Final Report

Conservation Potential Assessment

Prepared for:
Seattle City Light

October 13, 2006

quantec *Raising the bar in analytics™*

Prepared by:
Ken Seiden, Ph.D.
Collin Elliot
Quantec, LLC

K:\2005 Projects\2005-32 (SCL) Potential Analysis\Report and Presentations\Final CPA Report_10_11_06.doc

Quantec Offices

720 SW Washington, Suite 400
Portland, OR 97205
(503) 228-2992; (503) 228-3696 fax
www.quantecllc.com

1722 14th St., Suite 210
Boulder, CO 80302
(303) 998-0102; (303) 998-1007 fax

28 E. Main St., Suite A
Reedsburg, WI 53959
(608) 524-4844; (608) 524-6361 fax

3445 Grant St.
Eugene, OR 97405
(541) 484-2992; (541) 683-3683 fax

20022 Cove Circle
Huntington Beach, CA 92646
(714) 287-6521

Printed on recycled paper

Acknowledgements

This project was a complex undertaking that took over six months to complete. It required the compilation of a large amount of data from multiple sources. We relied heavily on staff in various departments at Seattle City Light for data and analytic support. Key contributors included Debra Tachibana, Deb Das, Dennis Pearson, Glenn Atwood, Michael Little, David Clement, Mary Winslow, Phoebe Warren, and Javad Maadanian. Furthermore, we also want to acknowledge Tom Eckman of the Northwest Power and Conservation Council, who provided assistance on efforts to incorporate non-energy conservation benefits in the analysis. Without the active participation, generous assistance, and timely response to our requests for information from these individuals, we could not have addressed many of the project challenges. We apologize to any whose efforts have gone erroneously unrecognized.

We are indebted to Marya Castillano, former Director of the Conservation Resources Division at Seattle City Light, for her confidence, unwavering support, and patience.

Finally, our enduring gratitude goes to our project manager, Steve Lush, who worked closely with us every step of the way and provided invaluable insight, direction, and decisiveness while allowing us to exercise our independent judgment, and to maintain objectivity.

Table of Contents

1. Executive Summary 1

CPA Findings 1

Caveats 2

2. Methodology 5

Estimating Technical and Achievable Potential 5

Base Case Forecast Calibration 11

Measure Savings 12

Measure Stacking and Interaction Effects 13

Non-Energy Benefits 14

3. Data Sources and Gap Analysis 17

Gap Analysis 18

4. Baseline Energy Consumption 23

Residential Sector 24

Commercial Sector 26

Industrial Sector 28

5. Achievable Conservation Potential 31

Residential Achievable Potential Results 32

Commercial Achievable Potential Results 36

Industrial Achievable Potential Results 39

Impact of Non-Energy Benefits (NEBs) 41

Appendix A: Detailed Data Tables 43

1. Executive Summary

This Conservation Potential Assessment (CPA) presents a comprehensive assessment of achievable demand side management (DSM) resources as part of Seattle City Light's (SCL) Integrated Resource Planning (IRP) process. The overall approach in this study distinguishes between two distinct, yet related, definitions of energy efficiency potential that are widely used in utility resource planning: technical and achievable potential. Technical potential assumes that all demand-side resource opportunities may be captured, regardless of their costs or market barriers. Achievable potential, on the other hand, represents that portion of technical that is likely to be available over the planning horizon, given prevailing market barriers that may limit the implementation of demand-side measures.

The study examined energy savings available across the major sectors in SCL's service area:

- Residential – three dwelling segments and 14 end uses
- Commercial – 12 building segments and 24 end uses
- Industrial – six industrial segments and seven end uses.

The CPA analysis considered dozens of individual measures, with hundreds of permutations across segments and construction vintages, distinguishing between discretionary (e.g., shell and lighting retrofit) and lost opportunity (equipment replacement and new construction) resources.

A wide range of measure-specific, economic, and market information was compiled for this study, including primary data (SCL's forecasts, customer characteristics surveys, DSM program achievements) and secondary sources (including the Northwest Power and Conservation Council's Regional Technical Forum, the Energy Information Association, and the California Energy Commission's Database for Energy Efficient Resources).

CPA Findings

For all three sectors, the estimation of achievable potential started with the development of technical potential through the application of Quantec's End Use Forecaster™ model in three separate steps:

a) Develop a baseline forecast,

b) Produce a potential forecast for each end use that incorporates installation of all feasible energy-efficiency measures, and

c) Calculate technical potentials by end-use as the difference between the two forecasts.

Once the estimates of technical potential were complete, a 70% market penetration assumption was incorporated to produce the achievable potential.

Based on the results of this study, cumulative 15-year achievable conservation potentials in SCL's service area are estimated at nearly 229 aMW of electricity, representing more than 18% of the baseline electricity consumption forecast in that year (2020).[1] The breakout of these savings in hypothetical maxima for years five, 10, and 15 are presented below in Table 1.

Table 1. Achievable Conservation by Sector

Segment	aMW Savings		
	5 Years	10 Years	15 Years
Residential	21.6	47.2	71.3
Commercial	37.7	81.3	120.4
Industrial	10.3	23.4	37.1
Total	***69.6***	***151.8***	***228.8***
Total as % of Baseline Forecast	***5.8%***	***12.9%***	***18.1%***

The final CPA task was the aggregation of results into resource blocks for incorporation into SCL's IRP modeling process. Table 2 shows the estimates of achievable potential broken out in $.01 increments based on the levelized cost of the resource. As the data show, around 53% of the achievable potential was available at $.06/kWh or less, which was the threshold used by SCL as an initial economic screen based on a preliminary estimate of the cost of the next available, least-cost supply-side resource. This was driven in large part by potential in the industrial sector, which had more than 95% of the savings available for less than $.06/kWh.

Table 2. Cumulative Achievable Potential by Cost Group

Cost Group	Residential (aMW)	Commercial (aMW)	Industrial (aMW)	Total (aMW)	Cumulative Percent
A. Up to $0.01	2.6	11.7	0.7	14.7	6%
B. $0.01 to $0.02	5.1	32.8	17.9	48.1	21%
C. $0.02 to $0.03	11.2	48.1	34.3	79.1	35%
D. $0.03 to $0.04	13.9	52.4	35.2	101.6	44%
E. $0.04 to $0.05	18.8	58.7	35.5	113.2	49%
F. $0.05 to $0.06	20.3	63.5	36.5	120.5	53%
G. $0.06 to $0.07	26.8	67.4	36.5	130.9	57%
H. $0.07 to $0.08	31.8	70.0	36.5	138.4	60%
I. $0.08 to $0.09	33.2	76.0	36.5	145.8	64%
J. $0.09 to $.10	35.8	78.4	37.1	150.9	66%
K. $.10 and Higher	71.3	120.4	37.1	228.8	100%

Caveats

There was an explicit understanding as this CPA commenced that many of SCL's internal data sources were out-of-date. Consequently, an additional objective of this study was to identify

[1] Since achievable potential estimates represent a percentage of the technical potential estimates, only the results for achievable potential are presented.

where the data were most wanting, and where they might lead to an inaccurate characterization of available resources.

Indeed, Quantec found this to be the case, as much of the data / information we relied upon to develop inputs for the CPA were very dated, and should not be used again in future CPA updates. This is particularly acute in the industrial sector where savings estimates are based on 15 year-old SCL research applied to current and forecasted loads, and in the residential sector where retrofit parameters were developed from the SCL's 1990 Residential Weatherization Study.

The lack of recent data is due, in part, to reductions in spending in basic research at SCL over the last decade. This surely provided customer benefits in terms of reduced bills. Further, SCL conservation programs were consistently meeting annual targets over this period, and there was no state or city requirement to conduct IRPs. The situation has changed markedly in recent years. Expanding IRP requirements, along with the notion that the so-called "low hanging conservation fruit" have been picked, indicate that SCL has to better understand how customers use electricity and make electric equipment purchases in order to rely on future CPA estimates as a real resource.

2. Methodology

This report presents a comprehensive assessment of technical and achievable conservation resources as part of Seattle City Light's (SCL) Integrated Resource Planning (IRP) process. It includes the following conservation resource analytics:

- Development of conservation resource bundles consistent with Global Energy Advisors' IRP model development for SCL
- Incorporation of SCL's existing energy efficiency program achievements
- Appropriate treatment of the relationship(s) between load forecast, existing conservation, and naturally occurring conservation, including both market effects and government-mandated codes and standards.

This chapter presents the overall Conservation Potential Assessment (CPA) methodology. The rest of the CPA report covers the major project tasks:

1. ***Baseline consumption***. The development of an accurate baseline – including the present stock of equipment efficiency characteristics and expected changes in stock equipment efficiencies over the planning horizon due to codes, standards, and naturally occurring conservation – is essential to accurately portray the size of conservation resources.
2. ***Technical and achievable potential***. Our comprehensive conservation resource assessment approach provides a traditional estimation of technical and achievable potential, along with the characterization of conservation achievable potential in resource blocks.

These processes represent the best practices and methods in the utility industry, and use the most recent data available. Moreover, studies such as this require compilation of large amounts of data from multiple sources on existing demand management strategies, technologies, and market dynamics that affect their adoption. They also rely on assumptions concerning the future, particularly changes in codes and standards, energy efficiency technologies, market conditions, and consumer behavior. It is, therefore, inevitable that the findings of this study will have to be periodically revisited to take into account new data and the changing energy market dynamics.

Estimating Technical and Achievable Potential

The overall approach in this study distinguishes between two distinct, yet related, definitions of resource potential that are widely used in utility resource planning: "technical potential" and "achievable potential." Technical potential assumes that all demand-side resource opportunities may be captured regardless of their costs or market barriers. Achievable potential, on the other hand, represents that portion of technical potential that is likely to be available over the planning horizon, given prevailing market barriers that may limit the implementation of demand-side measures.

Technical Potential. The technical potential estimates were comprised of a bottom-up analysis of electric energy savings in SCL's service area. The analysis, which was applied to the residential, commercial, and industrial sectors, assumes 100% market penetration where energy efficiency resources are applicable and measures are not already installed. Quantec's DSM potential analysis tool, End Use Forecaster, was used to estimate technical energy efficiency potential and involved three steps:

Step 1: Develop a baseline forecast that utilizes:

- Calibrated 2004 loads
- Retirement of existing end uses (through equipment decay functions tied to end-use lifetimes)
- Additional customers (e.g., new construction customers)
- Expected improvements in energy efficiency without market intervention
- Federal codes and energy standards that are in effect in 2006
- State of Washington or City of Seattle codes and standards that go beyond state or federal codes.

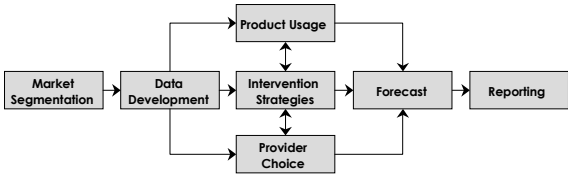
Step 2: Produce a potential forecast for each end use that incorporates installation of all feasible energy efficiency measures.

Step 3: Calculate technical potentials by end use as the difference between the two forecasts.

End Use Forecaster

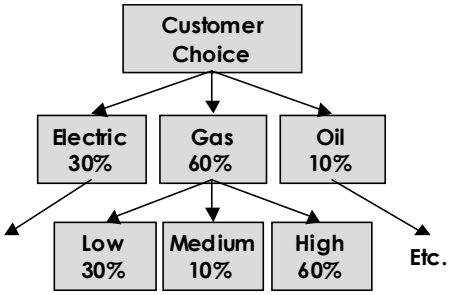
End Use Forecaster is a proprietary end-use forecasting and conservation potential modeling framework developed by Quantec. Seven primary modules form the heart of the End Use Forecaster framework: Market Segmentation, Data Development, Product Usage, Provider Choice, Intervention Strategies, Forecasting, and Reporting. The following figure depicts the relationships between these modules.

Modules and Structure



The usage module tracks the energy consumption by unit (e.g., building type, vintage, end use, fuel type, and equipment efficiency level) and represents annual consumption regardless of the market share of that equipment in the building stock. Put differently, for a customer that has this equipment, this is how much energy it uses per piece of equipment.

Choice Module Nesting



The Customer Choice module focuses on customer equipment decisions by fuel type and efficiency level. As depicted in the *Choice Module Nesting* figure, marginal market shares for replacement end uses, and new construction, are represented by a nested structure of fuel and efficiency choices.

The Intervention Strategies module captures the impacts associated with energy efficiency programs. This module simulates the "what-if" impacts on the usage, market shares, and the resulting demand forecast. Three general types of impacts can be modeled, consistent with conservation planning and program design:

Usage Retrofit in Existing Buildings. These scenarios reduce end use energy usage given the equipment customers already have (e.g., improve the efficiency of existing equipment by installing retrofit efficiency measures or through better O&M procedures).

Equipment Replacement in Existing Buildings. These scenarios modify equipment replacement efficiency shares.

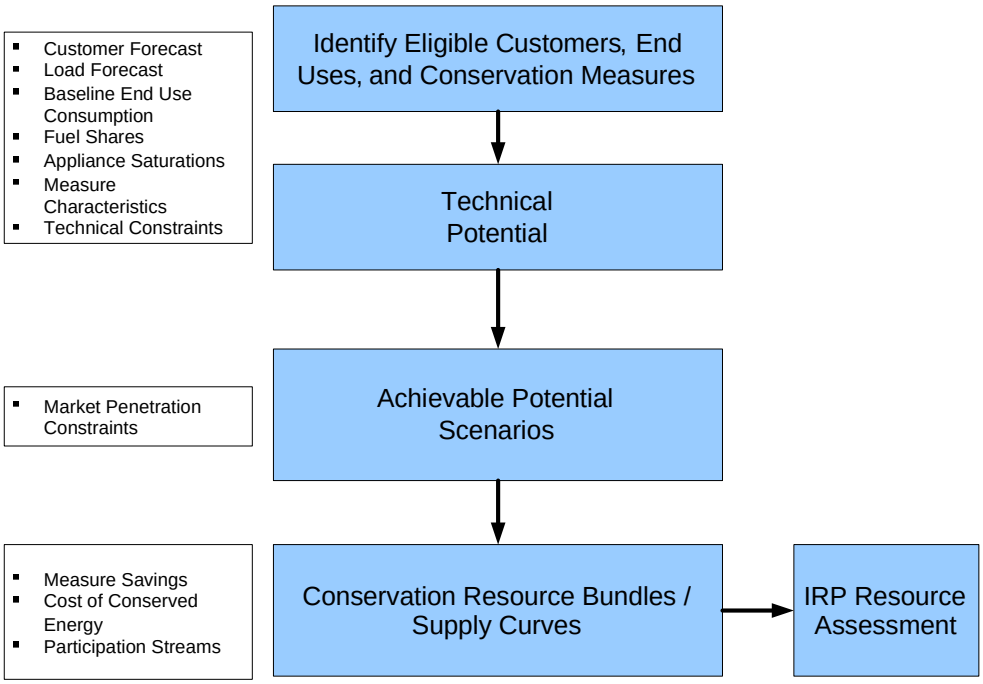
New Construction Equipment Shares and Usage. These scenarios modify the equipment for new buildings, and/or their end use energy usage through alternate building shell measures.

The Forecast Module incorporates all the information compiled from the other modules – Usage, Choice, and Intervention Strategies – related to the overall economic growth of the market segment and equipment lifetime (decay) functions to create the final forecast for a given scenario.

The general methodology and analytic techniques in this study conform to standard utility industry practices and methods. The approach begins with the current load forecast, deconstructs it into sector, market segment, and end-use components, and then examines the effect of the range of energy efficiency technologies and strategies on each end use. These impacts are then aggregated to produce energy efficiency potentials at the end use, sector, and system levels. This

general methodology is diagrammatically presented in Figure 1 and more detailed information is provided in the section that follows.

Figure 1. Methodological Approach



1) Develop Base Case Forecast: The base case end use forecast was calibrated to SCL's 2004 energy sales, customer forecasts, and appliance and equipment saturations from a variety of sources.[2] This step provides an estimate of future energy consumption in the absence of new energy efficiency programs. It establishes a benchmark against which the impacts of the phase-in technical and achievable energy-efficiency potentials can be assessed. Also taken into account are the effects of equipment standards and naturally occurring efficiency improvements, which emanate from the reduction of usage as low-efficiency equipment is retired.

2) Determine Measure Impacts: This step involved integrating measure-specific data (per unit costs, savings, and measure life) with baseline building stock data (base case fuel saturations, measure applicability factors, current measure saturations) and base case-calibrated energy usage data to produce estimates of levelized costs per unit of conserved energy. More information on measure savings calculations is presented later in this chapter.

3) Estimate Phased-In Technical Potential: Technical potential for energy efficiency was then estimated through the Intervention Strategies module, which effectively overrides the base case energy usage and market equipment efficiency shares. Alternative scenarios were incorporated directly into the relevant Product Usage and Provider Choice forecasts. Phased-in technical

[2] All data sources used in this study are described in the next chapter.

potentials were calculated by subtracting the energy forecast associated with the highest possible penetration of energy efficiency measures from the base case forecast.

As discussed in the End Use Forecaster text box above, Quantec distinguishes between equipment replacement measures, which are modeled based on adjusted market shares of equipment and appliances given their usage, and measures that change equipment usage given equipment efficiency market shares. This distinction is depicted in Figure 2. In this example, the commercial sector is broken down into different business segments, end uses within each segment, fuel types within each end use, and efficiency levels within each end use. This category, shown in the orange boxes below, has two purposes. In the base case, the shares of new construction and replacement of high and medium efficiency heat pumps are set at levels consistent with no further SCL conservation efforts. In the phased-in technical potential case, the share of all new construction and replacement equipment is shifted from the medium box to the high box.

Figure 2. Market Segmentation, End Uses, and Conservation Measures

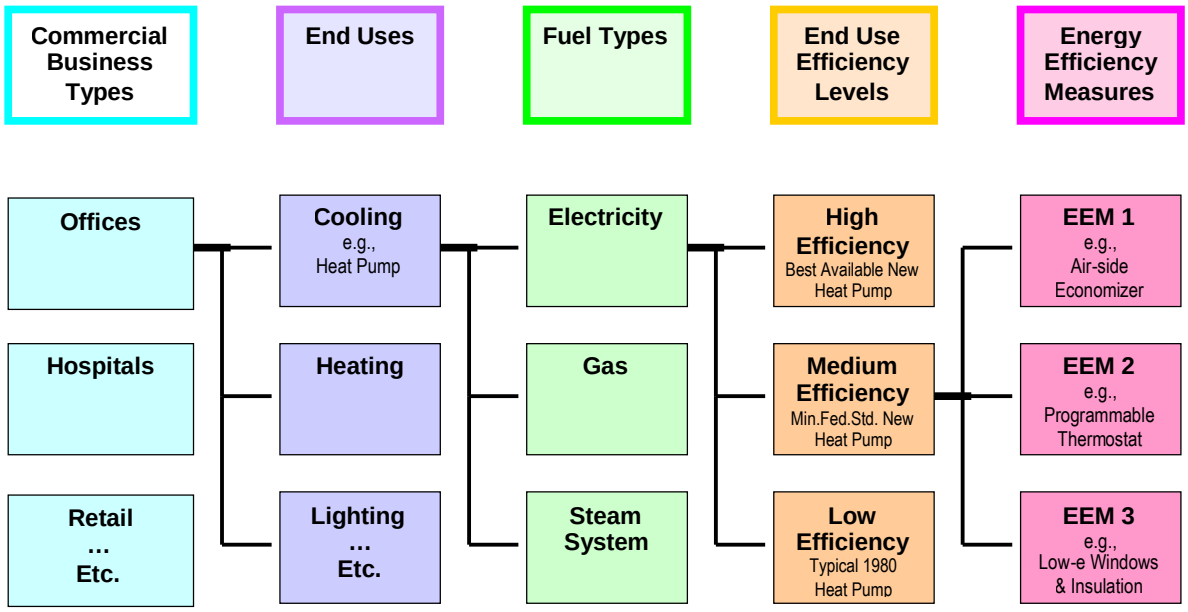


Figure Created by Debra Tachibana, SCL, 2006

Notice that this market share shift is based on a static level of consumption constant for each efficiency level, with revised market shares applying to new homes and the number of existing heat pumps that are replaced upon failure. The heat pump efficiency shift reduces consumption by the relative difference in efficiency ratings. As shown by the pink boxes in Figure 2 above, the model then applies a series of new construction shell measures and existing building retrofit measures that reduce the electric usage of each heat pump regardless of efficiency level.

4) Estimate Achievable Potential and Create Resource Bundles: An important study objective was to make an accurate assessment of achievable energy efficiency potentials. In addition to

considering realistic market penetration rates, the achievable conservation potential analyses aggregated the estimates into "blocks" of available energy efficiency resources that were sizable enough to compare to and evaluate against supply options on a balanced and consistent basis.

Based on preliminary estimates of SCL's avoided costs, the achievable energy efficiencies were disaggregated into distinct cost-per-kWh-based resource blocks in 10 mill cost increments as shown in Figure 3. The commercial and industrial price points are identical to this residential sector illustration, and also represent the levelized cost over the life of the resource. They can be viewed as a "contract price" akin to many electric supply resources.

Figure 3. Conservation Resource Block Price Points, Residential Example

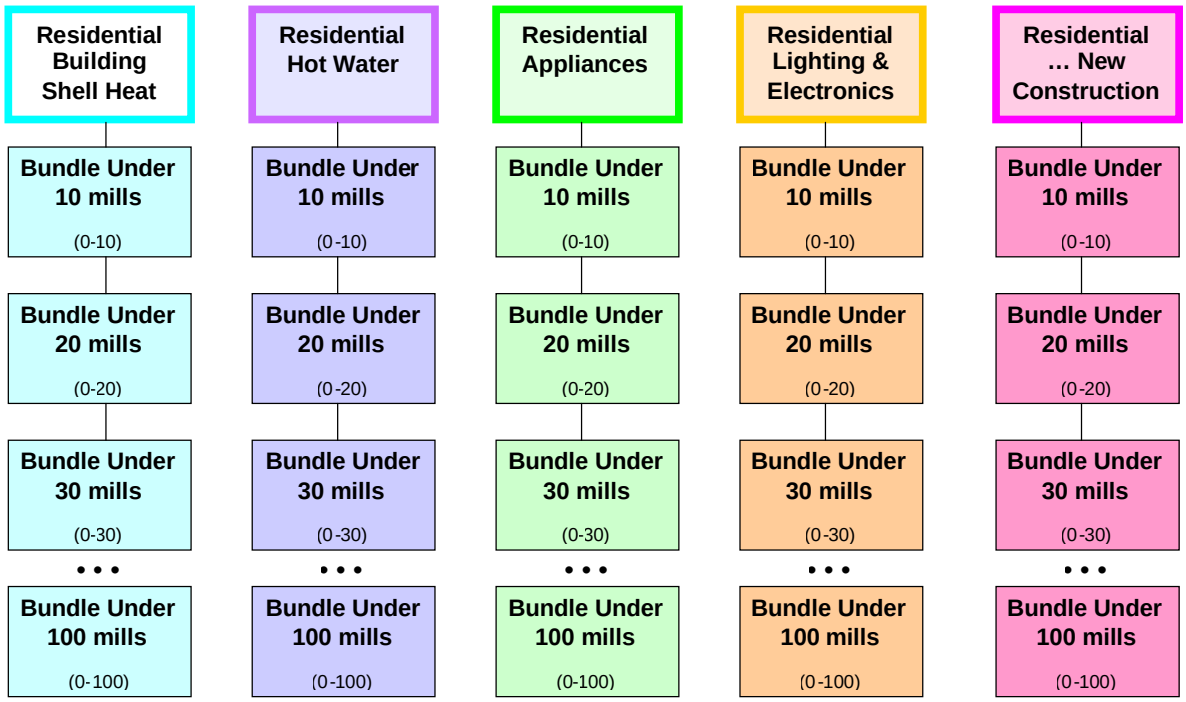


Figure Created by Debra Tachibana, SCL, 2006

The assessment of levelized cost is a means of capturing the economics, and ultimately economic potential, of each measure. Levelized costs are traditionally used by regional planning organizations to provide a broad comparison of energy efficiency resources to supply resources. It is important to recognize that levelized costs themselves do not represent cost-effectiveness criteria, and are not the same as total resource costs. They represent the cost of energy efficiency in terms of a level payment, similar to a mortgage payment. When combined with the size of the resource (kWh saved), the levelized costs effectively represent the "supply curve" of energy efficiency resources. The formula is as follows:

$$LevelizedCost = InstalledCost / \sum_{l=1}^{L} SAVE / (1 + DiscountRate) **l$$

where the denominator is the total savings of the measure over its lifetime (l), discounted back to the present. Suppose for example, a measure costs $50, and will save 100 kWh per year over a 10 year life. If the discount rate is 7.5%, the net present amount of the lifetime savings is 686 kWh. We then divide the installed cost of $50 by 686 to yield the levelized cost of $0.073. Each kWh saved over the lifetime of the measure costs 7.3 cents.

After breaking out these groups, four additional steps were required to convert the technical potential estimates into achievable potential blocks for IRP analysis:

1. Add an administrative cost adder of 15% that approximates the program delivery mechanisms and associated costs.
2. Estimate market penetration, which was assumed by SCL to be 70%.
3. Account for line losses at 5.2%.
4. Add appropriate non-energy benefit adders for lighting and water heating measures consistent with NWPC estimates.

Base Case Forecast Calibration

End Use Forecaster-generated annual baseline end use energy consumption was calculated in each market segment as shown in equation (1) as follows:

(1) $$EUSE_{ijf} = \Sigma_e \, ACCTS_i * UPA_i * SAT_{ij} * FSH_{ijf} * ESH_{ijfe} * EUI_{ijfe},$$

where:

- $EUSE_{ijf}$ = total energy consumption for end use j in building type i using fuel f
- $ACCTS_i$ = the number of accounts/customers in segment i
- UPA_i = the units per account in segment i (= average square feet per customer in commercial segments; = 1.0 in residential dwellings)
- SAT_{ij} = the share of customers in segment i with end use j
- FSH_{ijf} = the share of fuel f in end use j in segment i
- ESH_{ijfe} = the market share of efficiency level e in the equipment segment ijf
- EUI_{ijfe} = energy consumption per customer (per square foot for commercial) use by the equipment configuration ijfe

Total consumption in each sector was then determined by summing $EUSE_{ijf}$ across the end uses and customer segments. The key to ensuring an accurate baseline and reasonable estimates of energy efficiency potentials is to calibrate the historical starting year to actual SCL electricity sales in 2004. End Use Forecaster calibration was achieved in two steps:

1. If the initial End Use Forecaster total is less than the SCL historical value, residual energy is attributed to the “other” end use. This value should be greater than or equal to zero, but should not exceed 10% of 2004 electricity sales.

2. When non-calibrated total usage is more than 10% below actual usage (or above actual usage by any amount), the next step is to proportionately increase (reduce) end use energy usage of each end use until the total sector usage in the baseline equals 2004 electricity sales.

Since all energy savings potentials are defined in *percentage terms*, this process has no effect on energy efficiency savings potential estimates. Indeed, this calibration process ensures that resulting energy efficiency potentials are fully consistent with SCL's electricity sales, avoiding any systematic over- or under-estimate of potentials.

Measure Savings

The following data components are necessary to produce levelized costs per unit of energy saved, and the achievable potential resource blocks:

- Basic measure data, including percentage savings, costs, and measure life
- Baseline end use data (annual consumption per customer, number of customers, units per customer (square footage), equipment saturations, fuel shares)
- Measure applicability and share remaining to be completed.

Equation (2) below shows the basic equation for estimating *retrofit* or *new construction shell measure* savings, where the impact is defined as a measure that changes the annual consumption of an end use without affecting the basic end use equipment. The classic example is additional insulation in existing or new buildings. The insulation reduces consumption without changing the basic HVAC equipment in the building.

(2) $$SAVE_{ijfm} = EUI_{ijfe} * PCTSAV_{ijfem} * APPFACTOR_{ijfem} * INCFACTOR_{ijfem}$$

where:

- $SAVE_{ijfm}$ = annual energy savings for measure m for end use j in building type i using fuel f
- EUI_{ijfe} = calibrated annual end-use energy consumption for the equipment configuration ijfe
- $PCTSAV_{ijfem}$ = is the percentage savings of measure m relative to the base usage for the equipment configuration ijfe, and takes into account interactions among measures such as lighting and HVAC calibrated annual end use energy consumption
- $APPFACTOR_{ijfem}$ = is the fraction of the floor space or households that is applicable to install measure m. For non-competing measures, which are primarily non-lighting, this estimate is generally close to 100%, with lesser amounts due to engineering limitations (for example, the share of buildings with enough room in the wall cavities to install additional insulation). For competing measures within an end use, such as various types of lighting retrofits, this factor is used to represent the share of the end use associated with the measure.

- $INCFACTOR_{ijfem}$ = is the fraction of the applicable floor space or households that has not yet been converted to measure m.

As discussed previously, pure "equipment" measures in existing and new construction are modeled by adjusting market shares relative to the baseline.[3] Since the baseline forecast includes the impacts of federal codes and standards and the small penetration of high efficiency equipment that occurs without market intervention, it incorporates most "naturally-occurring" conservation as commonly defined by the demand-side management analysis community.

Measure Stacking and Interaction Effects

A well-known issue associated with determining retrofit energy efficiency potentials is measure stacking. Stacking effects occur when more than one measure (such as wall, ceiling, and floor insulation) are applied to a single end use. To incorporate stacking effects, it is necessary to establish a rolling reduced baseline as each new measure is added. This is shown in equations (3) through (5), where measures 1, 2, and 3 are applied to end use life:

(3) $SAVE_{ijf1} = EUI_{ij\ fe} * PCTSAV_{ijfe1} * APPFACTOR_{ijfe1} * INCFACTOR_{ijfe1}$

(4) $SAVE_{ijf2} = (EUI_{ijfe} - SAVE_{ijf1}) * PCTSAV_{ijfe2} * APPFACTOR_{ijfe2} * INCFACTOR_{ijfe2}$

(5) $SAVE_{ijf3} = (EUI_{ijfe} - SAVE_{ijf1} - SAVE_{ijf2}) * PCTSAV_{ijfe3} * APPFACTOR_{ijfe3} * INCFACTOR_{ijfe3}$

The stacking order for SCL is determined by the stand alone, levelized cost of each measure affecting the end use.

A similar result occurs in End Use Forecaster between retrofit and replacement measures impacting the same end use. Consider the example shown in Table 3 – the base case annual usage for this central heat pump is 8,000 kWh. Two measure packages are applied: a retrofit package consisting of insulation measures and a replacement high-efficiency heat pump. Note that the timing of these measure packages is likely to differ, with the heat pump replacement occurring when the customer's unit fails.

[3] Energy usage differences across efficiency levels for each end use are also determined in the baseline, consistent with the percentage of reduction in equipment energy consumption from moving up the equipment efficiency "ladder."

Table 3. Retrofit and Replacement Interaction Effects Example

Category	kWh	Percent Savings
Base case usage	8,000	
Non-interactive savings		
Building shell improvements	1,600	20%
High-efficiency heat pump	1,200	15%
Total savings	2,800	35%
Interactive savings		
Building shell improvements	1,600	20%
Usage after shell improvements	6,400	
High-efficiency heat pump	960	15% of 6,400 kWh
Total savings	***2,560***	***32% of 8,000 kWh***

If savings are estimated without these interaction effects, each measure package is treated independently with savings estimated relative to the base case. The 20% savings in building shell improvements are added to the 15% savings from the high efficiency heat pump to yield total savings, but this overstates the potential.

Interactive impacts are determined in a manner similar to retrofit measure stacking, with the order determined by the respective timing of the replacement and retrofit activities over the resource planning horizon.

Non-Energy Benefits

The incorporation of non-energy benefits (NEBs) into Seattle City Light's (SCL) conservation potential assessment (CPA) followed the approach used by the Northwest Power and Conservation Council (NPCC). Although NEBs include a wide variety of system benefits, for this CPA we focused on benefits that are quantifiable and where there is common consensus about their value. Consistent with these criteria, the analysis was limited to the following categories:

- Detergent, water, and sewer savings associated with residential clothes washers
- Water and sewer savings associated with residential dish washers
- O&M savings for residential CFLs
- O&M savings for commercial lighting.

The values for these benefits were derived from data available on the NPCC's Regional Technical Forum's (RTF) Web site. The first step was to map the RTF measures to their counterparts from the CPA. For the residential measures, this process was straightforward, with clearly recognizable counterparts in the RTF data for all of the CPA measures. For commercial lighting, the vast number of permutations in terms of segments, baseline technologies, lamp lengths, and fixture counts in both the RTF data and the CPA measures meant that there was no possible way to perform a one-to-one mapping of the NEBs with the specific CPA measures.

Instead, average NEBs for a subset of technology configurations were calculated for use in the analysis.

Once the measures were mapped, the values for the NEBs were used to determine net measure costs. For the residential measures, this involved taking the present value of the stream of benefits over the measure's lifetime and subtracting them from the installation cost. The net measure cost was then used in the subsequent calculation of the measure's levelized costs. For the commercial lighting measures, the RTF data already represented the levelized value of the benefit in $/kWh, and were removed directly from the calculated levelized cost as shown in Table 4. The table shows the NEBs as a percent of the total measure cost; the relative magnitude of the NEBs can be substantial.

Table 4. Non-Energy Benefits (NEB) as Percent of Total Measure Cost

NEB Category	NEB Value as Percent of Measure Cost	Notes
Detergent and water and sewer savings associated with residential clothes washers	90%	Detergent savings alone amount to more than $17/year, according to RTF data
Water and sewer savings associated with residential dish washers	5%	Council data specific to Seattle
O&M savings for residential CFLs	16%	Varies by average daily usage.
O&M savings for commercial lighting	80%	Figure based only on those measures where valid O&M savings were identified.

3. Data Sources and Gap Analysis

The full assessment of energy efficiency resource potentials required compilation of a large database of measure-specific technical, economic, and market data from a large number of existing primary and secondary sources. The main sources of data used in this study included, but were not limited to:

1. ***Seattle City Light***: 2005 load forecasts, economic assumptions, historical energy efficiency and load management program activities, 2000 Residential Customer Characteristics Survey (RCCS), 1995 industrial conservation potential study, and the Commercial Building Stock Assessment (CBSA). The CBSA is a study of the Northwest's commercial building characteristics sponsored jointly by the Bonneville Power Administration, the Northwest Energy Efficiency Alliance, and SCL. A complete list of data elements provided by SCE is shown in Table 5.

Table 5. SCL Data Sources

SCL Data Source	Key Variables	Use in This Study
2005 Load Forecasts: Commercial, Residential and Industrial	Energy and Peak Forecasts, Customer Counts, Employment and Population Forecasts	Base Case Calibration, Energy efficiency Potential Share of Forecast, Per Customer Use for Calibration, New Construction Forecast
Annual Conservation Accomplishments Reports, 1990-2005	Program Participation, Conservation Measures Installed Between 1990 and 2004	Incomplete Factors
2000 Residential Customer Characteristics Survey (RCCS)	Dwelling Characteristics, Equipment Saturations, and Fuel Shares	Dwelling Type Breakouts, Square Footage per Dwelling, Applicability Factors, Incomplete Factors, Forecast Calibration
2003 Commercial Building Stock Assessment (CBSA)	Building Characteristics, Equipment Saturations, and Fuel Shares	Building Type Breakouts, Square Footage per Dwelling, Applicability Factors, Incomplete Factors, Forecast Calibration
1995 Industrial Conservation Potential Study	Equipment Usage, Measure Characteristics	Industrial End Use / Process Consumption Estimates, Measure Characteristics (savings, cost, life)
1990 Residential Weatherization Study	Residential Retrofit Parameters	Saturation of weatherization measures (incomplete factors), building stock characteristics

2. ***Pacific Northwest Energy Studies***: Several Northwest entities provided data critical to this study, including the Northwest Power and Conservation Council (NPCC), the Regional Technical Forum (RTF), the Northwest Energy Efficiency Alliance (the Alliance), and Puget Sound Energy (PSE). This information included technical information on measure savings, costs, lives and non-energy benefits, hourly end use load shapes, and commercial building and energy characteristics. Details are provided in Table 6.

Table 6. Pacific Northwest Data Sources

Pacific Northwest Data Source	Key Variables	Use in This Study
NPCC 2004 Power Plan	Measure Data, Energy efficiency Potential Estimates	Measure Savings, Costs, Lives, and Non-Energy Benefits; Cross-Check of SCL Potential Estimates
NPCC Hourly Electric Load Model (HELM)	Hourly Load Shapes	Hourly End-Use Load Shapes for Residential, Commercial, and Industrial Sectors
RTF Web Site	Measure Data	Measure Savings, Costs and Lives, estimates of non-energy benefits
PSE 2005 Least Cost Plan	Measure Data, Energy Efficiency Potential Estimates	Measure Savings, Costs and Lives; Cross-Check of SCL Potential Estimates

3. ***California Energy Commission***: This study relied heavily on information available through the 2005 Database of Energy Efficiency Resources (DEER). These data included information on energy efficiency measure costs and savings, measure applicability factors, and technical feasibility factors.
4. ***Equipment Vendors***: Cost data for various measures were compiled from the original sources and, where necessary, updated based on the most recent information available from regional equipment suppliers.
5. ***Ancillary Sources***: Other data sources consisted primarily of available information from past energy efficiency market studies, energy efficiency potential studies and evaluations of energy-efficiency programs in the Northwest and elsewhere in the country. The primary source for information on the industrial section was the U.S. Department of Energy, Energy Information Administration Office of Industrial Technologies.

Gap Analysis

The previous chapter described the systematic approach taken to calibrate the end use forecast to actual sales in the base year. In practice, however, nearly all the assessments require a number of informal steps to get the end use forecasts within a range where it is then reasonable to apply the standardized approach to calibration. These steps are based on assessing the quality of the various inputs to the forecast, and making the necessary adjustments where it is reasonable to do so. The idea is to anchor the study in as much reliable data as possible, and restrict uncertainty to isolated areas. When a large number of data sources, or just some of the key inputs, are less reliable than is desired, both the level of uncertainty and where it lies become difficult to ascertain.

With this in mind, this study served as a review process, based on experience and collaboration with City Light staff, to identify the key issues concerning quality and age of the key data sources. Through this review process Quantec and SCL identified certain data that, while used in this effort due to study resource and time limitations, should not be relied upon in the future given SCL's commitment to accurately identifying cost-effective conservation resources. In

particular, the follow primary data collection activities are warranted either prior to, or as part of SCL's 2008 IRP and accompanying CPA:

- Update industrial sector data
- Update residential sector data
- Update commercial sector data
- Assess potential market penetration of conservation program offerings.

Update Industrial Sector Data

Due to its frequently intractable nature, the industrial sector often receives short shrift in potential assessments. This oversight is not due to researcher negligence, but is a decision made based on full consideration of the costs and benefits of conducting the necessary research to gather quality data. In the case of SCL, the industrial sector is sufficiently distinct and large enough that basic research is justified. Moreover, SCL has been successful in capturing the available potential from its top industrial customers (largest 200 or so), but there are at least one thousand industrial customers that SCL needs to know more about.

Unfortunately, SCL last conducted a major industrial customer base assessment in 1995 in a study using data from the early 1990s. At 15 years of age, the data are essentially unreliable for obtaining a baseline or projecting conservation potential. Current SCL industrial billing data are based on customers paying industrial rates (e.g., rate codes 35 and 39). This amounts to around 200 customers. However, according to SCL customer data, the number classified as industrial using the two-digit SIC code is approximately 1,200. This means that approximately 80% of the "true" industrial sector customers are not counted by SCL in the forecast or potential estimates. In the absence of up-to-date three- or four-digit SIC codes by customer, which are not utilized by SCL, there is no way to actually count actual customers or true industrial load at this time. In summary, industrial data collection is not only necessary to obtain actionable estimates of conservation resource potential, it is indispensable to accurately forecast future industrial loads.

Update Residential Sector Data

SCL's most recent residential customer assessment was a Customer Characteristics Survey (RCCS) conducted six years ago. At one time, the organization performed a RCCS biennially, but that practice stopped in the mid-1990s. More importantly, SCL has not collected in-field housing characteristics data since 2000. As with the industrial sector, reliance on old primary and secondary data in this CPA creates uncertainty about the conservation potential estimates accuracy.

Accurate estimates of residential conservation potential in future IRPs require regular basic RCCS information updates: appliance holdings and ages, fuel shares where a competing fuel is available to the customer, efficiency shares for new and replaced equipment, and trends in these and other key variables. Additionally, field work will be necessary to resolve the uncertainty surrounding the envelope characteristics of the existing housing stock. For example, how much insulation is out there? What are the physical constraints relating to adding insulation? How much more can be done? These data are needed across the lighting, HVAC, and water/

heating/plumbing end-uses. Given the distinct nature of SCL's service territory, where renovation and the construction of mixed-use multifamily are the dominant areas of activity, the need to gather data to accurately reflect the market is yet more critical.

Update Commercial Sector Market Data

From a market data standpoint, the commercial sector is in the best shape. SCL participated in the 2002 Commercial Building Stock Assessment (CBSA). Yet the field data collected by CBSA represent some of the largest buildings in the city. There is little data available to gauge the modeling assumption accuracy for small commercial customers (under 25,000 square feet)[4].

Key information requirements for small commercial customers will require on-site data collection efforts:

- Firmographic information (hours of operation, building type, etc.)
- Existing facility information (square footage, building construction, etc.)
- Energy-using equipment information (efficiency levels, age, kW capacity, etc.)
- Implemented energy efficiency strategies
- Opportunities to improve energy efficiency and reduce peak demand

Assess potential market penetration of conservation program offerings

In the Pacific Northwest, the achievable penetration rate has been traditionally set at 85% of technical potential for cost-effective measures. This figure is based on the results of BPA's successful direct-install program in Hood River the mid-1980s. The NPCC has used the 85% estimate in all subsequent Power Plans. SCL modifies this figure to a flat rate of 70% across all programs and services consistent with program results until a couple of years ago, and we employed the 70% per SCL staff instructions in this CPA.

The NPCC/SCL practice of setting a future market penetration "goal" based on past experience may, however, overstate future achievable conservation potential. A variety of factors affect the market penetration of conservation measures, including which markets and customers are targeted (e.g., large vs. small customers), inherent market barriers resulting from the customers' tendency to avoid paperwork and higher first costs, and SCL program marketing strategies and delivery mechanisms. This is why some programs, even with full incremental cost incentives, can have a wide range of penetration rates, and seldom achieve full market saturation. The available industry information suggests that, although incentive levels do play a significant role in determining program success, other non-financial factors may play an equal, if not more important, role.

To reduce market penetration uncertainty, we recommend that SCL conduct primary market research. This research can take the form of customer interviews, focus groups, or surveys

[4] This is not an explicit reference to customers in SCL's small commercial rate class, although there is likely a strong correspondence between the two.

exploring energy attitudes, behaviors, intentions, and ultimately, likely participation in various SCL program offerings. In cases where trade allies are the ultimate decision-maker or heavily influence the decision-maker, it would be better to conduct this research directly with them.

Quantec has also successfully implemented a cost-effective approach, called the Delphi Method, to obtain penetration rates. The notion behind this methodology is that well-informed individuals, calling on their insights and experience, are better equipped to predict the future than purely theoretical approaches or empirical approaches without relevant historical or market research data. These experts are well-informed staff, trade allies, external advisors, and customers. The process works as follows:

1. Delphi participants are sent market penetration related questions via email. Program concepts describe possible program implementation strategies and associated incentives.
2. Respondents send their market penetration estimates back. We then calculate key market penetration statistics for each program concept: median, minimum, maximum, etc.
3. To maintain anonymity, we send "blind" results back to each individual, asking whether they want to change their estimates. The process continues for an iteration or two until the estimates converge.

Gap Analysis Summary

The reductions in spending in basic research at SCL over the last decade surely provided customer benefits in terms of reduced bills. Further, SCL conservation programs were consistently meeting annual targets, and there was no state or city requirement to conduct IRPs.

The situation has changed markedly in recent years. Expanding IRP requirements, along with the notion that the so-called "low hanging conservation fruit" has been picked, indicate that SCL has to better understand how customers use electricity and make electric equipment purchases in order to rely on CPA estimates as a real resource. This data gap analysis identifies several areas where data collection is critical to maintain the necessary confidence in future CPA resource estimates, and we urge SCL to proceed to collect these data in advance of its next planning cycle.

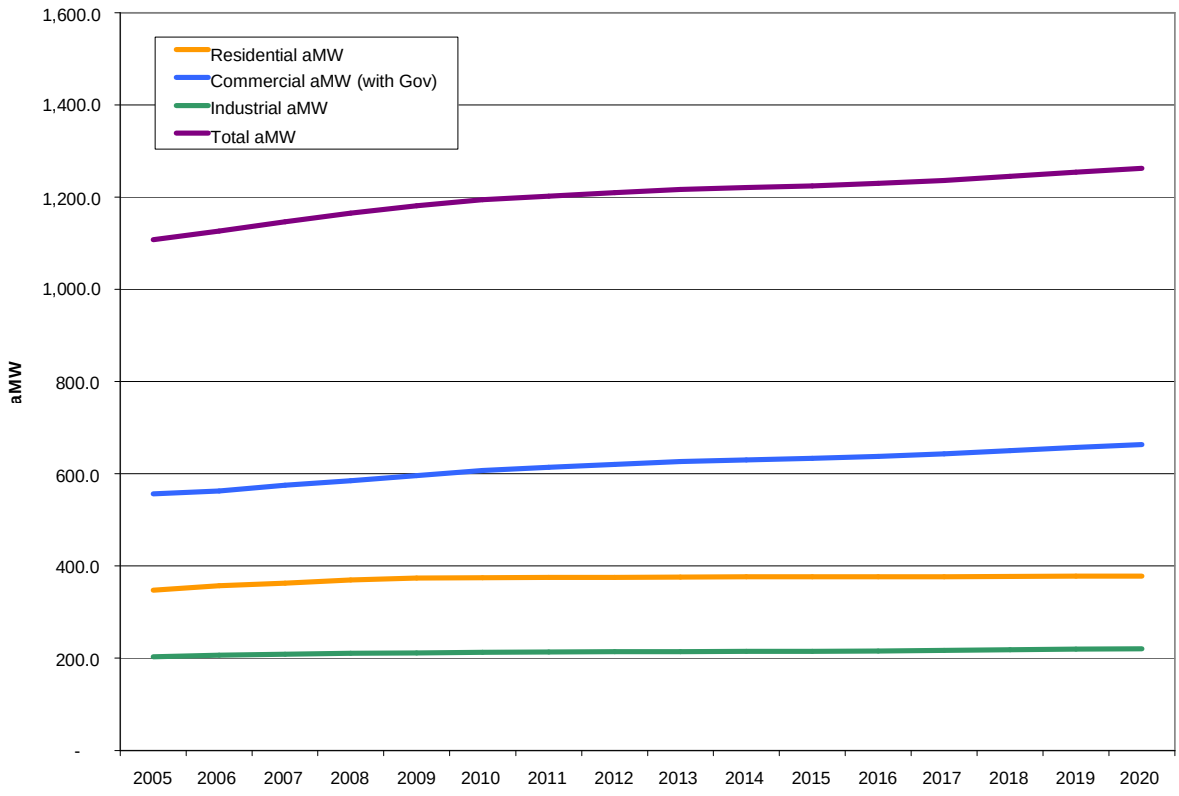
4. Baseline Energy Consumption

This chapter describes the segmentation design used to generate the baseline forecast and subsequent energy efficiency potential results, and presents the results of the baseline energy consumption forecast. The development of an appropriate and accurate baseline is essential to robust economic analysis of conservation resources and program design. The first step in characterizing the baseline was to appropriately partition SCL's customers by:

- Customer segments: residential, commercial, and industrial; and sub-segments by dwelling, building, and industry type
- Building vintage: existing and new construction
- End uses: those applicable for each customer segment.

As described in Chapter 2, the End Use Forecaster baseline is calibrated to SCL's official forecasts for each sector. These forecasts are shown in Figure 4.

Figure 4. SCL Energy Forecast



Residential Sector

The residential sector was divided into three segments and 14 end uses, as shown in Table 7 below. The segments chosen were based on their consistency with classifications available in SCL's most recent residential study, which had critical data on appliance and end use saturations and fuel shares. The end uses were broken out at the level necessary to assess the various measures of interest.

Table 7. Residential Segments and End Uses

Residential Segments	Electric End Uses
Single Family	Central_Heat
Multifamily 2- 4 Units	Room_Heat
Multifamily 5+ Units	Heat_Pump
	Central_AC
	Room_AC
	Lighting_Bulbs
	Lighting_Fixtures
	Water_Heat
	Refrigerator
	Freezer
	Cooking
	Dryer
	Plug_Load
	Other

Figure 5 shows base year (2004) energy consumption for each building type in the segmentation design. Given the higher usage per home in single family, the distribution of baseline usage by home type is consistent with the proportions of each home type in the residential study data used for the analysis.

Figure 5. Residential Base Year Consumption by Building Type

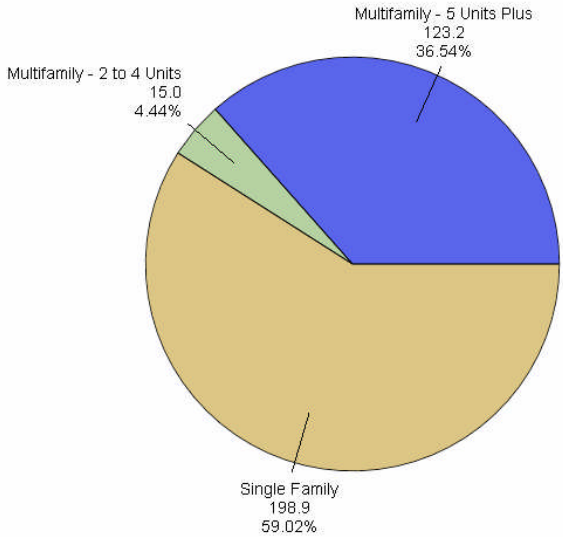
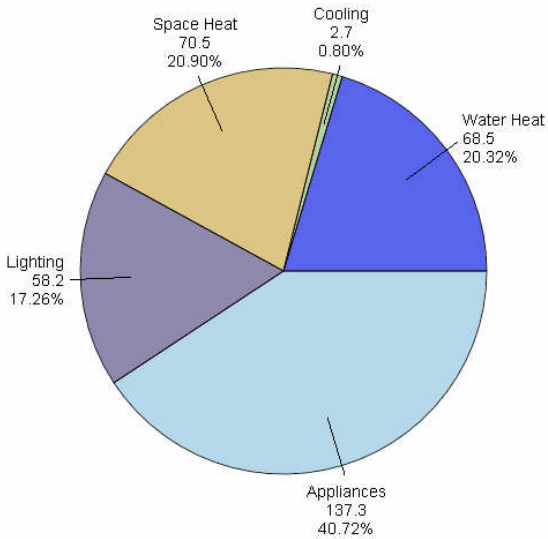


Figure 6 shows base year sales by end use. These breakouts take into account different fuel shares for the different end uses, with a substantial amount of gas heating and water heating reducing the overall share associated with those end uses. The low cooling load is due to the available residential data, which showed a very low saturation of room and central air conditioning in Seattle City Light's service territory. Anecdotal evidence suggests that these saturations are increasing, and this is one area where we anticipate that SCL efforts to eliminate data gaps will change the results presented here.

Figure 6. Residential Base Year Consumption by End Use



Commercial Sector

The commercial sector was divided into 13 segments and 24 end uses, as shown in Table 8 below. Following the detailed breakout available in the CBSA study, fluorescent lighting is disaggregated by number of bulbs, length of each bulb in feet, and diameter of each bulb in eighths of an inch. For example, Lighting_4L4T12 represents a 4 bulb fixture, 4 feet long, with an older, inefficient 12-eigths diameter.

Table 8. Commercial Segments and End Uses

Commercial Segments	Electric End Uses
Dry_Goods_Retail	Space_Heat_ASHP
Grocery	Space_Heat_WSHP
Office	Space_Heat_Boiler
Restaurant	Space_Heat_Furnace
Warehouse	Space_Heat_RadiantBase
Hospital	Cooling_Chillers
Hotel_Motel	Cooling_DX
School	Cooling_HeatPump
University	Ventilation
Other	Lighting_4L4T12
Data_Centers	Lighting_3L4T12
Biotech	Lighting_2L4T12
MF_Common	Lighting_2L8T12
	Lighting_4L4T8
	Lighting_3L4T8
	Lighting_2L4T8
	Lighting_INC75W
	Lighting_INC150W
	Lighting_MF_Common
	Water_Heat
	Refrigeration
	Cooking
	Plug_Load
	Other

Figure 7 shows base year energy consumption for each building type in the segmentation design. Nearly half of the baseline consumption is associated with the office segment, with the other segments accounting for the remaining energy usage in roughly equal proportions.

Figure 7. Commercial Base Year Consumption by Building Type

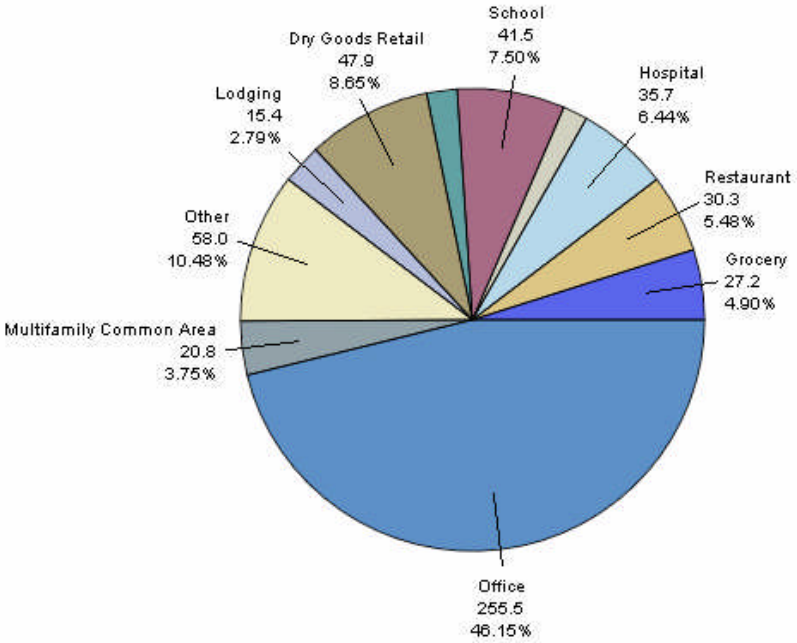
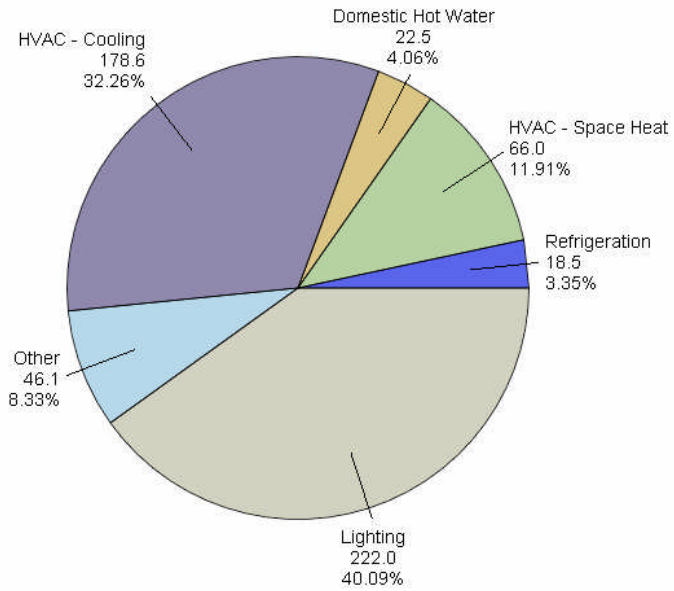


Figure 8 shows commercial base year sales by end use. The dominance of the office segment in the baseline consumption also explains the dominance of lighting and HVAC in the distribution by end use.

Figure 8. Commercial Base Year Consumption by End Use



Industrial Sector

The industrial sector was divided into six segments and seven end uses, as shown in Table 9 below. The segments and end uses were dictated by both the need to be consistent with previous assessment for this sector and the availability of key data inputs. The distribution of industrial base year energy consumption by segment and end use are shown in Figure 9 and Figure 10.

Table 9. Industrial Segments and End Uses

Industrial Segments	Electric End Uses
Food	Lighting
Stone_Clay_Glass	HVAC_Other
Metals	Air_Compressor
Aerospace	Motors
Ship	Process_Heat
Other	Refrigeration
	Welding

Figure 9. Industrial Base Year Consumption by Industry Type

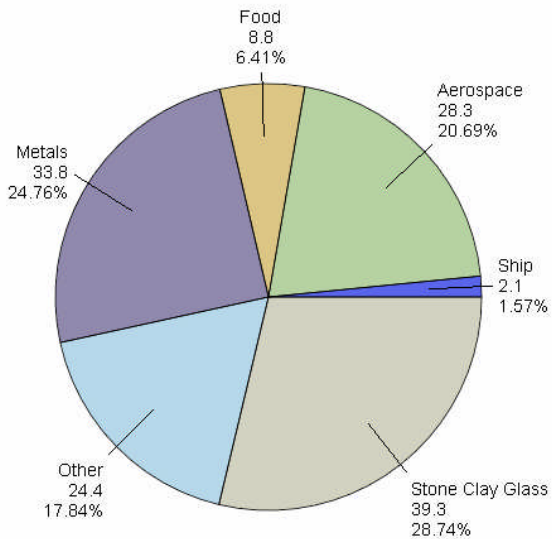
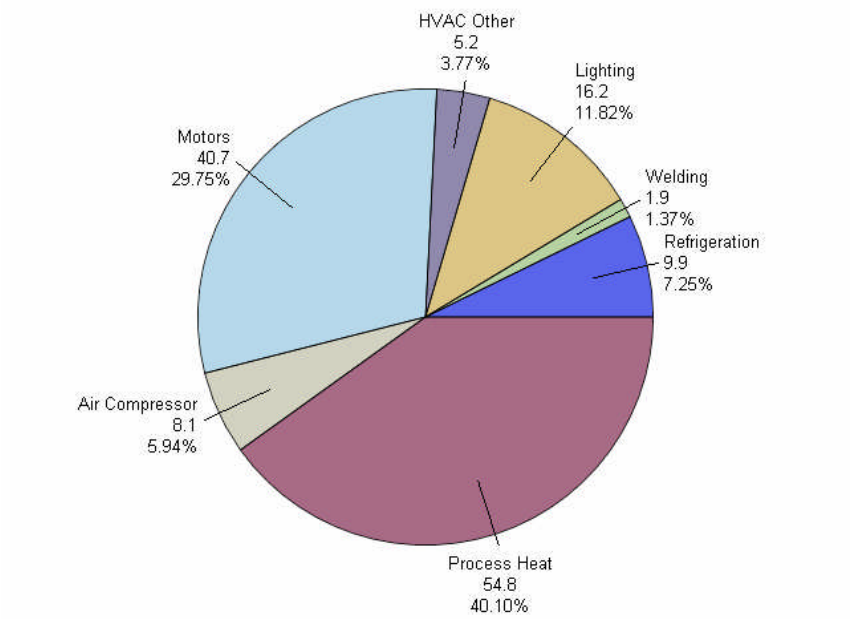


Figure 10. Industrial Base Year Consumption by End Use



5. Achievable Conservation Potential

As described in the *Methodology* chapter, the overall approach in this study distinguishes between two distinct, yet related, definitions of resource potential widely used in utility resource planning: "technical potential" and "achievable potential." Technical energy efficiency potential, which assumes that all demand-side resource opportunities may be captured regardless of their costs or market barriers, was estimated using End Use Forecaster in three steps:

1. Development a baseline forecast (presented in the previous Chapter)
2. Creation of a potential forecast for each end use that incorporates installation of all feasible energy-efficiency measures
3. Calculation of technical potentials by end-use as the difference between the two forecasts.

Achievable potential, on the other hand, represents that portion of technical potential that is likely to be available over the planning horizon given prevailing market barriers that may limit the implementation of demand-side measures. SCL deemed that the market penetration rate across all sectors, segments, vintages, end-uses, and measures should be 70% for 2006 IRP purposes. Because of the simplicity of this approach, the results are shown for the achievable potential only, which is the subject of most interest.

Based on the results of this study, cumulative 15-year achievable conservation potentials in SCL's service area are estimated at nearly 229 aMW of electricity, representing more than 18% of the baseline electricity consumption forecast in that year (2020). Table 10 shows these hypothetical maxima by sector for years five, 10, and 15 of the planning horizon.

Table 10. Achievable Conservation Potential by Sector

Segment	aMW Savings		
	5 Years	10 Years	15 Years
Residential	21.6	47.2	71.3
Commercial	37.7	81.3	120.4
Industrial	10.3	23.4	37.1
Total	***69.6***	***151.8***	***228.8***
Total as % of Baseline Forecast	***5.8%***	***12.9%***	***18.1%***

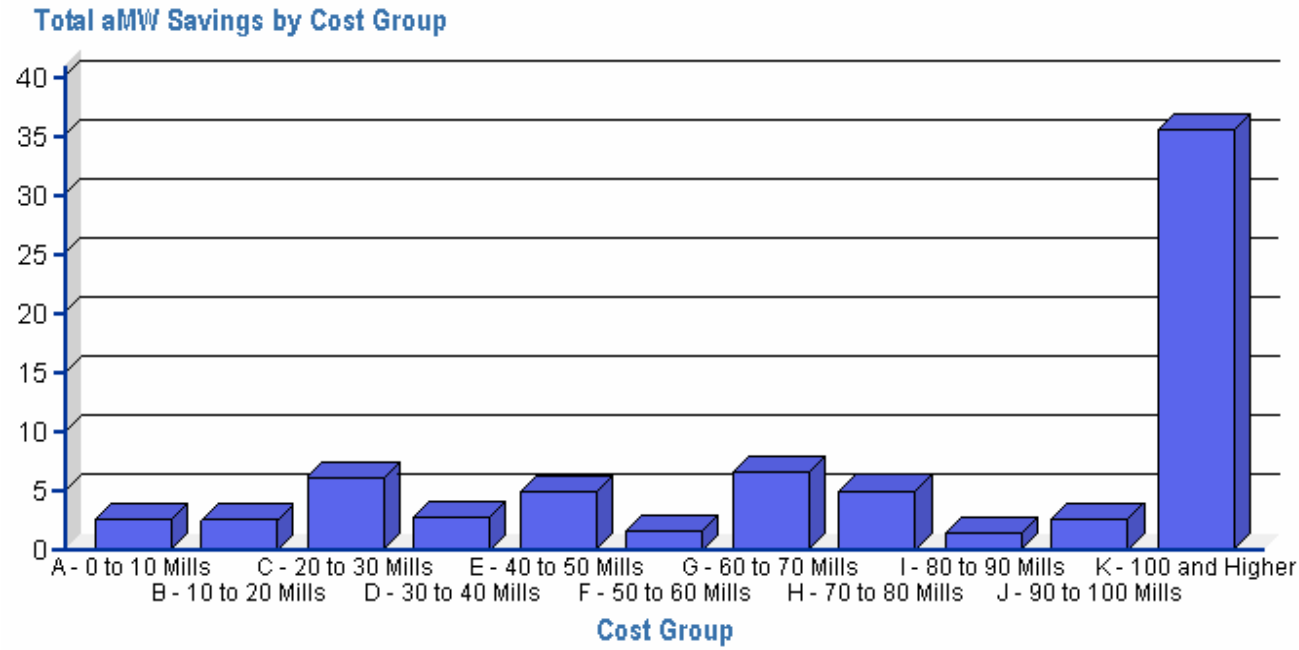
Residential Achievable Potential Results

Electricity energy efficiency achievable potential in the residential sector is estimated to be approximately 71.3 aMW in the 15th year of the planning horizon. The breakout of these savings by cost group and resource type is presented in Table 11. These savings represent approximately 19% savings relative to the base case (378 aMW) and 70% of technical potential. A full 20% of this potential (14 aMW) can be achieved at a cost of less than $.04 per kWh (Table 11 and Figure 11).

Table 11. Distribution of Residential Sector Achievable Potential by Cost Category

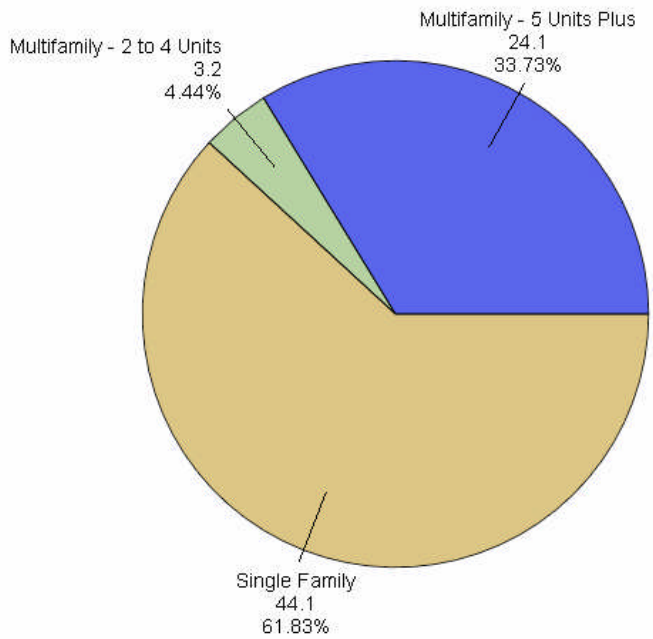
	Total aMW			Percent of Total by Cost Group		
	Equipment Replacement	New Construction	Retrofit	Equipment Replacement	New Construction	Retrofit
A - 0 to 10 Mills	-	0.1	2.5	0.0%	3.0%	3.9%
B - 10 to 20 Mills	-	-	2.5	0.0%	0.5%	3.9%
C - 20 to 30 Mills	-	0.7	5.4	0.0%	20.0%	8.6%
D - 30 to 40 Mills	-	-	2.8	0.0%	0.0%	4.4%
E - 40 to 50 Mills	-	-	4.8	0.0%	1.0%	7.6%
F - 50 to 60 Mills	-	-	1.5	0.0%	0.3%	2.4%
G - 60 to 70 Mills	1.9	0.1	4.5	40.8%	1.7%	7.1%
H - 70 to 80 Mills	0.5	0.1	4.4	9.9%	3.6%	6.9%
I - 80 to 90 Mills	0.7	0.2	0.5	14.8%	5.2%	0.9%
J - 90 to 100 Mills	-	-	2.6	0.0%	0.7%	4.1%
K - 100 and Higher	1.6	2.3	31.6	34.5%	63.9%	50.2%
Total	***4.8***	***3.5***	***63.1***	***100.0%***	***100.0%***	***100.0%***

Figure 11. Distribution of Residential Sector Achievable Potential by Cost Category



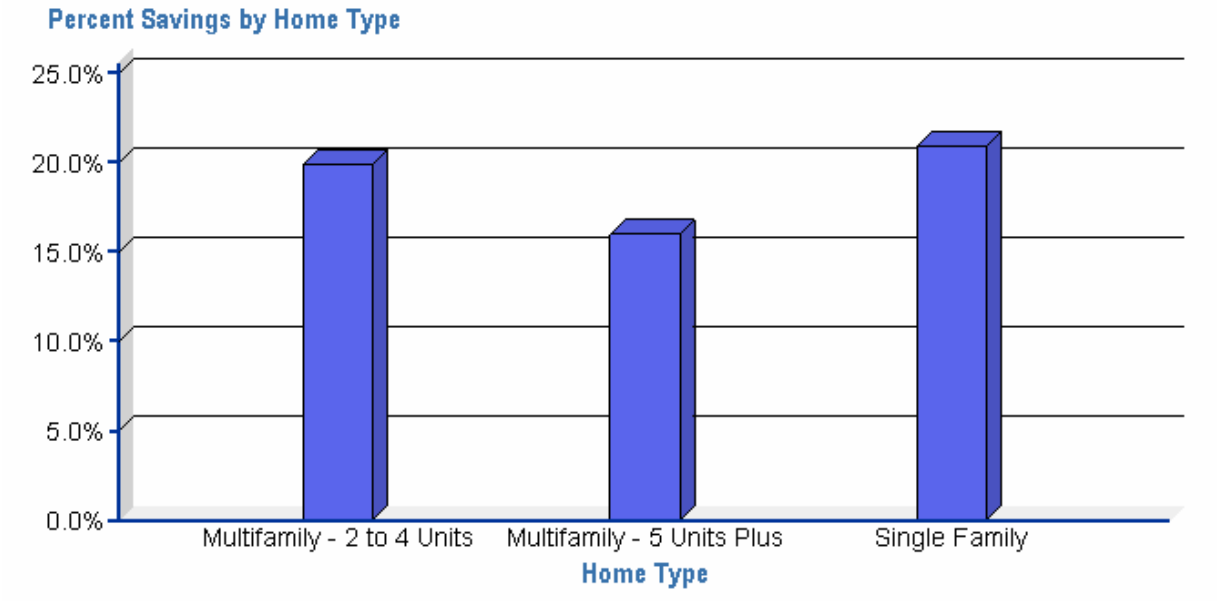
Single-family dwellings account for the largest share of achievable potential (62%) in the residential sector, followed by large multifamily dwellings, which account for approximately 34% of all residential achievable potential (Figure 12).

Figure 12. Distribution of Achievable Potential by Dwelling Type



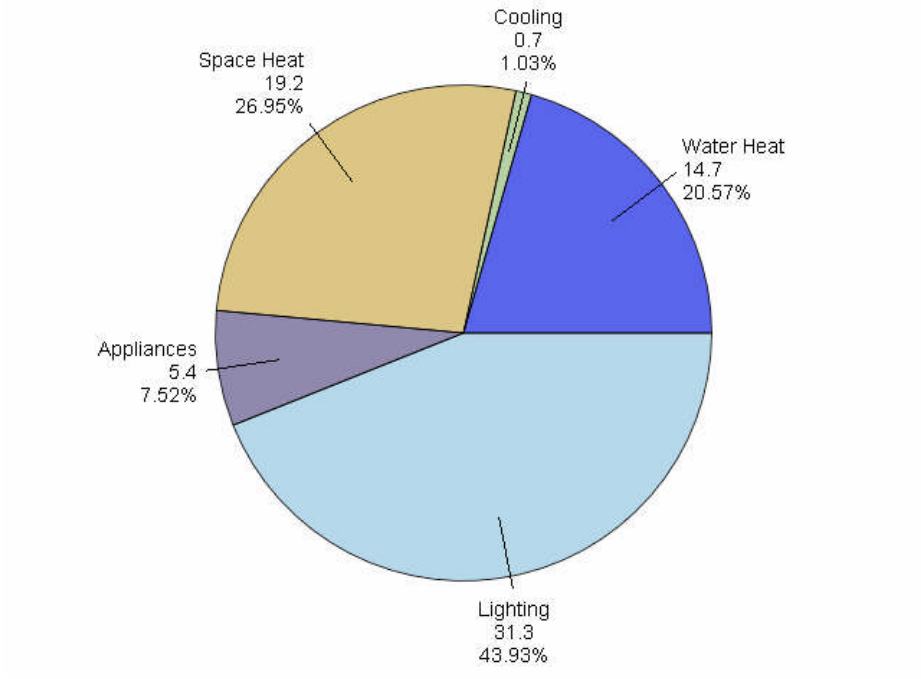
As shown in Figure 13, achievable potential within single family and small multifamily dwellings represents approximately 20% savings with respect to the total consumption in those dwellings. Large multifamily achievable potential represents about 16% of total consumption.

Figure 13. Achievable Potential as Percent Savings by Home Type



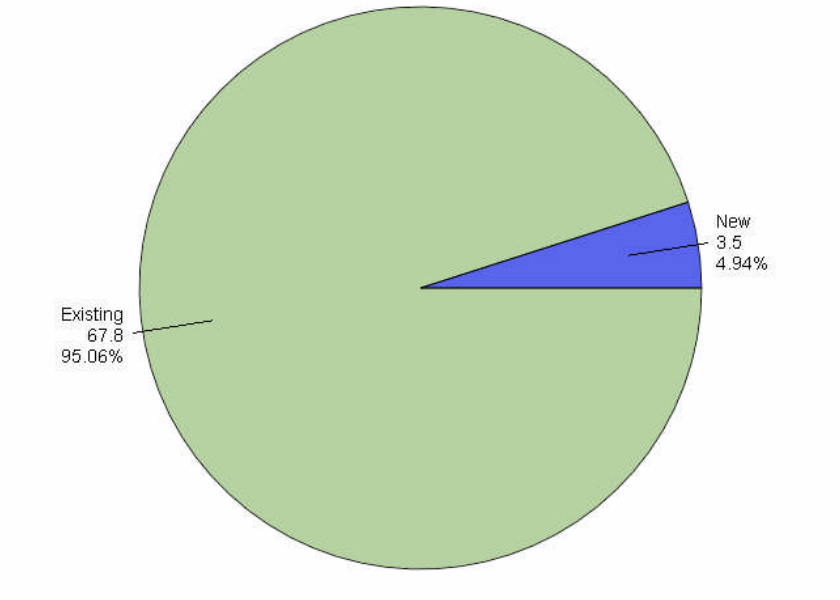
As shown in Figure 14, expected savings in lighting is the largest component of achievable potential in the residential sector, accounting for almost 44% of the total achievable potential across all end uses. Electric space heating and water heating account for nearly all of the remaining potential, with other end uses (refrigerators, freezers, etc.) accounting for less than 10% of the total achievable potential.

Figure 14. Distribution of Achievable Potential by End Use



Achievable potential in existing construction accounts for approximately 95% of total achievable potential, while the remaining 5% of achievable potential is attributed to new construction (Figure 15).

Figure 15. Distribution of Achievable Potential by Construction Type



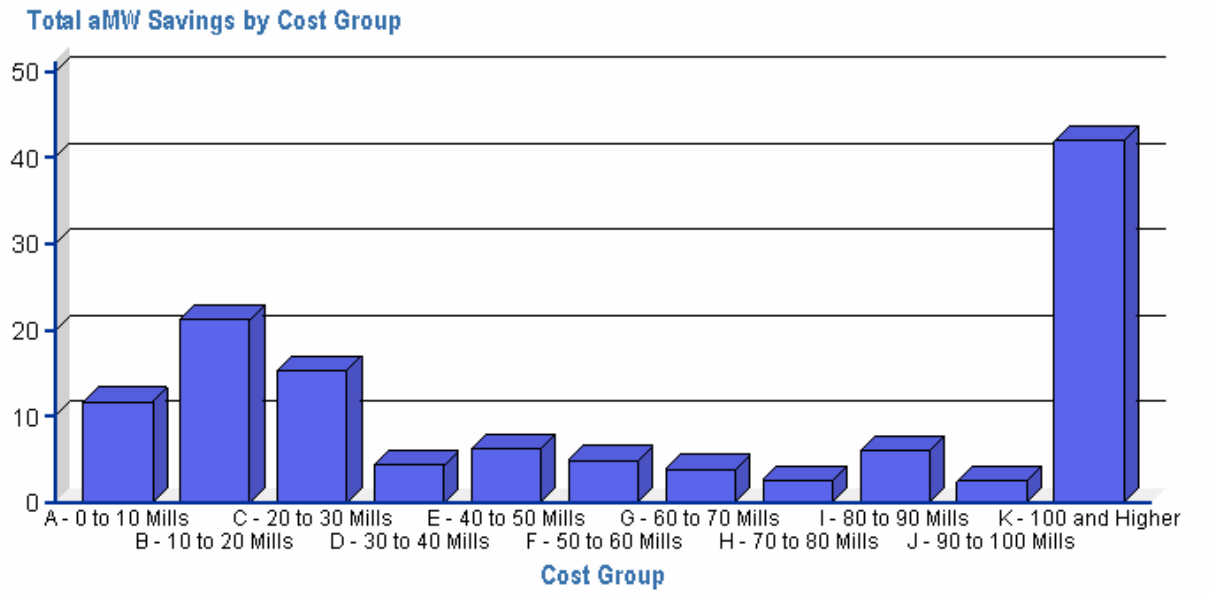
Commercial Achievable Potential Results

Electricity energy efficiency achievable potential in the commercial sector is estimated to be approximately 120 aMW in the 15th year of the planning horizon, which is approximately 18.2% savings relative to the base case (663 aMW) and 70% of technical potential. Around 44% of this potential (53 aMW) can be achieved at a cost of less than $.04 per kWh (Table 12 and Figure 16).

Table 12. Distribution of Commercial Sector Achievable Potential by Cost Category

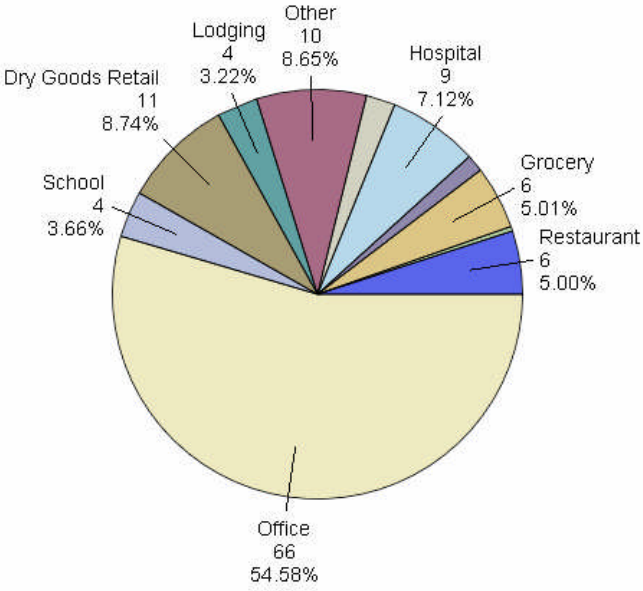
	Total aMW			Percent of Total by Cost Group		
	Equipment Replacement	New Construction	Retrofit	Equipment Replacement	New Construction	Retrofit
A - 0 to 10 Mills	0.9	1.1	9.6	0.0	6.4%	11.7%
B - 10 to 20 Mills	2.6	3.5	15.1	12.3%	20.2%	18.4%
C - 20 to 30 Mills	10.1	2.3	3.0	48.0%	13.1%	3.6%
D - 30 to 40 Mills	1.2	0.5	2.6	5.8%	2.9%	3.1%
E - 40 to 50 Mills	1.5	1.3	3.4	7.3%	7.7%	4.1%
F - 50 to 60 Mills	1.2	0.5	3.2	5.6%	3.0%	3.9%
G - 60 to 70 Mills	-	0.6	3.3	0.0%	3.4%	4.0%
H - 70 to 80 Mills	0.1	0.4	2.1	0.6%	2.2%	2.5%
I - 80 to 90 Mills	0.1	0.7	5.2	0.3%	4.3%	6.3%
J - 90 to 100 Mills	-	0.3	2.2	0.0%	1.7%	2.6%
K - 100 and Higher	3.3	6.1	32.6	15.6%	35.2%	39.7%
Total	***21.0***	***17.2***	***82.2***	***100.0%***	***100.0%***	***100.0%***

Figure 16. Distribution of Commercial Sector Achievable Potential by Cost Category



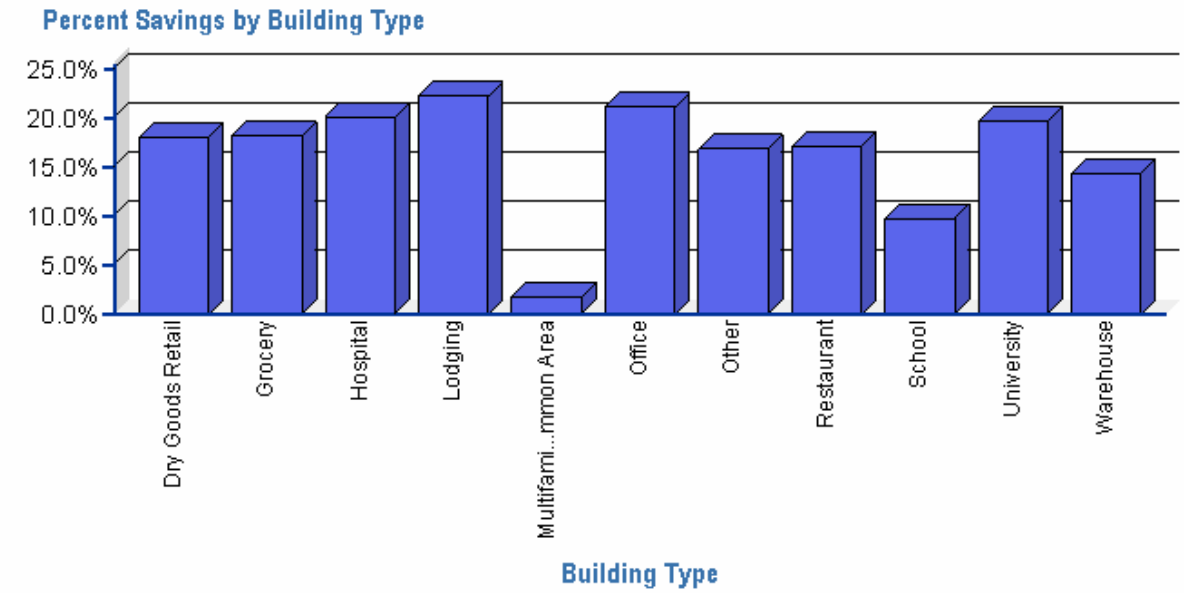
The office segment accounts for the largest share of achievable potential (55%) in the commercial sector, with no other segment accounting for more than 10% of the total achievable potential (Figure 17).

Figure 17. Distribution of Achievable Potential by Building Type



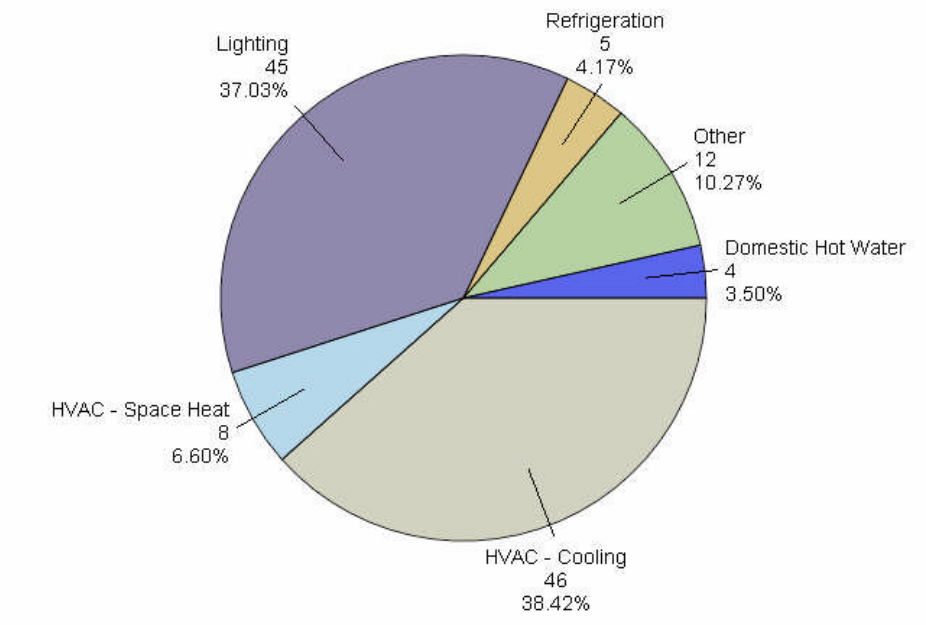
As a percentage of total consumption, achievable potential is highest within the lodging and office segments, with both at more than 20%. As shown in Figure 18, the lowest savings are with the school segment and multifamily common areas, which consists of lighting only.

Figure 18. Achievable Potential as Percent of Total Usage by Building Type



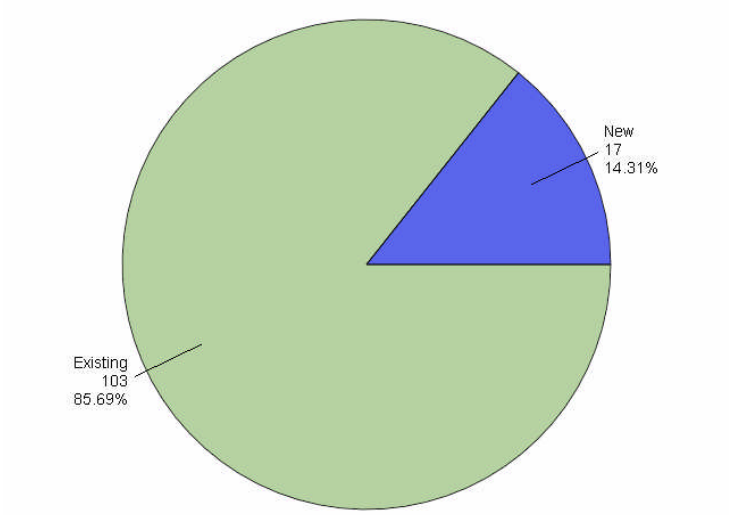
As shown in Figure 19, expected savings in HVAC is the largest component of achievable electricity energy efficiency potential in the commercial sector, accounting for 38% of the total achievable potential. Lighting is a close second with 37%.

Figure 19. Distribution of Achievable Potential by End Use



Achievable potential in existing construction accounts for approximately 86% of total achievable potential, while the remaining 14% of achievable potential is attributed to new construction (Figure 20).

Figure 20. Distribution of Achievable Potential by Construction Type



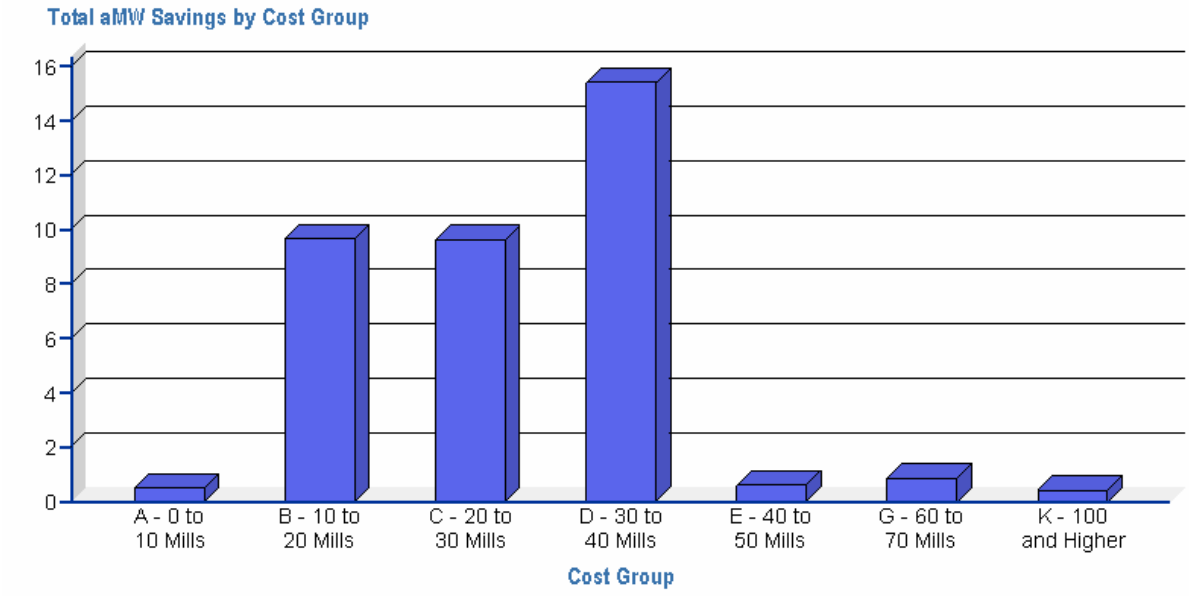
Industrial Achievable Potential Results

Electricity energy efficiency achievable potential in the industrial sector is estimated to be approximately 37 aMW in the 15th year of the planning. This represents approximately 17% savings relative to the base case (220 aMW) and 70% of technical potential. 95% of this potential (35 aMW) can be achieved at a cost of less than $.04 per kWh (Table 13 and Figure 21).

Table 13. Distribution of Industrial Sector Achievable Potential by Cost Category

	Retrofit Total MWh	Retrofit Percent of Total by Cost Group
A - 0 to 10 Mills	0.5	1.3%
B - 10 to 20 Mills	9.7	26.1%
C - 20 to 30 Mills	9.6	26.0%
D - 30 to 40 Mills	15.4	41.6%
E - 40 to 50 Mills	0.6	1.6%
G - 60 to 70 Mills	0.9	2.3%
K - 100 and Higher	0.4	1.1%
Total	**37.1**	**100.0%**

Figure 21. Distribution of Industrial Sector Achievable Potential by Cost Category



Industries in stone, clay, and glass accounted for over 39% of the achievable potential in the industrial sector (Figure 22), and were also the segment with the highest percentage of potential

in terms of base consumption (Figure 23). The metals category had the second highest achievable potential at nearly 27%, followed by the general other category and aerospace with 18% and 12%, respectively.

Figure 22. Distribution of Achievable Potential by Segment

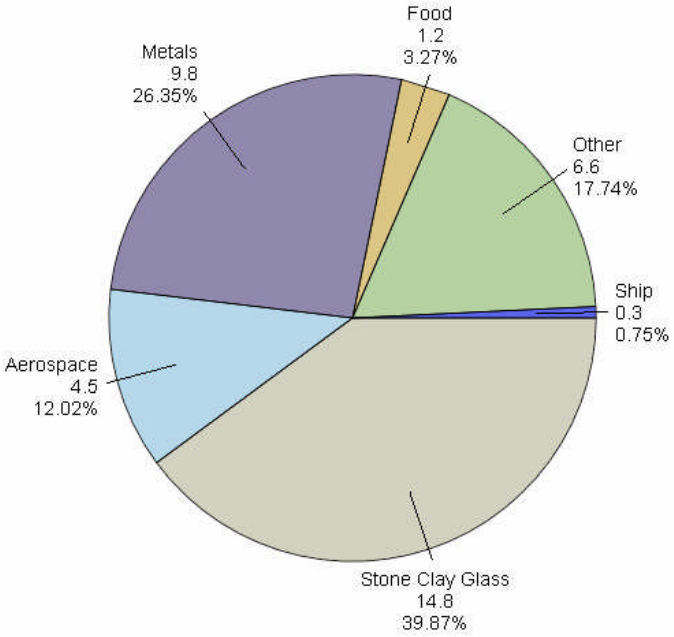
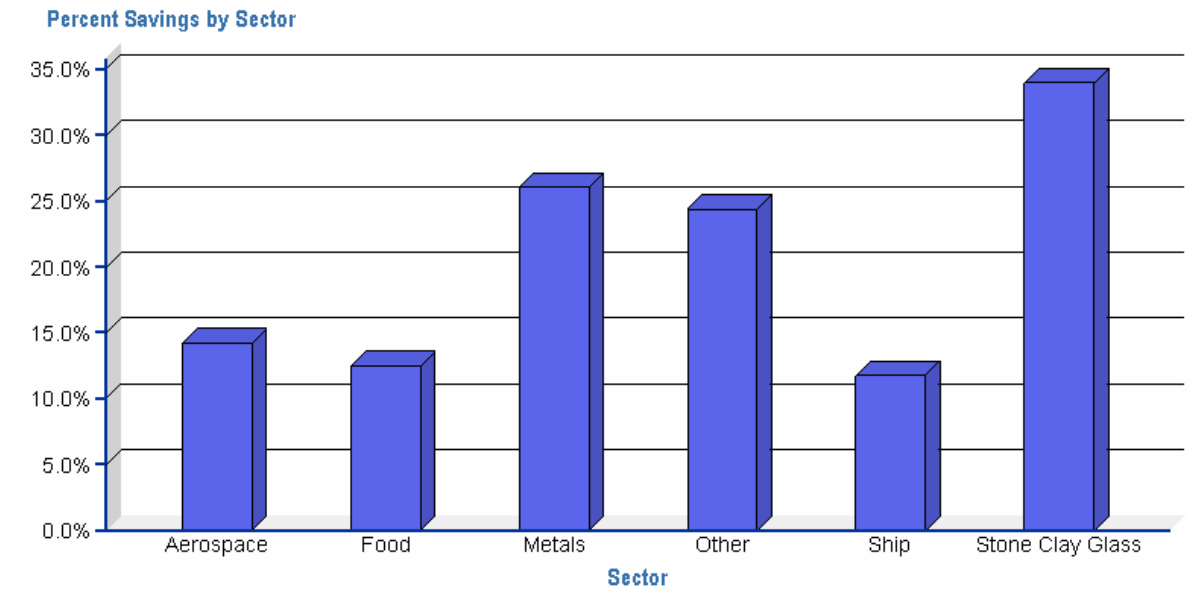
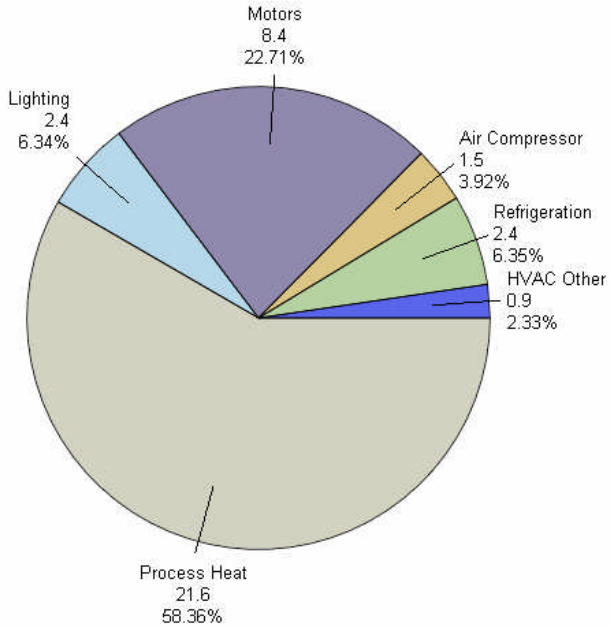


Figure 23. Achievable Potential as Percent of Total Usage by Industry



With respect to end uses, process heat accounted for 58.36% of the achievable potential (Figure 24), followed by motors at nearly 23%. Lighting, HVAC, and refrigeration all contributed less than 10% each.

Figure 24. Distribution of Achievable Potential by End Use

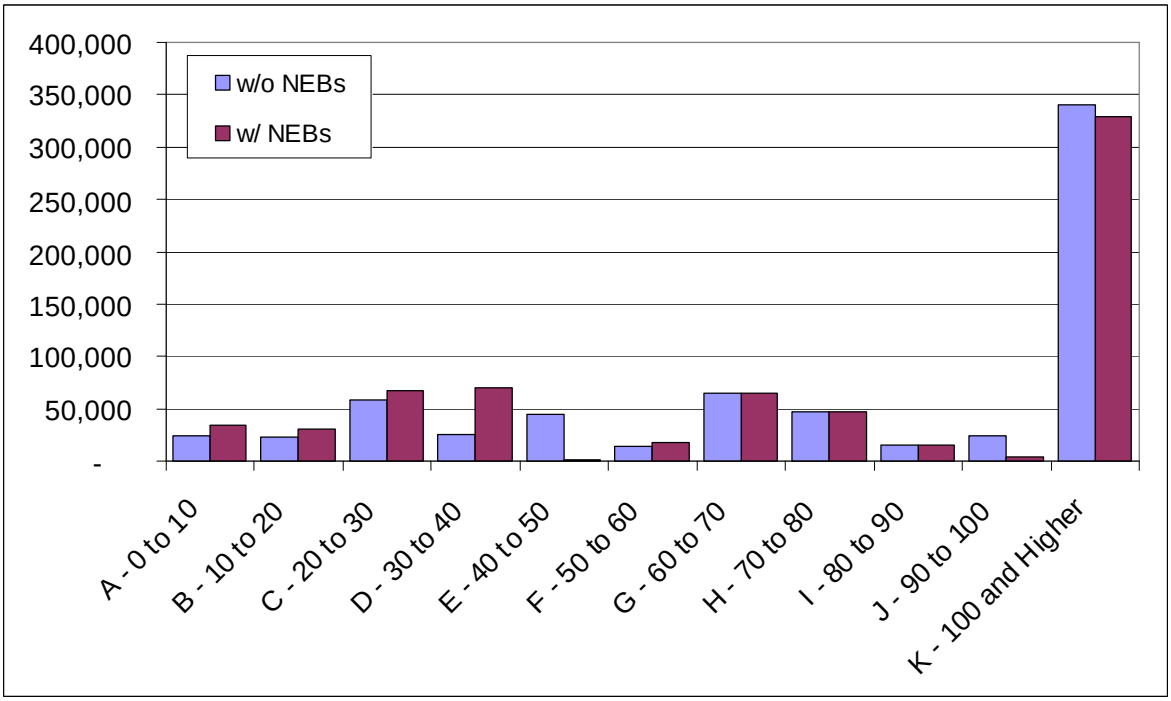


Impact of Non-Energy Benefits (NEBs)

The addition of NEBs had no effect on the absolute value of achievable potential, but rather had two effects on the relative cost-effectiveness among the mill bundles. First, there was a shifting of potential among the mill bundles, with potential moving from the higher to lower cost bundles. Second, within the bundles, there was a change in the average levelized cost where the NEB lowered the cost of a measure, but not enough to move it into a different mill bundle. Note that the results in this section of the report refer to the data that were provided for use in the IRP modeling efforts. As such, they are presented in terms of megawatt hours and levelized dollars per MWh. Furthermore, the potential is shown for year 20, consistent with the forecast horizon used for planning.

The end results of the analysis will come down to how the bundles with NEBs compare when used in the IRP modeling. However, there are ways to see what the effect of the analysis had on the makeup of the bundles. For the residential results, there were clear shifts of potential from one mill group to another. For example, in Figure 25, the total potential in the 90 to 100 mill group was reduced from more than 24,000 MWh to just over 3,500 with the addition of NEBs. Likewise, the MWh potential in the 30 to 40 mill group increased from around 25,500 to over 69,600.

Figure 25. Residential MWh Potential in Year 20 by Mill Bundle, with and without NEBs



For commercial achievable potential, the shifts are smaller and hard to perceive in a graphical representation. Instead, the effects of NEBs are shown in Table 14, where the average levelized cost in dollars per MWh is shown with and without NEBs for the different mill groups. The 40 to 50 mill group, for example, was reduced in average cost from $45.50 to $41.10 per MWh.

Table 14. Commercial Potential Bundle Costs, with and without NEBs

Mill Group	$/MWh w/o NEBs	$/MWh w/ NEBs
A - 0 to 10	$7.1	$6.0
B - 10 to 20	$13.3	$12.8
C - 20 to 30	$23.5	$22.8
D - 30 to 40	$34.8	$31.1
E - 40 to 50	$45.5	$41.1
F - 50 to 60	$53.3	$50.1
G - 60 to 70	$66.4	$66.4
H - 70 to 80	$73.2	$69.7
I - 80 to 90	$87.9	$87.9
J - 90 to 100	$96.7	$96.7
K - 100 and Higher	**$ 439.6**	**$ 439.6**

Appendix A: Detailed Data Tables

Conservation measure details are provided as Excel tables on the enclosed CD.