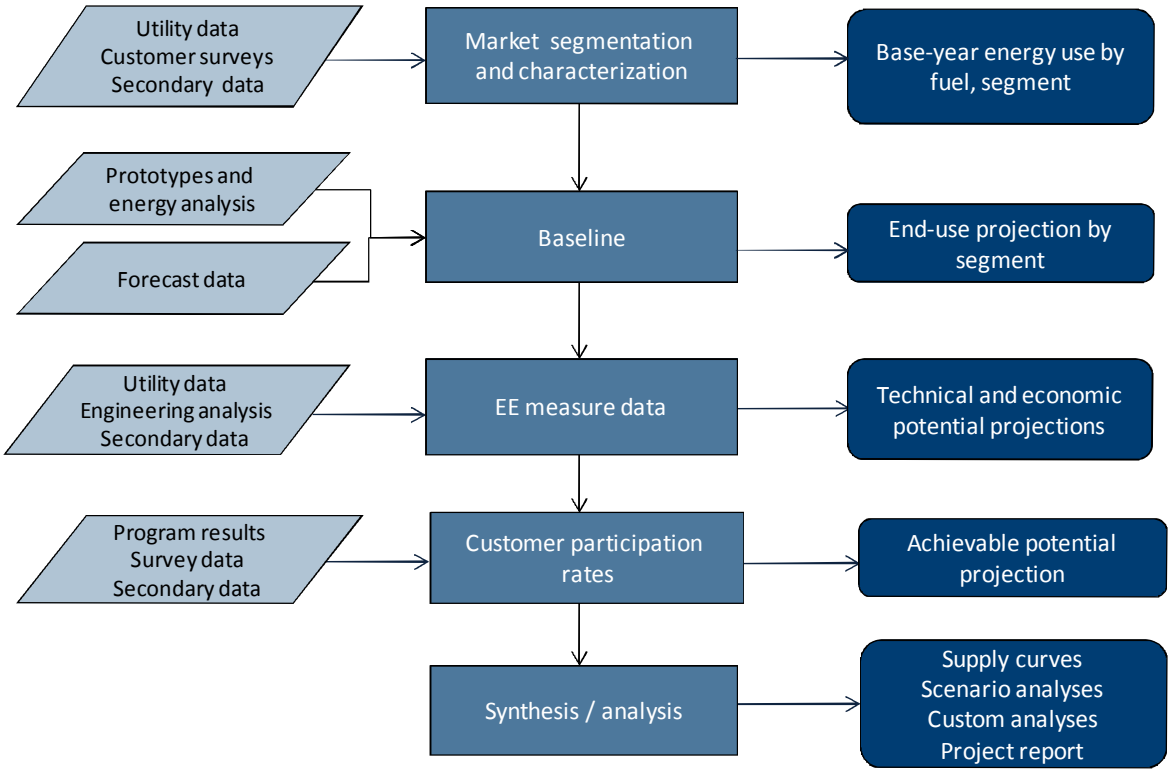
ANALYSIS APPROACH AND DATA DEVELOPMENT

This section describes the study analysis approach and the data sources EnerNOC used to develop the potential estimates.

Analysis Approach

EnerNOC employed a bottom-up analysis approach, as shown in Figure 2-1, to perform the conservation potential analysis.

Figure 2-1 Overview of Analysis Approach



The analysis involved the following steps.

1. Performed a market characterization to describe sector-level electricity use for the residential and non-residential (commercial and industrial) sectors for the base year, 2012. This step drew upon the market characterization from the 2011 CPA, but updated the characterization to incorporate new information from the NPCC, the Regional Technical Forum (RTF), the Northwest Energy Efficiency Alliance (NEEA) 2011 Residential Building Stock Assessment (RBSA), EnerNOC's own data, and the Energy Information Administration (EIA).
2. Developed a baseline electricity use projection by sector, segment, and end use for 2013 through 2033.
3. Identified and characterized conservation measures.
4. Estimated measure-level conservation potential for three cases: *Technical, Economic, and Achievable*.

The remainder of this chapter describes the analysis approach for these steps in further detail.

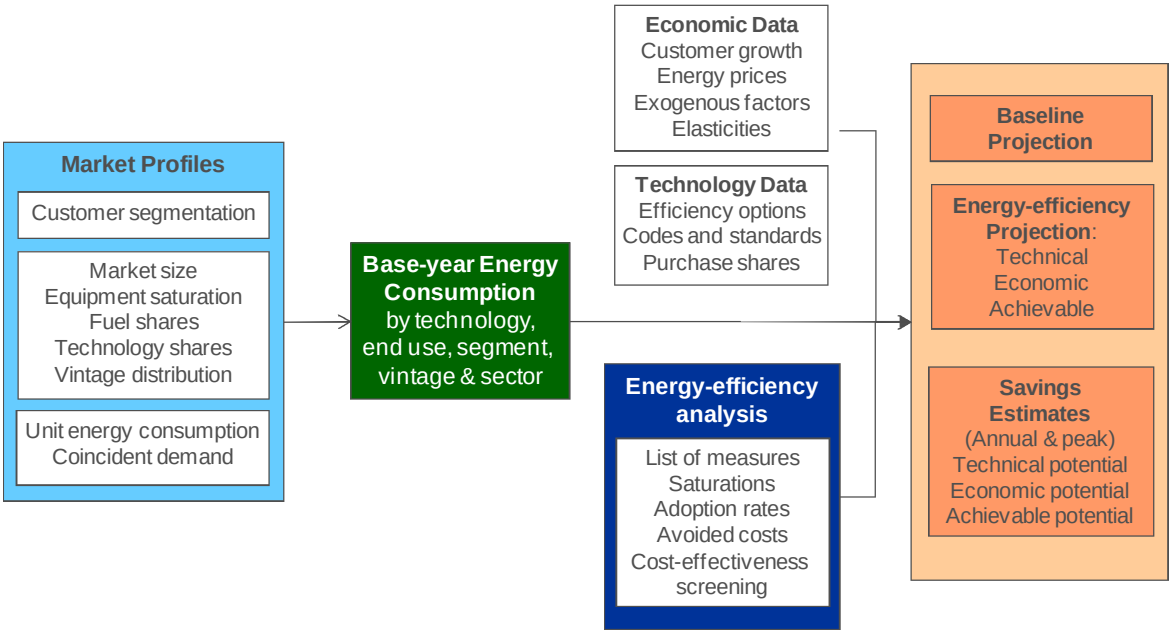
LoadMAP Model

We used EnerNOC's Load Management Analysis and Planning tool (LoadMAP™) version 3.0 to develop both the baseline projection and the estimates of conservation potential. EnerNOC developed LoadMAP in 2007 and has enhanced it over time, using it for the Electric Power Research Institute (EPRI) National Potential Study and numerous utility-specific potential studies. Built in Excel, the LoadMAP framework, illustrated in Figure 2-2, has the following key features.

- Embodies the basic principles of rigorous end-use models (such as EPRI's REEPS and COMMEND) but in a more simplified, accessible form.
- Includes stock-accounting algorithms that treat older, less efficient appliance/equipment stock separately from newer, more efficient equipment. Equipment is replaced according to the measure life and appliance vintage distributions defined by the user.
- Balances the competing needs of simplicity and robustness by incorporating important modeling details related to equipment saturations, efficiencies, vintage, and the like, where market data are available, and treats end uses separately to account for varying importance and availability of data resources.
- Isolates new construction from existing equipment and buildings and treats purchase decisions for new construction and existing buildings separately.
- Includes appliance and equipment models customized by end use. For example, the logic for lighting is distinct from refrigerators and freezers.

The LoadMAP model provides projections of baseline energy use by sector, segment, end use, and technology for existing and new buildings. It also provides projections of total energy use and conservation savings associated with the three levels of potential.

Figure 2-2 LoadMAP Analysis Framework



Market Characterization

To estimate the savings potential from conservation measures, it is necessary to understand how much energy customers use today and what equipment is consuming that energy. The project team began this characterization by segmenting City Light's energy footprint to quantify energy use by sector, segment, fuel, end-use application, and the current set of technologies used. The base year for this study is 2012, the most recent year for which City Light sales data were available.

Segmentation for Modeling Purposes

The market assessment first defined the market segments (building types, end uses and other dimensions) that are relevant in the City Light service territory. Table 2-1 presents this segmentation scheme.

Table 2-1 Overview of Segmentation Scheme for Potentials Modeling

Market Dimension	Segmentation Variable	Dimension Examples
1	Sector	Residential, commercial, industrial, street lighting
2	Building type	Residential (single family, multiplex, low-rise multifamily, high-rise multifamily) Commercial (small office, large office, restaurant, retail, etc.) Industrial (metals, transportation equipment, food products, stone and glass, utilities, other industrial)
3	Vintage	Existing and new construction
4	Fuel	Electricity
5	End uses	Cooling, space heating, lighting, water heat, motors, etc. (as appropriate by sector)
6	Appliances/end uses and technologies	Technologies such as lamp type, air conditioning equipment type, motors by application, etc.
7	Equipment efficiency levels for new purchases	Baseline and higher-efficiency options as appropriate for each technology

Following this scheme, we segmented the residential sector as described below, starting with customer segments by building type:

- Single family (including mobile homes)
- Multiplex (2–4 units)
- Low-Rise Multifamily (5 or more units in buildings 6 or fewer stories in height)
- High-Rise Multifamily (5 or more units in buildings 7 or more stories in height)

Mobile homes, which were a separate segment in the previous CPA but represent a small fraction of Seattle homes, are now included in the single family segment. The break between low-rise and high-rise multifamily corresponds to the number of stories used to separate building sizes in the RBSA.

In addition to segmentation by housing type, we identified the set of end uses and technologies that are appropriate for City Light's residential sector. These are shown in Table 2-2.

Table 2-2 Residential Electric End Uses and Technologies

End Use	Technology
Cooling	Central Air Conditioning (CAC)
Cooling	Room Air Conditioning (RAC)
Cooling/Space Heating	Air-Source Heat Pump
Heating	Electric Zonal Room Heat
Heating	Electric Furnace
Water Heating	Water Heater <= 55 Gal
Water Heating	Water Heater > 55 Gal
Interior Lighting	Screw-in Lamps
Interior Lighting	Linear Fluorescent Lamps
Interior Lighting	Specialty
Exterior Lighting	Screw-in Lamps
Appliances	Clothes Washer
Appliances	Clothes Dryer
Appliances	Dishwasher
Appliances	Refrigerator
Appliances	Freezer
Appliances	Second Refrigerator
Appliances	Stove
Appliances	Microwaves
Electronics	Personal Computers
Electronics	Monitor
Electronics	Laptops
Electronics	TVs
Electronics	Printer/Fax/Copier
Electronics	Set-top Boxes/DVR
Electronics	Devices and Gadgets
Miscellaneous	Pool Pump
Miscellaneous	Pool Heater
Miscellaneous	Hot Tub / Spa
Miscellaneous	Furnace Fan
Miscellaneous	Miscellaneous

The project team characterized non-residential energy as either commercial or industrial. For purposes of the CPA, we sought to distinguish between commercial facilities that are dominated by HVAC and lighting end uses, and industrial facilities, where the primary end uses are motors and process loads. This step facilitates modeling the efficiency measures that are most appropriate for the dominant end uses. As a result, some large energy users that City Light categorizes as commercial, such as the Port of Seattle and wastewater treatment facilities, are included in the industrial sector for purposes of the CPA. We also assigned to the industrial sector small industrial customers that may be considered commercial customers within City Light's records. Conversely, the project team assigned several facilities belonging to a large industrial customer, but which primarily contain office space, to the commercial sector for this analysis.

For the commercial sector, it is useful to think of the segments based on the unique characteristics of the type of building. This study used the building types listed below, which are largely consistent with those in the Sixth Plan.

- Small office
- Large office
- Restaurant
- Retail
- Large grocery
- Small grocery
- Warehouse
- School
- College
- Hospitals
- Other health
- Lodging
- Assembly
- Data centers
- Multifamily common area
- Miscellaneous

Table 2-3 lists the set of end uses and technologies for the commercial sector.

Table 2-3 Commercial Electric End Uses and Technologies

End Use	Technology
Cooling	Air-Cooled Chiller
Cooling	Water-Cooled Chiller
Cooling	Roof top AC
Cooling	Other Cooling
Cooling/Heating	Roof top Heat Pump
Heating	Electric Furnace
Heating	Electric Zonal Heat
Ventilation	Ventilation
Water Heating	Water Heater
Interior Lighting	Screw-in
Interior Lighting	High-Bay Fixtures
Interior Lighting	Linear Fluorescent
Exterior Lighting	Screw-in
Exterior Lighting	HID
Exterior Lighting	Linear Fluorescent
Refrigeration	Walk-in Refrigerator
Refrigeration	Reach-in Refrigerator
Refrigeration	Glass Door Display
Refrigeration	Open Display Case
Refrigeration	Icemaker
Refrigeration	Vending Machine
Food Preparation	Oven
Food Preparation	Fryer
Food Preparation	Dishwasher
Food Preparation	Hot Food Container
Office Equipment	Desktop Computer
Office Equipment	Laptop
Office Equipment	Server
Office Equipment	Monitor
Office Equipment	Printer/Copier/Fax
Office Equipment	POS Terminal
Miscellaneous	Non-HVAC Motors
Miscellaneous	Pool Pump
Miscellaneous	Pool Heater
Miscellaneous	Miscellaneous

Conservation potential studies typically segment the industrial sector by industry type. Because the industrial sector is complex, this study isolated the largest industries in terms of their energy use for analysis. The five major industrial segments we identified are Metals; Transportation Equipment; Food Products; Stone and Glass, including cement; and Utilities including water and wastewater. The remaining industries fall into the Other Industrial category.

In addition to segmentation by industry, we identified the set of end uses and technologies that are appropriate for City Light, as shown in Table 2-4.

Table 2-4 Industrial Electric End Uses and Technologies

End Use	Technology
Cooling	RTU
Cooling	Air-Cooled Chiller
Cooling	Water-Cooled Chiller
Cooling/Heating	Air-Source Heat Pump
Heating	Electric Resistance
Ventilation	Ventilation
Interior Lighting	Screw-in
Interior Lighting	High-Bay Fixtures
Interior Lighting	Linear Fluorescent
Exterior Lighting	Screw-in
Exterior Lighting	HID
Exterior Lighting	Linear Fluorescent
Motors	Pumps
Motors	Fans & Blowers
Motors	Compressed Air
Motors	Conveyors
Motors	Other Motors
Process	Process Heating
Process	Process Cooling
Process	Process Refrigeration
Process	Electrochemical Process
Process	Other Process
Miscellaneous	Miscellaneous

For the street lighting analysis, we did not divide the use into segments, but did allocate according to technology, based on City Light's data regarding its street lighting equipment inventory. The data identifies 93 categories based on fixture type (cobra head, low mount, flood, globe, wall mount, specific historic or architectural types, etc.) and wattage.

With the segmentation scheme defined, we then performed a high-level market characterization of electricity sales in the base year to allocate sales to each residential, commercial, and industrial customer segment. We used various data sources, as further described below and in Chapter 3, to identify the annual sales in each customer segment, as well as the number of customers for residential segments, the square footage for the commercial segments and employee count for the industrial segments. This information provided control totals (energy use and customers counts/square footage/employee totals) for calibrating the LoadMAP model to known data for the base-year.

Market Profiles

The project team next developed market profiles for each sector, customer segment, end use, and technology defined as described above. For each segment, we created two sets of market profiles. The *average* market profile represents existing vintage facilities in 2012. The new market profile characterizes new construction.

A market profile includes the following elements:

- **Market size** represents the number of customers in the segment. For the residential sector, it is the number of households. In the commercial sector, it is floor space measured in square feet. For the industrial sector, it is number of employees.
- **Saturations** define the fraction of homes, commercial square feet, or industrial employees with the various technologies. (e.g., homes with electric space heating).
- **UEC (unit energy consumption) or EUI (energy-use index)** describes the amount of energy that a specific technology consumed in 2012, in buildings that have the technology. UECs are expressed in kWh/household for the residential sector, while EUIs are expressed in kWh/square foot or kWh/employee for the commercial and industrial sectors respectively.

- **Intensity** for the residential sector represents the average energy use for the technology across all homes in 2012. We compute residential intensity as the product of the saturation and the UEC, with results expressed as kWh/household. For the commercial and industrial sector, intensity is the product of the saturation and the EUI, and represents the average use for the technology across all floor space or employees in 2012.
- **Usage** is the annual energy use by an end use technology in the segment. It is the product of the market size and intensity and is quantified in MWh. The market characterization results and the market profiles appear in Chapter 3.

Baseline Projection

The next step was to develop the baseline projection of annual electricity usage for 2013 through 2033 by sector, segment, and end use without new utility programs or naturally occurring efficiency. The end-use projection does include the relatively certain impacts of enacted codes and standards that will unfold over the study timeframe. All such mandates that were defined as of January 2012 are included in the baseline. The baseline projection is the foundation for the analysis of savings from future conservation efforts as well as the metric against which potential savings are measured.

Inputs to the baseline projection include:

- City Light historic sales data and conservation program achievements for 2007–2012
- Current economic growth projections (i.e., customer growth, income growth)
- Electricity price projections
- Trends in fuel shares and equipment saturations
- Existing and approved changes to building codes and equipment standards

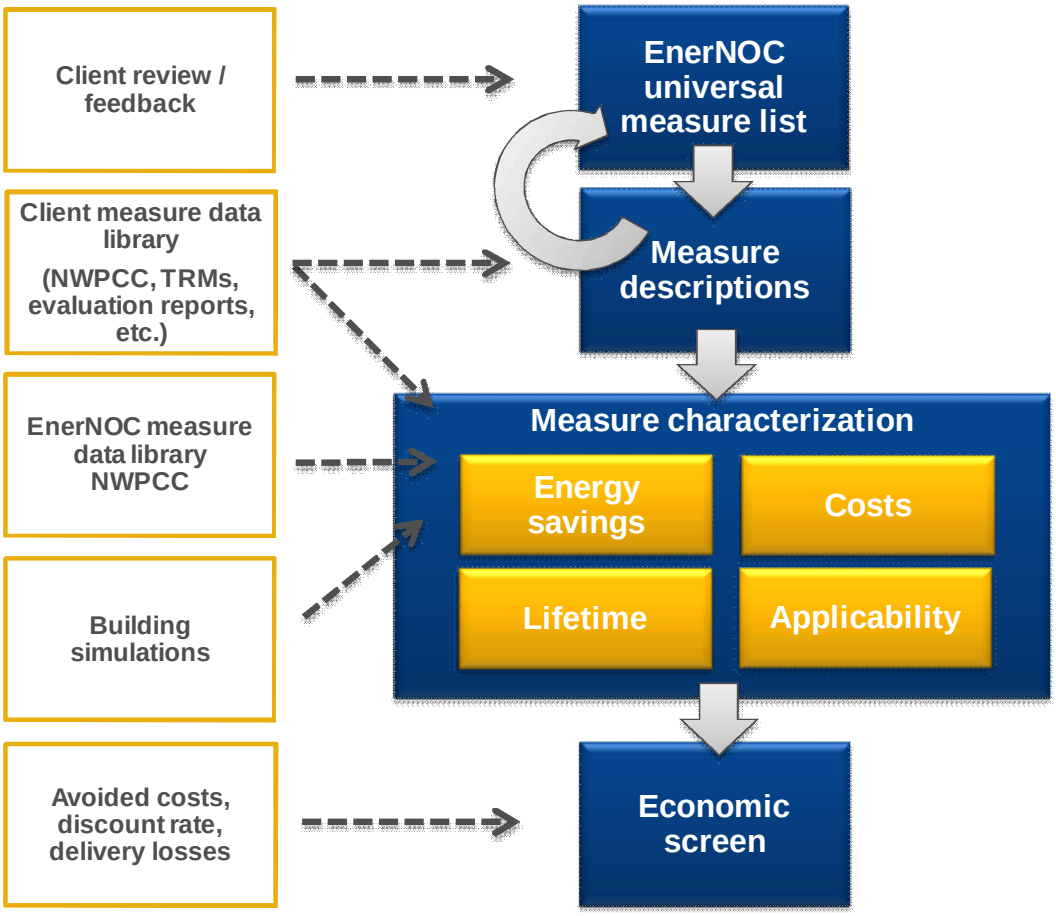
Conservation Measure Analysis

This section describes the framework used to assess the savings, costs, and other attributes of conservation measures. These characteristics form the basis for measure-level cost-effectiveness analyses as well as for determining measure-level savings. For all measures, EnerNOC assembled information on equipment performance, incremental costs, and equipment lifetimes. We used this information, along with City Light's avoided cost data, in the economic screen to determine cost-effective measures. Figure 2-3 outlines the framework for measure analysis.

The framework for assessing savings, costs, and other attributes of conservation measures involves identifying the list of conservation measures to include in the analysis, determining their applicability to each market sector and segment, fully characterizing each measure, and performing cost-effectiveness screening.

The first step of the conservation measure analysis was to identify the list of all relevant conservation measures that should be considered for the City Light potential assessment. EnerNOC prepared a preliminary list of measures that compared the list of measures included in City Light's previous CPA with those in the Sixth Plan, the RTF measure workbooks, and EnerNOC's own measure database in order to reconcile the various measure lists and provide the widest possible list of measures. This universal list of conservation measures covers all major types of end-use equipment, as well as devices and actions to reduce energy consumption. If considered today, some of these measures would not pass the economic screens initially, but may pass in future years as a result of lower projected equipment costs or higher avoided costs. After receiving feedback from City Light, we finalized the measures list. The final list included in the study, which reflects feedback and additions from City Light, is presented in Appendices B, C, and D for the residential, commercial, and industrial sectors respectively.

Figure 2-3 Approach for Measure Assessment



The selected measures are categorized into two types according to the LoadMAP taxonomy: equipment measures and non-equipment measures.

- **Equipment measures** are efficient energy-consuming pieces of equipment that save energy by providing the same service with a lower energy requirement than a standard unit. An example is an ENERGY STAR refrigerator that replaces a standard efficiency refrigerator. For equipment measures, many efficiency levels may be available for a given technology, ranging from the baseline unit (often determined by code or standard) up to the most efficient product commercially available. For instance, in the case of central air conditioners, this list begins with the current federal standard SEER 13 unit and spans a broad spectrum up to a maximum efficiency of a SEER 21 unit.
- **Non-equipment measures** save energy by reducing the need for delivered energy, but do not involve replacement or purchase of major end-use equipment (such as a refrigerator or air conditioner). An example would be a programmable thermostat that is pre-set to run heating and cooling systems only when people are home. Non-equipment measures can apply to more than one end use. For instance, addition of wall insulation will affect the energy use of both space heating and cooling. Non-equipment measures typically fall into one of the following categories:
  - Building shell (windows, insulation, roofing material)
  - Equipment controls (thermostat, energy management system)
  - Equipment maintenance (air conditioning and heat pump maintenance, changing setpoints)
  - Whole-building design (building orientation, passive solar lighting)
  - Lighting retrofits (included as a non-equipment measure because retrofits are performed prior to the equipment's normal end of life)

- Displacement measures (ceiling fan to reduce use of central air conditioners)
- Commissioning and retrocommissioning
- Behavioral programs

Table 2-5 summarizes the number of equipment and non-equipment measures evaluated for each segment within each sector.

Table 2-5 Number of Measures Evaluated

	Residential	Commercial	Industrial	Street Lighting	Total Number of Measures
Equipment Measures Evaluated	631	2,943	733	93	4,400
Non-Equipment Measures Evaluated	207	2,236	696	93	3,232
Total Measures Evaluated	838	5,179	1,429	186	7,632

Once we assembled the list of measures, the project team assessed their energy-saving characteristics. For each measure, we developed estimates of incremental cost, service life, and other performance factors, drawing upon data from the RTF measure workbooks, BPA data, and the Sixth Plan. Where measures were not characterized by the NPCC, the project team used data from EnerNOC's database of measure characteristics and simulation modeling. Following the measure characterization, we performed an economic screening of each measure, which serves as the basis for developing the economic potential.

Representative Measure Data Inputs

To provide an example of the measure data, Table 2-6 and Table 2-7 present examples of the detailed data inputs behind both equipment and non-equipment measures, respectively, for the case of air-source heat pumps in single-family homes. Table 2-7 displays the various efficiency levels available as equipment measures, as well as the corresponding useful life, energy usage, and cost estimates. The columns labeled On Market and Off Market reflect equipment availability due to codes and standards or the entry of new products to the market.

Table 2-6 Example Equipment Measures for Air-Source Heat Pump – Single Family Home

Efficiency Level	Useful Life	Equipment Cost	Energy Usage(kWh/yr)	On Market	Off Market
SEER 13, HSPF 7.7	15	1,002	4,176	2012	2014
SEER 14, HSPF 8.0	15	1,430	3,977	2012	n/a
SEER 15, HSPF 8.2	15	1,532	3,855	2012	n/a
SEER 16, HSPF 8.5	15	1,620	3,686	2012	n/a
SEER 18, HSPF 12.0	15	2,850	3,188	2012	n/a

Note: Energy usage includes both heating and cooling, where cooling is approximately 5% of total usage.

Table 2-7 lists some of the non-equipment measures applicable to heating in an existing single-family home. All measures are evaluated for cost-effectiveness based on the lifetime benefits relative to the cost of the measure. The total savings and costs are calculated for each year of the study and depend on the base year saturation of the measure, the applicability[3] of the measure, and the savings as a percentage of the relevant energy end uses.

[3] The applicability factors take into account whether the measure is applicable to a particular building type and whether it is feasible to install the measure. For instance, attic fans are not applicable to homes where there is insufficient space in the attic or there is no attic at all.

Table 2-7 Example Non-Equipment Measures – Single Family Home, Existing

End Use	Measure	Saturation in 2012[4]	Applicability	Lifetime (yrs)	Measure Installed Cost	Energy Savings (%)
Heating	Insulation – Ceiling	36%	94%	25	$694	8.1%
Heating	Insulation – Ducts inside	15%	90%	25	$726	3.5%
Heating	Insulation – Infiltration Control	24%	90%	25	$383	5.6%
Heating	Insulation – Wall Cavity	50%	90%	25	$5,724	3.4%
Heating	Ducting – Repair and Sealing	12%	90%	20	$831	11.3%
Heating	Doors - Storm and Thermal	38%	90%	25	$140	1.4%
Heating	Thermostat - Clock/Programmable	81%	95%	15	$118	10.5%
Heating	Central Heat Pump – Maintenance	41%	90%	2	$175	5.0%
Heating	Behavioral Measures	1%	90%	1	$10	1.0%

Screening Measures for Cost-Effectiveness

Only measures that are cost-effective are included in economic and achievable potential. Therefore, for each individual measure, LoadMAP performs an economic screen. This study uses the TRC test that compares the lifetime energy and peak demand benefits, as well as well as any non-energy benefits included in the RTF measure database, with the measure's incremental installed cost, including material and labor. The lifetime benefits are calculated by multiplying the annual energy and demand savings for each measure by all appropriate avoided costs for each year, and discounting the dollar savings to the present value equivalent. The analysis uses each measure's values for savings, costs, and lifetimes that were developed as part of the measure characterization process described above. The analysis also accounts for transmission and distribution losses, and for program administration costs.

The LoadMAP model performs this screening dynamically, taking into account changing savings and cost data over time. Thus, some measures pass the economic screen for some — but not all — of the years in the study period.

It is important to note the following about the economic screen:

- The economic evaluation of every measure in the screen is conducted relative to a baseline condition. For instance, in order to determine the kilowatt-hour (kWh) savings potential of a measure, kWh consumption with the measure applied must be compared to the kWh consumption of a baseline condition. For the City Light study, a weighted market baseline was used, consistent with NPCC methodology. For example, the energy use of an efficient LED would be compared against the weighted average energy usage of the prevailing market mix of incandescent, CFL, and LED lamps in a given year of the baseline case.
- The economic screening was conducted only for measures that are applicable to each building type and vintage; thus if a measure is deemed to be irrelevant to a particular building type and vintage, it is excluded from the respective economic screen.
- Non-energy benefits that are quantified by the RTF are accounted for in the LoadMAP model by means of an additional factor for measures that have these benefits, such as clothes washers that have water-related and/or detergent-related benefits.

[4] Note that saturation levels reflected for the base year change over time as more measures are adopted.

If the measure passes the screen with a benefit to cost (B/C) ratio greater than or equal to 1, based on the TRC test as defined by the NPCC, the measure is included in economic potential. Otherwise, it is screened out for that year. If multiple equipment measures have B/C ratios greater than or equal to 1.0, the most efficient technology is selected by the economic screen.

Conservation Potential

The approach we used for this study adheres to the approaches and conventions outlined in the National Action Plan for Energy-Efficiency (NAPEE) Guide for Conducting Potential Studies (November 2007).[5] The NAPEE Guide represents the most credible and comprehensive industry practice for specifying energy-efficiency potential. As described in Chapter 1, three types of potentials were developed as part of this effort: Technical potential, Economic potential, and Achievable potential.

- **Technical potential** is a theoretical construct that assumes the highest efficiency measures that are technically feasible to install are adopted by customers, regardless of cost or customer preferences. Thus, determining the technical potential is relatively straightforward. LoadMAP selects the most efficient equipment options for each technology at the time of equipment replacement. In addition, it installs all relevant non-equipment measures for each technology to calculate savings.

  For example, for an air-source heat pump, as shown in Table 2-6, the most efficient option is a SEER 18 system. The multiple non-equipment measures shown in Table 2-7 are then applied to the energy used by SEER 18 to further reduce heat pump energy use. LoadMAP applies the savings due to the non-equipment measures one-by-one to avoid double counting of savings. The measures are evaluated in order of their B/C ratio, with the measure with the highest B/C ratio applied first. Each time a measure is applied, the baseline energy use for the end use is reduced and the percentage savings for the next measure is applied to the revised (lower) usage.

- **Economic potential** results from the purchase of the most efficient cost-effective option available for a given equipment or non-equipment measure as determined in the cost-effectiveness screening process described above. As with technical potential, economic potential is a phased-in approach. Economic potential is still a hypothetical upper-boundary of savings potential as it represents only measures that are economic but does not yet consider customer acceptance and other factors.

- **Achievable potential** defines the range of savings that is very likely to occur. It accounts for customers' awareness of efficiency options, any barriers to customer adoption, limits to program design, and other factors that influence the rate at which conservation measures penetrate the market.

The calculation of technical and economic potential is straightforward as described above. To develop estimates for achievable potential, we specified market adoption rates for each measure and each year. For City Light, we began with the ramp rates specified in the Sixth Plan conservation workbooks. As appropriate, we adjusted these ramp rates to reflect Seattle-specific conditions and program history. For specific measures, we examined historic program results from 2007 through 2012. We then selected market acceptance rates so that the achievable potential for these measures in 2014 and 2015 aligned with the program history trends. For future years, we increased the potential factors to model increasing market acceptance and program improvements. For measures not currently included in City Light programs, we relied upon the Sixth Plan ramp rates and recent EnerNOC potential studies to create market adoption rates. The market adoption rates for each measure appear in Appendix D.

Results of all the potentials analysis are presented in Chapter 4.

Sensitivity Analysis

The reference case used avoided costs based on projected market costs of energy, assuming that the marginal generation unit is a conventional combined cycle turbine (CCT). In addition, avoided costs included adders for renewable energy credits, carbon dioxide offsets, transmission and distribution costs, and a 10% credit for the Regional Act bonus. Note that City Light has sufficient capacity for the study period and thus did not provide an avoided cost of capacity. To support the City Light Integrated Resource Plan

[5] National Action Plan for Energy Efficiency (2007). *National Action Plan for Energy Efficiency Vision for 2025: Developing a Framework for Change*. www.epa.gov/eeactionplan.

development, the EnerNOC team also developed a set of potential estimates based on a second stream of projected avoided costs, under a scenario corresponding to City Light's preferred resource portfolio.

Data Development

This section details the data sources EnerNOC used in this study, followed by a discussion of how we applied the data. In general, we adapted information to local conditions, for example, by using local sources for measure data and local weather for building simulations.

Data Sources

The data sources are organized into the following categories:

- City Light data
  - Data Marketing Incorporated (DMI) non-residential database
- NPCC and RTF data
- EnerNOC's databases and analysis tools
- Other secondary data and reports

Seattle City Light Data

Our highest priority data sources for this study were those that were specific to City Light.

- 2012 billing data — customer counts and electricity sales by sector (residential, commercial, industrial, outdoor lighting) from EIA Form 861
- Multifamily housing database based on King County Assessor data, representing 12,071 buildings and 174,158 multifamily housing units, and including information on number of stories, number of units in each building, and unit square footage
- Billing data for all non-residential customers including annual energy, Standard Industrial Classification (SIC) codes, and building type (where available)
- 2009 Residential Customer Characteristics Survey (RCCS) report, a residential saturation survey
- Energy forecast, at the sector level
- Forecasts of customer growth, persons per household, income, and business employment
- Price forecast
- Avoided energy costs forecast
- Discount rate
- Line loss factors
- Description of existing conservation programs and results from these programs
- Program administration expenses
- Inventory of street lighting fixtures from two City Light record keeping systems, including its Work and Asset Management System

Data Marketing, Incorporated

A unique aspect of this project was the work that DMI, EnerNOC's subcontractor, performed to characterize City Light's non-residential customers. DMI combined City Light's non-residential billing data with information from the King County Assessor to match assessor data on the building uses and square footage to City Light billing records. For purposes of the CPA, the primary objective was to improve how meter level energy use from billing records is allocated to specific commercial building or industrial segments. A second objective was to develop more accurate data on building square footage and energy intensity (kWh/sq.ft.) for each commercial building type segment. EnerNOC and City Light reviewed the DMI database, particularly the records for the 1,000 largest accounts, and adjusted the assignment of

records to segments as necessary to accurately reflect the facility's use. Beyond the CPA, City Light is using the resulting database to improve its understanding of its non-residential customers and their past participation in utility demand side management (DSM) programs, as well as to support future marketing activities.

Data resulting from DMI's work include:

- Energy use by building type or industry type
- Estimates of square footage by building type

Northwest Power and Conservation Council Data

- **NPCC Sixth Plan Conservation Supply Curve Workbooks, 2010.** To develop its Power Plan, the Council created workbooks with detailed information about measures, available at http://www.nwcouncil.org/energy/powerplan/6/supplycurves/default.htm .
- **RTF Unit Energy Savings Measure Workbooks:** The RTF maintains workbooks that characterize selected measures and provide data on unit energy savings (UES), measure cost, measure life, and non-energy benefits, available at http://www.nwcouncil.org/energy/rtf/measures/Default.asp.
- **RTF Standard Protocols:** The RTF also maintains standard workbooks containing useful information for characterizing more complex measures for which UES values have not been developed, such as commercial sector lighting.
- **Regional Technical Forum Residential Simple Energy Enthalpy Model (SEEM) modeling results:** http://rtf.nwcouncil.org/measures/support/Default.asp

EnerNOC Databases, Analysis Tools, and Reports

EnerNOC maintains several databases and modeling tools that we use for forecasting and potential studies.

- **EnerNOC Energy Market Profiles**: For more than 10 years, EnerNOC staff have maintained profiles of end-use consumption for the residential, commercial, and industrial sectors. These profiles include market size, fuel shares, unit consumption estimates, and annual energy use by fuel (electricity and natural gas), customer segment and end use for 10 regions in the U.S. The Energy Information Administration surveys — Residential Energy Consumption Survey (RECS), Commercial Building Energy Consumption Survey (CBECS), and Manufacturing Energy Consumption Survey (MECS) as well as state-level statistics and local customer research provide the foundation for these regional profiles.
- **Building Energy Simulation Tool (BEST)**. EnerNOC's BEST is a derivative of the DOE 2.2 building simulation model, used to estimate base-year UECs and EUIs, as well as measure savings for the HVAC-related measures.
- **EnerNOC's EnergyShape™:** This database of load shapes includes the following: Residential – electric load shapes for 10 regions, 3 housing types, 13 end uses; Commercial – electric load shapes for 9 regions, 54 building types, 10 end uses; Industrial – electric load shapes, whole facility only, 19 2-digit SIC codes, as well as various 3-digit and 4-digit SIC codes
- **EnerNOC's Database of Energy Efficiency Measures (DEEM):** EnerNOC maintains an extensive database of measure data for our studies. Our database draws upon reliable sources including the California Database for Energy Efficient Resources (DEER), the EIA Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case, RS Means cost data, and Grainger Catalog Cost data.
- **Recent studies**. EnerNOC has conducted numerous studies of conservation potential in the last five years. We checked our input assumptions and analysis results against the results from these other

studies, which include Idaho Power, and Avista. In addition, we used the information about impacts of building codes and appliance standards from a recent report for the Institute for Energy Efficiency.[6]

Other Secondary Data and Reports

Finally, EnerNOC used a variety of secondary data sources and reports for this study. The main sources are as follows:

- **Residential Building Stock Assessment, Single Family:** NEEA's 2011 Residential Building Stock Assessment (RBSA) provides results of a regional survey. City Light requested an oversample, resulting in 141 homes from City Light's service territory being included in the total sample of 1,404 homes. The single family survey also includes multiplex (2–4 units) homes. http://neea.org/docs/reports/residential-building-stock-assessment-single-family-characteristics-and-energy-use.pdf?sfvrsn=6
- **Residential Building Stock Assessment, Multifamily:** At the time of this project, the report on NEEA's 2011 RBSA multifamily homes survey had not yet been published. City Light had commissioned the RBSA contractor, Ecotope, to perform an oversample within City Light's service territory. Although the full report was not available, Ecotope provided summary tables, with results from the 111 buildings and 234 units in the City Light service territory. The report was published in September, 2013. http://neea.org/docs/default-source/reports/residential-building-stock-assessment--multi-family-characteristics-and-energy-use.pdf?sfvrsn=4
- **Commercial Building Stock Assessment:** NEEA's Commercial Building Stock Assessment (CBSA) provides data on regional commercial buildings. As of the most recent update in 2009, the database contains site-specific information for 2,061 buildings. http://neea.org/resource-center/regional-data-resources/commercial-building-stock-assessment
- **Bonneville Power Authority (BPA) Reference Deemed Measure List**, version 2.5, which was the most recent available when the study was performed.
- **American Community Survey:** The US Census American Community Survey (ACS) is an ongoing survey that provides data every year on household characteristics. http://www.census.gov/acs/www/
- **Residential Energy Consumption Survey (RECS).** http://www.eia.gov/consumption/residential/data/2009/
- **Annual Energy Outlook**. The Annual Energy Outlook (AEO), conducted each year by the EIA presents yearly projections and analysis of energy topics. For this study, we used data from the 2011 AEO.
- **California Statewide Surveys**. The Residential Appliance Saturation Survey (RASS) and the Commercial End Use Survey (CEUS) are comprehensive market research studies conducted by the California Energy Commission. These databases provide a wealth of information on appliance use in homes and businesses. RASS is based on information from almost 25,000 homes and CEUS is based on information from a stratified random sample of almost 3,000 businesses in California.
- **Database for Energy Efficient Resources (DEER).** The California Energy Commission and California Public Utilities Commission sponsor this database, which is designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) for the state of California. We used the DEER database to cross check the measure savings we developed using BEST and DEEM.
- **Electric Power Research Institute — Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S.**, also known as the EPRI National Potential Study (2009). In 2009, EPRI hired EnerNOC to conduct an assessment of the national potential for energy efficiency, with estimates derived for the four DOE regions.

[6] "Assessment of Electricity Savings in the U.S. Achievable through New Appliance/Equipment Efficiency Standards and Building Efficiency Codes (2010 – 2025)." Global Energy Partners, LLC for the Institute for Electric Efficiency, May 2011. http://www.edisonfoundation.net/iee/reports/IEE_CodesandStandardsAssessment_2010-2025_UPDATE.pdf

- **EPRI End-Use Models (REEPS and COMMEND)**. These models provide the elasticities we apply to electricity prices, household income, home size and heating and cooling.
- **Other relevant sources.** These include reports from the Consortium for Energy Efficiency, the EPA, and the American Council for an Energy-Efficient Economy.

Data Application

We now discuss how the data sources described above were used for each step of the study.

Data Application for Residential Market Characterization

To construct the high-level market characterization of electricity use and number of households for each segment, we applied the following data sources:

- City Light billing data reported on EIA Form 861
- ACS census data on distribution of households for each housing type
- 2009 RCCS, RBSA, and RTF/SEEM data on average energy use per household
- King County Assessor data on multifamily housing buildings

Table 2-8 shows the sample sizes in the various survey data used for residential market characterization.

Table 2-8 Sample Size in Data Sources Used for Residential Market Characterization

Sample size	RCCS 2009	RBSA Single Family Oversample	RBSA Multifamily Oversample Buildings	RBSA Multifamily Oversample Units	Multifamily Assessor data
Single Family	1,753	140			
Multiplex	112	1			2,007
Low- Rise Multifamily	447		90	234	100,156
High-Rise Multifamily			21		18,861
Total	**2,312**	**141**	**111**	**234**	**121,024**

Data Application for Non-Residential Market Characterization

To construct the high-level market characterization of electricity use and intensity (energy use/square foot for commercial buildings and energy use/employee for industrial), EnerNOC applied the following data sources:

- City Light billing data reported on EIA Form 861
- DMI database incorporating City Light billing data and King County Assessor data

Data Application for Street Lighting Characterization

- City Light street lighting equipment inventory data
- City Light street lighting efficiency upgrades results to date

Data Application for Market Profiles

The specific data elements for the market profiles, together with the key data sources, are shown in Table 2-9. To develop the market profiles for each segment, we used the following approach:

1. Developed control totals for each segment. These include market size, segment-level annual electricity use, and annual intensity.
2. Used the Sixth Plan, RTF/SEEM data, NEEA reports including the recently released RBSA Single Family report, City Light's RCCS, BEST simulation results, and City Light program results data to provide information about market size for customer segments, appliance and equipment saturations,

appliance and equipment characteristics, UECs, EUIs, building characteristics, customer behavior, operating characteristics, and energy-efficiency actions already taken.

3. Incorporated secondary data sources to supplement and corroborate the data from items 1 and 2 above.
4. Compared and cross-checked with regional data obtained as part of the EPRI National Potential Study and with the Energy Market Profiles Database.
5. Ensured calibration to control totals for annual electricity sales in each sector and segment.
6. Worked with City Light staff to vet the data against their knowledge and experience.

The specific data elements for the market profiles, together with the key data sources, are shown in Table 2-9.

Table 2-9 Data Applied for the Market Profiles

Model Inputs	Description	Key Sources
Market size	Base-year residential dwellings, commercial floor space, and industrial employment	City Light billing data, King County Assessor multifamily data, DMI database, NEEA reports, NPCC Sixth Plan
Annual intensity	Residential: Annual energy use (kWh/household) Commercial: Annual energy use (kWh/ sq ft) Industrial: Annual energy use (kWh/employee)	City Light billing data, DMI analysis, Energy Market Profiles, NEEA reports, AEO, previous studies
Appliance/equipment saturations	Fraction of dwellings with an appliance/technology; Percentage of commercial floor space or industrial employment with equipment/technology	NEAA reports, RECS, Energy Market Profiles, and other secondary data
UEC/EUI for each end-use technology	UEC: Annual electricity use for a technology in dwellings that have the technology EUI: Annual electricity use per square foot/employee for a technology in floor space that has the technology	NEAA reports, RTF/SEEM data, RTF UES workbooks, RASS, CEUS, engineering analysis, BEST prototype simulations, engineering analysis
Appliance/equipment vintage distribution	Age distribution for each technology	NEEA reports, RASS, CEUS, secondary data (DEEM, EIA, EPRI, DEER, etc.)
Efficiency options for each technology	List of available efficiency options and annual energy use for each technology	Prototype simulations, engineering analysis, appliance/equipment standards, secondary data (DEEM, EIA, EPRI, DEER, etc.)

Data Application for Baseline Projection

Table 2-10 summarizes the LoadMAP model inputs requirements. These inputs are required for each segment within each sector, as well as for new construction and existing dwellings/buildings.

Table 2-10 Data Needs for the Baseline Projection and Potentials Estimation in LoadMAP

Model Inputs	Description	Key Sources
Customer growth forecasts	Forecasts of new construction in residential and C&I sectors	Data provided by City Light
Equipment purchase shares for baseline projection	For each equipment/technology, purchase shares for each efficiency level; specified separately for existing equipment replacement and new construction	Shipments data from AEO AEO 2012 regional forecast assumptions RTF data on current market baseline RBSA Appliance/efficiency standards analysis City Light program results
Electricity prices	Forecast of average energy and capacity avoided costs and retail prices	City Light projections
Utilization model parameters	Price elasticities, elasticities for other variables (income, weather)	EPRI's REEPS and COMMEND models AEO 2011 City Light's historical data for normal cooling & heating degree days.

We developed initial baseline purchase shares based on the Energy Information Agency's *Annual Energy Outlook* report (2011), which utilizes the National Energy Modeling System to produce a self-consistent supply and demand economic model. We adjusted the purchase shares in some cases where data was available from the RBSA, the RTF, or City Light conservation program results to reflect market transformation that has already occurred in the City Light service territory. For example, for compact fluorescent lighting (CFL), we matched the baseline purchase shares to the existing market saturation from the RBSA to reflect the assumption that for sockets already converted to CFLs, consumers will continue to purchase CFLs.

Beyond 2013, we assumed a frozen efficiency case in which the purchase shares for efficient equipment do not change during the study period, unless equipment standards remove a technology option from the market. Table 2-11 through Table 2-13 show the assumptions regarding upcoming equipment standards, based on known standards as of January 2013. This approach, which is consistent with the NPCC methodology, removes from the baseline any effects of naturally occurring conservation or effects of future DSM programs. Thus the CPA's resulting projections of potential compared to this baseline are gross, because naturally occurring conservation effects have been removed.

Table 2-11 Residential Electric Equipment Standards Applicable to City Light

Today's Efficiency or Standard Assumption | 1st Standard (relative to today's standard) | 2nd Standard (relative to today's standard)

End Use	Technology	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Cooling	Central AC	SEER 13				SEER 14										
	Room AC	EER 9.8			EER 11.0											
Cooling/Heating	Heat Pump	SEER 13.0/HSPF 7.7				SEER 14.0/HSPF 8.0										
Water Heating	Water Heater (<=55 gallons)	EF 0.90				EF 0.95										
	Water Heater (>55 gallons)	EF 0.90				Heat Pump Water Heater										
Lighting	Screw-in/Pin Lamps	Incandescent			Advanced Incandescent - tier 1						Advanced Incandescent - tier 2					
	Linear Fluorescent	T8														
Appliances	Refrigerator/2nd Refrigerator	NAECA Standard			25% more efficient											
	Freezer	NAECA Standard			25% more efficient											
	Dishwasher	Conventional (355 kWh/yr)		14% more efficient (307 kWh/yr)												
	Clothes Washer	Conventional (MEF 1.26 for top loader)				MEF 1.72 for top loader			MEF 2.0 for top loader							
	Clothes Dryer	Conventional (EF 3.01)				5% more efficient (EF 3.17)										
	Range/Oven	Conventional														
	Microwave	Conventional														

Table 2-12 Commercial Electric Equipment Standards Applicable to City Light

Today's Efficiency or Standard Assumption | 1st Standard (relative to today's standard) | 2nd Standard (relative to today's standard)

End Use	Technology	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Cooling	Chillers	2007 ASHRAE 90.1														
	Roof Top Units	EER 11.0/11.2														
	Packaged Terminal AC/HP	EER 9.8	EER 11.0													
Lighting	Screw-in/Pin Lamps	Incandescent			Advanced Incandescent - tier 1						Advanced Incandescent - tier 2					
	Linear Fluorescent	T12	T8													
	High Intensity Discharge	Metal Halide														
Refrigeration	Walk-in Refrigerator/Freezer	EISA 2007 Standard														
	Reach-in Refrigerator	EPACT 2005 Standard														
	Glass Door Display	EPACT 2005 Standard	42% more efficient													
	Open Display Case	EPACT 2005 Standard	18% more efficient													
	Vending Machines	EPACT 2005 Standard	33% more efficient													
	Icemaker	2010 Standard														
Miscellaneous	Non-HVAC Motors	62.3% Efficiency				70% Efficiency										
	Commercial Laundry	MEF 1.26		MEF 1.6												

Table 2-13 Industrial Electric Equipment Standards Applicable to City Light

Today's Efficiency or Standard Assumption
1st Standard (relative to today's standard)
2nd Standard (relative to today's standard)

End Use	Technology	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Cooling	Chillers	2007 ASHRAE 90.1														
	Roof Top Units	EER 11.0/11.2														
	Packaged Terminal AC/HP	EER 9.8	EER 11.0													
Lighting	Screw-in/Pin Lamps	Incandescent			Advanced Incandescent - tier 1						Advanced Incandescent - tier 2					
	Linear Fluorescent	T12	T8													
	High Intensity Discharge	Metal Halide														
Machine Drive	Less than 5 HP	62.3% Efficiency				70% Efficiency										
	5-24 HP	EISA 2007 Standards														
	25-99 HP	EISA 2007 Standards														
	100-249 HP	EISA 2007 Standards														
	250-499 HP	EISA 2007 Standards														
	500 or more HP	EISA 2007 Standards														

Conservation Measure Data Application

Table 2-14 details the data sources used for measure characterization.

Table 2-14 Data Needs for the Measure Characteristics in LoadMAP

Model Inputs	Description	Key Sources
Energy Impacts	The annual reduction in consumption attributable to each specific measure. Savings were developed as a percentage of the energy end use that the measure affects.	City Light program results RTF workbooks NPCC workbooks BPA Reference Deemed Measure List NEEA reports BEST DEEM DEER Other secondary sources
Peak Demand Impacts	Savings during the peak demand periods are specified for each electric measure. These impacts relate to the energy savings and depend on the extent to which each measure is coincident with the system peak.	BEST EnergyShape
Costs	Equipment Measures: Includes the full cost of purchasing and installing the equipment on a per-household, per-square-foot, or per employee basis for the residential, commercial, and industrial sectors, respectively. Non-equipment measures: Existing buildings – full installed cost. New Construction - the costs may be either the full cost of the measure, or as appropriate, it may be the incremental cost of upgrading from a standard level to a higher efficiency level.	City Light program results RTF workbooks NPCC workbooks BPA Reference Deemed Measure List DEEM DEER RS Means Other secondary sources
Measure Lifetimes	Estimates derived from the technical data and secondary data sources that support the measure demand and energy savings analysis.	City Light program results RTF workbooks NPCC workbooks BPA Reference Deemed Measure List NEEA reports DEEM DEER Other secondary sources
Applicability	Estimate of the percentage of either dwellings in the residential sector or square feet/employment in the C&I sector where the measure is applicable and where it is technically feasible to implement.	DEEM DEER RTF workbooks NPCC workbooks Other secondary sources
On Market and Off Market Availability	Expressed as years for equipment measures to reflect when the equipment technology is available or no longer available in the market.	EnerNOC appliance standards and building codes analysis

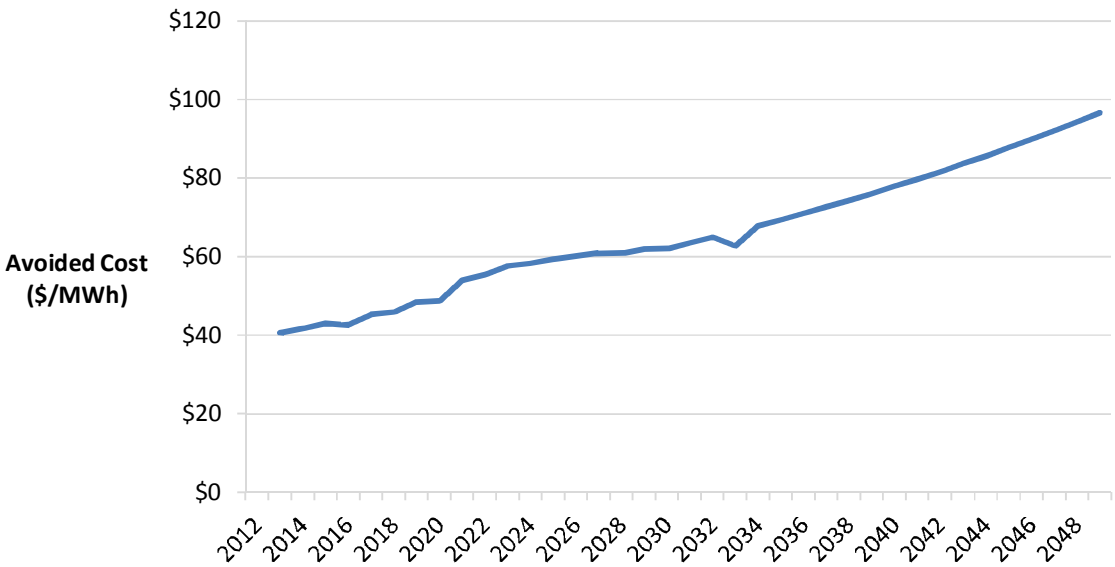
Data Application for Cost-effectiveness Screening

To perform the cost-effectiveness screening, EnerNOC applied the following information:

- Preliminary avoided cost of energy and capacity provided by City Light, as shown in Figure 2-4. In the reference case, the avoided costs are based on market costs and assume that the marginal generation unit is a conventional CCT. In addition, avoided costs include adders for renewable energy credits, carbon dioxide offsets, transmission and distribution costs, and a 10% credit for the Regional Act Bonus. Note that City Light has sufficient capacity for the study period and thus did not provide an avoided cost of capacity.
- Line losses of 9.1%, provided by City Light
- Discount rate of 3%, provided by City Light

- Program administration costs. Program administration costs are a significant portion of DSM program budgets, and can vary based on the particular market and delivery mechanism. For this study, we used values of 20% of incremental measure costs, consistent with the Sixth Plan.

Figure 2-4 Avoided Costs of Energy Projection.



Achievable Potential Estimation

To estimate potentials, two sets of parameters were required.

- **Diffusion rates for non-equipment measures.** The CPA approach assumes that equipment is replaced at the end of its useful life. But for non-equipment measures, a set of factors is required to model the gradual implementation over time. Rather than all non-equipment measures being installed in the first year of the projection (instantaneous potential), the LoadMAP model phases them in according to diffusion schedules that vary based on equipment cost and measure complexity, to emulate the diffusion rates of the stock turnover model for equipment measures. These diffusion rates are used within LoadMAP to generate the technical and economic potentials.
- **Market acceptance rates (MARs).** These factors are applied to Economic potential to estimate Achievable potential. We developed these factors by beginning with the NPCC ramp rates but then adjusting them to reflect City Light's DSM program history.

MARs are included in Appendix E.

Consistency with the Sixth Plan Methodology

The CPA approach is consistent with the Sixth Plan's methodology and fulfills the requirements of the utility analysis option as specified in WAC 194-37-070 subsection (6), (a)(i) through (xv).[7] This CPA, like the Sixth Plan, uses an end-use model, with a bottom-up approach that distinctly considers and accounts for the following:

- Building characteristics
- Fuel and equipment saturations
- Measure life
- Stock accounting

[7] http://apps.leg.wa.gov/WAC/default.aspx?cite=194-37&full=true

- Existing and new vintage
- Lost- and non-lost opportunities
- Measure saturation and applicability
- Measure savings, including contribution to peak
- Customer growth
- Economic trends

Like the Sixth Plan, the CPA uses a frozen efficiency approach that assumes equipment efficiency purchase decisions are fixed, with the exception of changes due to the phase in of new codes and standards. The CPA determines cost-effectiveness based on the Total Resource Cost test, as defined by the NPCC. It includes non-energy benefits, as well as the Regional Act 10% credit, which is added to the avoided costs.

In terms of conservation measures, this analysis comprises all major measures incorporated in the Sixth Plan, though the CPA mainly analyzes measures individually, whereas the Sixth Plan bundles measures in some cases. In addition to the Sixth Plan measures, the CPA also evaluated additional measures specific to City Light, such as measures for data centers. Measures analysis used data from the Sixth Plan and RTF workbooks, as well as other sources typically cited by the NPCC in its analyses.

The market acceptance rate factors that we used to develop achievable potential in the City Light CPA are based upon the Sixth Plan residential and commercial ramp rates. In general, the Sixth Plan ramp rates yield a maximum penetration rate after 20 years of 85% for non-lost opportunity measures and 65% for lost opportunity measures. However, in some cases, we adjusted these market acceptance factors, either up or down, to calibrate achievable potential results with recent City Light conservation program results.

CHAPTER | 3

MARKET CHARACTERIZATION AND MARKET PROFILES

The Seattle City Light Department is the tenth largest publicly owned utility in the United States in terms of retail energy sales. Its 131 square mile service area includes Seattle and several surrounding cities. City Light serves approximately 403,000 customers and has total operating revenues of approximately $800 million. Since 1977, the Conservation Resources Division has provided its customers conservation services. The results of these efforts have been significant: delivering a cost-effective energy resource for the utility; reducing residential, commercial, and industrial customers' bills; and avoiding greenhouse gas emissions and other environmental impacts of energy production.

Energy Use Summary

Total electricity use for the residential, non-residential, and outdoor lighting sectors for City Light in 2012, the study base year, was 9,494,297 MWh.[8] As shown in Table 3-1, the largest sector is non-residential, accounting for 66% of use, followed by residential, with 33% of sales. Street lighting represents only about 1% of sales. Later in this chapter, we describe how the non-residential sales were separated into two sectors, commercial and industrial.

Table 3-1 Customer Counts and Energy Sales by Sector, 2012

Sector / Rate Class	Number of meters (customers)	2012 Electricity sales (MWh)
Residential	362,524	3,146,951
Non-residential	40,084	6,255,467
Street Lighting	3,301	91,879
Total	**405,909**	**9,494,297**

Residential Sector Market Characterization

This section characterizes the residential market at a high level, and then provides a profile of how customers in each segment use electricity by end use. Total residential electricity use in 2012 was 3,146,951 MWh, for an average use per home of 8,681 kWh/year. Summary information for each segment is shown in Table 3-2 and Figure 3-1. The single-family segment consumed 60% of total residential sector electricity in 2012 as a result of having the largest number of customers and the highest intensity.

Note that the resulting use per household for all housing types is higher than the values from the data sources used to develop the segmentation. For example, the single-family RBSA Seattle oversample indicates a household intensity of 8,976 kWh/year, while the Assessor data suggested intensities of 7,695 kWh/yr, 5,842 kWh/yr, and 4,617 kWh/year respectively for multiplex, low-rise, and high-rise. It was necessary to increase the intensity for all housing types in order to match the total 2012 residential sector sales.

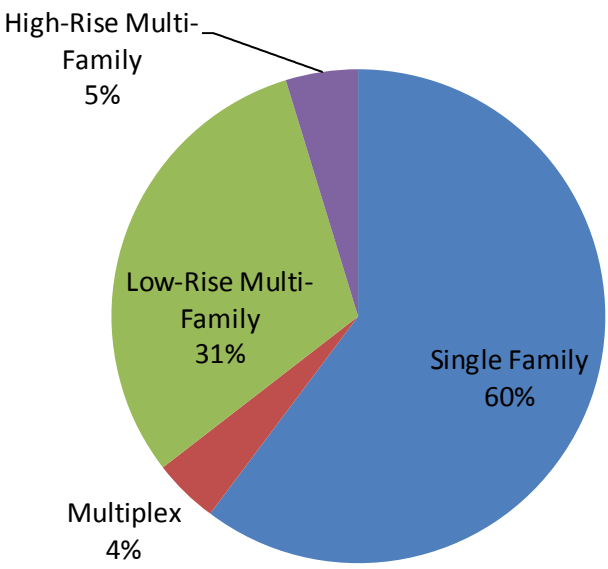
[8] Based on EIA Form 861. Energy usage as measured "at-the-meter," i.e., does not include line losses.

Table 3-2 Residential Sector Market Segmentation by Housing Type, 2012

Segment	Allocation of Customers	Electricity Sales (MWh)	% of Total Usage	Avg. Use/ Customer (kWh)
Single Family (including mobile homes)	190,032	1,895,657	60%	9,975
Multiplex (2–4 units)	15,852	135,050	4%	8,520
Low-Rise Multifamily (≥5 units, ≤6 stories)	131,817	966,343	31%	7,331
High-Rise Multifamily (≥5 units, ≥7 stories)	24,823	149,902	5%	6,039
Total, All segments	**362,524**	**3,146,951**	**100%**	**8,681**

Note: For the 2013 CPA, we combined the mobile home segment with single family.

Figure 3-1 Residential Electricity Use by Customer Segment, 2012



Residential Sector Energy Market Profiles

As we describe in Chapter 2, the market profiles provide the foundation upon which we develop the baseline projection. Table 3-3 presents the average existing home market profile for all residential segments, with intensity indicated on a per household (HH) basis. The existing-home profile represents all the housing stock in 2012. Market profiles for each of the residential segments appear in Appendix A.

Table 3-3 Average Residential Sector Market Profile

End Use	Technology	Saturation	UEC (kWh)	Intensity (kWh/HH)	Usage (MWh)
Cooling	Central AC	1.9%	267	5	1,792
Cooling	Room AC	7.0%	335	23	8,505
Cooling	Air-Source Heat Pump	2.0%	240	5	1,744
Space Heating	Electric Resistance	47.4%	3,148	1,494	541,525
Space Heating	Electric Furnace	4.4%	7,003	306	111,071
Space Heating	Air-Source Heat Pump	1.7%	4,148	71	25,873
Water Heating	Water Heater <= 55 Gal	65.8%	2,150	1,416	513,300
Water Heating	Water Heater > 55 Gal	3.0%	3,136	94	34,107
Interior Lighting	Screw-in	100.0%	828	828	300,237
Interior Lighting	Linear Fluorescent	100.0%	59	59	21,226
Interior Lighting	Specialty	100.0%	208	208	75,412
Exterior Lighting	Screw-in	100.0%	110	110	39,731
Appliances	Clothes Washer	74.4%	123	92	33,193
Appliances	Clothes Dryer	72.3%	675	488	176,862
Appliances	Dishwasher	74.8%	373	279	100,995
Appliances	Refrigerator	100.0%	777	777	281,742
Appliances	Freezer	22.7%	666	151	54,705
Appliances	Second Refrigerator	18.5%	961	178	64,628
Appliances	Stove	83.0%	417	346	125,500
Appliances	Microwave	84.8%	125	106	38,286
Electronics	Personal Computers	75.2%	273	206	74,525
Electronics	Monitor	78.2%	55	43	15,447
Electronics	Laptops	82.0%	117	96	34,797
Electronics	TVs	186.2%	154	286	103,664
Electronics	Printer/Fax/Copier	81.1%	42	34	12,305
Electronics	Set-top Boxes/DVR	243.3%	111	271	98,105
Electronics	Devices and Gadgets	100.0%	49	49	17,687
Miscellaneous	Pool Pump	0.7%	1,575	12	4,190
Miscellaneous	Pool Heater	0.2%	5,230	10	3,479
Miscellaneous	Hot Tub / Spa	6.7%	995	67	24,128
Miscellaneous	Furnace Fan	41.7%	222	93	33,580
Miscellaneous	Miscellaneous	100.0%	482	482	174,613
	Total			**8,681**	**3,146,951**

Table 3-4 and Figure 3-2 present the end-use shares of electricity use by housing type. Due to Seattle's relatively mild climate, across all housing types, space conditioning (air conditioning, furnaces, resistance heating, and heat pumps) accounts for only 23% of annual use. Appliances represent 28% of usage, water heating 17%, and interior lighting 13%. Electronics, which includes personal computers, TVs, set top boxes,

home audio, etc., represent 11% of use, while the miscellaneous end use, which encompasses such devices as furnace fans, pool pumps, hot tubs, and other "plug" loads (hair dryers, power tools, coffee makers, etc.), consumes about 7%. Compared with the other housing types, single family homes allocate a smaller portion of their electricity use to space heating, due mainly to a higher saturation of gas heat in single family homes.

Table 3-4 Residential Electricity Use by End Use and Segment (kWh/HH, 2012)

End Use	Single Family	Multiplex	Low-Rise Multifamily	High-Rise Multifamily	Total Residential
Cooling	47	43	15	13	33
Heating	1,463	2,630	2,654	1,570	1,954
Water Heating	1,781	1,333	1,281	764	1,510
Interior Lighting	1,372	941	748	912	1,095
Exterior Lighting	209	-	-	-	110
Appliances	2,964	2,317	1,738	1,886	2,416
Electronics	1,252	992	656	657	983
Miscellaneous	886	264	239	238	579
Total	**9,975**	**8,520**	**7,331**	**6,039**	**8,681**

Figure 3-2 Percentage of Residential Electricity Use by End Use and Segment (2012)

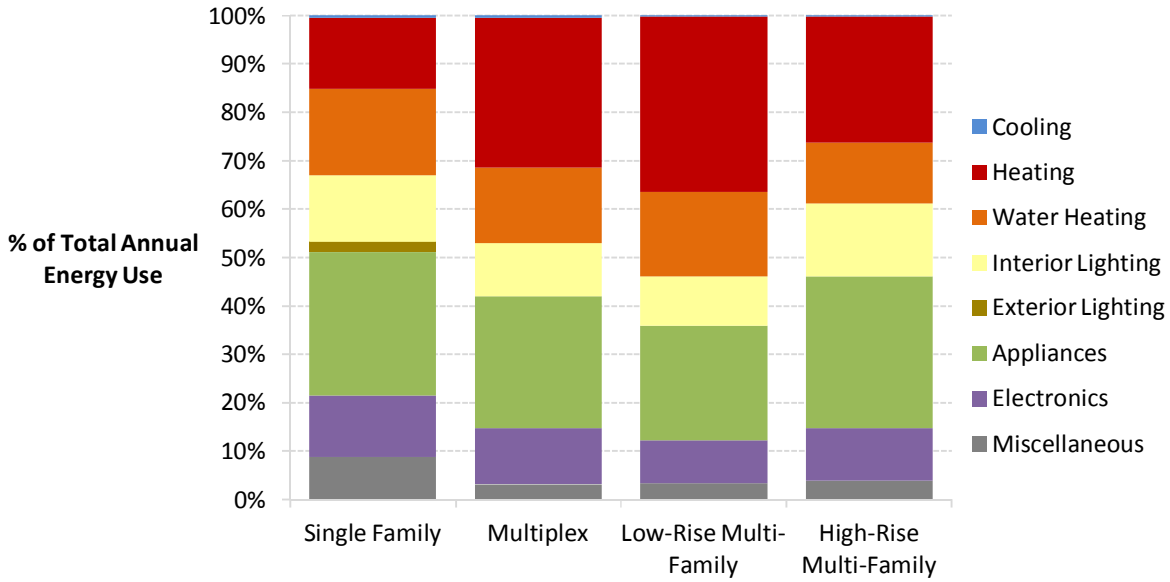
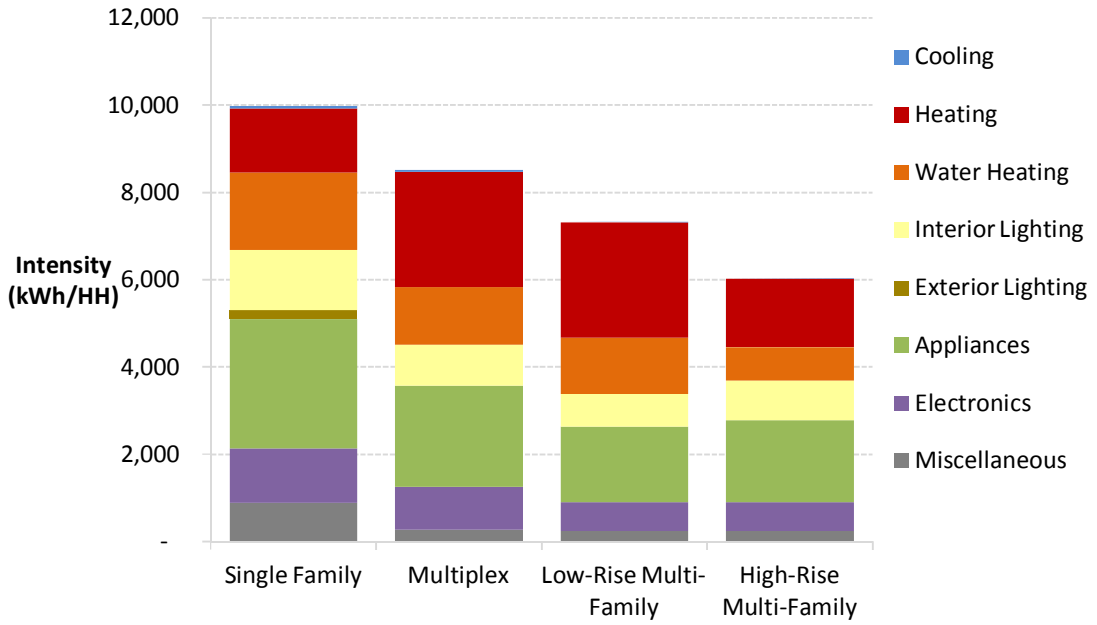


Figure 3-3 presents the end-use breakout in terms of intensity, kWh/household-year, by segment. Note that high-rise units use about 82% of the electricity that low-rise units do, despite the fact that they are slightly larger. We attribute this difference to three factors: high-rise buildings are generally newer and have better thermal shells as well as more efficient equipment overall, the high-rise units have a smaller ratio of exterior surfaces to total unit space, and heating and cooling in high-rise buildings is more often provided by central building systems.

Figure 3-3 Residential Intensity by End Use and Segment (kWh/household, 2012)



Distribution of Non-Residential Energy Use to Commercial and Industrial Sectors

As described in Chapter 2, EnerNOC's subcontractor DMI matched City Light's non-residential billing data with information from the King County Assessor to enable more accurately characterizing City Light's customers by building or industry type. EnerNOC and City Light reviewed the resulting database, focusing on the 1,000 largest accounts and comparing segment assignments with the previous CPA, to ensure that the largest customers were assigned to the correct segments. The DMI database was particularly helpful for segmenting the smaller customers, which did not merit individual inspection, and for distinguishing between small and large offices. Also, DMI's work helped the project team to identify commercial sector facilities that were not well characterized in the previous CPA, particularly facilities that are not buildings per se, such as parking garages/lots, parks, transit or rail facilities, and telecommunications towers or switching facilities, These facilities are now included in the Commercial sector, Miscellaneous segment. Port and shipping facilities are included within the Industrial sector, Other segment.

Table 3-5 compares the resulting allocation of energy usage between the commercial and industrial sector with the commercial and industrial usage reported in City Light's EIA Form 861. City Light's EIA Form 861 reported that 17% of non-residential sales are consumed by industrial customers, but the DMI database indicates that industrial accounts for roughly 21% of non-residential sales. This difference occurs because for the CPA, we assigned facilities to the commercial or industrial sectors mainly based on how the facility is used and whether the primary end uses are lighting and HVAC, which is the case for commercial facilities, or whether the primary end uses are motors and process uses, which is the case for industrial facilities. Doing so enables modeling the efficiency measures that are most appropriate for the dominant end uses. As a result, some large energy users that City Light considers commercial, such as the Port of Seattle and wastewater treatment facilities, are classified as industrial for purposes of the CPA. We also assigned some smaller industrial facilities, which City Light may classify as commercial, to the industrial sector for the CPA.

Table 3-5 Commercial and Industrial Energy Use, EIA Form 861 and CPA, 2012

Sector	Seattle City Light EIA Form 861 (MWh)	CPA Usage (MWh)
Commercial	5,173,899	4,961,098
Industrial	1,081,568	1,294,369
Non-Residential Total	**6,255,467**	**6,255,467**

Commercial Sector Market Characterization and Market Profiles

Based on the above, total electricity use in the commercial sector in 2012 was 4,961,098 MWh. The DMI database data was used to allocate this energy use to 15 building type segments described below, with the resulting shares shown in Figure 3-4.

- **Small office** (less than 50,000 square feet) — all types of offices (agriculture; finance, insurance, real estate; services; no classifiable establishments)
- **Large office** (greater than or equal to 50,000 square feet) — all types of offices as above, also includes large government facilities
- **Restaurant**
- **Retail**
- **Large grocery** — supermarkets
- **Small grocery** — convenience stores and mini-markets
- **College** — colleges, universities, and technical colleges
- **School** — primary and secondary schools
- **Hospital**
- **Other Health** — nursing homes and residential care facilities
- **Lodging** — motels, hotels, and resorts
- **Assembly** — meeting halls, churches, and libraries
- **Warehouse** — refrigerated and non-refrigerated warehouses
- **Data Center**
- **Multifamily Common Area**— the area within multifamily buildings that is not billed to the individual apartment units, which are covered in the residential sector
- **Miscellaneous** — all remaining building types such as fire stations, amusement parks, and parking garages; this segment also includes facilities that may have no building or only a small building on the premises, such as parking lots, railroad or transportation facilities, telecommunications towers, etc.

The building types selected for this analysis correspond to those used in the Sixth Plan, with a few exceptions that were made to simplify the analysis. Offices are broken out into small and large, whereas the Sixth Plan segments offices into small, medium, and large. Similarly, the Sixth Plan used multiple segments for retail, but the City Light CPA consolidates these into a single segment. One additional segment, data centers, was added due to the significant energy use of this building type in the City Light market.

These segments are the same as those used in the previous CPA, with the following exceptions:

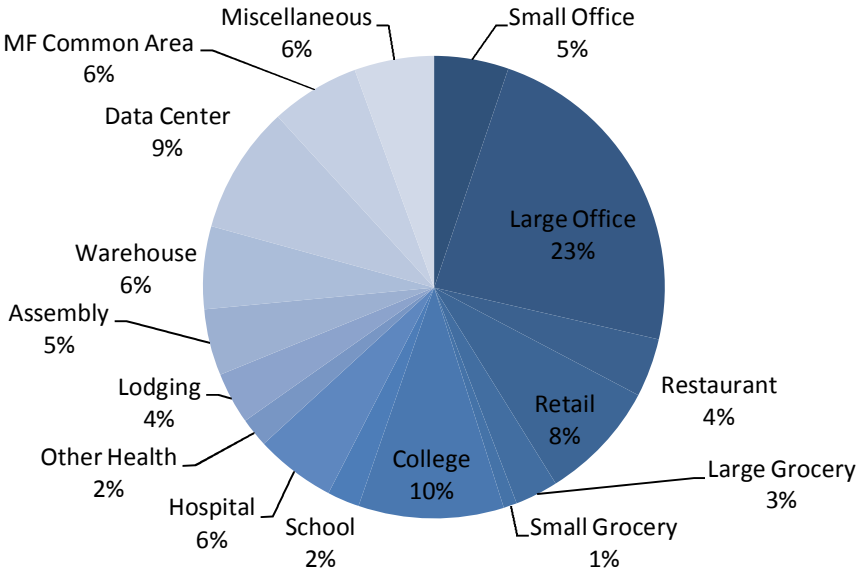
- **Multifamily Common Area** — This segment was added to cover the portion of multifamily building use that is billed on a commercial rate. It includes common area energy use, exterior lighting, parking garages, and may also include HVAC and domestic hot water if those are provided at the building level

rather than via equipment in individual units. In the previous CPA, this load was not treated separately, but was allocated to small offices, restaurant, and retail.

- **Warehouses** — In the previous CPA, refrigerated warehouses were including under the Industrial sector, Food segment. In the current CPA, this segment includes both refrigerated and unrefrigerated warehouses.
- **Other Health** — In the previous CPA, other health included both medical offices and residential care. In the current CPA, this segment now covers only residential care facilities. Medical offices are now included in either Large Office or Small Office segments, based on their size. This change is consistent with proposed NPCC changes regarding commercial building segments.

Figure 3-4 shows the relative energy use of each segment as a percentage of commercial sector energy sales. The four largest segments are large office, college, data center, and retail, which together make up about 50% of sales in the commercial sector. The remaining segments individually constitute less than 6% of sales. In the 2011 CPA, energy use associated with the Small Office segment was 10% of the total, but now it is only 5% of the total. As noted above, in the previous CPA, we distributed the energy use associated with multifamily and multi-use buildings among the Small Office, Restaurant, Retail, and Small Grocery segments. Now that Multifamily Common Area is treated as a separate segment, a significant part of the Small Office energy use has been moved to the new segment, where it can be more accurately modeled. The percentage of use associated with Restaurants, Retail, and Small Grocery has also decreased slightly.

Figure 3-4 Share of Commercial Sector Electricity Use by Building Type, 2012



The DMI database was also used to calculate segment level building intensities (annual kWh/sq. ft.) for the commercial building types. We compared the intensities from the DMI database with the intensities used in the previous CPA and other data sources (Sixth Plan workbooks, NEEA CBSA, and EnerNOC's Energy Market Profiles). While many of the resulting values were reasonable, several seemed unreasonably low, likely due to problems with the assignment of square footage in the assessor data. Therefore, for each building segment, the project team decided whether to use the intensity values from the DMI data or to override that value with the intensity used in the previous CPA. For Multifamily Common Area, we used the value from DMI, but adjusted it because for some buildings, the Assessor data included both the common area and the residential unit area.

Table 3-6 provides the results of this analysis. Finally, using the electricity use and selected intensity estimates, we infer floor space, which is the unit of analysis in LoadMAP for the commercial sector. Data centers have the highest intensity, followed by restaurants and groceries. The warehouse, school, assembly, and miscellaneous segments have the lowest intensities.

Table 3-6 Commercial Sector Market Characterization Results, 2012

Segment	Electricity Use (MWh)	Intensity (kWh/SqFt)	Floor Space (million SqFt)
Small Office[1]	260,243	16.5	15.8
Large Office	1,160,558	21.5	54.0
Restaurant[1]	203,061	40.2	5.1
Retail	418,029	13.1	32.0
Large Grocery[1]	149,763	47.3	3.2
Small Grocery	46,298	44.3	1.0
College	505,537	16.8	30.0
School[1]	112,791	8.1	13.9
Hospital	279,291	31.4	8.9
Other Health	100,236	10.3	9.7
Lodging	181,133	17.6	10.3
Assembly[1]	229,978	10.5	21.9
Warehouse	287,243	9.3	30.9
Data Center	444,152	175.5	2.5
MF Common Area[2]	309,955	19.0	16.3
Miscellaneous[1]	274,829	11.0	24.9
Total	**4,961,098**	**17.7**	**280.4**

1. *Intensity values for these segments are based on the 2011 CPA intensities. Intensities for other segments are based on the DMI database values.*
2. *MF Common Area intensity is based on the DMI database values, but adjusted to account for the inclusion of residential unit area as well as common area within the King County Assessor data.*

For each of the segments defined above, we developed Energy Market Profiles, as described in Chapter 2, that characterize energy use in terms of sector, customer segment, end use, and technology for the base year. Table 3-7 shows the average market profile for electricity for the commercial sector as a whole, representing a composite of all the building types. Market profiles for each building type are presented in Appendix A.

Table 3-7 Total Commercial Segment Market Profile, 2012

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/Sqft)	Usage (MWh)
Cooling	Air-Cooled Chiller	16.6%	2.34	0.39	108,872
Cooling	Water-Cooled Chiller	13.5%	4.18	0.56	157,883
Cooling	Roof top AC	26.8%	2.90	0.78	217,876
Cooling	Roof top Heat Pump	11.5%	2.65	0.30	85,259
Cooling	Other Cooling	3.3%	3.08	0.10	28,643
Heating	Roof top Heat Pump	11.5%	5.93	0.68	190,725
Heating	Electric Room Heat	1.9%	5.98	0.12	32,418
Heating	Electric Furnace	25.5%	4.96	1.26	354,207
Ventilation	Ventilation	100.0%	2.09	2.09	584,612
Water Heating	Water Heating	52.9%	1.64	0.86	242,308
Interior Lighting	Screw-in	100.0%	0.74	0.74	207,807
Interior Lighting	High-Bay Fixtures	100.0%	0.52	0.52	146,592
Interior Lighting	Linear Fluorescent	100.0%	2.81	2.81	787,509
Exterior Lighting	Screw-in	100.0%	0.19	0.19	54,086
Exterior Lighting	HID	100.0%	0.42	0.42	118,320
Exterior Lighting	Linear Fluorescent	100.0%	0.20	0.20	56,428
Refrigeration	Walk-in Refrigerator	6.8%	3.56	0.24	68,059
Refrigeration	Reach-in Refrigerator	11.9%	0.21	0.02	6,891
Refrigeration	Glass Door Display	42.1%	0.72	0.31	85,590
Refrigeration	Open Display Case	42.1%	0.60	0.25	70,596
Refrigeration	Icemaker	42.1%	0.29	0.12	34,011
Refrigeration	Vending Machine	42.1%	0.28	0.12	33,507
Food Preparation	Oven	17.4%	0.88	0.15	42,851
Food Preparation	Fryer	10.4%	0.90	0.09	26,318
Food Preparation	Dishwasher	27.5%	1.86	0.51	143,594
Food Preparation	Hot Food Container	12.3%	0.27	0.03	9,286
Office Equipment	Desktop Computer	92.6%	0.76	0.70	196,031
Office Equipment	Laptop	77.0%	0.16	0.12	34,821
Office Equipment	Server	77.8%	1.17	0.91	254,091
Office Equipment	Monitor	92.6%	0.21	0.19	54,644
Office Equipment	Printer/Copier/Fax	88.1%	0.14	0.12	33,490
Office Equipment	POS Terminal	48.6%	0.06	0.03	8,300
Miscellaneous	Non-HVAC Motors	68.3%	0.27	0.19	52,438
Miscellaneous	Pool Pump	20.5%	0.02	0.00	900
Miscellaneous	Pool Heater	4.0%	0.01	0.00	158
Miscellaneous	Miscellaneous	100.0%	1.54	1.54	431,980
Total				**17.69**	**4,961,098**

Figure 3-5 shows the breakdown of annual commercial electricity usage by end use for the commercial sector as a whole. Heating, ventilation, and cooling collectively account for 36% of energy use. Interior and exterior lighting combined represent 27% of consumption. Office equipment is significant as well, due to the large presence of data centers in the service territory. The relatively high consumption for the miscellaneous end use category, 10%, is due to the increasing use of various plug load equipment across all commercial building types. The remaining end uses — water heating, refrigeration, and food preparation — comprise 6% or less of total usage.

Figure 3-5 Commercial Electricity Consumption by End Use, 2012

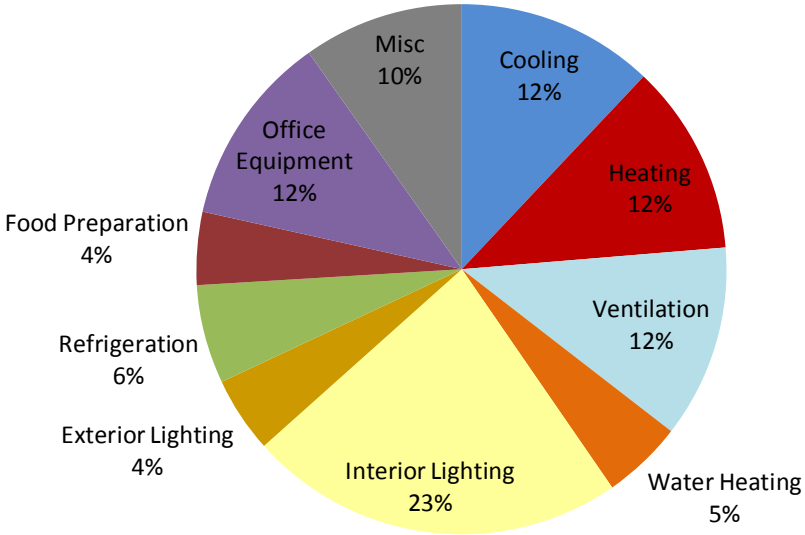


Figure 3-6 shows the electricity intensity by end use and building type in terms of kWh per square foot of building floor space. Data centers are the most energy intensive due to high server loads as well as significant cooling and ventilation requirements. The grocery sector is the next most energy intensive as a result of high refrigeration loads, followed by restaurants, due to high refrigeration and electric food preparation loads. Hospitals have relatively high miscellaneous end use consumption due to a wide range of diagnostic and treatment equipment. Within the Miscellaneous segment, many of the facilities are non-buildings, such as parks, transit facilities, and telecommunications systems. As a result, within the Miscellaneous segment, slightly more than 40% of use has been allocated to the miscellaneous end use.

Figure 3-6 Commercial Electricity Intensity by End Use and Segment (2012)

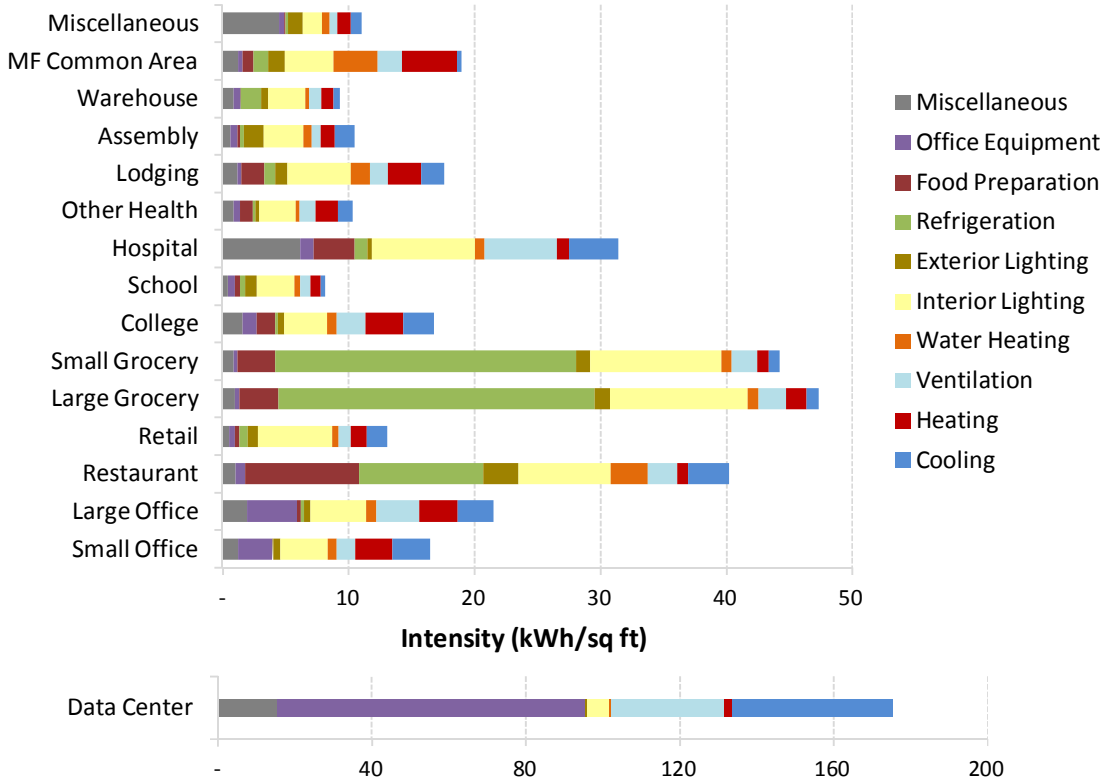


Figure 3-7 and Table 3-8 present 2012 electricity usage by end use and building type. As one might expect, offices account for the highest share of electricity use in City Light's commercial sector.

Figure 3-7 Commercial Electricity Usage by End Use and Segment (GWh, 2012)

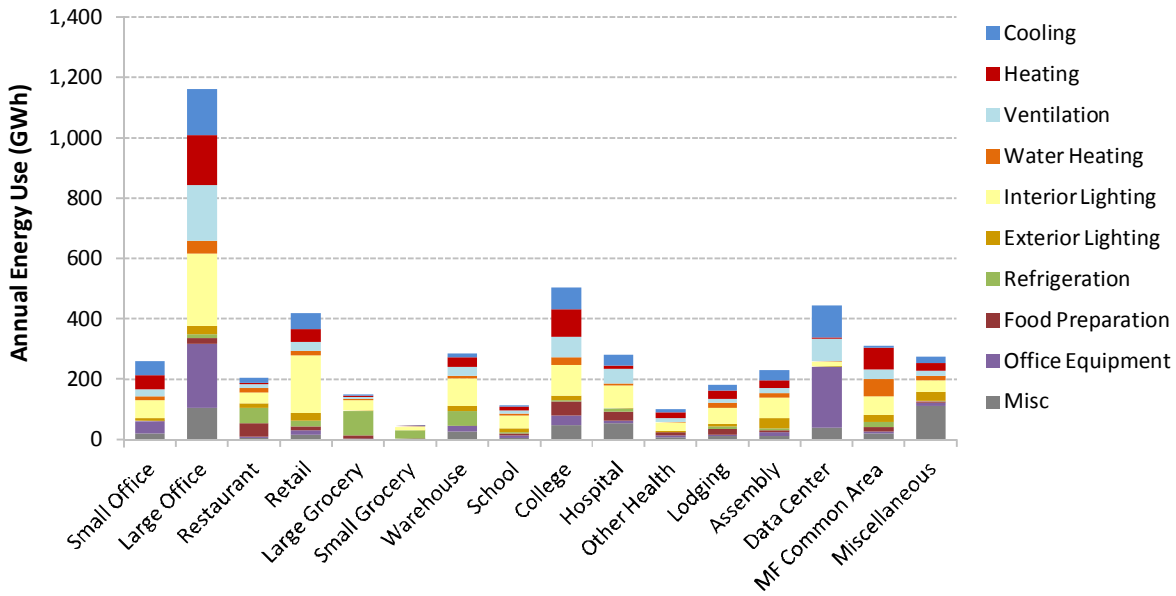


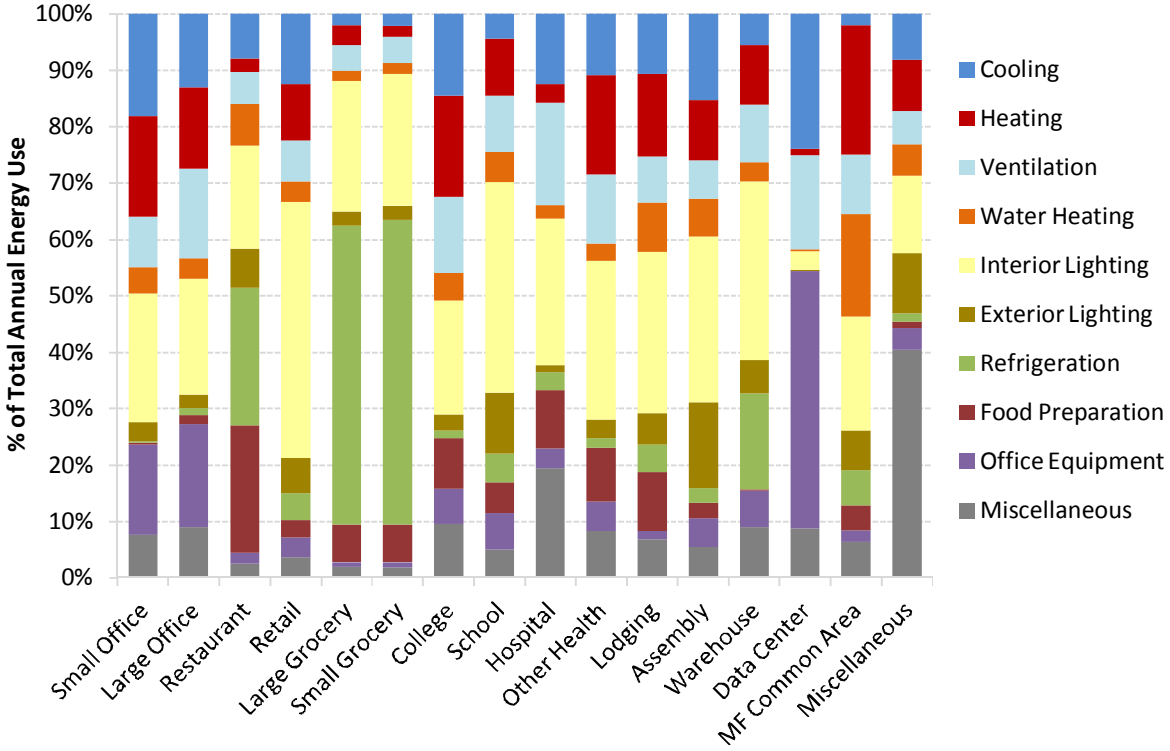
Table 3-8 Commercial Electricity Consumption by End Use and Segment (GWh, 2012)

End Use	Small Office	Large Office	Restau-rant	Retail	Large Grocery	Small Grocery	Ware-house	School
Cooling	47	151	16	52	3	1	16	5
Heating	46	167	5	41	5	1	31	11
Ventilation	24	185	12	30	7	2	29	11
Water Heating	12	42	15	15	3	1	10	6
Interior Lighting	59	239	37	190	35	11	91	42
Exterior Lighting	9	28	14	26	4	1	17	12
Refrigeration	1	14	50	20	80	25	49	6
Food Preparation	1	18	46	13	10	3	0	6
Office Equipment	42	213	4	15	1	0	19	7
Miscellaneous	20	104	5	15	3	1	26	6
Total	**260**	**1,161**	**203**	**418**	**150**	**46**	**287**	**113**

	College	Hospital	Other Health	Lodging	Assem-bly	Data Center	MF Common Area	Miscella-neous	TOTAL
Cooling	73	35	11	19	35	106	6	22	**599**
Heating	91	9	18	27	25	5	71	25	**577**
Ventilation	68	51	12	15	16	74	32	16	**585**
Water Heating	24	6	3	16	15	1	57	16	**242**
Interior Lighting	102	73	28	52	68	15	63	38	**1,142**
Exterior Lighting	15	3	3	10	35	1	22	29	**229**
Refrigeration	6	9	2	9	6	0	19	4	**299**
Food Preparation	45	29	10	19	6	0	14	3	**222**
Office Equipment	32	10	5	3	12	203	6	11	**581**
Miscellaneous	48	54	8	12	13	39	20	111	**485**
Total	**504**	**279**	**100**	**181**	**230**	**444**	**310**	**275**	**4,961**

Figure 3-8 shows each end use as a percentage of the segment's total use.

Figure 3-8 Commercial Electricity Usage by End Use and Segment (2012)

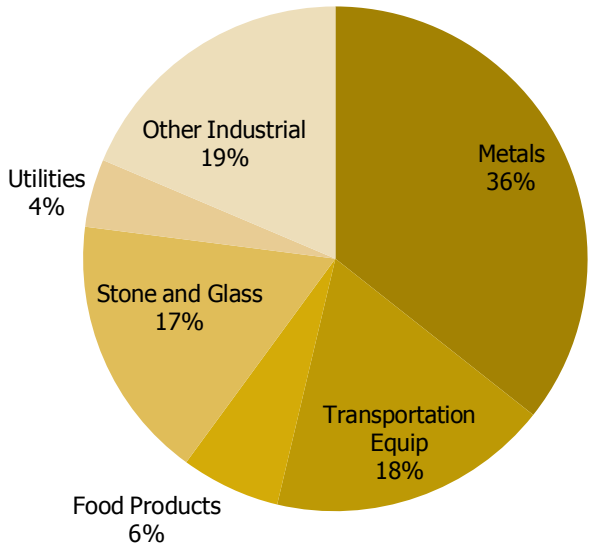


Industrial Sector Market Characterization and Market Profiles

The industrial sector used 1,294,369 MWh in 2012, as shown in Table 3-5, which represents about 13.6% of total City Light electricity sales. Figure 3-9 shows how the industrial sales break out by industry type. Using the DMI database, the study isolated the largest industries in terms of their energy use for analysis. The five major industrial segments thus identified are Metals; Transportation Equipment; Food Products; Stone and Glass, including cement; and Utilities including water and wastewater. The remaining industries were combined into the Other Industrial category. This classification was largely the same as used in the previous City Light CPA, with the segments described below, including any changes to their definitions.

- **Metals** — This segment includes not only City Light's single largest metal-industry customer, as was the case in the previous, but also other smaller customers involved in metals industries.
- **Transportation Equipment** — The previous CPA segment included an Aerospace segment. For 2013, Aerospace equipment manufacturing is included as well as other transportation equipment manufacturing. As a result, ship building activities previously included within Other Industrial have been moved to Transportation Equipment.
- **Food Production** — In the previous CPA, this segment included refrigerated warehouses. For 2013, refrigerated warehouses were being modeled within the Commercial sector, Warehouses segment.
- **Stone and Glass** — This segment primarily includes cement manufacturing and glass industries.
- **Utilities** — Water and wastewater processing are the primary industries in this segment.
- **Other industrial** — This segment comprises all remaining industrial customers.

Figure 3-9 Industrial Sector Electricity Use by Industry, 2012



Using intensity estimates for each industry type, we inferred the number of employees which is the unit of analysis in LoadMAP for the industrial sector. Table 3-9 provides 2012 sales by segment as well as the inferred number of employees for each segment.

Table 3-9 Industrial Market Segmentation by Industry Type, Base Year 2012

Industrial	Number of Employees	2012 Electricity Use (MWh)
Metals	2,766	461,409
Transportation Equip	12,539	233,474
Food Products	8,412	82,239
Stone and Glass	1,316	219,547
Utilities	873	56,590
Other Industrial	11,461	241,110
Total	**37,368**	**1,294,369**

For each of the segments defined above, we developed Energy Market Profiles that characterize electricity use in terms of sector, customer segment, end use, and technology for the base year. Table 3-10 shows the aggregate industrial market profile. The market profiles for each segment are shown in Appendix A.

Table 3-10 Total Industrial Sector Market Profile, 2012

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/Employee)	Usage (MWh)
Cooling	Air-Cooled Chiller	2.5%	2,984	75	2,788
Cooling	Water-Cooled Chiller	2.5%	3,738	93	3,492
Cooling	RTU	6.6%	4,234	280	10,471
Cooling	Air-Source Heat Pump	7.5%	3,523	266	9,935
Heating	Air-Source Heat Pump	7.5%	9,569	722	26,988
Heating	Electric Resistance	7.3%	10,048	735	27,484
Ventilation	Ventilation	100.0%	1,520	1,520	56,797
Interior Lighting	Screw-in	100.0%	217	217	8,095
Interior Lighting	High-Bay Fixtures	100.0%	711	711	26,558
Interior Lighting	Linear Fluorescent	100.0%	1,352	1,352	50,513
Exterior Lighting	Screw-in	100.0%	58	58	2,158
Exterior Lighting	HID	100.0%	345	345	12,891
Exterior Lighting	Linear Fluorescent	100.0%	23	23	864
Motors	Pumps	100.0%	1,389	1,389	51,918
Motors	Fans & Blowers	100.0%	2,200	2,200	82,221
Motors	Compressed Air	100.0%	1,315	1,315	49,152
Motors	Conveyors	100.0%	7,197	7,197	268,955
Motors	Other Motors	100.0%	1,475	1,475	55,132
Process	Process Heating	100.0%	4,855	4,855	181,408
Process	Process Cooling	100.0%	758	758	28,316
Process	Process Refrigeration	100.0%	758	758	28,316
Process	Electro-Chemical Processes	100.0%	5,899	5,899	220,425
Process	Other Process	100.0%	114	114	4,265
Miscellaneous	Miscellaneous	100.0%	2,281	2,281	85,228
	Total			**34,638**	**1,294,369**

Figure 3-10 shows the distribution of electricity energy consumption by end use for all industrial customers. Motors and Process are the largest overall end uses for the industrial sector, accounting for 39% and 36% of energy use respectively.[9] Lighting is the next highest, followed by miscellaneous, cooling, heating, and ventilation.

[9] Note that the motor sub-categories differ from the previous City Light CPA study, where they were specified in terms of horsepower size. In this study, they are specified in terms of function, to better ascribe relevant efficiency measures. The functions comprise a wide range of industrial equipment, such as air compressors, pumps, conveyor motors, and fans.

Figure 3-10 Industrial Electricity Use by End Use, 2012

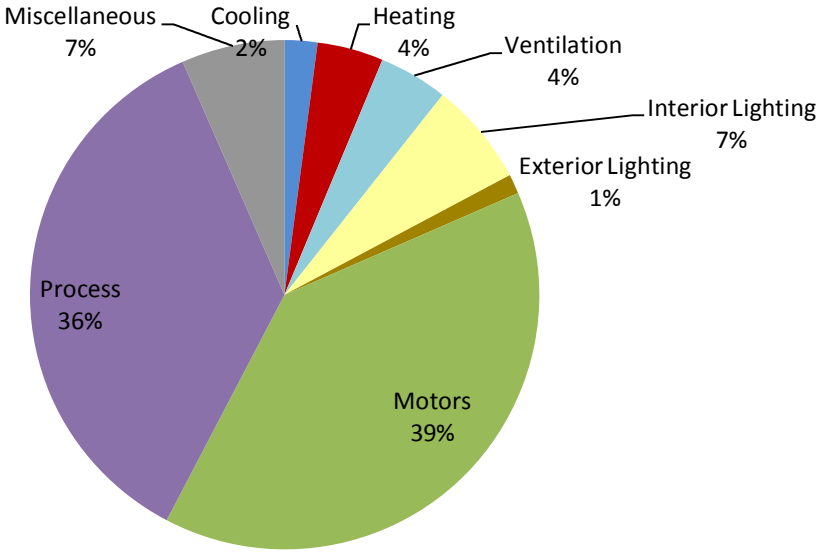


Figure 3-11 and Table 3-11 present the electricity consumption by end-use and industry type. Figure 3-12 shows each end use as a percentage of the segment's total use.

Figure 3-11 Industrial Electricity Use by End Use and Segment (MWh, 2012)

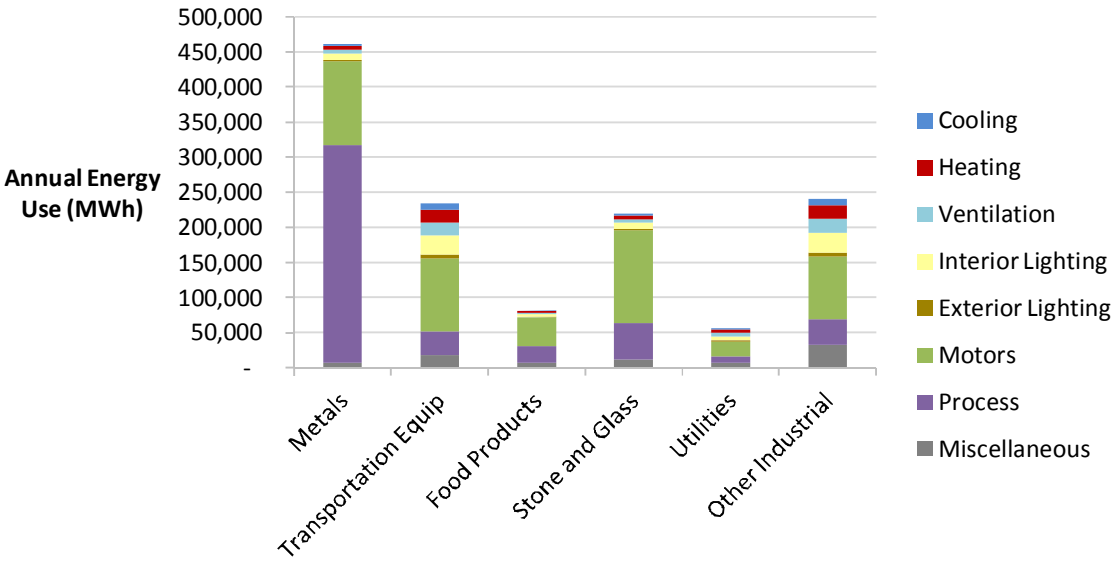
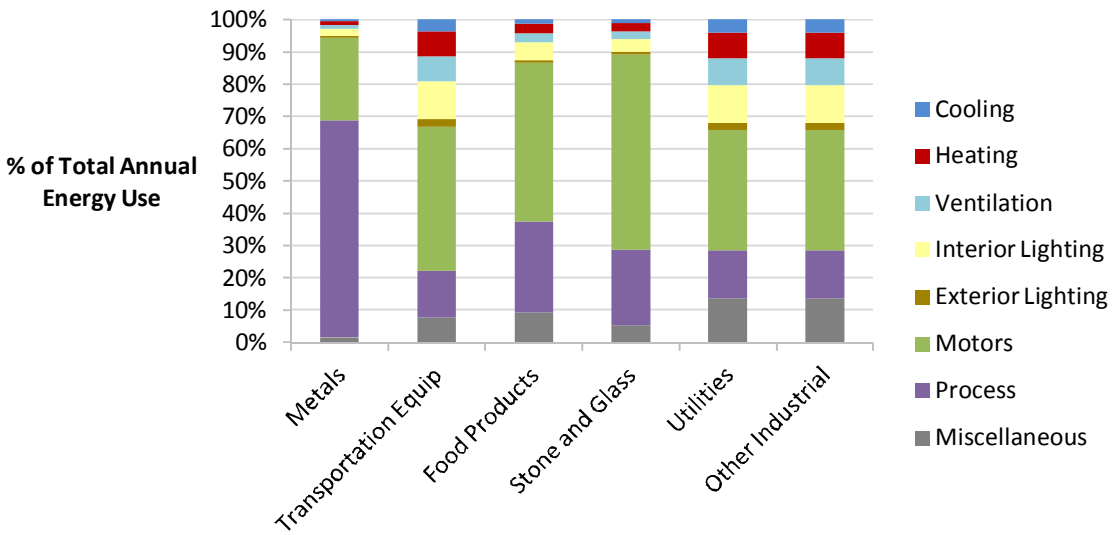


Table 3-11 Industrial Electricity Use by End Use and Segment (MWh, 2012)

End Use	Metals	Transportation Equip	Food Products	Stone and Glass	Utilities	Other Industrial	Total
Cooling	2,610	8,643	1,123	2,617	2,223	9,470	2,610
Heating	5,327	17,643	2,293	5,343	4,537	19,330	5,327
Ventilation	5,554	18,396	2,391	5,571	4,730	20,155	5,554
Interior Lighting	9,837	27,526	4,462	8,530	6,617	28,194	9,837
Exterior Lighting	1,838	5,143	834	1,594	1,236	5,268	1,838
Motors	119,085	103,995	40,352	132,575	21,170	90,199	119,085
Process	309,450	33,991	23,099	51,735	8,451	36,005	309,450
Miscellaneous	7,708	18,137	7,684	11,583	7,626	32,490	7,708
Total	**461,409**	**233,474**	**82,239**	**219,547**	**56,590**	**241,110**	**461,409**

Figure 3-12 Industrial Electricity Use by End Use and Segment, 2012



Street Lighting Characterization

City Light's 2012 EIA form 861 reports street lighting usage of 91,879 MWh. Per City Light, the 2012 count of street lighting fixtures is approximately 90,000, Seattle City Light's inventory of street lighting fixtures mainly consists of high-pressure sodium, metal halide, induction, and LED lamps. Characterization of this use is straightforward compared with the other sectors. City Light databases provide a breakdown of the street lighting inventory by fixture type, and also provide the lamp and fixture wattages for each type. The great majority of the street lighting fixtures, approximately 86%, are cobra head street lighting fixtures that traditionally use high-pressure sodium lamps. Beginning in 2010, City Light began replacing the cobra head street lighting fixtures with LED fixtures. Phase 1 of this project is expected to convert 40,763 fixtures by the end of 2013. Phase 2 of the project will begin in 2014.

Using the provided fixture counts and nominal fixture wattages, the total street lighting usage was calculated. To exactly match the street lighting usage of 91,879 MWh reported in the 2012 EIA form 861, we adjusted the timing of existing LED retrofits between 2012 and 2013. An assumption that 52% of Phase 1 retrofits occurred by 2012 provided a match to the targeted 2012 sales total.

CHAPTER | 4

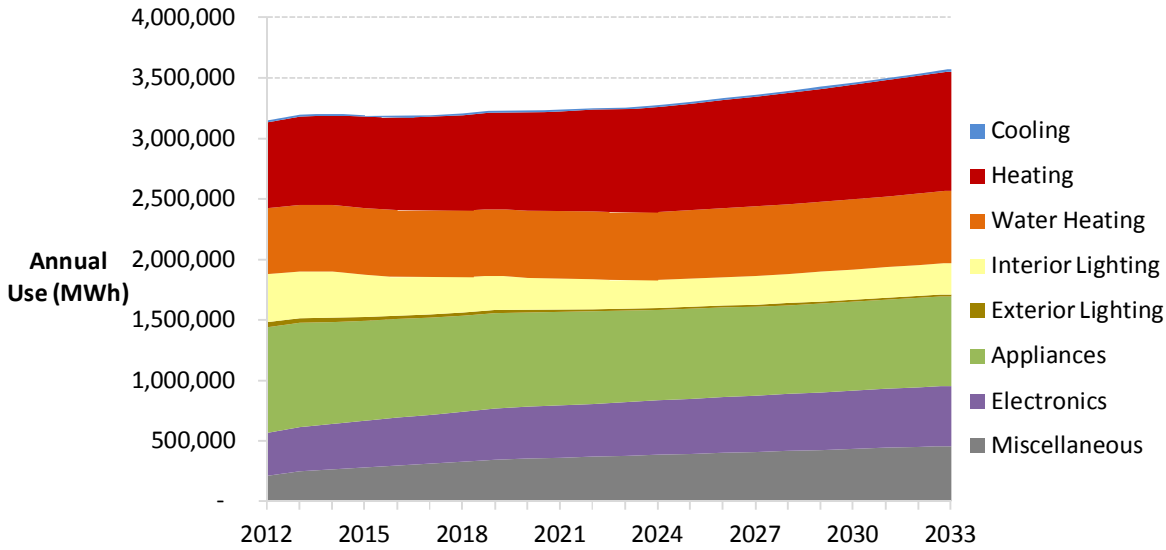
BASELINE PROJECTION

Prior to developing estimates of conservation potential, a baseline end-use projection was developed to quantify how electricity is used by end use in the base year and what the consumption is likely to be in the future in absence of new utility programs and naturally occurring conservation. The baseline projection serves as the metric against which conservation potentials are measured. The baseline projection we developed for City Light was within 5% of the City Light load forecasting group's forecast.

Residential Sector

The baseline projection incorporates assumptions about economic growth, electricity prices, and appliance/equipment standards and building codes already mandated, as described in Chapter 2. Figure 4-1 and Table 4-1 present the baseline projection at the end-use level for the residential sector as a whole. Table 4-2 shows the end-use projection at the technology level.

Figure 4-1 Residential Baseline Projection by End Use



Overall, residential use increases modestly, from 3,146,951 MWh in 2012 to 3,577,236 MWh in 2033, a 13.7% increase. Specific observations include:

- The primary reason for the modest initial growth in the baseline projection is the phase-in, beginning in 2012, of the federal Energy Independence and Security Act of 2007(EISA) lighting standards. However, because City Light has aggressively pursued lighting DSM programs over the past several years, this effect is less pronounced than would be the case otherwise. The standard causes a decline in interior lighting use by 34% and exterior lighting use by 58% over the 20-year projection period.
- Appliances energy use also decreases, due to mandated efficiency gains, particularly in refrigeration appliances.

- There is some growth in heating and cooling that reflects higher saturations of electric heating and cooling in new construction, mostly multifamily, as well as slightly larger homes and overall population growth.
- Water heating grows modestly as a result of higher electric saturations in new construction, mostly multifamily, though more efficient equipment offsets this trend.
- Growth in electricity use in electronics is substantial and reflects an increase in the saturation of electronics and the trend toward higher-powered computers, and additional devices such as electronic gaming. This increase is somewhat tempered by higher efficiency televisions.
- Growth in miscellaneous use is also substantial. This use includes various plug loads not elsewhere classified (e.g., hair dryers, power tools, coffee makers, etc.). This end use has grown consistently in the past and we incorporate future growth assumptions that are consistent with the Annual Energy Outlook.

Table 4-1 Residential Baseline Projection by End Use (MWh)

End Use	2012	2014	2015	2018	2023	2028	2033	% Change ('12-'33)	Avg. Growth Rate ('12-'33)
Cooling	12,041	13,491	13,657	14,373	15,657	16,911	18,075	**50%**	**1.9%**
Heating	708,477	742,497	755,188	787,323	853,901	921,776	987,812	**39%**	**1.6%**
Water Heating	547,407	550,314	551,792	551,937	561,616	575,007	594,405	**9%**	**0.4%**
Interior Lighting	396,876	381,617	348,877	292,762	232,458	242,939	260,534	**-34%**	**-2.0%**
Exterior Lighting	39,731	34,210	29,512	23,743	15,966	16,200	16,871	**-58%**	**-4.1%**
Appliances	875,910	843,679	829,806	794,549	755,921	733,716	742,389	**-15%**	**-0.8%**
Electronics	356,529	374,420	384,354	414,479	444,134	470,810	497,651	**40%**	**1.6%**
Miscellaneous	209,981	265,050	280,473	327,688	376,866	417,854	459,499	**119%**	**3.7%**
Total	**3,146,951**	**3,205,277**	**3,193,660**	**3,206,854**	**3,256,520**	**3,395,213**	**3,577,236**	**14%**	**0.6%**

Table 4-2 Residential Baseline Projection by End Use and Technology (MWh)

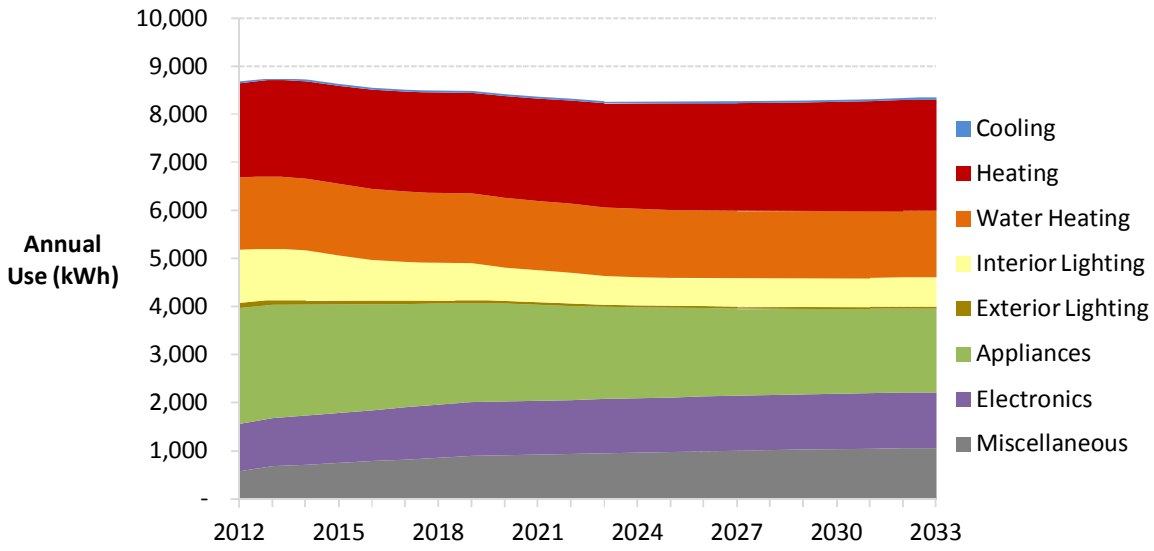
End Use	Technology	2012	2014	2015	2018	2023	2028	2033	% Change ('12-'33)	Avg. Growth Rate ('12-'33)
Cooling	Central AC	1,792	2,016	2,042	2,143	2,283	2,444	2,616	**46.0%**	**1.8%**
	Room AC	8,505	9,530	9,672	10,295	11,401	12,436	13,340	**56.8%**	**2.1%**
	Air-Source Heat Pump	1,744	1,945	1,942	1,935	1,973	2,031	2,119	**21.5%**	**0.9%**
Heating	Air-Source Heat Pump	25,873	26,270	26,273	26,239	26,842	27,707	28,826	**11.4%**	**0.5%**
	Electric Zonal Room Heat	583,618	613,442	624,870	654,242	714,977	777,213	838,179	**43.6%**	**1.7%**
	Electric Furnace	98,986	102,785	104,044	106,842	112,082	116,857	120,807	**22.0%**	**0.9%**
Water Heating	Water Heater <= 55 Gal	513,300	516,175	518,567	521,989	536,862	555,070	576,848	**12.4%**	**0.6%**
	Water Heater > 55 Gal	34,107	34,139	33,225	29,948	24,754	19,937	17,557	**-48.5%**	**-3.2%**
Interior Lighting	Screw-in	300,237	284,733	250,587	205,131	141,018	146,512	156,305	**-47.9%**	**-3.1%**
	Linear Fluorescent	21,226	21,943	22,367	23,298	25,202	27,234	29,214	**37.6%**	**1.5%**
	Specialty	75,412	74,941	75,924	64,333	66,239	69,194	75,014	**-0.5%**	**0.0%**
Exterior Lighting	Screw-in	39,731	34,210	29,512	23,743	15,966	16,200	16,871	**-57.5%**	**-4.1%**
Appliances	Clothes Washer	33,193	33,783	33,299	31,554	27,996	24,547	23,752	**-28.4%**	**-1.6%**
	Clothes Dryer	176,862	173,856	170,740	162,657	152,656	148,732	151,535	**-14.3%**	**-0.7%**
	Dishwasher	100,995	92,343	90,429	89,052	88,821	90,381	94,041	**-6.9%**	**-0.3%**
	Refrigerator	281,742	263,059	254,776	231,631	204,969	185,377	182,337	**-35.3%**	**-2.1%**
	Freezer	54,705	54,811	54,916	54,548	52,421	49,982	47,645	**-12.9%**	**-0.7%**
	Second Refrigerator	64,628	58,689	56,248	50,085	44,026	39,768	38,569	**-40.3%**	**-2.5%**
	Stove	125,500	127,256	128,562	131,544	138,495	145,745	152,747	**21.7%**	**0.9%**
	Microwave	38,286	39,882	40,838	43,478	46,537	49,184	51,762	**35.2%**	**1.4%**

Table 4-2 Residential Baseline Projection by End Use and Technology (MWh) (continued)

End Use	Technology	2012	2014	2015	2018	2023	2028	2033	% Change ('12-'33)	Avg. Growth Rate ('12-'33)
Electronics	Personal Computers	74,525	71,134	69,909	72,599	77,602	82,216	86,828	**16.5%**	**0.7%**
	Monitor	15,447	15,767	16,418	19,193	20,832	22,035	23,162	**49.9%**	**1.9%**
	Laptops	34,797	35,101	35,681	38,063	40,947	43,529	46,095	**32.5%**	**1.3%**
	TVs	103,664	105,192	106,647	111,246	116,551	122,293	128,340	**23.8%**	**1.0%**
	Printer/copier/fax	12,305	12,218	12,332	12,887	13,692	14,471	15,263	**24.0%**	**1.0%**
	Set-top Boxes/DVR	98,105	115,174	122,307	135,534	145,964	154,902	163,648	**66.8%**	**2.4%**
	Devices and Gadgets	17,687	19,834	21,059	24,958	28,546	31,363	34,315	**94.0%**	**3.2%**
Miscellaneous	Pool Pump	4,190	4,317	4,393	4,580	4,907	5,222	5,505	**31.4%**	**1.3%**
	Pool Heater	3,479	3,433	3,438	3,484	3,691	3,925	4,118	**18.4%**	**0.8%**
	Hot Tub / Spa	24,128	24,866	25,306	26,397	28,310	30,161	31,835	**31.9%**	**1.3%**
	Furnace Fan	33,580	34,431	34,957	36,234	38,535	40,767	42,689	**27.1%**	**1.1%**
	Miscellaneous	144,604	198,003	212,380	256,993	301,423	337,779	375,351	**159.6%**	**4.5%**
Grand Total		**3,146,951**	**3,205,277**	**3,193,660**	**3,206,854**	**3,256,520**	**3,395,213**	**3,577,236**	**13.7%**	**0.6%**

Figure 4-2 presents the projection of use per household. Most noticeable once again is that lighting use decreases significantly after 2012, as the EISA lighting standard comes into effect. Appliance use also decreases over the study period due to appliance standards. However, growth in miscellaneous end uses and electronics keeps energy use per household relatively flat.

Figure 4-2 Residential Baseline Electricity Use per Household by End Use



Commercial Sector

Electricity use in the commercial sector continues to grow during the study horizon, as new commercial construction increases overall square footage in the commercial sector. In addition, existing buildings are renovated to incorporate additional amenities, such as full-scale kitchens and work-out facilities. Consumption starts at 4,961,098 MWh in 2012 and increases to 7,713,040 MWh in 2033, an overall growth of 55%, or average annual growth of 2.1%.

Figure 4-3 and Table 4-3 present the baseline projection at the end-use level for the commercial sector as a whole. All end uses show growth over the study period, with the exception of cooling. Growth in lighting is less than in the other end uses, due to the EISA lighting standards. Table 4-4 presents the commercial sector projection by technology.

Specific observations include:

- Growth in the HVAC and water heating end uses is commensurate with projected growth in floor space and employment, the two principal drivers of commercial sector consumption. Air conditioning increases at a slightly greater rate as more buildings add air conditioning systems, while ventilation grows more slowly due to the trend toward VAV systems in new construction.
- Food preparation, though remaining a small percentage of total usage, grows at a higher rate than other end uses. This reflects the addition of kitchen facilities to commercial office buildings during new construction or renovation, as well as the expansion of food service offerings in other building types as well.
- Refrigeration drops substantially as new standards take effect that cover most types of commercial refrigeration equipment.
- Lighting energy grows at a lower rate than most end uses, driven by the EISA lighting standards. For linear fluorescent lighting, the effects of the EISA standards have largely already occurred prior to the

start of the study period, because City Light lighting programs have led to the replacement of most T-12 lighting systems with more efficient T-8s. As a result, linear fluorescent use grows by 24%. On the other hand, the baseline projection indicates that EISA's effects during 2012-2015 will be most evident for screw in lighting, causing energy use for this technology to remain nearly flat for interior lighting and to drop for exterior lighting.

- Energy use for computers, servers, printers, and other office equipment continues to grow, due to increased saturation of this category, even as the efficiency of individual units increases.
- Consumption by miscellaneous equipment, which includes a wide range of plug loads, also increases. This reflects the assumption that plug loads continue to increase in the commercial sector as we embrace new uses of electricity.

Figure 4-3 Commercial Baseline Electricity Projection by End Use

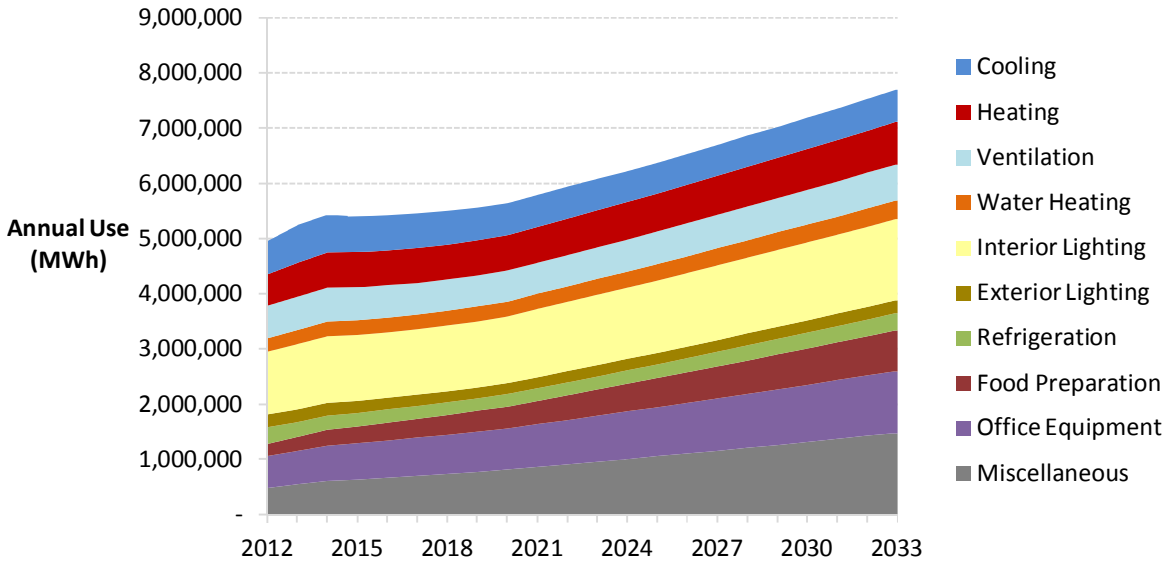


Table 4-3 Commercial Electricity Consumption by End Use (MWh)

End Use	2012	2014	2015	2018	2023	2028	2033	% Change ('12-'33)	Avg. Growth Rate ('12-'33)
Cooling	598,538	679,906	655,527	605,016	567,487	558,664	583,042	**-3%**	**-0.1%**
Heating	577,361	642,762	636,899	634,664	669,058	720,554	771,627	**34%**	**1.4%**
Ventilation	584,612	608,038	591,863	567,921	574,062	613,008	652,325	**12%**	**0.5%**
Water Heating	242,308	266,602	265,391	268,967	288,688	313,855	337,883	**39%**	**1.6%**
Interior Lighting	1,141,908	1,214,488	1,194,876	1,187,526	1,272,794	1,377,796	1,472,666	**29%**	**1.2%**
Exterior Lighting	228,834	227,547	217,518	202,538	205,697	220,122	233,942	**2%**	**0.1%**
Refrigeration	298,653	259,759	247,168	228,329	236,110	270,520	310,206	**4%**	**0.2%**
Food Preparation	222,049	282,960	299,257	356,226	475,295	605,775	739,950	**233%**	**5.7%**
Office Equipment	581,377	647,275	657,493	707,874	832,361	975,618	1,124,339	**93%**	**3.1%**
Miscellaneous	485,475	605,759	636,234	742,348	960,740	1,213,504	1,487,059	**206%**	**5.3%**
Total	**4,961,114**	**5,435,096**	**5,402,226**	**5,501,409**	**6,082,292**	**6,869,417**	**7,713,040**	**55%**	**2.1%**

Table 4-4 Commercial Baseline Electricity Projection by End Use and Technology (MWh)

End Use	Technology	2012	2014	2015	2018	2023	2028	2033	% Change ('12-'33)	Avg. Growth Rate ('12-'33)
Cooling	Air-Cooled Chiller	108,872	131,696	130,094	129,672	135,377	143,059	152,068	39.7%	1.6%
	Water-Cooled Chiller	157,883	173,455	165,275	152,419	143,214	139,114	142,428	-9.8%	-0.5%
	Roof top AC	217,876	244,555	234,562	208,265	180,722	168,833	179,501	-17.6%	-0.9%
	Air Source Heat Pump	85,264	94,846	90,421	79,198	70,323	66,468	64,384	-24.5%	-1.3%
	Other Cooling	28,643	35,353	35,175	35,462	37,851	41,191	44,661	55.9%	2.1%
Heating	Electric Furnace	354,207	397,980	395,616	398,529	424,604	459,924	493,227	39.2%	1.6%
	Air Source Heat Pump	190,736	199,174	191,971	175,261	162,392	156,636	152,793	-19.9%	-1.1%
	Electric Zonal Heat	32,418	45,608	49,312	60,874	82,062	103,994	125,608	287.5%	6.4%
Ventilation	Ventilation	584,612	608,038	591,863	567,921	574,062	613,008	652,325	11.6%	0.5%
Water Heating	Water Heater	242,308	266,602	265,391	268,967	288,688	313,855	337,883	39.4%	1.6%
Interior Lighting	Screw-in	207,807	171,648	152,958	129,275	139,702	150,179	158,305	-23.8%	-1.3%
	High-Bay Fixtures	146,592	152,891	148,822	137,902	135,302	151,281	154,496	5.4%	0.3%
	Linear Fluorescent	787,509	889,949	893,096	920,348	997,790	1,076,337	1,159,865	47.3%	1.8%
Exterior Lighting	Screw-in	54,086	47,961	44,666	40,044	44,171	48,267	51,640	-4.5%	-0.2%
	HID	118,320	117,053	110,610	100,023	96,300	101,687	106,841	-9.7%	-0.5%
	Linear Fluorescent	56,428	62,533	62,242	62,471	65,226	70,168	75,461	33.7%	1.4%
Refrigeration	Walk-in Refrigerator	68,059	66,842	64,195	62,424	71,501	87,419	105,299	54.7%	2.1%
	Reach-in Refrigerator	6,891	6,160	5,644	4,823	4,781	5,593	6,694	-2.8%	-0.1%
	Glass Door Display	85,590	48,543	44,724	37,902	35,115	39,215	44,034	-48.6%	-3.2%
	Open Display Case	70,596	69,139	65,837	61,334	63,606	70,935	79,278	12.3%	0.6%
	Icemaker	34,011	36,763	36,354	36,670	40,357	45,432	50,673	49.0%	1.9%
	Vending Machine	33,507	32,312	30,415	25,177	20,751	21,927	24,227	-27.7%	-1.5%

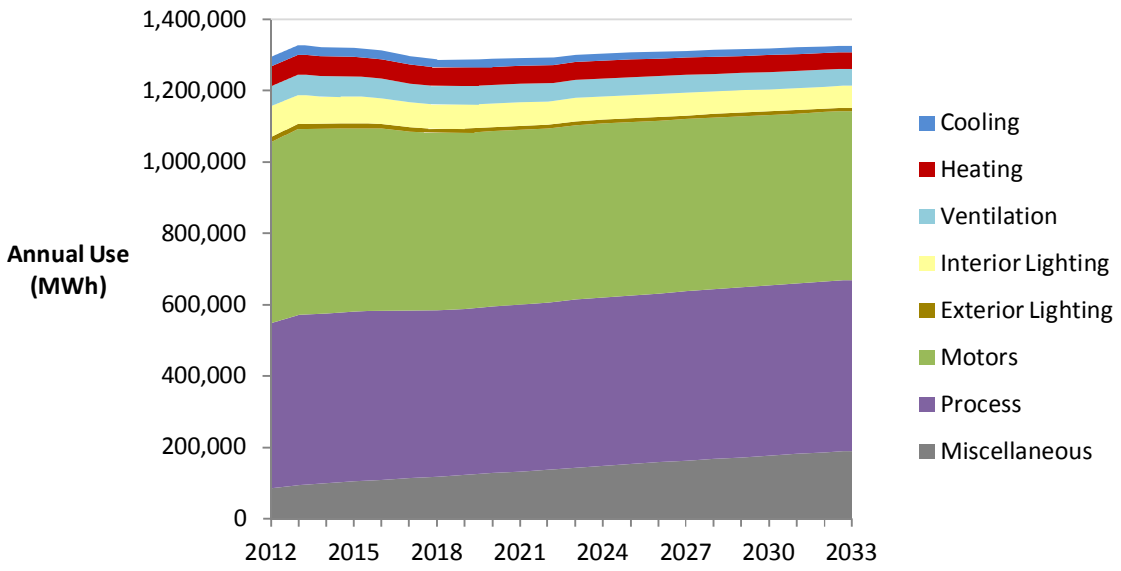
Table 4-4 Commercial Baseline Electricity Projection by End Use and Technology (MWh) (continued)

End Use	Technology	2012	2014	2015	2018	2023	2028	2033	% Change ('12-'33)	Avg. Growth Rate ('12-'33)
Food Preparation	Oven	42,851	67,980	78,017	109,408	168,903	227,208	286,999	569.8%	9.1%
	Fryer	26,318	30,385	30,767	32,627	37,263	42,489	47,685	81.2%	2.8%
	Dishwasher	143,594	174,791	180,552	203,456	255,701	318,919	384,049	167.5%	4.7%
	Hot Food Container	9,286	9,804	9,922	10,735	13,428	17,160	21,217	128.5%	3.9%
Office Equipment	Desktop Computer	196,031	213,177	211,911	217,570	241,906	271,002	300,687	53.4%	2.0%
	Laptop	34,821	38,070	38,061	39,492	43,964	49,316	54,791	57.3%	2.2%
	Server	254,091	292,727	304,398	342,730	423,375	514,527	609,951	140.1%	4.2%
	Monitor	54,644	57,089	56,632	58,531	65,073	72,898	80,879	48.0%	1.9%
	Printer/Copier/Fax	33,490	37,627	38,059	41,063	48,934	57,919	67,220	100.7%	3.3%
	POS Terminal	8,300	8,584	8,432	8,489	9,110	9,956	10,811	30.2%	1.3%
Miscellane-ous	Non-HVAC Motors	52,438	58,655	58,616	59,904	64,777	70,713	76,655	46.2%	1.8%
	Pool Pump	900	1,028	1,035	1,080	1,207	1,346	1,482	64.6%	2.4%
	Pool Heater	158	181	183	192	217	244	269	70.3%	2.5%
	Miscellaneous	431,980	545,895	576,399	681,171	894,538	1,141,201	1,408,653	226.1%	5.6%
Grand Total		**4,961,114**	**5,435,096**	**5,402,226**	**5,501,409**	**6,082,292**	**6,869,417**	**7,713,040**	**55.5%**	**2.1%**

Industrial Sector

The industrial sector as defined for the CPA (see Table makes up only 14% of City Light's total electricity usage. Figure 4-4 and Table 4-5 present the baseline projection at the end-use level for the industrial sector as a whole. Overall, industrial annual energy use increases modestly from 1,294.369 MWh in 2012 to 1,327,294 MWh in 2033, a 2.5% increase. Equipment standards for lighting and HVAC equipment cause these uses to decline and keep the baseline projection or less flat during the first years of the forecast. However, projected industrial growth, as well as increased use of industrial automation, which is included here in the miscellaneous category, cause the overall forecast to grow slightly. Table 4-6 shows the baseline projection at the technology level.

Figure 4-4 Industrial Baseline Electricity Projection by End Use



Street Lighting

As discussed in Chapter 3, City Light provided data on its existing 90,000 fixtures, including information on fixture type, lamp type, and lamp wattage. Reported street lighting use in 2012 was 91,879 MWh. EnerNOC's analysis projects that the remaining planned conversions of cobra head fixtures to LEDs will drop 2013 use to 88,592 kWh. For the 2014–2033 timeframe, it was assumed that no additional poles or luminaires will be added to the system. Therefore, in the baseline case, use remains constant at 88,592 kWh for the study period.

Baseline Projection Summary for All Sectors

Table 4-7 and Figure 4-5 provide an overall summary of the baseline projection by sector and for City Light as a whole. Overall, the projection for the next 20 years grows steadily, dominated by growth in the commercial sector, as discussed above.

Table 4-5 Industrial Electricity Consumption by End Use (MWh)

End Use	2012	2014	2015	2018	2023	2028	2033	% Change ('12-'33)	Avg. Growth Rate ('12-'33)
Cooling	26,686	26,313	25,754	23,574	20,989	19,230	18,274	**-32%**	**-1.8%**
Heating	54,472	55,097	54,561	51,869	49,872	48,102	46,516	**-15%**	**-0.8%**
Ventilation	56,797	56,694	55,828	52,533	50,578	48,956	47,381	**-17%**	**-0.9%**
Interior Lighting	85,166	76,566	74,965	67,833	65,619	63,311	61,449	**-28%**	**-1.6%**
Exterior Lighting	15,913	13,946	13,389	11,777	10,843	10,447	10,135	**-36%**	**-2.1%**
Motors	507,377	517,826	515,436	496,815	489,140	481,223	473,309	**-7%**	**-0.3%**
Process	462,731	475,478	476,478	466,274	471,012	475,448	479,884	**4%**	**0.2%**
Miscellaneous	85,228	98,937	104,318	117,533	143,144	167,405	190,347	**123%**	**3.8%**
Total	**1,294,369**	**1,320,856**	**1,320,729**	**1,288,208**	**1,301,196**	**1,314,122**	**1,327,294**	**2.5%**	**0.1%**

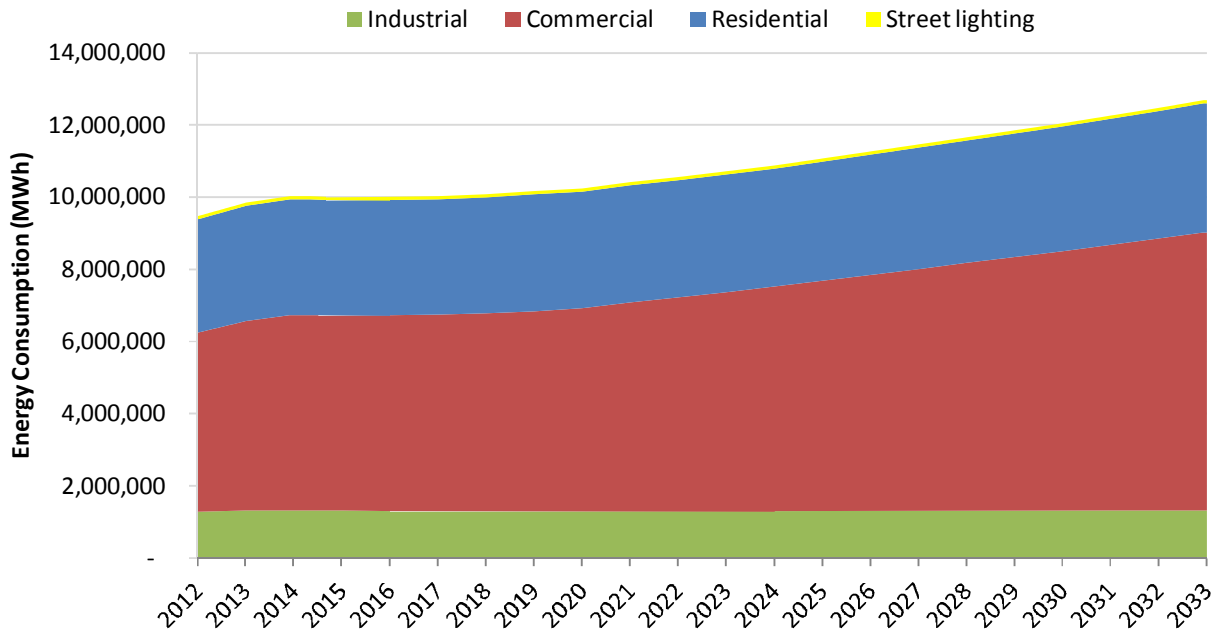
Table 4-6 Industrial Baseline Electricity Projection by End Use and Technology (MWh)

End Use	Technology	2012	2014	2015	2018	2023	2028	2033	% Change ('12-'33)	Avg. Growth Rate ('12-'33)
Cooling	Air-Cooled Chiller	2,788	2,822	2,795	2,653	2,531	2,406	2,308	**-17.2%**	**-0.9%**
	Water-Cooled Chiller	3,492	3,484	3,438	3,182	2,727	2,267	2,019	**-42.2%**	**-2.6%**
	Air Source Heat Pump	9,935	9,751	9,519	8,641	7,653	7,077	6,778	**-31.8%**	**-1.8%**
	RTU	10,471	10,256	10,002	9,098	8,077	7,481	7,168	**-31.5%**	**-1.8%**
Heating	Air Source Heat Pump	26,988	27,158	26,841	25,381	24,162	23,186	22,392	**-17.0%**	**-0.9%**
	Electric Resistance	27,484	27,939	27,720	26,488	25,709	24,916	24,123	**-12.2%**	**-0.6%**
Ventilation	Ventilation	56,797	56,694	55,828	52,533	50,578	48,956	47,381	**-16.6%**	**-0.9%**
Interior Lighting	Screw-in	8,095	5,889	5,640	4,613	4,621	4,635	4,599	**-43.2%**	**-2.7%**
	High-Bay Fixtures	26,558	20,207	19,462	16,137	16,201	15,488	14,994	**-43.5%**	**-2.7%**
	Linear Fluorescent	50,513	50,469	49,863	47,083	44,797	43,187	41,856	**-17.1%**	**-0.9%**
Exterior Lighting	Screw-in	2,158	1,159	1,059	844	845	848	841	**-61.0%**	**-4.5%**
	HID	12,891	11,917	11,469	10,122	9,228	8,859	8,578	**-33.5%**	**-1.9%**
	Linear Fluorescent	864	871	860	810	771	741	716	**-17.1%**	**-0.9%**
Motors	Pumps	51,918	53,106	52,996	51,561	51,420	51,276	51,132	**-1.5%**	**-0.1%**
	Fans & Blowers	82,221	83,963	83,631	80,818	79,850	78,852	77,856	**-5.3%**	**-0.3%**
	Compressed Air	49,152	50,322	50,253	48,863	48,774	48,667	48,561	**-1.2%**	**-0.1%**
	Conveyors	55,132	56,484	56,444	54,914	54,913	54,884	54,855	**-0.5%**	**0.0%**
	Other Motors	268,955	273,951	272,111	260,659	254,184	247,543	240,905	**-10.4%**	**-0.5%**
Process	Process Cooling	181,408	185,916	185,825	180,833	180,930	180,924	180,918	**-0.3%**	**0.0%**
	Process Heating	4,265	4,343	4,311	4,117	3,998	3,876	3,754	**-12.0%**	**-0.6%**
	Process Refrigeration	28,316	28,855	28,680	27,592	27,039	26,477	25,916	**-8.5%**	**-0.4%**
	Electrochemical Process	28,316	28,855	28,680	27,592	27,039	26,477	25,916	**-8.5%**	**-0.4%**
	Other Process	220,425	227,509	228,982	226,140	232,006	237,693	243,381	**10.4%**	**0.5%**
Miscellaneous	Miscellaneous	85,228	98,937	104,318	117,533	143,144	167,405	190,347	**123.3%**	**3.8%**
Grand Total		**1,081,568**	**1,294,369**	**1,320,856**	**1,320,729**	**1,288,208**	**1,301,196**	**1,314,122**	**1,327,294**	**2.5%**

Table 4-7 Baseline Projection Summary (MWh)

Sector	2012	2014	2015	2018	2023	2028	2033	% Change ('12-'33)	Avg. Growth Rate ('12-'33)
Residential	3,146,951	3,205,277	3,193,660	3,206,854	3,256,520	3,395,213	3,577,236	13.7%	0.6%
Commercial	4,961,114	5,435,096	5,402,226	5,501,409	6,082,292	6,869,417	7,713,040	55.5%	2.1%
Industrial	1,294,369	1,320,856	1,320,729	1,288,208	1,301,196	1,314,122	1,327,294	2.5%	0.1%
Street Lighting	91,879	88,592	88,592	88,592	88,592	88,592	88,592	-3.6%	-0.2%
Total	9,494,313	10,049,821	10,005,208	10,085,063	10,728,599	11,667,344	12,706,161	33.8%	1.4%

Figure 4-5 Baseline Projection Summary (MWh)



CHAPTER | 5

CONSERVATION POTENTIAL

This chapter presents the results of the potential analysis. First, we provide the overall potential, followed by results for each sector. Based on the total achievable potential of 118.4 aMW in 2023, City Light is establishing a conservation target for the 2014–2015 biennium of 23.7 aMW, which is 20% of the ten-year cumulative potential (118.4 aMW in 2023).

Overall Potential

Figure 5-1 and Table 5-1 summarize the achievable potential across all sectors. The commercial sector, which accounts for 59% of baseline use in 2023, is projected to provide approximately 66% of cumulative achievable potential in that same year.

Figure 5-1 Cumulative Achievable Potential by Sector (MWh)

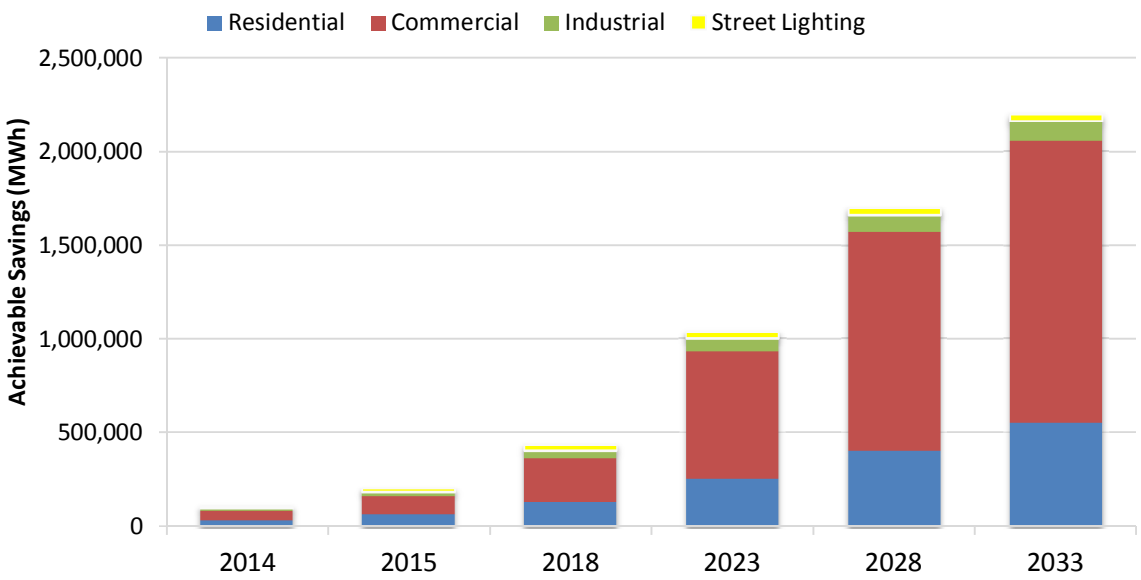


Table 5-1 Cumulative Achievable Potential by Sector (MWh)

	2014	2015	2018	2023	2028	2033
Achievable Cumulative Savings (MWh)						
Residential	28,500	59,974	127,865	249,900	398,666	548,450
Commercial	47,025	95,335	234,290	680,625	1,172,913	1,503,855
Industrial	14,509	22,765	37,031	69,591	90,627	106,463
Street Lighting	9,950	19,901	34,185	36,861	36,876	36,876
Total	**99,985**	**197,975**	**433,371**	**1,036,977**	**1,699,082**	**2,195,644**
Achievable Cumulative Savings (aMW)						
Residential	3.3	6.8	14.6	28.5	45.5	62.6
Commercial	5.4	10.9	26.7	77.7	133.9	171.7
Industrial	1.7	2.6	4.2	7.9	10.3	12.2
Street Lighting	1.1	2.3	3.9	4.2	4.2	4.24
Total	**11.4**	**22.6**	**49.5**	**118.4**	**194.0**	**250.6**

Table 5-2 presents the baseline projections of energy consumption, as well as the three levels of cumulative conservation potential for the residential, commercial, industrial, and street lighting sectors combined. As discussed in detail in Chapter 4, the baseline projection across all sectors increases over the 20-year time period. This is due largely to the growth in the commercial sector, which is tempered somewhat due to appliance and equipment standards, building codes, and a sluggish economy in the initial years. Key findings related to potentials are summarized below.

- **Achievable potential** across the four sectors is 197,975 MWh (22.6 aMW) in 2015 or 2.0% of the projected baseline. Cumulative achievable potential grows to 1,036,977 MWh or 118.4 aMW in 2023. This level of savings is consistent with other EnerNOC potential studies for utilities with mature conservation programs.
- **Economic potential**, which reflects the savings when all cost-effective measures are taken, is 57.5 aMW in 2015 or 5% of the projected baseline consumption. Cumulative economic potential is 179.8 aMW in 2023.
- **Technical potential,** which reflects the adoption of all conservation measures regardless of cost-effectiveness, is a theoretical upper bound on savings. In 2013, technical potential is 74.9 aMW or 6.6% of the baseline projection. In 2023, cumulative technical potential savings are 249.4 aMW.

Table 5-2 Summary of Achievable, Economic, and Technical Conservation Potential, All Sectors

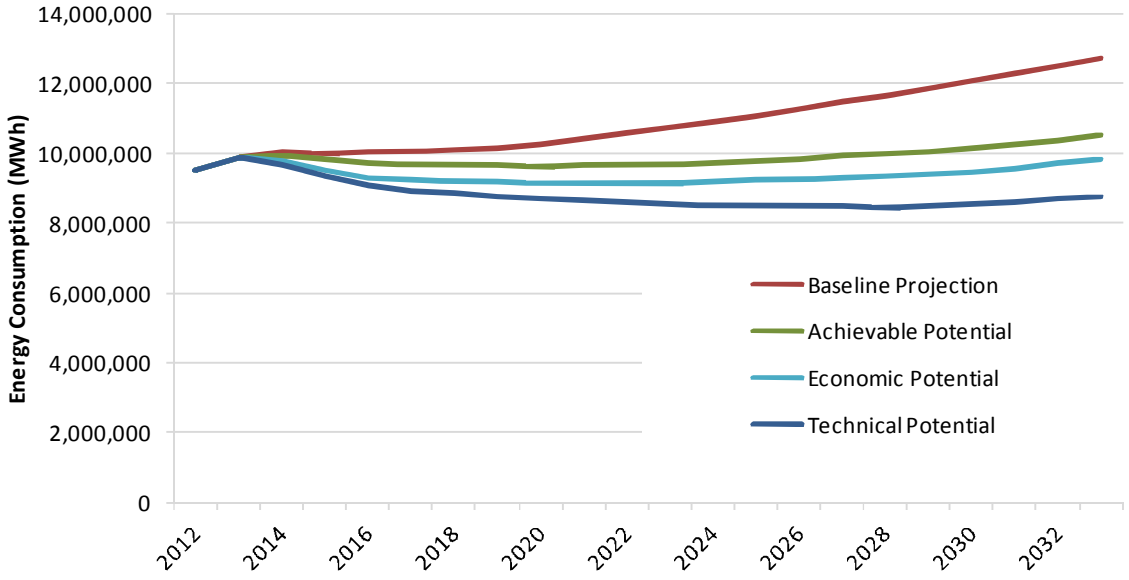
	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	10,049,821	10,005,208	10,085,063	10,728,599	11,667,344	12,706,161
Cumulative Savings (MWh)						
Achievable Potential	99,985	197,975	433,371	1,036,977	1,699,082	2,195,644
Economic Potential	285,794	504,001	911,503	1,574,823	2,342,961	2,893,157
Technical Potential	376,456	656,464	1,243,763	2,185,003	3,209,910	3,938,790
Cumulative Savings (aMW)						
Achievable Potential	11.4	22.6	49.5	118.4	194.0	250.6
Economic Potential	32.6	57.5	104.1	179.8	267.5	330.3
Technical Potential	43.0	74.9	142.0	249.4	366.4	449.6

Per WAC 194-37-070 (6), the NPCC methodology yields a maximum penetration rate after 20 years of 85% for non-lost opportunity measures and 65% for lost opportunity measures achieved through a mix of utility programs and local, state and federal codes and standards. For 10-year potential, the penetration rates are 64% for non-lost opportunity measures and 23% for lost opportunity measures with a weighted average of 46% for both.[10] The results of this CPA analysis show 10-year achievable potential for the residential, commercial, and industrial sectors combined that is 65% of the economic (cost-effective) potential, greater than the 46% weighted average cited in WAC 194-37-070. Note that the CPA projection of achievable savings is attributed to utility programs and market transformation efforts (such as NEEA activities supported by City Light and other regional utilities) and excludes savings due to codes and standards, which are incorporated in the baseline projection. The CPA projection of achievable 20-year potential for lost and non-lost opportunities combined is 76%.

[10] http://apps.leg.wa.gov/WAC/default.aspx?cite=194-37&full=true#194-37-070, 194-37-070, (6) (a) (xii).

Figure 5-2 displays the baseline and conservation potential projections.

Figure 5-2 Baseline and Conservation Potential Energy Projections (MWh)



Residential Sector

Table 5-3 presents estimates for the three types of potential for the residential sector.

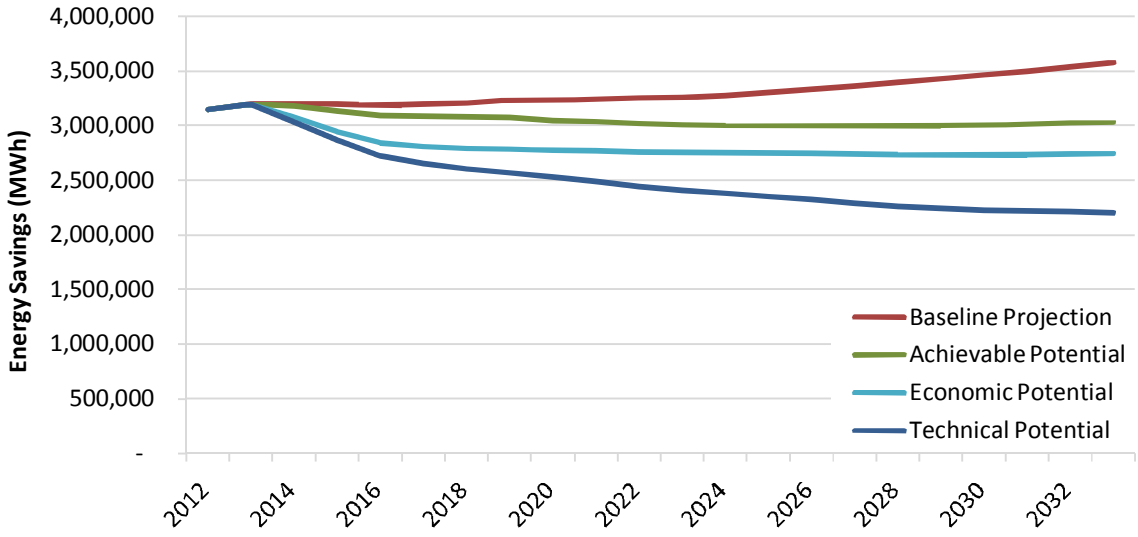
Table 5-3 Conservation Potential for the Residential Sector

	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	3,205,277	3,193,660	3,206,854	3,256,520	3,395,213	3,577,236
Cumulative Savings (MWh)						
Achievable Potential	28,500	59,974	127,865	249,900	398,666	548,450
Economic Potential	130,668	247,102	415,827	504,274	662,997	833,258
Technical Potential	173,554	327,293	604,761	845,762	1,136,914	1,375,499
Cumulative Savings (aMW)						
Achievable Potential	3.3	6.8	14.6	28.5	45.5	62.6
Economic Potential	14.9	28.2	47.5	57.6	75.7	95.1
Technical Potential	19.8	37.4	69.0	96.5	129.8	157.0

- **Achievable potential** is 59,974 MWh (6.8 aMW) in 2015, equivalent to 1.9% of the baseline projection. By 2023, the cumulative achievable conservation savings are 249,900 MWh (29 aMW).
- **Economic potential**, which reflects the savings when all cost-effective measures are taken, is 247,102 MWh (28.2 aMW) in 2015, 7.7% of the baseline energy projection. By 2023, economic potential reaches 504,274 MWh. The relatively wide gap between achievable and economic potential reflects the fact that substantial savings are available from emerging technology measures such as ductless heat pumps and heat pump water heaters, which face substantial market barriers.
- **Technical potential**, which reflects the adoption of all energy conservation measures regardless of cost, is a theoretical upper bound on savings. In 2015, technical potential is 327,293 MWh (37.4 aMW), or 10.2% of the baseline energy projection. The 10-year technical potential is 845,762 MWh.

Figure 5-3 displays the projections under the three types of potential along with the baseline projection. In 2033, achievable potential, as indicated by the green line, offsets the growth projected in the baseline case.

Figure 5-3 Residential Baseline and Conservation Potential Projection



Residential Potential by End Use, Technology, and Measure Type

Table 5-4 provides estimates of savings for each end use and type of potential. Focusing first on technical and economic potential, there are significant savings that are both possible and economic in numerous end uses:

- **Heating** offers the highest technical potential, which would be achieved if all electric furnaces were replaced with SEER 16 heat pumps (either when furnaces fail or by installing a heat pump in lieu of a furnace during new construction) and all electric resistance heat was converted to ductless minisplit systems. Ductless minisplit conversions pass the economic screen as early as 2014 in existing construction in single family and multiplex housing.
- **Water Heating** offers the second-largest technical potential, which reflects the across the board-installation of heat pump water heaters and solar water heating. However, solar water heating is not found to be cost-effective.
- **Home electronics** offers the third-largest technical potential savings. Much of the savings come from TVs. Note that in order to calibrate with City Light's historical savings, which include NEEA's savings, we used a market baseline similar to that used in the Sixth Plan. However, the market has transformed significantly, such that almost all TVs now sold are ENERGY STAR labeled.
- **Interior lighting** is close behind electronics. For technical potential, LED lamps are the most efficient option, which drives the high level of technical potential. LEDs are cost-effective for standard screw-in lighting in most cases starting in 2014, which also leads to a high level of economic potential.
- **Appliances** offer relatively little potential, as compared to years past. Current equipment efficiency standards have moved the baseline unit to a relatively high efficiency level.

Table 5-4 Residential Cumulative Savings by End Use and Potential Type (MWh)

End Use	Potential Case	2014	2015	2018	2023	2028	2033
Cooling	Achievable	37	53	58	73	95	123
	Economic	105	107	116	139	175	221
	Technical	86	98	250	720	1,292	1,693
Heating	Achievable	2,373	4,458	11,912	34,982	64,737	99,092
	Economic	17,082	26,441	51,963	96,433	141,460	192,836
	Technical	40,840	71,573	156,257	285,030	404,654	531,209
Water Heating	Achievable	2,096	3,583	8,332	29,231	65,467	128,748
	Economic	16,779	26,318	58,338	119,386	179,458	244,172
	Technical	27,467	44,766	101,431	203,094	304,377	350,741
Interior Lighting	Achievable	13,581	32,359	61,444	84,901	122,415	152,188
	Economic	60,227	131,702	178,268	121,642	138,657	167,657
	Technical	62,400	135,655	187,875	140,390	162,307	190,155
Exterior Lighting	Achievable	1,191	2,996	5,214	6,614	9,612	10,963
	Economic	5,616	12,691	16,192	9,368	10,912	11,918
	Technical	5,893	12,891	16,354	9,725	11,530	12,901
Appliances	Achievable	2,949	4,092	5,645	9,210	13,448	18,820
	Economic	7,784	8,035	9,599	13,670	18,594	24,977
	Technical	9,728	12,177	19,703	34,012	50,685	65,113
Electronics	Achievable	5,560	11,327	33,749	82,723	119,859	134,264
	Economic	20,758	39,062	97,465	138,475	167,102	183,622
	Technical	23,963	45,731	115,217	160,103	184,221	203,365
Miscellaneous	Achievable	713	1,106	1,510	2,166	3,033	4,253
	Economic	2,318	2,746	3,885	5,160	6,640	7,855
	Technical	3,177	4,402	7,672	12,688	17,847	20,322
Total	**Achievable**	**28,500**	**59,974**	**127,865**	**249,900**	**398,666**	**548,450**
	Economic	**130,668**	**247,102**	**415,827**	**504,274**	**662,997**	**833,258**
	Technical	**173,554**	**327,293**	**604,761**	**845,762**	**1,136,914**	**1,375,499**

Moving from technical and economic potential to achievable potential, we focus on the residential cumulative achievable potential in 2015, as shown in Figure 5-4.

- **Interior lighting** provides the greatest achievable potential, with savings from both standard screw-in and specialty lighting. The study assumes that LED costs will continue to drop rapidly, and that they will be accepted by consumers.
- **Home electronics** offers the second largest achievable potential in the near term. A large portion of the savings is due to televisions. As noted above, the baseline for televisions was adjusted to more closely correspond to that used by NEEA for calculating savings. However, the market has transformed significantly, such that almost all TVs now sold are ENERGY STAR labeled. Savings also come from efficient set-top boxes and digital video recorders.
- **Heating** offers the third largest achievable potential, due mainly to the adoption of ductless heat pumps in single family and multiplex homes. Insulation measures are a small contributor to savings because City Light's long running programs have already achieved much of that potential.
- **Appliances** offer the next highest near-term savings. However, appliances' contribution to potential in future years diminishes as equipment standards move the market to efficient units. Clothes washers and freezers are the exceptions, although savings are modest.
- **Water Heating** achievable potential is limited in the near term because HPWH, which are the cost-effective option, still face significant market barriers. Therefore, most of the near-term water heating savings are due to low-flow showerheads and faucet aerators.
- **Behavioral measure,** assumed to be a comparative feedback program, provides savings across all end uses. See below for additional details regarding modeling assumptions used for this measure.

Figure 5-4 Residential Cumulative Achievable Potential by End Use in 2015

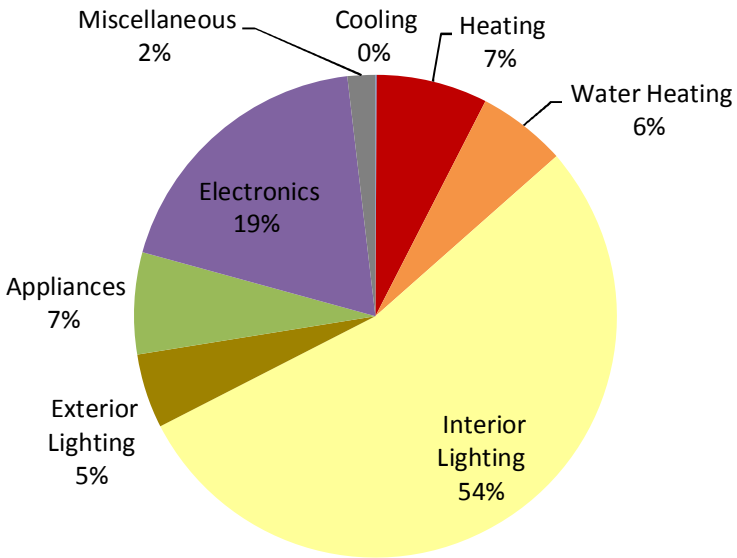


Table 5-5 presents the top twenty measures, which account for 99.9% of residential cumulative achievable potential in 2015. The top five measures alone represent 86% of potential, with lighting measures as three of those top five.

Table 5-5 Residential Top 20 Measures, Cumulative Achievable Potential in 2015

Rank	Measure	Savings (MWh)	% of Total Savings
1	Interior Lighting Screw-in	24,573	41%
2	Behavioral Measure	9,468	16%
3	Electronics TVs	7,722	13%
4	Interior Lighting Specialty	6,735	11%
5	Exterior Lighting Screw-in	2,869	5%
6	Heating Electric Zonal Room Heat	2,263	4%
7	Electronics Set-top Boxes/DVR	1,935	3%
8	Water Heater - Low-Flow Showerheads	1,023	2%
9	Appliances Clothes Washer	976	2%
10	Water Heater - Faucet Aerators	459	1%
11	Refrigerator - Decommissioning and Recycling	343	1%
12	Water Heating HPWH <= 55 Gal	319	0.5%
13	Electronics Laptops	302	0.5%
14	Thermostat - Clock/Programmable	239	0.4%
15	Insulation - Infiltration Control	213	0.4%
16	Electronics Monitor	105	0.2%
17	Miscellaneous Pool Heater	97	0.2%
18	Appliances Freezer	96	0.2%
19	Insulation - Ceiling	81	0.1%
20	Ducting - Repair and Sealing	71	0.1%
	Total	**59,890**	**99.9%**

The second largest conbributor to savings is a beheavioral measure, assumed to be a comparative feedback measure, in which householders receive a personalized home energy reports every month or two that compares the customer's usage with neighboring homes of similar size and location. Several evaluations of this program type provide savings estimates in the range of 1%–3%: We note however that many of the savings gained are related to the installation of tangible, efficient equipment or measures rather than pure behavioral changes, such as turning out lights or changing water heater temperature settings. The tangible measures are already covered in the CPA analysis framework and must be removed from savings estimates that include both tangible measures and behavioral ones to avoid double counting savings. One study estimates the tangible, non-behavioral component of these programs at 32% of the total savings[11] and it could possibly be higher. Therefore, the City Light analysis assumes 1.0% annual net savings per household for behavioral aspects alone. These savings are distributed across all of the end uses. Cost is assumed at $10 per year per household per year for the study.

With regard to measure life, the CPA uses a one-year measure life that coincides with ongoing reports during that year. Persistence of the program effect is assumed to decay if consumers stop receiving the reports. As a result, cumulative savings do not increase year-over-year, as is the case with many other

[11] California 2012 Potential Study. Table 2. "Forecast Behavioral Technical Potential (GWh)" http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

measures. In fact, they decline slightly over time, because the total energy use per household also drops in the achievable potential case.

City Light is currently running a comparative information behavioral program. This study assumes that program participation will be increased from current levels of roughly 40,000 households to 70,000 households in 2014, 100,000 in 2015, and held at that level for each year thereafter.

Residential Potential by Market Segment

Single-family homes are slightly more than half of City Light's residential customers, but consumed 60% of the sector's energy use in 2012. Furthermore, potential as a percentage of baseline energy use is generally higher in single family homes, which have larger saturations of equipment beyond the basics of heating, water heating, and appliances. Thus, single-family homes account for the largest share of potential savings by segment, representing 72% of achievable potential in 2014. By the end of the study period, however, the share of residential potential in single family homes drops slightly to 65% as indicated in Table 5-6. This trend reflects that housing growth in the City Light service territory is expected to occur mainly in the multifamily housing types.

Table 5-6 Residential Cumulative Achievable Potential by Market Segment

	2014	2015	2018	2023	2028	2033
Achievable Savings (MWh)						
Single Family	21,059	43,157	88,244	170,457	273,177	357,448
Multiplex	1,459	2,941	6,610	15,085	26,087	36,964
Low-Rise Multifamily	4,940	11,445	27,386	51,595	77,518	122,616
High-Rise Multifamily	1,043	2,431	5,624	12,763	21,884	31,422
Total	**3,205,277**	**3,193,660**	**3,206,854**	**3,256,520**	**3,395,213**	**3,577,236**
Achievable - % of Savings						
Single Family	74%	72%	69%	68%	69%	65%
Multiplex	5%	5%	5%	6%	7%	7%
Low-Rise Multifamily	17%	19%	21%	21%	19%	22%
High-Rise Multifamily	4%	4%	4%	5%	5%	6%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Commercial Sector Potential

Table 5-7 presents the savings associated with each level of potential for the commercial sector. The baseline projection for the commercial sector grows steadily during the study period as the region emerges from the economic downturn. As a result, opportunities for energy-efficiency savings are significant for the commercial sector.

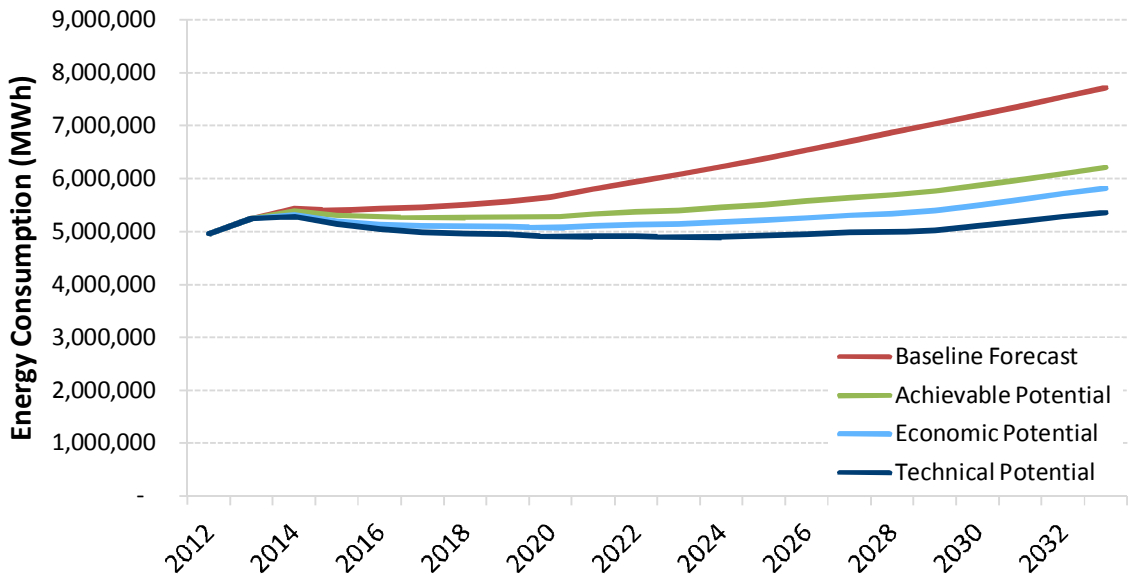
- **Achievable potential** projects 95,335 MWh (11 aMW) of energy savings in 2015, which corresponds to 1.8% of the baseline projection. In 2023, cumulative achievable potential reaches 680,625 MWh (78 aMW).
- **Economic potential**, which reflects the savings when all cost-effective measures are taken, is 946,480 MWh (108 aMW) in 2023.
- **Technical potential,** which reflects the adoption of all energy conservation measures regardless of cost, is a theoretical upper bound on savings. In 2023, technical potential energy savings are 1,186,159 MWh.

Table 5-7 Cumulative Conservation Potential for the Commercial Sector

	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	5,435,096	5,402,226	5,501,409	6,082,292	6,869,417	7,713,040
Cumulative Savings (MWh)						
Achievable Potential	47,025	95,335	234,290	680,625	1,172,913	1,503,855
Economic Potential	116,007	201,851	410,776	946,480	1,530,031	1,889,671
Technical Potential	157,533	265,915	541,388	1,186,159	1,878,483	2,346,823
Cumulative Savings (aMW)						
Achievable Potential	5.4	10.9	26.7	77.7	133.9	171.7
Economic Potential	13.2	23.0	46.9	108.0	174.7	215.7
Technical Potential	18.0	30.4	61.8	135.4	214.4	267.9

Figure 5-5 shows the commercial sector baseline projection and the three potential level projections.

Figure 5-5 Commercial Energy Efficiency Potential Projection



Commercial Potential by End Use, Technology, and Measure Type

Table 5-8 presents the commercial sector savings by end use and potential type. The end uses with the highest technical and economic potential are:

- Interior lighting, the largest end use in the commercial sector, also has the highest technical potential. Because LEDs are found to be the cost-effective technology option for screw-in lighting, as are super T8s for linear fluorescent systems and T5s for high-bay fixtures, economic potential is highest for lighting as well, at 447,935 MWh in 2023.
- Ventilation provides the second highest technical potential savings due mainly to conversion of constant volume to variable volume systems, but also to control systems and operating strategies. Economic potential is about three-quarters of technical potential.
- Water heating is the next most promising end use for technical potential, which would include installation of heat pump water heaters in place of all existing electric water heating units as well as low-flow fixtures. Because these measures are cost-effective, economic potential for water heating is close on the heels of ventilation.

- Office equipment, including servers and measures to reduce energy use in data centers, has the fourth highest level of technical, about half of which is found to be cost-effective.

Table 5-8 Commercial Cumulative Potential by End Use and Potential Type (MWh)

End Use	Potential	2014	2015	2018	2023	2028	2033
Cooling	Achievable Potential	1,308	2,362	7,270	17,331	34,049	58,788
	Economic Potential	4,930	6,057	10,867	24,084	47,293	82,276
	Technical Potential	9,150	12,921	25,347	51,488	87,108	130,426
Heating	Achievable Potential	1,002	2,003	7,398	23,990	42,233	60,984
	Economic Potential	5,127	7,526	16,015	36,243	61,271	89,176
	Technical Potential	8,061	11,435	23,133	50,832	86,398	130,955
Ventilation	Achievable Potential	4,391	10,458	34,292	81,628	108,622	130,777
	Economic Potential	15,411	29,347	66,719	135,827	162,005	193,430
	Technical Potential	21,090	39,995	90,095	181,762	215,035	253,152
Water Heating	Achievable Potential	851	1,501	8,166	34,791	85,342	128,320
	Economic Potential	17,499	26,927	59,271	113,152	186,108	208,381
	Technical Potential	18,235	27,875	61,085	116,164	188,498	210,785
Interior Lighting	Achievable Potential	26,090	51,737	112,161	389,909	688,478	837,480
	Economic Potential	45,949	80,822	149,968	447,935	785,168	938,986
	Technical Potential	59,013	97,417	178,966	515,039	894,517	1,074,858
Exterior Lighting	Achievable Potential	4,686	9,760	22,079	59,910	96,602	119,635
	Economic Potential	7,880	15,518	30,212	64,242	104,887	128,133
	Technical Potential	9,077	16,890	32,211	73,427	119,978	148,160
Refrigeration	Achievable Potential	1,692	3,228	7,887	16,445	29,425	47,199
	Economic Potential	3,240	5,034	10,289	21,164	38,482	63,359
	Technical Potential	6,171	8,790	16,607	33,553	60,344	98,600
Food Preparation	Achievable Potential	880	1,995	6,255	18,662	40,679	63,659
	Economic Potential	4,575	9,003	21,903	45,378	72,537	99,697
	Technical Potential	6,058	10,969	25,926	56,935	99,786	152,410
Office Equipment	Achievable Potential	6,034	12,079	28,218	36,760	45,638	54,862
	Economic Potential	11,247	21,296	44,746	56,859	69,859	83,504
	Technical Potential	20,526	39,298	87,220	105,349	124,385	144,745
Miscellaneous	Achievable Potential	92	211	565	1,198	1,845	2,149
	Economic Potential	150	322	787	1,596	2,420	2,730
	Technical Potential	152	325	797	1,608	2,434	2,734
Total	**Achievable Potential**	**47,025**	**95,335**	**234,290**	**680,625**	**1,172,913**	**1,503,855**
	Economic Potential	**116,007**	**201,851**	**410,776**	**946,480**	**1,530,031**	**1,889,671**
	Technical Potential	**157,533**	**265,915**	**541,388**	**1,186,159**	**1,878,483**	**2,346,823**

Figure 5-6 illustrates how the commercial cumulative achievable potential of 95,335 MWh in 2015 is distributed among the end uses. We note the following:

- Interior and exterior lighting combined represent nearly two-thirds of all potential, consistent with lighting's preponderance in technical and economic potential. Given that these are mature technologies, they have relatively high market acceptance.
- Ventilation provides 11% of achievable savings, while HVAC overall represents 16% of potential
- Office Equipment constitutes 13% of achievable potential, which reflects that efficient technologies in this area are both cost-effective and widely accepted in the market
- Water heating savings are modest at 2% of total achievable potential, despite significant technical and achievable potential. This reflects ongoing market barriers to widespread adoption of HPWH.

Figure 5-6 Commercial Cumulative Achievable Potential by End Use in 2015

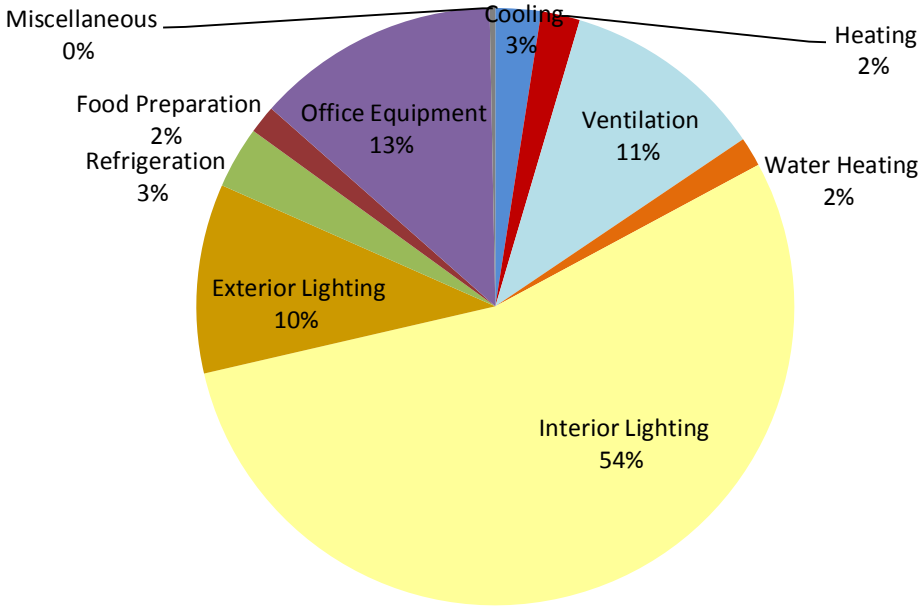


Table 5-9 presents the top twenty measures, which account for 94% of cumulative commercial sector achievable potential in 2015. Consistent with the discussion above, lighting measures dominate the list.

Table 5-9 Commercial Top 20 Measures, Cumulative Achievable Potential in 2015

Rank	Measure	Savings (MWh)	% of Total Savings
1	Interior Lighting Linear Fluorescent	23,945	25.1%
2	Interior Lighting Screw-in	14,913	15.6%
3	Office Equipment Server	10,121	10.6%
4	Variable Air Volume Ventilation	8,840	9.3%
5	Interior Lighting High-Bay Fixtures	7,650	8.0%
6	Exterior Lighting Screw-in	5,082	5.3%
7	Exterior Lighting HID	4,009	4.2%
8	Interior Lighting - Occupancy Sensors	2,818	3.0%
9	Refrigeration Walk-in Refrigerator	2,310	2.4%
10	Interior Lighting - Daylighting Controls	2,011	2.1%
11	Water Heating Heat Pump Water Heater	1,347	1.4%
12	Office Equipment Laptop	1,155	1.2%
13	Food Preparation Dishwasher	1,073	1.1%
14	Thermostat - Clock/Programmable	958	1.0%
15	Heating Electric Zonal Heat	721	0.8%
16	Ventilation - Variable Speed Control	688	0.7%
17	Office Equipment Printer/Copier/Fax	603	0.6%
18	Retrocommissioning	518	0.5%
19	Cooling Air-Cooled Chiller	510	0.5%
20	Office Equipment - Plug Load Occupancy Sensors	495	0.5%
	Total	**89,768**	**94%**

Industrial Sector Potential

Conservation potential was analyzed using conservation measures included in the Sixth Plan industrial measure analysis tool, as well as other relevant industrial measures. Where City Light was aware of the potential for heat recovery generation in industrial facilities, it was explicitly included in the study.

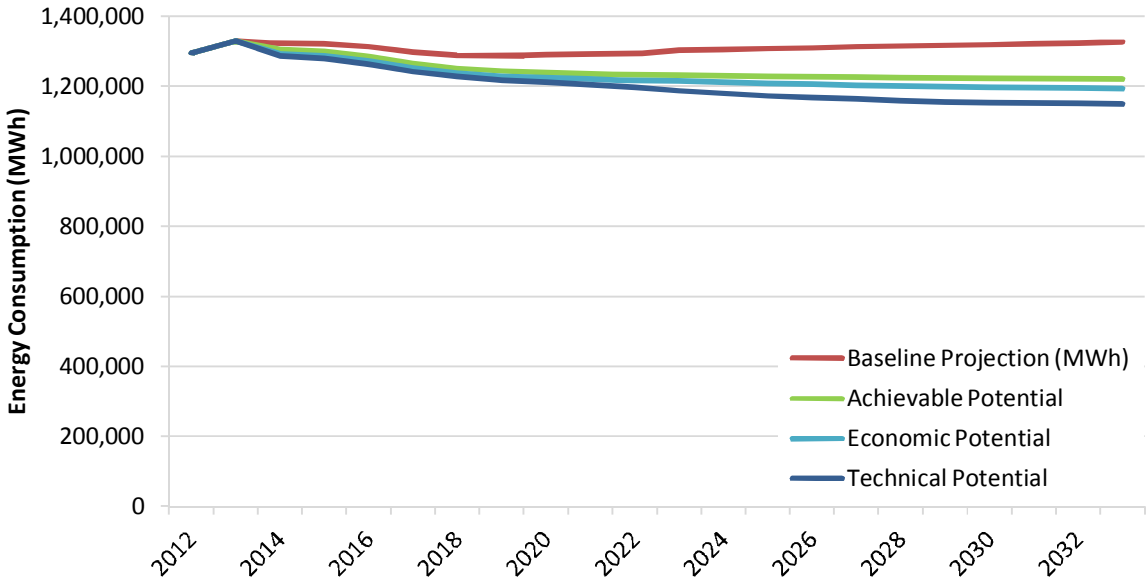
Table 5-10 presents the savings for the various levels of potential considered in this study. Figure 5-7 shows the baseline and the potential projections.

- **Achievable potential** is 22,765 MWh (2.6 aMW) in 2015, equal to 1.7% of the baseline projection. By 2023, the cumulative achievable conservation savings are 69,591 MWh (7.9 aMW).
- **Economic potential** which reflects the savings when all cost-effective measures are taken, is 35,148 MWh (4.0 aMW) in 2015 or 2.7% of the baseline energy projection. By 2023, economic potential reaches 87,208 MWh.
- **Technical potential** in 2015 is 42,346 MWh (4.8 aMW) or 3.2% of the baseline energy projection. The 10-year technical potential is 114,501 MWh,

Table 5-10 Cumulative Conservation Potential for the Industrial Sector

	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	1,320,856	1,320,729	1,288,208	1,301,196	1,314,122	1,327,294
Cumulative Savings (MWh)						
Achievable Potential	14,509	22,765	37,031	69,591	90,627	106,463
Economic Potential	29,168	35,148	50,715	87,208	113,056	133,352
Technical Potential	34,913	42,346	61,822	114,501	155,932	177,887
Cumulative Savings (aMW)						
Achievable Potential	1.7	2.6	4.2	7.9	10.3	12.2
Economic Potential	3.3	4.0	5.8	10.0	12.9	15.2
Technical Potential	4.0	4.8	7.1	13.1	17.8	20.3

Figure 5-7 Industrial Baseline and Conservation Potential Energy Projections (MWh)



Industrial Potential by End Use

Table 5-11 presents the savings by end use and type of potential, while Figure 5-8 shows cumulative achievable potential by end use in 2015. Motor end uses, which are 36% of achievable potential in 2015, also offer the greatest opportunity for energy savings across the all three levels of potential and all years. Because of motor standards, much of the cost-effective and achievable savings are not due to more efficient motors, but rather to controls and system optimization strategies. Process loads and lighting are the next greatest sources of savings, followed by ventilation.

Table 5-11 Industrial Potential by End Use and Potential Type (MWh)

End Use	Potential	2014	2015	2018	2023	2028	2033
Cooling	Achievable Potential	300	374	557	890	1,346	1,858
	Economic Potential	596	658	853	1,329	1,953	2,626
	Technical Potential	959	1,109	1,581	2,646	3,827	4,687
Heating	Achievable Potential	578	754	1,256	2,204	3,092	3,849
	Economic Potential	1,282	1,443	1,974	3,295	4,581	5,682
	Technical Potential	1,896	2,127	2,888	4,584	6,413	8,051
Ventilation	Achievable Potential	860	1,754	4,236	7,657	7,888	7,772
	Economic Potential	1,240	2,347	5,226	9,231	9,349	9,228
	Technical Potential	1,868	3,560	7,957	14,063	14,230	14,030
Interior Lighting	Achievable Potential	3,485	4,867	6,842	12,996	14,546	15,699
	Economic Potential	5,410	7,027	9,209	16,237	17,896	19,780
	Technical Potential	6,335	8,025	10,451	29,002	41,995	44,499
Exterior Lighting	Achievable Potential	481	786	1,192	1,652	1,951	2,197
	Economic Potential	703	1,077	1,514	1,956	2,292	2,631
	Technical Potential	838	1,224	1,705	3,059	5,751	6,723
Motors	Achievable Potential	6,392	8,178	14,316	28,197	39,532	47,735
	Economic Potential	12,134	14,059	20,892	36,538	50,749	60,938
	Technical Potential	14,197	16,590	24,480	41,071	55,832	66,052
Process	Achievable Potential	2,413	6,053	8,632	15,995	22,272	27,354
	Economic Potential	7,805	8,537	11,047	18,621	26,236	32,467
	Technical Potential	8,820	9,710	12,760	20,077	27,884	33,844
Miscellaneous	Achievable Potential	-	-	-	-	-	-
	Economic Potential	-	-	-	-	-	-
	Technical Potential	-	-	-	-	-	-
Total	**Achievable Potential**	**14,509**	**22,765**	**37,031**	**69,591**	**90,627**	**106,463**
	Economic Potential	**29,168**	**35,148**	**50,715**	**87,208**	**113,056**	**133,352**
	Technical Potential	**34,913**	**42,346**	**61,822**	**114,501**	**155,932**	**177,887**

Figure 5-8 Industrial Cumulative Achievable Potential by End Use in 2015

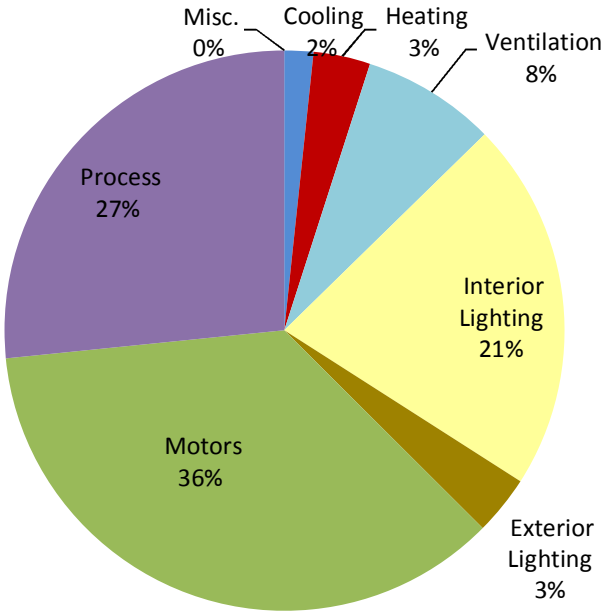


Table 5-12 presents the top twenty industrial measures, which account for 96% of cumulative commercial sector achievable potential in 2015. Consistent with the discussion above, motor-related measures including variable speed controls, compressed air optimization and upgrades are significant savers.

Table 5-12 Industrial Top 20 Measures, Cumulative Achievable Potential in 2015

Rank	Measure	Savings (MWh)	% of Total Savings
1	Motors - Variable Speed Controls	3,684	16.2%
2	Waste Heat Generation – Custom	2,984	13.1%
3	Process - Timers and Controls	2,047	9.0%
4	Compressed Air - Operations and Maintenance	1,864	8.2%
5	Variable Air Volume Ventilation	1,708	7.5%
6	Compressed Air - Equipment Upgrade	1,524	6.7%
7	Interior Lighting High-Bay Fixtures	1,370	6.0%
8	Interior Lighting Linear Fluorescent	1,138	5.0%
9	Transformer - High Efficiency	1,065	4.7%
10	Energy Management System	835	3.7%
11	Interior Lighting - Occupancy Sensors	651	2.9%
12	Interior Lighting - Time Clocks and Timers	601	2.6%
13	Exterior Lighting HID	561	2.5%
14	Interior Lighting Screw-in	417	1.8%
15	Motors - Rewind	352	1.5%
16	Thermostat - Clock/Programmable	271	1.2%
17	Refrigerated Storage Tuneup	228	1.0%
18	Refrigeration - Floating Head Pressure	207	0.9%
19	Heat Pump - Maintenance	200	0.9%
20	Refrigerated Storage Retrofit	194	0.9%
	Total	**21,902**	**96%**

Street Lighting Potential

Table 5-13 provides results of the street lighting analysis. The 10-year achievable savings in 2023 are 4.2 aMW, which is 36,861 MWh or 41.6% of the baseline street lighting forecast. Most equipment retrofits for LED lamps were found to be cost effective, but smart dimming controllers were only cost effective in select fixture types and situations. For the street lighting sector, economic and achievable potential are the same. City Light controls the implementation of lighting upgrades to the fixtures it owns and thus no market barriers exist to the implementation of these measures.

Table 5-13 Cumulative Conservation Potential for the Street Lighting Sector

	2014	2015	2018	2023	2028	2033
Baseline Projection (MWh)	**88,592**	**88,592**	**88,592**	**88,592**	**88,592**	**88,592**
Cumulative Savings (MWh)						
Achievable Potential	9,950	19,901	34,185	36,861	36,876	36,876
Economic Potential	9,950	19,901	34,185	36,861	36,876	36,876
Technical Potential	10,455	20,910	35,793	38,581	38,581	38,581
Cumulative Savings (aMW)						
Achievable Potential	1.1	2.3	3.9	4.2	4.2	4.2
Economic Potential	1.1	2.3	3.9	4.2	4.2	4.2
Technical Potential	1.2	2.4	4.1	4.4	4.4	4.4

Avoided Cost Sensitivity Analysis

To assist City Light in evaluating variations in potential due to changes in avoided costs, EnerNOC also evaluated conservation potential, for the residential, commercial, and industrial sectors, based on an alternate stream of avoided costs. Street lighting measures were mainly cost-effective under the reference case, and thus were not modeled under the avoided costs alternative case.

- In the reference case, for which results are presented above, and referred to here as Market + CCT, the avoided costs are based on market costs and assume that the marginal generation unit is a conventional combined cycle turbine. In addition, avoided costs include adders for renewable energy credits, carbon dioxide offsets, transmission and distribution costs, and a 10% credit for the Regional Act Bonus, consistent with the Sixth Power Plan methodology. Note that City Light has sufficient capacity for the study period and thus did not provide an avoided cost of capacity.
- The second scenario, referred to here as the IRP Preferred Portfolio, assumed higher avoided energy costs starting in 2021. City Light does not expect to acquire generation resources before roughly 2021. At this point, all new resources will be from a renewable source. As with the reference case, it also includes transmission and distribution costs and a 10% credit for the Regional Act Bonus. The changes in avoided costs affect economic potential directly and flow through to achievable potential. As avoided costs increase, the benefits of savings from conservation increase, causing the benefit-cost ratio to increase. If higher avoided costs result in measure B/C ratios rising to a value of 1.0 or above, then the measures are included in economic potential.

Figure 5-9 shows the two avoided costs streams used in the analyses. Table 5-14 compares the cumulative achievable and economic potential in 2023 under the two cases. The baseline and technical projections are not shown because by definition they are the same in both cases. In 2023, achievable potential under the IRP Preferred Portfolio case is 1,077,688 MWh, or 104% of the 1,036,977 MWh reference case.

Figure 5-9 Avoided Costs of Energy Projections

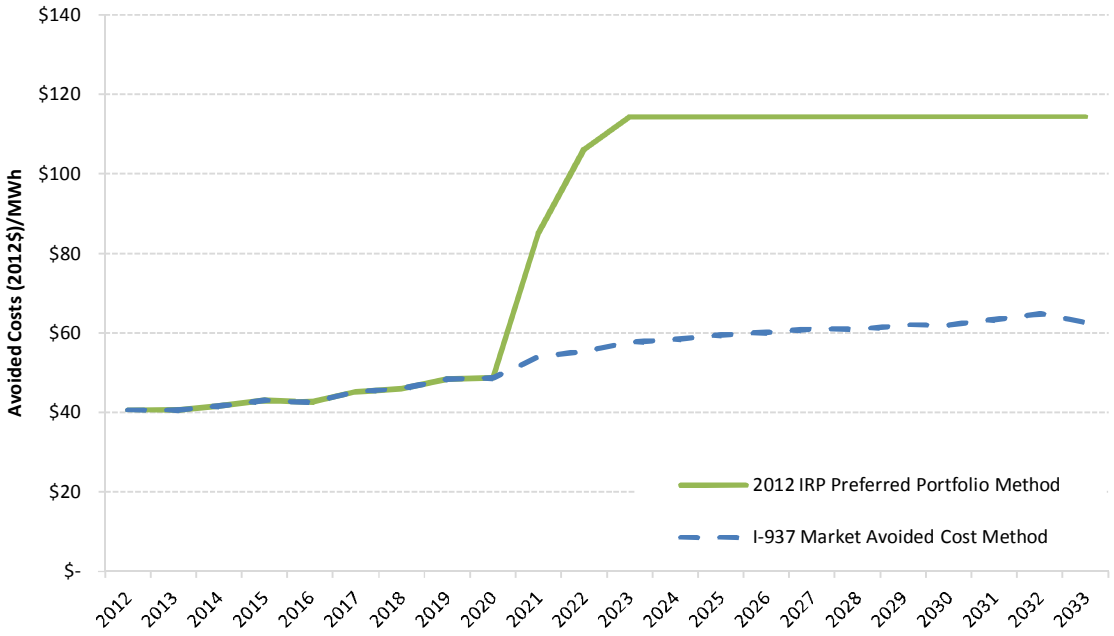


Table 5-14 Comparison of Potentials by Avoided Costs, 2023

Avoided Cost Case	Cumulative Achievable Potential	Change in Achievable Relative to I-937 Case	Cumulative Economic Potential	Change in Economic Relative to I-937 Case
I-937 Market Avoided Cost	1,036,977	n/a	1,574,823	n/a
2012 IRP Preferred Portfolio	1,077,688	104%	1,687,860	107%

About EnerNOC

EnerNOC's Utility Solutions Consulting team is part of EnerNOC's Utility Solutions, which provides a comprehensive suite of demand-side management (DSM) services to utilities and grid operators worldwide. Hundreds of utilities have leveraged our technology, our people, and our proven processes to make their energy efficiency (EE) and demand response (DR) initiatives a success. Utilities trust EnerNOC to work with them at every stage of the DSM program lifecycle – assessing market potential, designing effective programs, implementing those programs, and measuring program results.

EnerNOC's Utility Solutions deliver value to our utility clients through two separate practice areas – Implementation and Consulting.

- Our Implementation team leverages EnerNOC's deep "behind-the-meter expertise" and world-class technology platform to help utilities create and manage DR and EE programs that deliver reliable and cost-effective energy savings. We focus exclusively on the commercial and industrial (C&I) customer segments, with a track record of successful partnerships that spans more than a decade. Through a focus on high quality, measurable savings, EnerNOC has successfully delivered hundreds of thousands of MWh of energy efficiency for our utility clients, and we have thousands of MW of demand response capacity under management.
- The Consulting team provides expertise and analysis to support a broad range of utility DSM activities, including: potential assessments; end-use forecasts; integrated resource planning; EE, DR, and smart grid pilot and program design and administration; load research; technology assessments and demonstrations; evaluation, measurement and verification; and regulatory support.

The team has decades of combined experience in the utility DSM industry. The staff is comprised of professional electrical, mechanical, chemical, civil, industrial, and environmental engineers as well as economists, business planners, project managers, market researchers, load research professionals, and statisticians. Utilities view EnerNOC's experts as trusted advisors, and we work together collaboratively to make any DSM initiative a success.

EnerNOC Utility Solutions Consulting
500 Ygnacio Valley Road, Suite 450
Walnut Creek, CA 94596

P: 925.482.2000
F: 925.284.3147