ENERGY EFFICIENCY AND CONSERVATION MEASURE RESOURCE ASSESSMENT FOR THE YEARS 2010-2030

Prepared for the

Energy Trust of Oregon, Inc.

Final Report

January 25, 2011

By

Stellar Processes

And

Ecotope

Table of Contents

List of Figures

List of Tables

Project Overview

The goal of this project was to provide Energy Trust of Oregon, Inc. (Energy Trust) with the amount and cost of potential energy efficiency and renewable energy measures that could provide electricity and natural gas demand-side savings for Oregon consumers by 2030 within the Energy Trust service territory. This resource assessment is designed to inform strategic planning, the project development and selection process, and for use in utility resource planning. By 2030, a technical potential of approximately 766 Average Megawatts (aMW) of electric savings and 108 million annual therms of gas savings were identified in this study[1].

Table 1: Summary of Technical Potential

Electric Utilities	**Both Utilities, aMW**
Residential	181
Commercial	358
Industrial	178
Conservation Voltage Reduction	49
Total (Including voltage reduction)	766
Natural Gas Utilities	**Both Utilities, Mmtherm**
Residential	67
Commercial	21
Industrial	20
Total (Including cross-utility impact)	108

Conservation Voltage Reduction is a potential measure applicable by the utility at the substation level. Hence, it is not a measure that would be targeted by the Energy Trust but it is included in order to give a complete picture of the demand side potential. Quantification of Conservation Voltage reduction comes from the work of the Northwest Power and Conservation Council and was not explicitly developed in this project.

Stellar Processes and Ecotope, Inc., reviewed existing demographic and energy efficiency measure data sources to identify and quantify the resource potential. The contractors created updateable planning tools to develop these estimates and for Energy Trust to incorporate in their ongoing planning processes. The tools to evaluate the cost of individual measures and packages

[1] Electric measure savings are quantified in average MW as well as peak MW savings for summer and winter heavy demand periods. Gas savings are quantified in annual therms.

of measures consider the measure life, equipment and installation, annual O&M expenses, and the discount rate employed by the Energy Trust to produce levelized costs and a Benefit Cost Ratio (BCR). Levelized costs are useful to compare program options and conservation strategies that have different measure lives. The BCR provides a comparison to long-term benefits that include the lifetime and load shape value of the savings. In this sense, the BCR is a more thorough comparison and is the index used to screen for cost-effectiveness.

It is important to note that program related costs are not included because Energy Trust staff directed that they are outside the scope of this study. It is equally important to note that the levelized costs shown in this study are the entire societal cost of efficiency measures for situations where existing, working equipment is retrofit, and the incremental cost of efficiency when considering new purchases of efficiency versus standard equipment. The incentive costs to the Energy Trust are often only a portion of these "total measure costs". This study provides the basic information on the cost of measures, which the Energy Trust will combine with their knowledge of markets and programs and incentives to develop estimates of total program costs to the society and (separately) to the utility system.

While this project was not intended to provide program design, it does identify and quantify estimates of electricity and gas use and measures of activity (such as number and energy use of households or total floor space) in the target markets for the industrial / agriculture, residential, and commercial sectors. Residential savings potential is quantified by housing type for new and existing single family, multifamily, and manufactured homes. Commercial savings are quantified on a square footage basis for typical business type designations such as retail, grocery, and large and small office spaces. The industrial analysis quantifies savings and costs by process type such as wood products, food, and electronics.

Determining the applicability of potential measures to specific segments or subsectors of the commercial and industrial building stock can be difficult. For these segments, many "cross cutting" measures such as lighting improvements for commercial applications or motor efficiency improvements for industrial customers were analyzed. Cross cutting measures can be applicable across a wide variety of circumstances and building types. In the industrial sector, many measures are relevant for specific applications or processes rather than in discrete building types. The industrial technical potential section discusses the assumptions used to determine measure applicability.

Summary of Results

The resource potential can be considered "technical" or "achievable". The technical potential is an estimate of all energy savings that could be accomplished immediately without the influence of any market barriers such as cost and customer awareness. As such, it provides a snapshot of everything that could be done. Technical potential does not present what can be saved through programs; it would be impossible to get every customer to install every possible measure. Furthermore, some resources may cost more than the Energy Trust or participants wish to pay. The achievable potential represents a more realistic assessment of what could be expected – taking into account the fact that not all consumers can be persuaded to participate and other real world limitations.

The following figures and tables summarize the results of this analysis for 2030. In providing summary statistics for this section, we screened measures to a BCR of 1 or better. This provides a summary of the savings potential that has a reasonable chance of being cost effective when compared to avoided energy costs. Although the list of cost-effective measures does not include the highest cost measures, the supply curves and detailed tables of measures in the Technical Appendix lists all measures considered in this study. Both supply curves show some additional potential just beyond the current cost-effectiveness screen. Should higher avoided costs occur, there would be more additional measures available for conservation programs.

Figure 1: Electricity Supply Curve

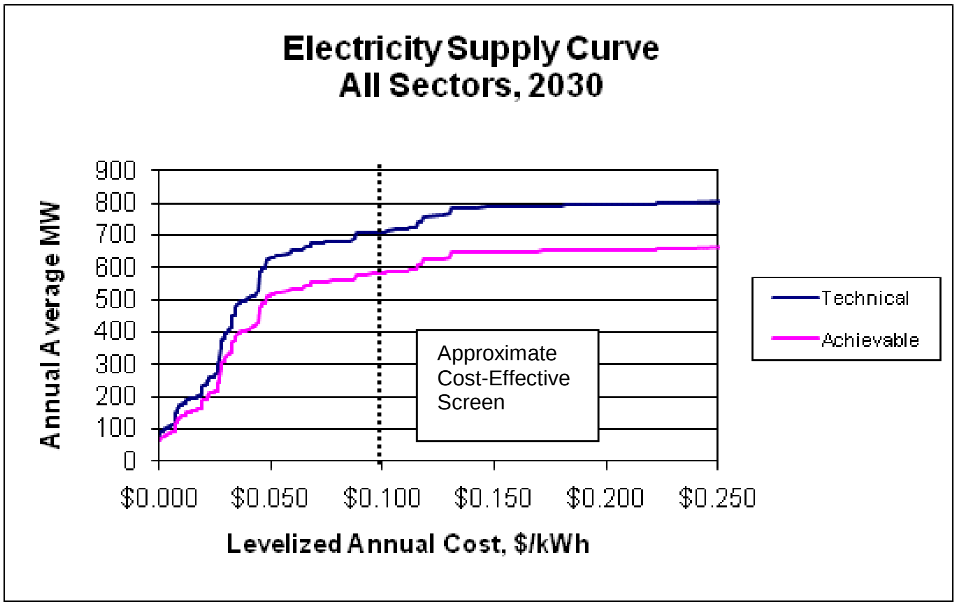


Figure 2: Electricity Technical Potential

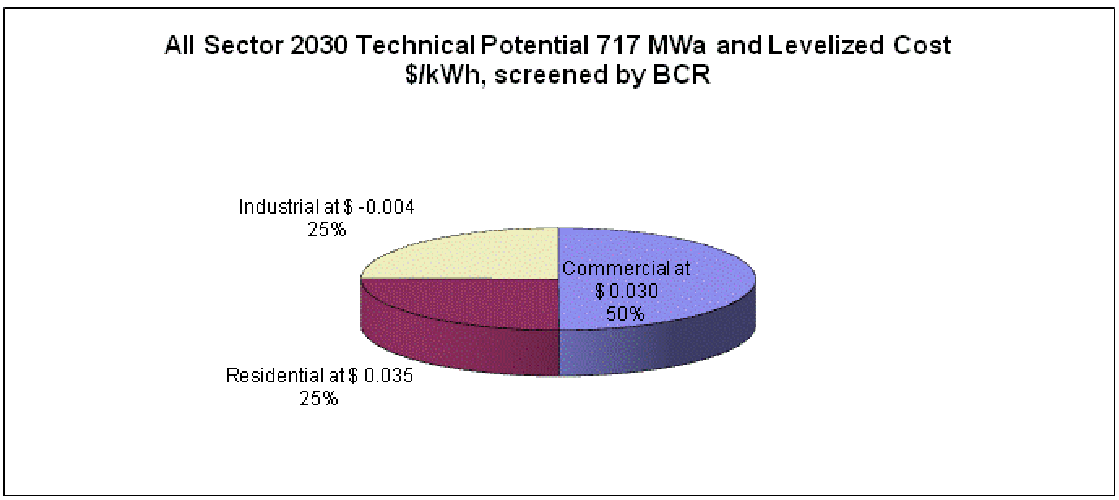


Figure 1 shows that the estimated savings from all electricity measures would reduce electricity use by 717 aMW of technical potential for cost-effective measures. Most of the proposed measures fall within the cost-effectiveness screen. One large exception is solar water heaters, which remain expensive even after tax credits. Energy Trust has found solar water heat to be cost-effective using a more complex cost-effectiveness methodology than the simple first0cut approach employed in this study. Figure 2 shows the distribution of potential electric savings across market segments.

Figure 3 shows that natural gas conservation measures could reduce consumption by an estimated 108 million therms. Figure 4 shows the distribution of potential natural gas savings across market segments.

Figure 3: Natural Gas Supply Curve

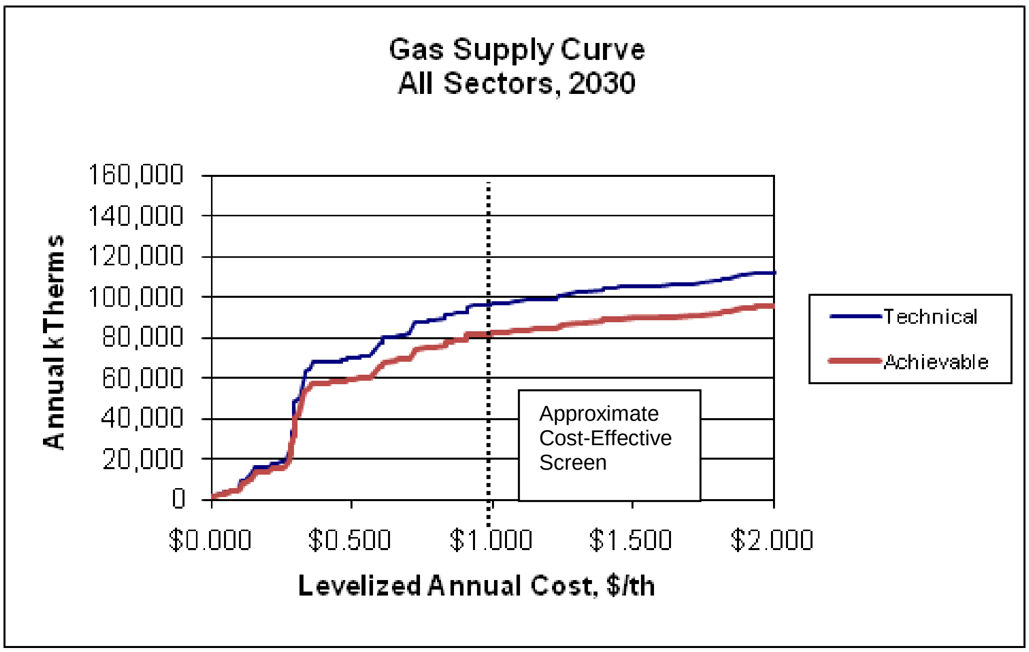
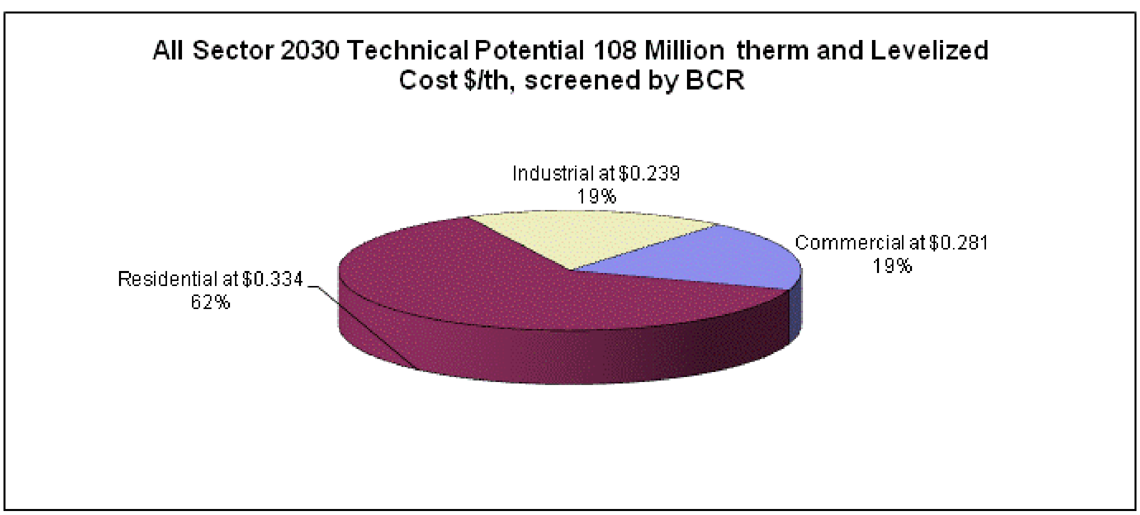


Figure 4: Natural Gas Technical Potential



Significant Efficiency Measures

Utility Sector

As mentioned previously, Conservation Voltage Reduction (CRV) is a set of measures that would be implemented at the utility level. The estimate of conservation potential was developed by the Northwest Power and Conservation Council (NPCC). The savings estimate amounts to saving 1.3% of current utility sales across all customer classes. In general, these measures could be negative in cost after credit for deferred utility investment in capacity expansion. No independent analysis was conducted for that set of measures. For further information, the reader is referred to NPCC.

Industrial Sector

Industrial customers of investor owned utilities in Oregon with over 1 aMW demand have the option of using their payment to the energy efficiency portion of the public purpose charge to self-direct implementation of efficiency projects. Under current policy, these customers are eligible for Energy Trust programs, albeit for additional conservation investments, and at reduced incentives. In addition, some industrial customers are transmission customers only for the utilities, but still pay the public purpose charges that funds the Energy Trust and are eligible for Energy Trust programs. For this study, neither of these types of industrial customers were removed – that is, these results apply to all the industries within Energy Trust territory because they are all eligible for Energy Trust programs,..

For this sector, measures can be thought of either as cutting across industries or process- specific segments. For example, motors and lighting occur in all segments; however, other measures may be specific to paper manufacturing or another process. Due to proprietary concerns, it is difficult to obtain information on specific facilities; the actual amount of process savings is likely to be much larger than estimated here. Management and engineering optimization are difficult to define and quantify but represent the most resource potential. With this sort of study, it is important that national-level process and end use data by industry type be carefully considered and adjusted for relevance to the local industry. Large potential savings are estimated for the electronics sector due to anticipated new growth as reflected in utility load forecasts.

Figure 5: Major Industrial Measures

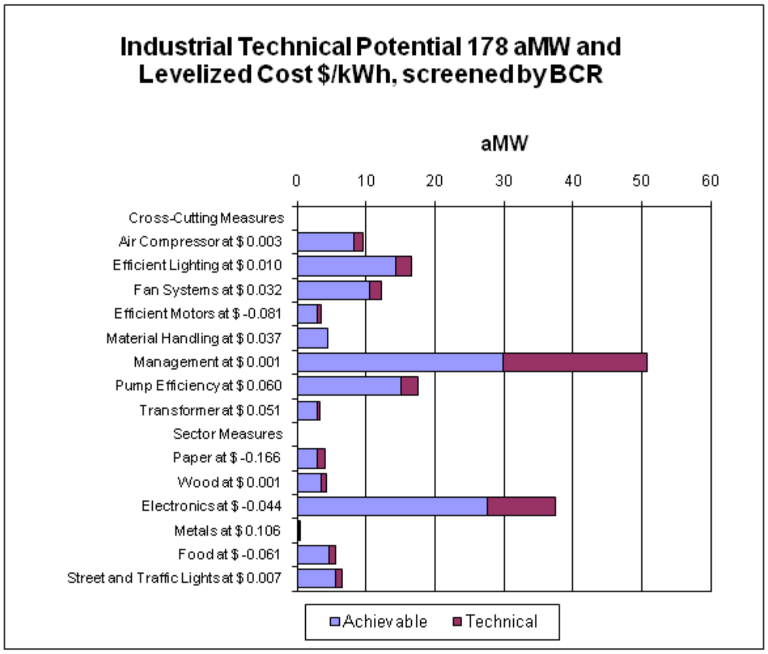


Table 2: Industrial Sector Technical Potential Saving in 2030 by Segment Screened by BCR

Segment	Consumption, aMW	Potential Savings, aMW	Savings Fraction
Hi Tech - Chip Fab	391	35	9%
Paper	42	9	23%
Kraft Pulp	111	25	22%
Foundries	96	3	3%
Metal Fab	42	2	5%
Transportation, Equip	35	3	8%
Other Food	43	9	21%
Frozen Food	23	6	24%
Wood - Lumber	64	9	14%
Wood - Panel	25	4	16%
Wood - Other	20	3	17%
Chemical	14	1	8%
Misc Manf	176	17	10%
Street Lighting	107	6	5%
Agriculture	109	0	0%
Total	**1,299**	**133**	**10%**

As Table 3 shows, industrial sector measures appear low in cost from a societal perspective because there are non-energy benefits in terms of increased production and reduced use of raw materials.

Table 3: Industrial Sector Technical Potential Saving in 2030, Screened by BCR

Measure Category	aMW Savings	Level Cost, $/kWh
Cross-Cutting Measures		
Air Compressor	9.6	$0.014
Efficient Lighting	16.6	$0.009
Fan Systems	12.2	$0.023
Efficient Motors	3.4	$0.014
Material Handling	5.2	$0.036
Management	50.7	$0.036
Pump Efficiency	17.5	$0.017
Transformer	3.4	$0.006
Segment Measures		
Paper	4.1	$0.027
Wood	4.3	-$0.056
Electronics	37.4	-$0.060
Metals	0.4	-$1.991
Food	5.5	$0.027
Street and Traffic Lights	6.7	$0.041
Ag Irrigation	0.7	$0.000
Total	**177.9**	**$0.001**

In a change from the previous study, both small and large industrial gas customers are included in the current study. Figure 6 and Table 4 show the potential for gas conservation measures. In general, much of the opportunity lies in some form of boiler improvement.

Figure 6: Industrial Natural Gas Measures

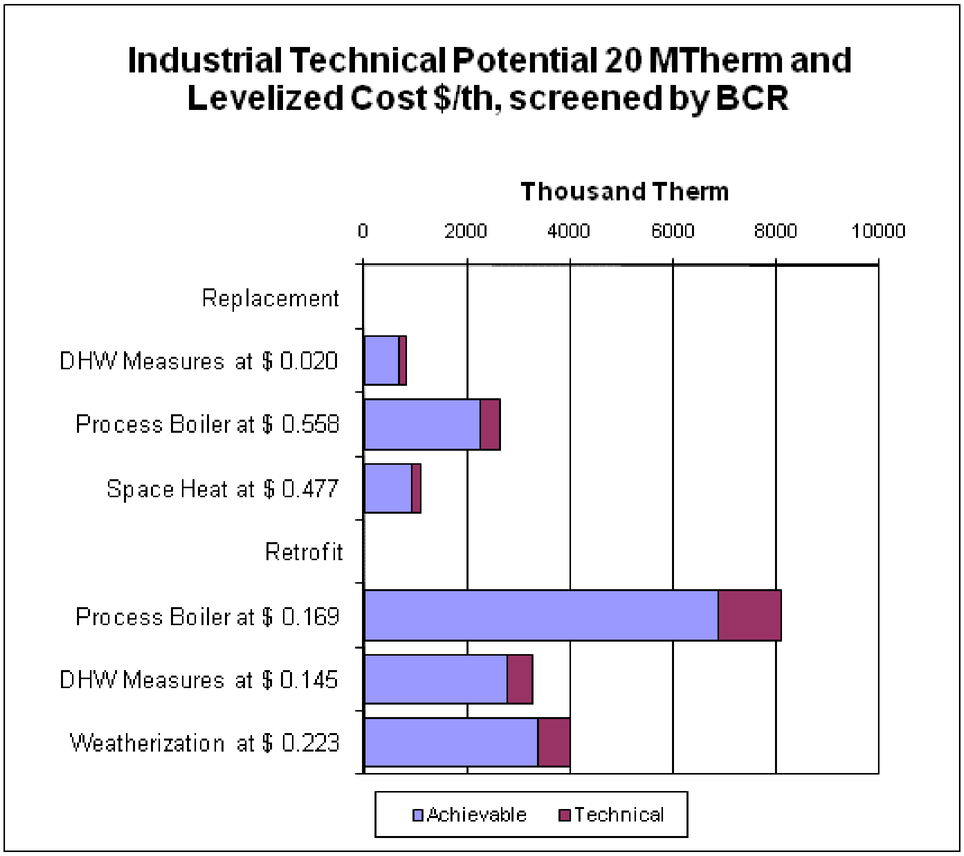


Table 4 Industrial Gas 2030 Technical Potential Savings, Screened by BCR

Measure Category	Technical Potential, ktherm	Levelized Cost, $/th
	Replacement	
Process Boiler	2,653	$0.558
DHW Measures	811	$0.020
Space Heat	1,097	$0.477
	Retrofit	
Process Boiler	3,271	$0.145
DHW Measures	8,084	$0.169
Weatherization	3,988	$0.223
Total	**19,903**	**$0.239**

Commercial Sector

Figure 7 and Table 5 show the potential for groups of measures in the commercial sector with most significant savings. These measure groups are broken out according market segments that affect program design. These groups are shown as retrofit, replacement of existing stock and new construction. Clearly, new lighting opportunities dominate, in part due to emerging technology. In most cases, achievable potential is estimated as 85% of technical potential. Details are shown in Table 5. In these tables "equipment" means mechanical equipment not included in the other specified end uses.

Figure 7: Major Commercial Segment Measures, Electricity

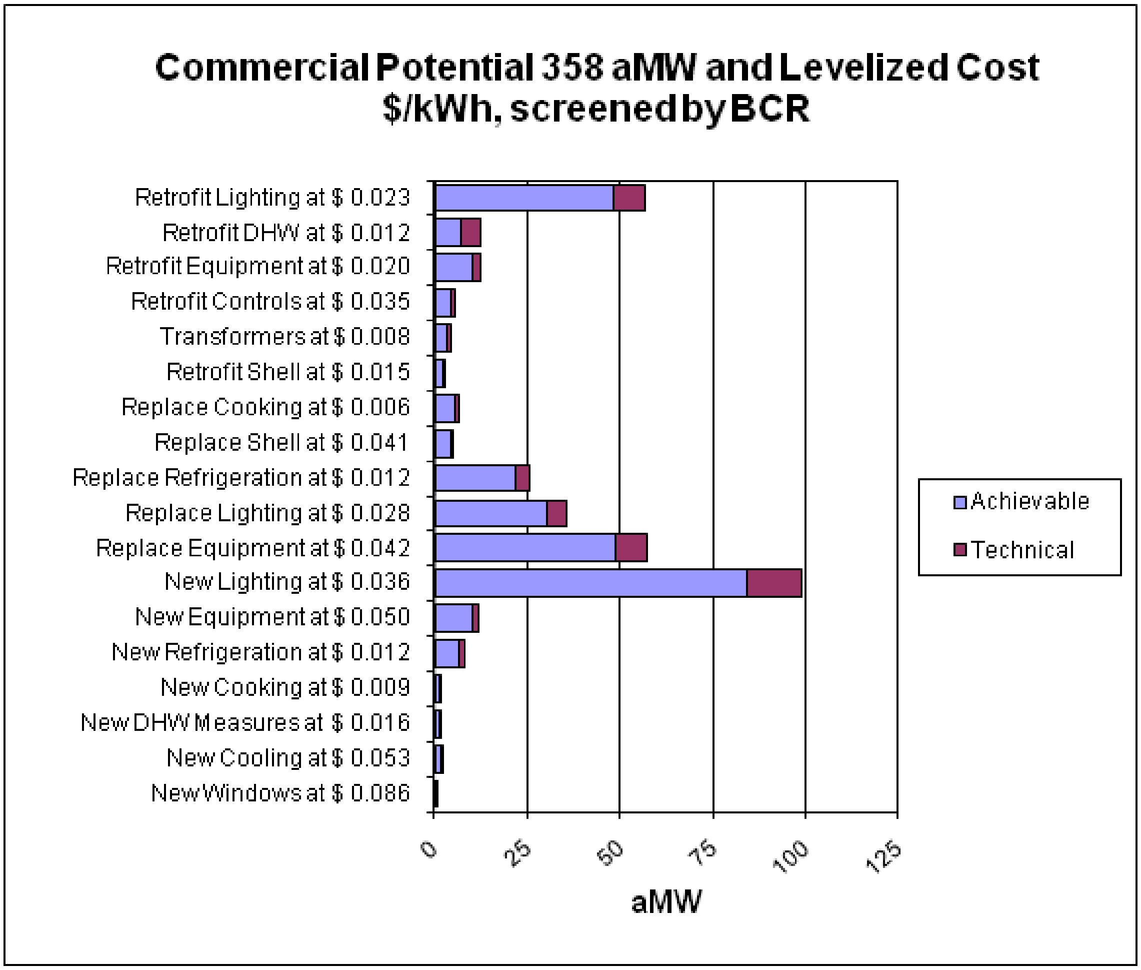


Table 5: Commercial Sector 2030 Technical Potential Savings, Screened by BCR

Measure Category	aMW Savings	Winter Peak Savings, MW	Summer Peak Savings, MW	Level Cost, $/kWh
New Windows	0	1	0	$0.086
New Cooling	2	4	4	$0.053
New Cooking	2	2	2	$0.053
New Equipment	12	21	19	$0.050
New Lighting	99	80	103	$0.036
New Refrigeration	8	10	13	$0.012
New DHW Measures	2	2	2	$0.016
Replace Cooling	9	18	16	$0.034
Replace Cooking	7	7	7	$0.006
Replace Shell	5	15	1	$0.041
Replace Lighting	36	43	56	$0.028
Replace Refrigeration	26	31	40	$0.012
Replace Equipment	57	59	59	$0.042
Retrofit Shell	3	8	1	$0.015
Retrofit Equipment	12	27	23	$0.020
Retrofit Lighting	57	68	88	$0.023
Transformers	4	4	4	$0.008
Retrofit Controls	5	6	6	$0.035
Retrofit DHW	12	13	21	$0.012
Total	**358**	**417**	**464**	**$0.030**

Major opportunities lie in upgrading the building shell and improving heating and cooling equipment. Shell measures include windows and insulation.

Figure 8 and Table 6 show the conservation potential for natural gas in the commercial sector. These measures are also grouped by retrofit, replacement and new construction. Major opportunities lie in upgrading the building shell and improving heating and cooling equipment. Shell measures include windows and insulation.

Figure 8: Major Commercial Sector Measures, Gas

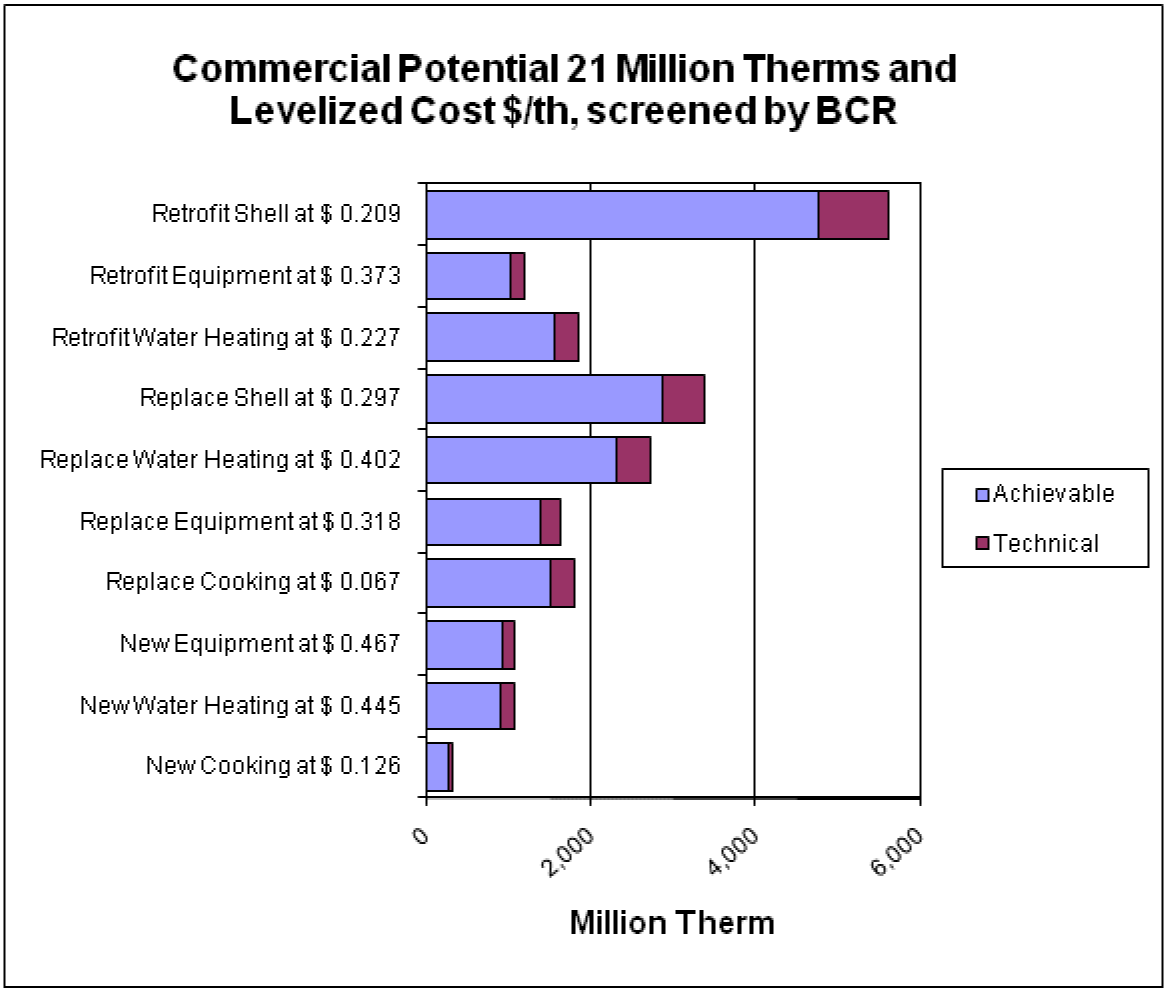


Table 6: Commercial Sector Gas Technical Potential Savings for 2030, Screened by BCR

Measure Category	Thousand therm	$/therm
New Cooking	321	$0.126
New Equipment	1,088	$0.467
New Water Heating	1,069	$0.445
Replace Cooking	1,798	$0.067
Replace Shell	3,389	$0.297
Replace Equipment	1,629	$0.318
Replace Water Heating	2,723	$0.402
Retrofit Shell	5,621	$0.209
Retrofit Equipment	1,206	$0.373
Retrofit Water Heating	1,853	$0.227
Total	**20,698**	**$0.281**

Residential Sector

Figure 9 and Table 7 show residential electricity potential in 2030 grouped by existing and new construction opportunities. The large savings in HVAC Retrofit (compared to past studies) are due to ductless heat pumps. This measure is borderline cost-effective. Lighting savings are largely from specialty CFL bulbs, as conventional CFLs or their equivalent will be required by law soon. The large savings for Appliance Replacement are due to low power consumer electronic appliances that are large in the near-term but will be replaced anyway in the long-term. There is significant potential for replacement of heating systems and appliances. Emerging heat pump water heaters are expected to be a major resource although commercially available models for Oregon's climate have just arrived and are still being tested for functionality.

Figure 9: Major Residential Segment Measures, Electricity

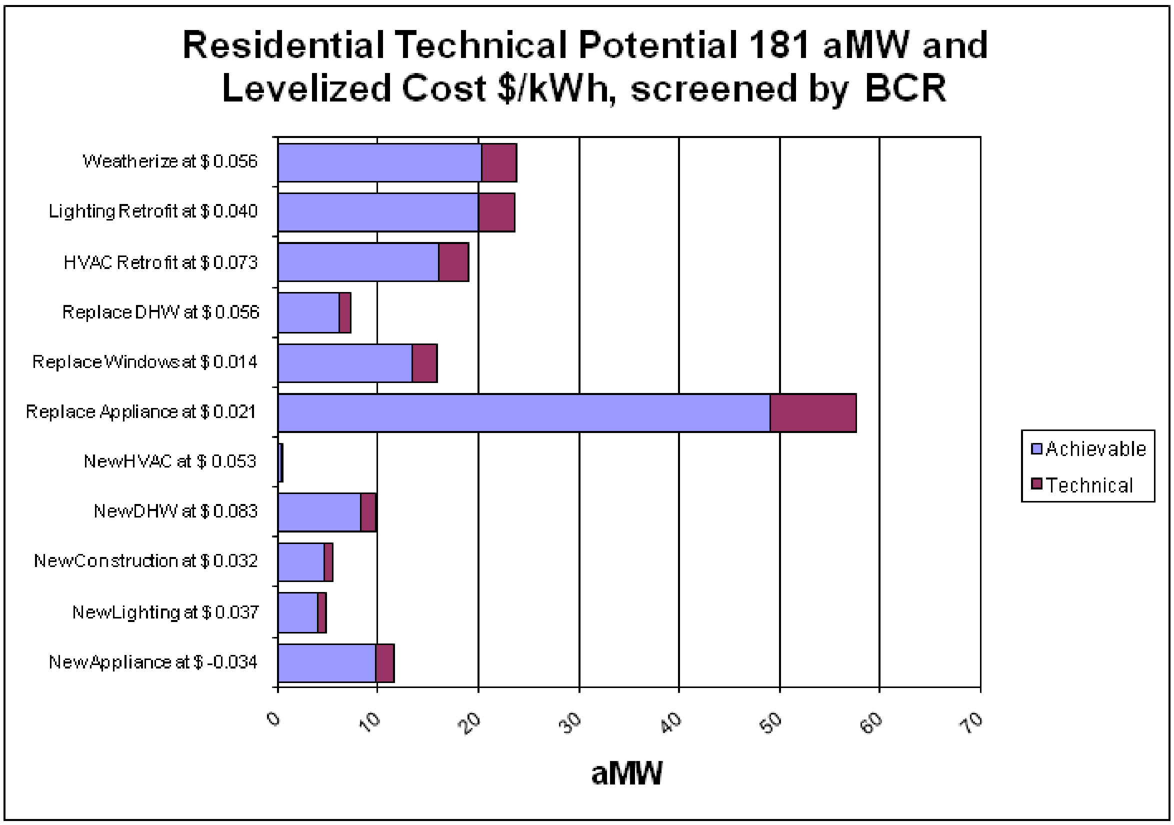


Table 7: Residential Sector Electric Technical Potential Savings for 2030, Screened by BCR

Measure	aMW Savings	Winter Peak Savings, MW	Summer Peak Savings, MW	Level Cost, $/kWh
New Appliance	12	13	12	-$0.034
New DHW	10	12	10	$0.083
New Construction	6	11	2	$0.032
New Lighting	5	5	5	$0.037
New HVAC	1	1	0	$0.053
Replace Windows	16	32	2	$0.014
Replace Appliance	58	62	60	$0.021
Replace DHW	7	9	8	$0.056
Replace Equipment	1	2	0	$0.061
HVAC Retrofit	19	28	7	$0.073
Lighting Retrofit	24	24	24	$0.040
Weatherize	24	46	5	$0.056
Total	**181**	**246**	**136**	**$0.035**

Figure 10 and Table 8 show residential potential for natural gas savings in 2030 grouped by existing and new construction. For natural gas, the greatest opportunity lies in weatherization of existing homes, retrofit of existing heating equipment, and increased efficiency for new construction. Opportunities during new construction include better insulation and windows, duct sealing, high efficiency furnaces, and heat recovery ventilation. The fact that some appliances are negative in cost reflects the fact that there are non-energy benefits, such as water savings, that offset cost for some appliances.

Figure 10: Major Residential Sector Measures, Gas

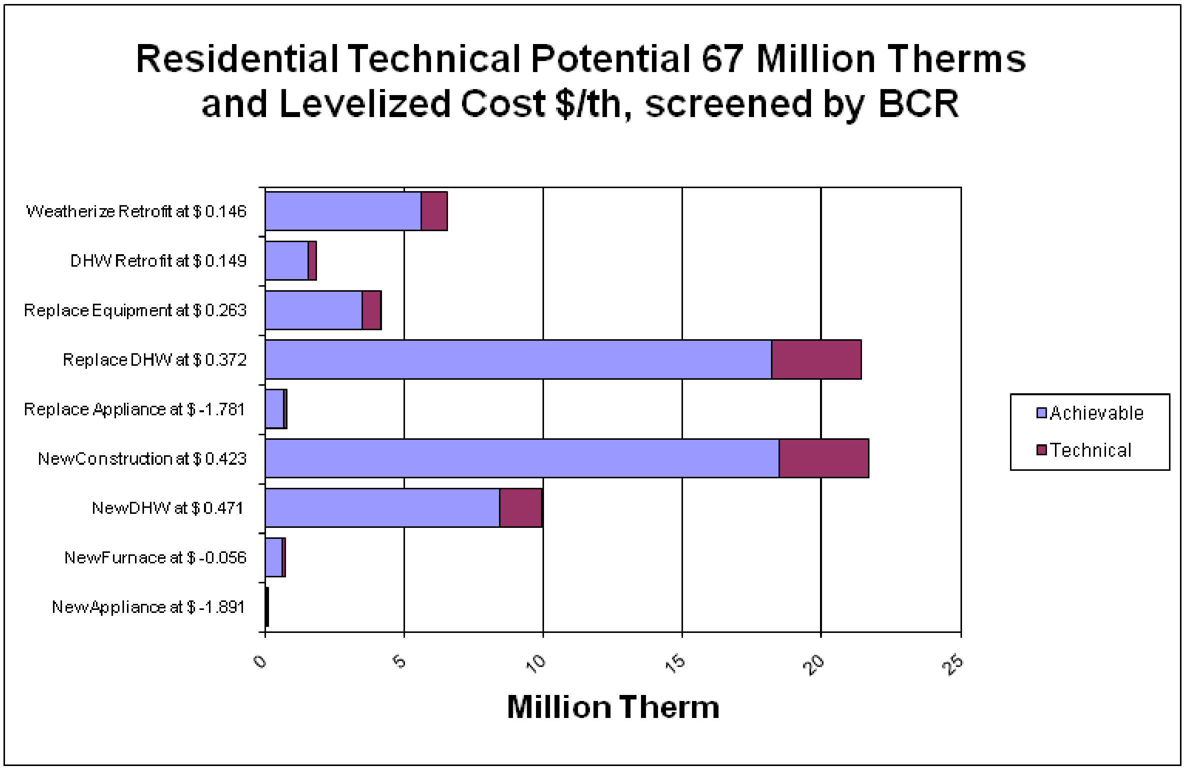


Table 8: Residential Sector Gas Technical Potential Savings for 2030, Screened by BCR

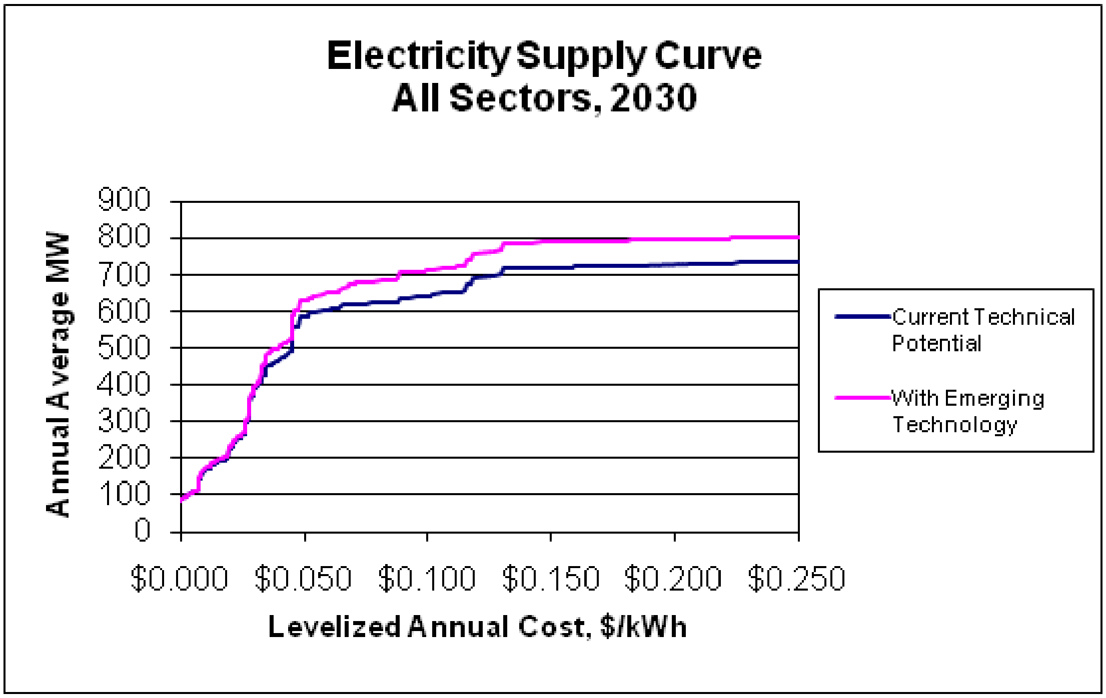
Measure Category	Thousand Therm	$/therm
New Appliance	97	-$1.891
New Furnace	737	-$0.056
New Construction	21,728	$0.423
New DHW	9,931	$0.471
Replace Equipment	4,161	$0.263
Replace DHW	21,425	$0.372
Replace Appliance	815	-$1.781
Weatherize Retrofit	6,587	$0.146
DHW Retrofit	1,871	$0.149
Total	**67,352**	**$0.334**

Emerging Technology

Distinction should be noted between those measures that are new -- that is, available but not yet in widespread practice -- and those that are emerging but not yet available in the market. These measures are expected to become widespread in the future even if they are not yet considered mainstream. Measures in this category deserve discussion and possible support for demonstration because they are quite likely to become important opportunities. Unfortunately, the methodology of resource assessment is not well suited to exploring hypothetical new options (see Fred Gordon, et al., "Beyond Supply Curves", ACEEE Conference Proceedings, 2008).

Given that our ability to predict future inventions is limited, one can still develop some sensitivity estimates for products that are known or expected to be almost market ready. Figure 11 shows emerging technology increases the supply curve by almost 20%.

Figure 11. With Emerging Technology



The specific measures treated as emerging are discussed in more detail titled “New Measure Development” on page 21. In general, most of these measures we could identify as “emerging” are in the residential sector.

Residential consumer electronics are a rapidly changing market. One anticipates that many new products will start to use “smart” capabilities including internet controls. If done properly, this could lead to energy savings during “sleep” mode. California has identified large savings opportunities and is pursuing a program for Low Power Mode Appliances. Such savings would occur through new standards to be implemented at the manufacturing level and would not be immediate program opportunities. Within programs, we include emerging opportunities for new lighting products and heat pump water heaters.

The importance of these new technologies is illustrated in Table 9, which shows the amount of included resource potential that is anticipated as "emerging". Assuming that the new products occur, they would then be responsible for 16% of the new and increased technical potential for the residential sector.

Table 9: Residential Emerging Technology

Measure	aMW Savings	Emerging Technology as Percent of Total
New HVAC	0	30%
New DHW	1	91%
New Lighting	5	83%
Lighting Retrofit	7	46%
Heat Pump HW	7	94%
Total	**20**	**16%**

Resource Assessment Methodology

This section describes the methodology used in this report. More detailed description is provided in the detailed appendix and many of the specifics are documented in the calculation spreadsheets.

To summarize the approach, we applied the following steps in this study:

- Establish Energy Consumption Baseline.

We quantified current energy use by segment unit (residential household, commercial square footage, and industrial by typical facility) and customer type within each segment (single family, small office, wood products, etc.). It is important to understand how much energy is currently consumed for specific end uses and market segments in order for the eventual savings estimates to be realistic. We utilized the utility estimates of sales by customer group and market segment and best estimates of Energy Use Index (EUI kWh/sq. ft.) factors to calibrate our estimates to the actual utility sales data.

- Estimate Energy Consumption by End Use for Each Customer Type.

The methods varied by customer group. For the industrial sector, we estimated the "share down" factors, that is, the fraction of consumption for specific process uses. For the commercial sector, the EUI factors provided consumption by end use. For the residential sector, we applied prototype models to estimate major end use consumption, calibrated to actual sector consumption

- Forecast future consumer population.

We applied the utility forecasted growth rate to estimate the customer base available in future years.

- Compile And Screen List Of Measures, Develop Measure Details

We reviewed information on specific measures for applicability to ETO territory customers. This information includes estimates of incremental cost and savings but also assesses the market potential for specific measures. Applicability of some measures depends on the fuel for space heating, for example. Also the amount to which the market is currently saturated affects the amount of remaining potential. We focused on measures with significant savings for a significant portion of the housing, building, or equipment stock in question. The intention was not to represent every possible measure, but represent the available cost and savings by choosing the most significant measures.

- Implement Worksheet Tool To Aggregate And Sum Conservation Potential.

We developed a series of worksheets to compute the savings potential and cost for each measure and customer type, and then results were aggregated for an estimate of the total potential.

Data Collection

To develop the inputs required by the tool, the team utilized a wide variety of resources. A literature review was conducted to collect equipment and O&M costs and energy savings. This review was augmented by internal data developed by the team members for use in prior projects. Where available, the Northwest Power & Conservation Council's (NPCC) Regional Technical Forum (RTF) data was utilized in the residential sector to collect costs and energy benefits. In addition, the NPCC libraries provided cost and benefit data for many of the commercial sector measures. In some cases, technical papers or data provided by manufacturers was used. Energy Trust historical program data and measure screening analysis also provided data input for the study. The data source(s) used for each measure are noted in the Notes and Sources section of each measure workbook.

To determine the applicability of measures to the Energy Trust service territory and to assess market conditions, economic and census data was collected from Economy.com and from the U.S. Census Bureau and the Department of Housing and Urban Development. Population estimates were also collected from the Portland State University Center for Population Studies and from the Manufactured Housing Association.

Where available, public documents prepared by the individual utilities were used to generate electricity and gas end use or device saturation and penetration rates for the Energy Trust service territory. Where not available, these rates were extrapolated from county- or state-level data.

Selection of Potential Measures

In residential sector, we utilized 121 measures. Each measure is developed separately for three building types. In the commercial sector, we utilized 106 measures. Each measure is then developed separately for 12 building types.

The measures identified in the initial list were then analyzed for cost and performance in the Energy Trust service territory. We used a wide variety of resources to develop measure-specific inputs for this study. We conducted a literature review to collect equipment and labor costs and energy benefits. Energy Trust project data and measure cost effectiveness screening models were combined with Northwest Power & Conservation Council's Regional Technical Forum (RTF) data and other regional sources for measure costs, savings, and non energy benefits assumptions. We studied the Oregon market to identify the total market size, infrastructure, climate, energy use, energy costs, and other variables that impact the usefulness of each of the measures in the particular market served by the Energy Trust.

The study is structured to present efficiency potential by measures directed to “New Construction,” “Retrofit,” or “Replacement.” “Replacement” applies to the annual turnover of equipment in any year. We can also compute this resource as a cumulative total for a future year. Retrofit applies to upgrading existing equipment that has not yet reached its useful life.

For each measure, we attempted to identify and quantify the potential market for which that measure was applicable. While this is relatively straightforward in the residential sector and only slightly problematic in the commercial sector, it is very difficult to provide the same level of detail for a technical potential assessment in the industrial sector. Nevertheless, we have provided an approximate technical potential for each measure that can be used to estimate overall program size and savings potential.

To calculate the cost of each measure, the following assumptions were generally followed. Where appropriate, exceptions have been noted within the measure workbook. Only actual equipment and labor costs were included in the measure cost calculation used in this analysis. In addition, incremental costs (or savings) related to differences in operations and maintenance was considered in the cost analysis. We did not consider program administrative costs, marketing or other overhead expenses.

For each measure, the incremental cost of the equipment examined in the measure over that required by the relevant energy code was used where applicable in new construction, renovation, and replacement markets. The entire cost of substitute equipment was considered in retrofit situations[2]. These measures generally examine one-for-one equipment selections so all other costs, such as maintenance, are assumed to be the same. In cases where additional maintenance costs would be associated with the equipment in the measure, these incremental costs have also been included.

The impact of the measure on O&M expenses was calculated and included in the cost-effectiveness analysis. In some cases, there are negative O&M costs – that is, non-energy benefits – that are included in the analysis. In planning terms, we utilized a cost that represents the full societal cost or total resource cost (TRC). The cost-effectiveness approach employed here is a simplification of the more sophisticated approach used to qualify individual measures at the Energy Trust, intended to get about the right answer in aggregate. Individual measures that pass by this method may not pass Energy Trust’s more detailed screening, and the reverse is also true.

For the technical potential savings analysis, we assumed that the measure would be applied to all applicable situations and where no related measure was applied. For retrofit measures, we assumed that the existing population would be addressed to the extent possible. For replacement measures, we first calculated a replacement rate and then assumed that the measure was applied for the cumulative number of replacements up to the target year. For “new” measures in new construction, we assumed that all of the applicable new construction was treated every year. Growth rates were developed based on utility projections. For replacement and new measures, it

[2] A retrofit situation is where working equipment might be replaced with more efficient equipment primarily for energy savings purposes.

is important to specify a target year sufficiently into the future that significant new resources will be counted. We utilized the year 2030 as the target year for assessment. Because replacement and new potential occurs as equipment is sold or buildings constructed, it is only available over the course of the period of study; that is, savings cannot be accelerated beyond the rate of sales or construction.

Retrofit and replacement can be in conflict; if one does a retrofit, the efficiency opportunity is no longer available to become a replacement candidate later. At the same time, there are measures that occur only as retrofit or only as replacement options. We worked with the measures in various ways to assure that retrofit and replacement would not be "double-counted." Often, the retrofit is much more expensive because the replacement is only an incremental cost over replacement with a less efficient but otherwise similar piece of equipment. In cases where retrofit was clearly more expensive than grid power and pipe gas, yet replacement was feasible, we ruled out the retrofit as not feasible. Another option was to compute the cumulative replacements and remove those from eligibility as retrofits. The Resource Assessment spreadsheets allow the analyst to choose an approach.

Another potential conflict can occur when two technologies go after the same energy end use. For example, heat pump water heaters and solar water heaters are competing technologies. In these cases, we divided the market between the two options to avoid double-counting.

Since we are dealing with two fuels, we must be aware of some other factors. In general, we can develop a supply curve for only one fuel at a time. That is, the gas and electricity supply curves are independent. Of course, that does not mean that efficiency opportunities for the two fuels are always independent – many measures save both electricity and gas on the same site (e.g. building energy management system) and many markets can only be effectively approached by a dual fuel program (e.g. new homes.) This merely means that the impacts of investment in one fuel on energy use for the other are not captured in the supply curve graph. These impacts are maintained in the output tables and they do influence the levelized cost.

New Measure Development

In preparing this version of the planning tools, the primary focus was on updating costs and savings for previously developed measures. However, we considered a number of new and revised measures as the request of reviewers.

1. Gas weatherization measures, reviewed for consistency with recent evaluation results
2. Solar water heating, review ETO files for cost and savings information.
3. Cooking measures, matched to EnergyStar appliance calculation worksheets..
4. Gas Furnace. Based on 2009 Market Transformation study, the baseline is now a high-efficiency model.
5. Tankless water heaters, updated cost and savings, based on survey of vendors.
6. Gas Hearths, added efficiency measure.
7. Commercial clothes washer, updated measure based on Northwest Power Planning and Conservation Council.
8. Fleet management of HVAC, added new measure for operation of HVAC units as a group by EMCS system.

9. Corridor ventilation in MF, added new measure for reduction of excess outside air.
10. DHW, updated baseline for new standard in 2015
11. Destratification fan, added new measure in warehouse
12. Boiler measures, updated baseline to the new IECC.
13. Exterior LED, added measure based on Northwest Power Planning and Conservation Council.
14. Streetlights and traffic lights, added measures based on Northwest Power Planning and Conservation Council.
15. Ozone Treated Laundry, added new measure. Ozone treatment allows use of less hot water and chemicals.
16. Heat Recovery chillers, limited application for Hot Water Heat recovery in MF garage.
17. Industrial Electricity, added entire new set of measures based on Northwest Power Planning and Conservation Council. Significant addition is Integrated Energy Management.

Heat pump water heaters are identified as having a large technical potential in both the residential and the commercial sector. Larger products for commercial customers are available. For homes, new products are very recently available, but have not been lab tested for functionality in our climate.. We consider this measure to be an emerging technology.

The Home Energy Monitor connects a digital readout to the customer's utility meter so that the customer has direct feedback to their consumption level. We project this product as currently available but, with respect to predictable savings, as an emerging technology.

Lighting measures are an unusual case. New federal standards will require efficient lighting starting in about 2015. As a result, the lifetime for installing lighting measures in the current stock of buildings has been reduced. We expect that a new generation of LED lighting products will be available by 2015 and even more efficient lighting products will emerge around 2020. This study does not include LED down lights for homes and screw in LEDs for commercial buildings which became commercially available and cost-effective as the study approached completion, and are now included in Energy Trust programs. These would add modestly to the technical potential shown here, because the efficiencies are not yet radically better than those for compact fluorescents. They are suitable to some niches where compact fluorescent bulbs are inappropriate.

Prototype units of condensing natural gas packaged heaters have been demonstrated in Canada. However, the condensing feature of these units was not the primary source of their savings – rather it was the fact that exposed ductwork was better insulated. Furthermore, manufacturers have not indicated willingness to bring these units into production due to the higher cost of the hardware.

One area of interest was the application of residential gas water heating systems for combined space heat and water heat. We considered various combinations of available technology. Although there would be cost savings by eliminating the furnace, the added cost of a hydronic heating system would be comparable to that cost reduction. Furthermore, although a tankless water heater would be higher efficiency for hot water, for space heat it would be competing against an already-efficient gas furnace for space heating. Only one combination option appears to be currently cost-effective – that would be a combination involving a low-cost hydrocoil applied to an air distribution system. We also include a high efficiency combination system based on the Polaris water heater. However, the base case assumes that a conventional gas boiler and hydronic slab heating system would otherwise be installed, so the efficiency improvement from the combination option is small relative to the incremental cost.

A similar niche on the electricity side would be new ductless heat pump systems. These systems are designed for easier installation that may eliminate some of the installer errors that have plagued large heat pumps. Current models are small in capacity, which limits their retrofit potential. They are suggested for homes with electric baseboard heating – which makes them one of the few retrofit equipment measures possible for older homes with baseboard heating. Energy savings will depend on the extent to which customers operate these units to offset baseboard heat and the addition of summertime cooling might offset winter savings. Recent evaluations indicate that these are cost-effective for single family home applications. In multi-family housing - they would provide the equivalent of an efficient through-the-wall heat pump - These are included as an emerging technology measure. The cost estimate gives credit for the fact that a window air conditioner would otherwise have to be included to provide a similar cooling benefit.

A new set of high efficiency gas water heaters is becoming available. We include a low-cost gas water heater with 0.70 EF rating that will shortly be available as emerging technology. Tankless gas water heaters have an EF rating of 0.85. There is an incremental upgrade possible to another tankless heater at 0.89 EF rating that would be cost effective even for the high cost system.

Waste heat recovery from wastewater has been previously reviewed as a potential measure. It is not well suited for residential applications, as it is a relatively expensive retrofit limited to full basements. As a result, this measure is limited to commercial facilities.

Other commercial measures that were changed include high performance lighting systems. More efficient T8 systems can replace the previous generation of older T8s. T5 systems are somewhat more expensive but can be a worthwhile replacement for metal halide lights. One advantage of the new fluorescent system is that it can be switched off or dimmed, allowing the application of occupancy sensors that were not an option for halide lights.

Tax credits are now recognized as an offset to costs for both demand-side and supply-side measures. While there are currently available Federal tax credits, those are significantly diminished, but do not disappear at the end of 2010. Given the complexity of Federal credits, to keep things simple, we only deducted Oregon tax credits from measure costs. We assumed that all commercial and industrial measures could receive the BETC tax credit, evaluated as reducing initial cost by 31%. Credit was applied for the residential measures shown in Table 10. Note that these Oregon tax credits do not apply to Northwest Natural Gas territory in Washington.

Table 10. Oregon Residental Tax Credits

MEF 2.0 Washer	$150
MEF 2.2 Washer	$180
MEF 8.0 Dishwasher	$80
Efficient Refrigerator	$50
Heat Pump Commissioning	$250
PTCS Ducts (with bonus)	$400
Hydronic Fan	$125
Heat Recovery Ventilation	$220
Water Heat Exchanger	$100

Tool Selection and Use

One of the primary goals of this project was to continue use of, and improve upon the method of analyzing measures across segments and technology types that would provide a means of comparing anticipated costs and benefits associated with a variety of program options.

The Assessment Tool used by the team includes several favorable features:

- Standardized program assumptions. This spreadsheet tool allows the same set of program assumptions for each measure, so that differences in the results of the analysis of any two measures were impacted only by the variables of interest (cost, benefits, and technical potential).
- Updateable. The measure cost and performance, market penetration and other inputs into the tool can be easily changed to analyze a particular measure under a variety of program and cost conditions. For example, Trust personnel can easily modify the cost of the measure or number of program participants and calculate a new levelized cost.
- Consistent analysis approach. Team members individually assessed the measures with expertise in particular areas. The use of this tool ensured that measure assessments performed by different analysts were comparable.
- Record of assumptions, sources, etc. The input requirements of the tool provide a record of the data and processes used by the analysts to develop levelized costs. We believe this will be extremely informative and provide insights to the Trust that will be helpful during program design, particularly in cases where multiple measures are combined into a single conservation package targeted at a particular customer, segment or building type.

Tool Limitations

While the strict data input structure of the Assessment Tool provides a consistent way to compare measures across sectors, it does impose some limitations:

- The total measure costs and benefits calculations are based on an estimate of the number of cases for which the measure is applicable; i.e., the program participation was estimated to be the total technical potential. These figures will need to be adjusted for programs that target only a portion of the identified market.

- The tool does not allow multiple-measure "what if" analysis. While we have assessed a number of combined-measure packages, the costs and benefits must be calculated and combined outside the tool and entered as one set of assumptions.
- The tool provides limited flexibility. The tool did not provide optimum flexibility to analyze measures by segment or across segments without creating multiple worksheets. While this did impose some limits on the analysis methodology, the strict requirements of the tool ensure that comparable computations across all types of measures and sectors are made.

Benefit Cost Ratio (BCR)

In previous studies, we used the levelized cost as a screening criterion to determine cost effectiveness. One problem is that the levelized cost fails to take into account Time-Of-Use (TOU), that fact that savings during a peak period may have higher value and, hence, be more cost-effective. In order to better account for this feature, we computed the total benefit, net present value of lifetime savings and Non Energy Benefits (NEB), evaluated at each measure's load shape. This lifetime benefit can then be compared to the total resource cost. If the benefits are greater than cost, the benefit-cost ratio is greater than one. This ratio offers a simple comparison.

$$BCR = \frac{\text{Net Present Value of Benefits (including TOU, NEB, hedge and externality value)}}{\text{Total Resource Cost}}$$

In general, screening by BCR rarely results in a different cost-effectiveness determination than that afforded by the levelized cost. The exception occurs with some residential sector end uses that occur during peak periods.

In cases where the total resource cost is actually negative, due to non-energy benefits that offset cost, the calculation for BCR returns a negative value. While this is technically correct, it could be confusing. For this reason, we defined the BCR to be 100 whenever total cost is negative. This facilitates sorting the measures in order of declining BCR.

Utility Avoided Cost

One complication with computing BCR lies in obtaining realistic estimates of the utility system avoided cost at different times of the day. Utilities are in the process of updating their avoided costs estimates. However, the schedule of their Integrated Resource Plans (IRPs) did not coincide with the timing of this report. For this report, we used values previously approved by Oregon Public Utility Commission in 2007. This estimate includes a value for the future cost of CO2 mitigation.

Supply Curve of Conservation Measures

The results of the assessment are provided in the form of separate spreadsheets for the industrial, commercial, and residential sectors (see appendix for the final lists of measures). For each measure or package of measures, we developed cost and savings estimates (including peak load savings), as well as an estimate of overall achievable energy savings over the future study period. To generate both the cost and savings impacts over time, we assumed that the measure was applied to all potential candidates. These calculations could change considerably as specific programs are developed, but provide an overview of the maximum potential available from each measure. As a final step, the list of measures was ranked by overall cost-effectiveness.

Levelized Cost Calculation

To compare and prioritize measures, we calculate the levelized cost for each measure opportunity. The levelized cost calculation starts with the incremental capital cost of a given measure or package of measures as described previously. We add the present value of any net operation and maintenance (O&M) cost. The total cost is amortized over an estimated measure lifetime using a discount rate (in this case a real discount rate of 5.2 percent per year) which is the standard value used by Energy Trust. This annual net measure cost is then divided by the annual net energy savings (in kilowatt-hours or therms) from the measure application (again relative to a standard technology) to produce the levelized cost estimate in dollars per kWh saved, as illustrated in the following formula.

$$Levelized\ Cost = \frac{Net\ Annual\ Cost\ (\$)}{Net\ Annual\ Savings}$$

The levelized cost is a figure that can be compared with the full cost of delivering power from electricity generation options. The levelized cost approach was chosen as the most practical and useful method of comparing measures of various types and applications.

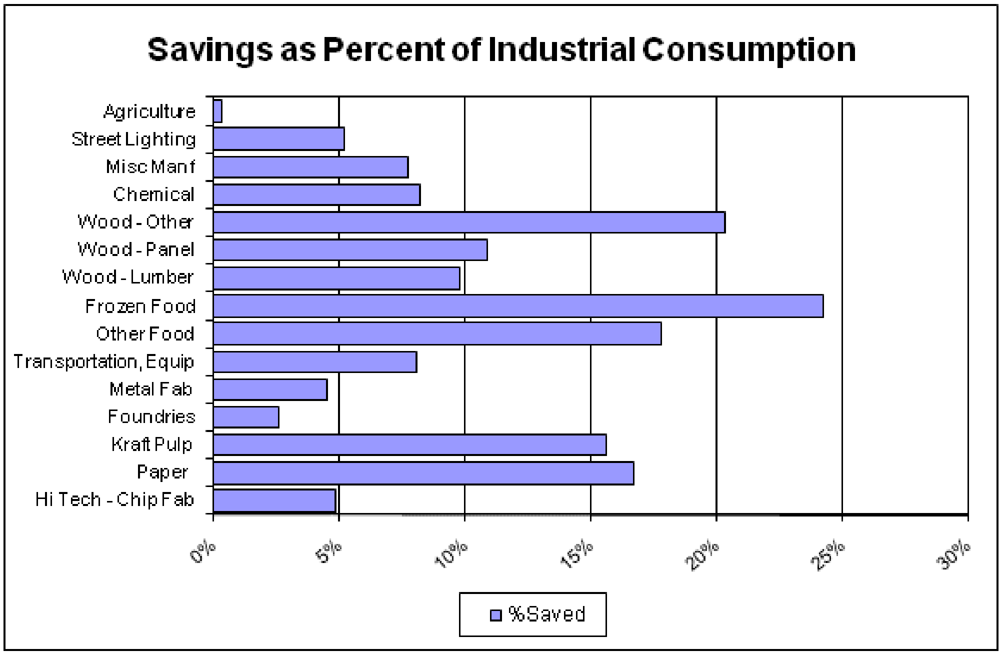
In dealing with two fuels (electricity and natural gas), we must be aware that there are cross-impacts. For example, a lighting program will save electricity but increase consumption of natural gas for space heating. In this case, we compute the Net Present Value (NPV) based on the avoided cost of natural gas and add that value to the O&M component of cost.

A more complicated case occurs when the same measure has positive savings for both fuels. In that case, we compute the NPV of avoided cost for both fuels and use the ratio of the NPVs to apportion the measure cost between the two fuels. Thus, both fuels would see a reduced levelized cost because they are only "charged" for part of the measure cost. The final result of this analysis provides the cumulative amount of potential resource available at a given levelized cost, as shown in the supply curves.

Technical Potential Savings Check

Since the potential savings estimate results in large numbers, it is useful to apply a reality check to verify that the numbers are reasonable. One procedure to check the potential is to compare estimated savings to the amount of estimated consumption. Such a comparison may be presented as the expected percent of end use savings. Note that the amount of consumption for new and existing building stock is quite different due to the inherently different deployment approach to achieve savings.

Figure 12: Savings Percentages for Industrial Segments



For existing stock, generally it is more cost-effective to replace old equipment with more efficient equipment as it wears out. We assumed that replacement of existing stock is limited to the turnover rate of the old equipment. In the case of new construction, it is technically possible to change the choice for all the new equipment at the time it is first installed. Thus, for some appliances, the potential savings percentage is higher for new installations merely because of the deployment limitations. On the other hand, because the older stock is less efficient, for some measures the existing stock offers a higher savings percentage that can be addressed. Figure 12 demonstrates that our analysis focused on the segments that account for the most energy consumption. The technical potential for the industrial sector is high and, in many cases, the cost is offset by non-energy economic benefits.

Figure 13 shows savings percentages for residential electricity consumption.

Figure 14 shows savings percentages for residential gas measures. While heating equipment is difficult to retrofit, there is good potential to replace existing gas water heaters with higher efficiency units.

Figure 13: Residential Savings Percentages by Electricity End Use

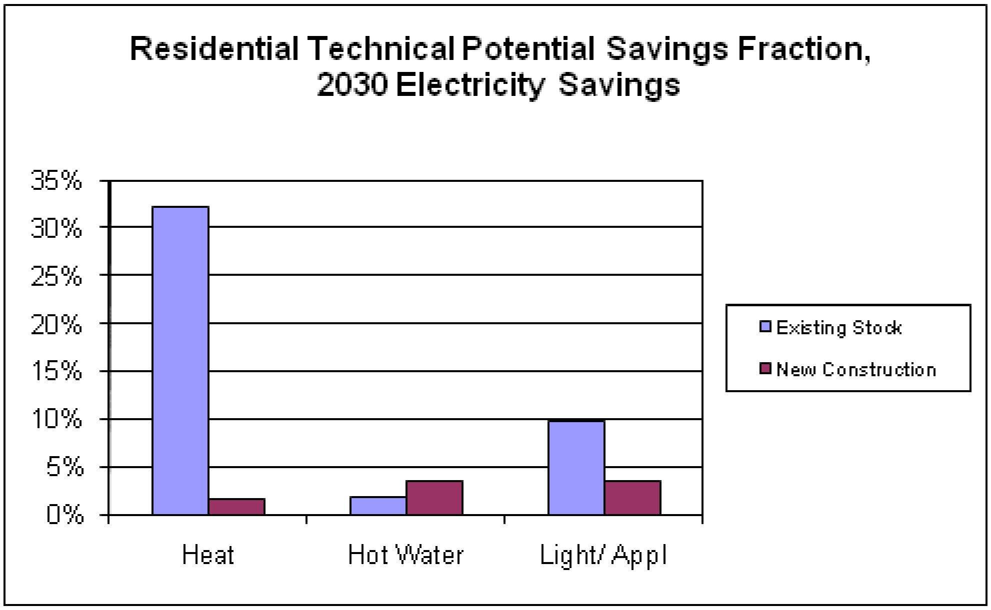


Figure 14: Residential Savings Percentages by Gas End Use

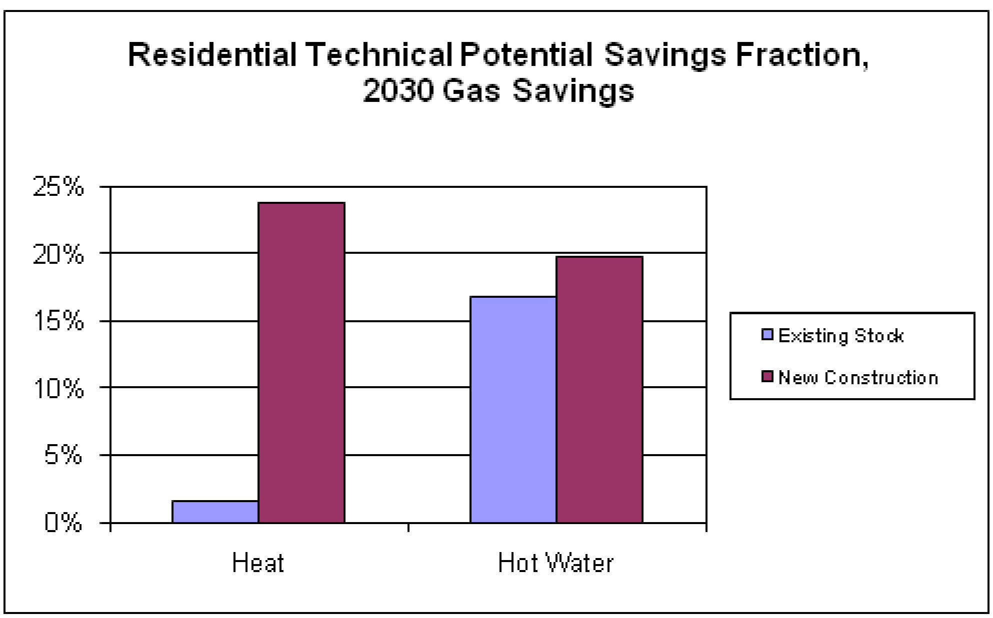


Figure 15 and

Figure **16** show savings percentages for the commercial sector. Refrigeration savings reflect recovered heat in addition to the refrigeration end use. Gas DHW savings are high, based on controls, a number of boiler improvements, and heat recovery for water heating.

Figure 15: Commercial Savings Percentages by Electricity End Use

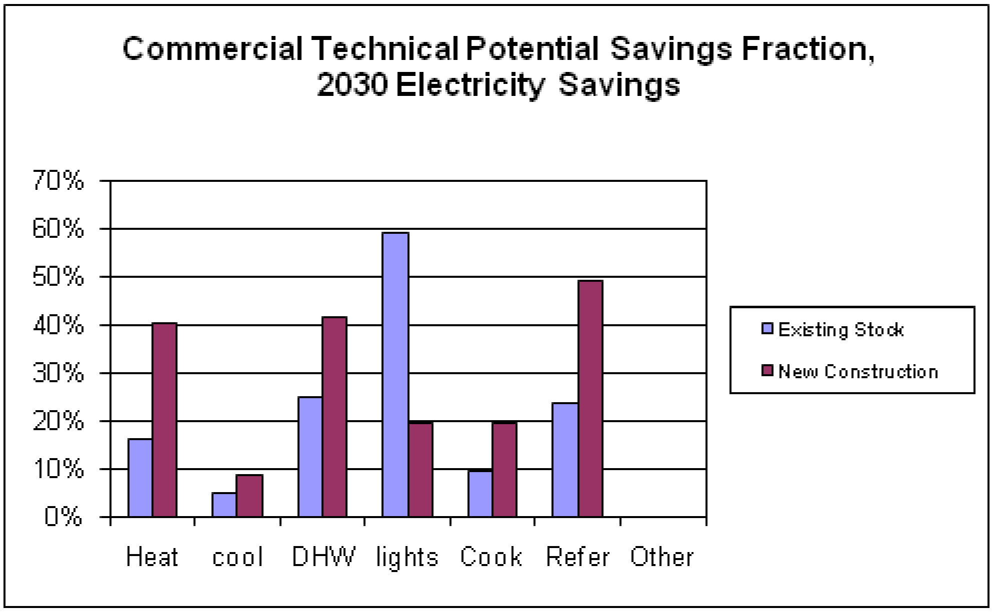
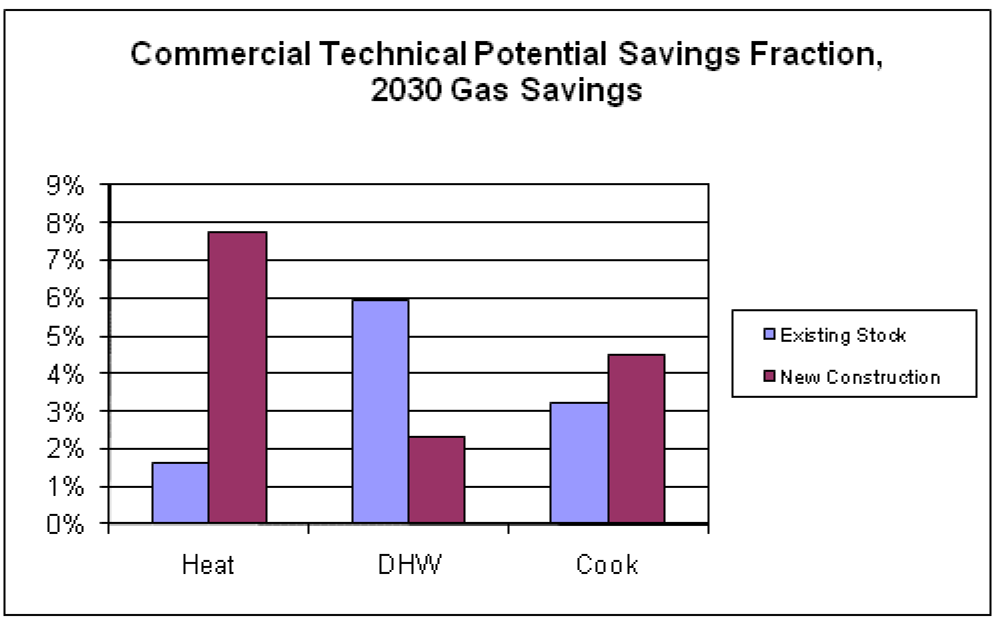


Figure 16: Commercial Savings Percentages by Gas End Use



Industrial Sector Resource Assessment

A list of the recommended industrial measures, ordered by the levelized cost, is provided in Table 12. This list presents individual measures, with incremental capital costs and net operations and maintenance costs (or benefits—shown as negative O&M costs) expressed in units of kWh of annual energy savings by the measure. In the section that follows, we provide a discussion of the potential application of these measures, as well as selected recommendations regarding potential program designs for the industrial sector.

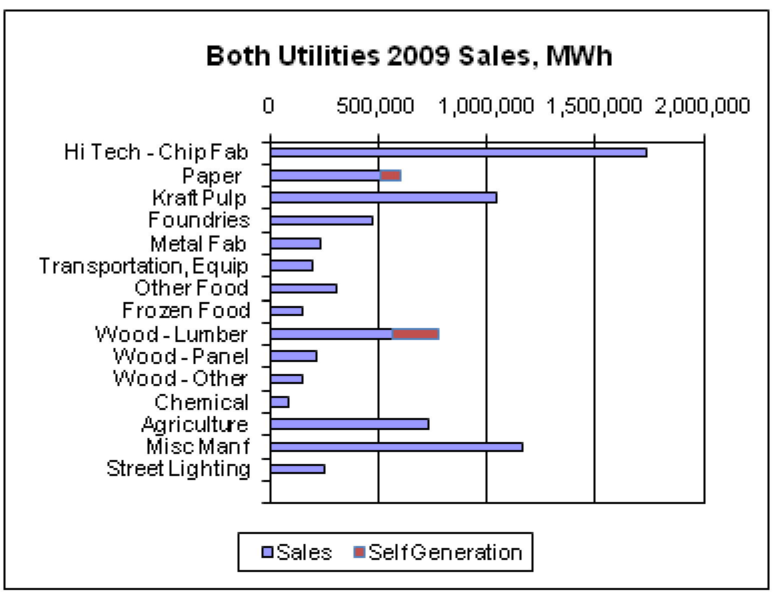
Industrial Sector Characterization

There are several important caveats to understanding the industrial approach. First, it is a top-down assessment. That is, it estimates the potential for conservation starting with MWh sales. (This approach differs from the residential and commercial sectors, which build up from an estimate of the number of customers.) In fact, economic growth has not been robust in recent years– the electronic segment in particular suffered from business reverses. We applied the same forecasted growth rates as used by the utilities in their planning to project future MWh sales.

Energy Trust serves participating industries, yet these industries have the option of self-direction. In fact, some industrial customers are transmission customers only for the utilities. For this study, we did not remove any of these loads – that is, these results apply to all the industries within Energy Trust territory regardless of whether they are currently eligible for Energy Trust programs.

The savings potential is derived from the total electrical consumption of the customer. To the extent that customers produce their own electricity, we need to include that generation as part of overall consumption. Figure 15 shows our estimate of current industrial consumption including self-generation where it is significant.

Figure 17: Industrial Electricity Consumption



We examined the potential for further generation from co-generation or Combined Heat and Power (CHP) but found it too difficult to generalize since it depends on various market factors that are not technical issues. Accordingly, CHP is an additional opportunity that is not included in this study.

Figure 18: PPL Industrial Growth Forecast

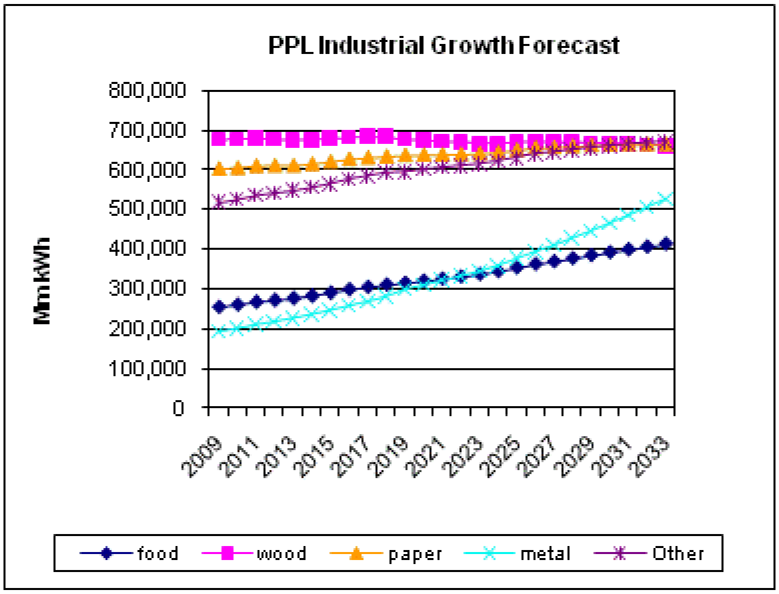
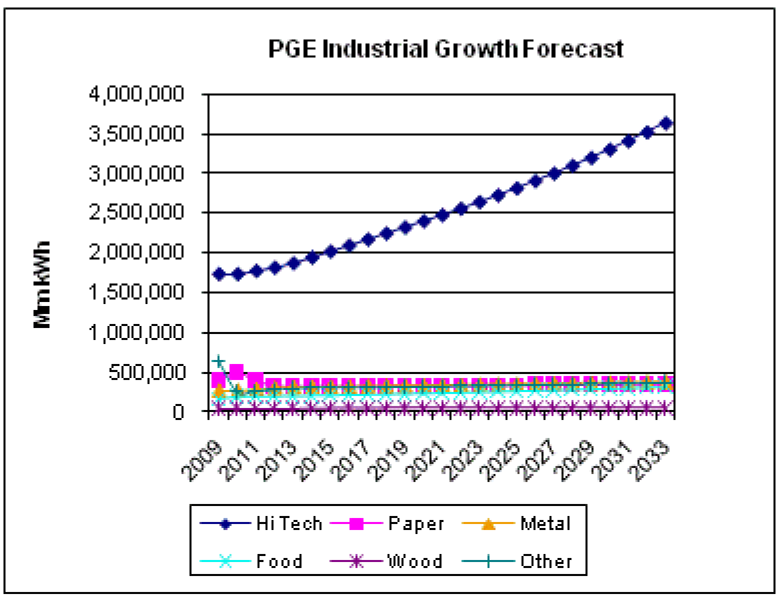


Figure 19. PGE Industrial Growth Forecast



Historically, industry has been based primarily on natural resource extraction and processing (Food and Forest Products). These industries are expected to decline or exhibit low growth rates. One notable exception is the electronics sector – this is the only industry expected to show future growth. However, past events have shown that this sector is dependent on the global business outlook and can be extremely volatile. Growth in solar photovoltaic manufacture has been proposed as a source for Oregon's future economic development. The forecast above includes solar photovoltaics as part of the electronics sector. Currently only one specific new photovoltaic plant is in operation. Other plants are projected but not yet confirmed at specific sites.

The next step is to estimate how the electricity sales are distributed to various end uses and processes within the facility. Table 11 shows the estimated shares for various processes within each type of facility.

We reviewed the current program list of committed projects in determining the extent to which further measures are applicable. For example, where one paper plant has adopted a new technology under the Trust program – that measure is no longer applicable. In general, the currently committed projects account for savings of a few percent within industrial segments – so there is still plenty of remaining opportunity.

It is difficult to estimate the extent to which technically possible industrial opportunities are achievable in the real world. We rated measures loosely as high (85% achievable), medium (50% achievable), or low (25% achievable) based on judgment.

Table 12 lists the industrial measures by increasing levelized cost. Screening by the BCR ratio is to screening by a levelized cost of about $0.09 per kWh.

Table 11: Industrial Process Share Downs

	Percent Electricity by End Use															
	Motors									Process Heating						
	Pumps	**Fans and Blowers**	**Compressed Air**	**Material Handling**	**Material Processing**	**Low Temp Refer**	**Med Temp Refer**	**Pollution Control**	**Other Motors**	**Drying and Curing**	**Heat Treating**	**Heating**	**Melting and Casting**	**HVAC**	**Lighting**	**Other**
Kraft Pulp	30%	10%	4%	12%	27%			1%	10%	3%				0%	1%	2%
Paper	26%	14%	7%	17%	17%			1%	10%	3%				1%	2%	2%
Foundries	3%	5%	5%	6%	7%			1%	6%	0%	0%	19%	9%	2%	3%	34%
Frozen Food	8%	2%	2%	6%	4%	45%	18%					6%		2%	1%	7%
Other Food	10%	18%	8%	4%	17%		26%							4%	10%	2%
Wood - Lumber		11%	13%	23%	34%			1%	4%	3%				2%	6%	2%
Wood - Panel	3%	20%	8%	20%	18%		12%	1%	4%	3%				2%	5%	3%
Wood - Other		10%	18%	29%	20%			1%	4%	3%				3%	7%	6%
Hi Tech - Chip Fab	10%	10%	5%	3%	15%			3%	17%			5%		25%	3%	4%
Metal Fab		6%	2%	16%	25%			1%	2%	3%	6%	7%	0%	9%	11%	13%
Transportation, Equip		8%	3%	13%	24%			1%	2%	1%	3%	4%	1%	15%	14%	9%
Agriculture						95%								1%	2%	2%
Lighting							83%							1%	2%	14%
Chemical	18%	5%	20%	5%	30%			1%	2%			3%		2%	10%	4%
Misc Manf	33%	5%	9%	0%	4%	0%	0%	1%	0%	0%	0%	2%	0%	1%	10%	34%
Total	**14%**	**8%**	**6%**	**8%**	**15%**	**10%**	**4%**	**1%**	**7%**	**1%**	**0%**	**3%**	**1%**	**7%**	**5%**	**10%**

Table 12: List of Industrial Measures

Conservation Measure	Potential Savings (MWh/yr)	Measure Life, yr	Initial Cost (1000$)	Annual Non-Energy Cost (1000$)	Levelized Cost ($/kWh)	Annual Non-Energy Benefit ($1000)	BCR
Air Compressor Demand Reduction	31,906	10	$1,924	$866	$0.035		2.42
Air Compressor Equipment2	13,641	10	$688	$370	$0.034		2.53
Air Compressor Optimization	38,224	10	$6,401	$1,037	($0.010)	$2,241	3.07
HighBay Lighting 1 Shift	8,494	10	$1,865		$0.029		3.79
HighBay Lighting 2 Shift	6,340	10	$751		$0.015		6.37
HighBay Lighting 3 Shift	49,757	10	$3,280		$0.009		10.94
Efficient Lighting 1 Shift	8,687	10	$545		$0.008		11.86
Efficient Lighting 2 Shift	6,209	10	$220		$0.005		19.94
Efficient Lighting 3 Shift	50,698	10	$959		$0.002		34.23
Lighting Controls	15,518	10	$3,091		$0.026		4.41
Motors: Rewind 20-50 HP	3,630	10	$995		$0.036		2.40
Motors: Rewind 51-100 HP	1,575	10	$391		$0.032		2.79
Motors: Rewind 101-200 HP	3,072	10	$544		$0.023		3.76
Motors: Rewind 201-500 HP	1,878	10	$212		$0.015		5.76
Motors: Rewind 501-5000 HP	2,316	10	$191		$0.011		7.86
Efficient Centrifugal Fan	5,357	10	$779		$0.019		4.76
Fan Energy Management	14,084	10		$459	$0.033		2.63
Fan Equipment Upgrade	35,787	10	$2,362	$1,165	$0.041		2.07
Fan System Optimization	52,078	10	$5,041	$2,035	$0.009	$2,205	2.51
Pump Energy Management	23,263	10		$758	$0.033		2.61
Pump Equipment Upgrade	64,727	10	$6,154	$2,108	$0.045		1.89
Pump System Optimization	65,638	12	$13,586	$2,993	($0.042)	$7,268	2.96
Transformers-Retrofit	22,202	10	$13,664		$0.080		1.23
Transformers-New	7,242	32	$4,990		$0.045		2.73
Synchronous Belts	17,534	10	$2,861		$0.021		4.04

Elec Chip Fab: Eliminate Exhaust	15,715	10	$3,447		$0.029		4.63
Elec Chip Fab: Exhaust Injector	59,864	10	$20,205		($0.107)	$9,034	5.34
Elec Chip Fab: Solidstate Chiller	155,168	10	$59,141		($0.088)	$21,428	4.47
Elec Chip Fab: Reduce Gas Pressure	32,351	10			($0.016)	$512	100.00
Clean Room: Change Filter Strategy	24,587	1	$168		$0.007		16.20
Clean Room: Clean Room HVAC	15,263	20	$2,825		$0.015		9.66
Clean Room: Chiller Optimize	24,791	10	$2,211		$0.012		10.61
Food: Cooling and Storage	31,418	10	$7,591		$0.032		2.91
Food: Refrig Storage Tuneup	16,892	3	$886		$0.019		4.39
Metal: New Arc Furnace	3,499	10	$246		($1.991)	$6,997	230.31
Kraft: Effluent Treatment System	4,170	10	$232		$0.007		11.65
Kraft: Efficient Agitator	17,700	10	$1,178		$0.009		10.32
Paper: Efficient Pulp Screen	1,327	10	$180		$0.018		4.78
Paper: Premium Fan	2,557	10	$348		$0.018		4.75
Paper: Material Handling	1,070	10	$980		$0.120		1.34
Paper: Large Material Handling	2,254	10	$2,513		$0.146		1.12
Paper: Premium Control Large Material	6,970	10	$2,764		$0.052		1.96
Material Handling2	8,929	10	$3,784		$0.055		1.87
Material Handling VFD2	36,821	10	$9,082		$0.032		2.91
Wood: Replace Pneumatic Conveyor	35,564	10	$376		($0.059)	$2,139	115.51
Panel: Hydraulic Press	2,266	10	$314		$0.018		4.72
Plant Energy Management	160,994	10	$2,856	$5,110	$0.034		2.55
Energy Project Management	122,837	11	$13,025	$3,867	$0.044		2.01
Integrated Plant Energy Management	160,535	11	$29,306	$6,274	($0.020)	$13,111	2.94
Irrigation: Ditch > Pipe	2,811	10	$166	-$2,840	($0.000)	-$2,818	1.09
Irrigation: Nozzles	129	3	$23		($0.000)	$8	2.34
Irrigation: Pump Systems Repair	109	7	$148	-$1	($0.000)	$25	1.36
Irrigation: Pump Systems Adjust	2,405	3	$414	-$114		$38	2.38

Irrigation: Water Management	1,093	5	$157	$73	($0.000)	$109	1.86
Rural Area Lights	317	23	$390	-$19	$0.032		1.67
Replace Traffic Light: Red Ball 8-inch	362	6	$37	-$12	($0.013)		5.76
Replace Traffic Light: Red Ball 12-inch	688	6	$52	-$13	($0.003)		6.79
Replace Traffic Light: Yellow Ball 8-inch	517	6	$2,153	-$312	$0.222		0.83
Replace Traffic Light: Yellow Ball 12-inch	529	6	$1,473	-$178	$0.216		0.76
Replace Traffic Light: Green Ball 8-inch	517	6	$92	-$22	($0.008)		3.59
Replace Traffic Light: Green Ball 12-inch	529	6	$70	-$13	$0.002		4.10
Replace Traffic Light: Red Arrow	327	6	$89	-$32	($0.044)		3.39
Replace Traffic Light: Green Arrow	322	6	$89	-$32	($0.045)		3.37
Replace Traffic Light: Yellow Bi-Modal Arrow	102	6	$50	-$10	($0.004)		1.90
Replace Traffic Light: Green Bi-Modal Arrow	105	6	$36	-$10	($0.032)		2.69
Replace Traffic Light: White Walking Person	658	6	$135	-$20	$0.011		2.80
Replace Traffic Light: Orange Hand	653	6	$135	-$20	$0.011		2.78
Replace Traffic Light: Orange Countdown	16	6	$9	-$1	$0.029		1.50
Replace Streetlight: 100WHPS>LED78W	34,318	17	$39,171	-$1,802	$0.050		1.35
Replace Streetlight: 100WHPS>LED60W	4,957	23	$5,141	-$382	$0.001		2.19
Replace Streetlight: 150HPS>LED117W	8,516	23	$10,487	-$523	$0.032		1.67
Replace Streetlight: 150HPS>LED111W	5,169	14	$5,055	-$320	$0.038		1.49
Retro Streetlight: 100WHPS>LED78W	31,906	10	$1,924	$866	$0.035		2.42
Retro Streetlight: 150HPS>LED117W	13,641	10	$688	$370	$0.034		2.53
Retro Streetlight: 150HPS>LED111W	38,224	10	$6,401	$1,037	($0.010)	$2,241	3.07

Cross Cutting Measures

Industrial measures were updated based on the latest set of measures from the Northwest Power Planning and Conservation Council. A significant change to the methodology is an inventory accounting to avoid double-counting savings when multiple measures apply to the same enduse. In that event, the mo0re cost-effective measure is assumed to occur first and savings for subsequent measures are derated.

Transformers

All electric power passes through one or more transformers on its way to service equipment, lighting, and other loads. Currently available materials and designs can considerably reduce both load and no-load losses. The new NEMA TP-1 standard is used as the reference definition for energy-efficient products. Tier-1 represents TP-1 dry-type transformers while Tier-2 reflects a switch to liquid immersed TP-1 products. More efficient transformers with attractive payback periods are estimated to save 40 to 50 percent of the energy lost by a "typical" transformer, which translates into a one to three percent reduction in electric bills for commercial and industrial customers. Typical paybacks range from 3 to 5 years (Nadel, et al. 1998). These opportunities are grouped into retrofit and new categories. Retrofit reflects the fact that existing units are being replaced with more efficient ones as a baseline.

Motor Rewinding

This measure has been the mainstay of past industrial programs. However, we recognize limited application since large motors are already rebuilt efficiently. In addition, regional efforts have partially transformed the market.

Industrial Lighting

High-bay lighting, required to provide overall ambient lighting throughout manufacturing and storage spaces, is typically provided by high-intensity discharge (HID) sources, including metal halide, high-pressure sodium and mercury vapor lamps. HID accounts for approximately 60 percent of industrial lighting energy consumption (Johnson 1997). Supplementary lighting is used to provide low-bay and task-specific lighting for inspection, equipment operation, and fine assembly activities. Fluorescent, compact fluorescent and incandescent light sources are commonly used for task lighting needs and together account for approximately 40 percent of industrial lighting energy.

One measure is the replacement of HID lighting with high-intensity fluorescent lighting in high-bay applications. New high-intensity fluorescent lighting systems incorporate high-efficiency twin-tube or linear T5 fluorescent lamps, advanced electronic ballasts, and high-efficacy fixtures that maximize light output to the work plane. Each of the system components confers advantages over traditional HID fixtures. Advantages include: lower energy consumption; lower lumen depreciation over the lifetime of the lamp; better dimming options; faster start-up and re-strike (virtually “instant-on” capability); better color rendition; higher pupil lumens ratings (translating into improved worker productivity and performance); and less glare (given fixture design and the more diffuse nature of the fluorescent light source) (Rogers and Krepchin 2000).

We broke the lighting measure into High Bay and other configurations. The cost and savings for the lighting measures are based on the same measures in commercial buildings. Since High Bay lighting and industrial HVAC are unlikely to disrupt processes, we assume a high achievable potential. However, lighting and HVAC in clean rooms and other critical environments is considered disruptive by the facility staff and we assume a low achievable potential.

Air Compressors

Achieving peak compressed air system performance requires addressing the performance of individual components, analyzing the supply and demand sides of the system, and assessing the interaction between the components and the system. This “systems approach” moves the focus away from components to total system performance. System opportunities have been shown to be the area of greatest efficiency opportunity. At the system level, savings opportunities can be grouped into three general categories: leaks, inappropriate uses of CA, and system pressure level. The goal of a management plan is to minimize all three.

The best strategy to avoid further problems is to set up a prevention program that monitors the system for new leaks and fixes them as they develop (DOE 1998). Reductions in wasted air due to inadequate maintenance, leaks, and inappropriate uses can save 20-30 percent of CA energy. A system's pressure level should be set at the lowest pressure that meets all requirements of the facility. Lowering the compressed air header pressure by 10 psi reduces the air leak losses by approximately 5 percent and improves centrifugal compressor capacity by 2-5 percent. One element of this may be the application of controls. Reducing system pressure also decreases stress on system components, lessening the likelihood of future leaks (DOE 1998). It is necessary to implement an ongoing maintenance program by plant staff, which requires both awareness and technical training (DOE 1998). Most of the barriers to improved compressors result from the lack of awareness of the opportunity. The staff reductions that have become common in United States industry and a hesitation to pay for outside consultants compound this problem. The Compressed Air Challenge (CAC) has developed a CA management training program that is available for plant staff and the Compressed Air and Gas Institute (CAGI) has developed CA training.

Overall, air compressor measures are grouped in order as follows: demand reduction (fixed leaks, etc.), two levels of equipment replacement, and system optimizing to redesign unnecessary processes.

Duct/Pipe Insulation

ACEEE identified repair and replacement of insulation as a conservation measure. Savings apply to processes that transfer heat or "cool". Because these are relatively easy to implement, we assume they are highly achievable.

Fan and Pump System Improvements

Just as motor systems benefit from optimal design and sizing, so do these systems. Overall, these measures are grouped in order as follows: demand management, equipment replacement, and system optimizing to redesign unnecessary processes.

Synchronous Belts

This is an O&M measure that applies to all motors. The measure is low-cost to implement but is short-lived. Due to ease of implementation, we assume it is highly achievable.

Plant Management

This study adds significant potential for management. The field covers a wide range of actions. For this study, they were grouped as Plant Energy Management, Energy Project Management and Integrated Plant Energy Management. The later includes hiring a dedicated staff person specifically to manage energy issues.

Specific Industrial Segments

Metal Segment

Primary metal production occurs in a few facilities within the Trust territory. There is one steel mill operating on recycled scrap and one exotic metal plant. Without specific audits of these individual facilities, we estimate the potential based on national level assumptions provided by ACEEE. The suggested potential should be considered as likely but not verified.

Metal: New Arc Furnace

While modern EAFs are generally more energy efficient many technologies exist to improve energy efficiency in existing furnaces, such as process control, efficient transformers, oxy-fuel injection, bottom stirring, post-combustion, eccentric bottom-tapping and scrap preheating (Worrell et al. 1999). Several new EAF-designs are under development, which combine energy saving features like increased fuel and oxygen injection with scrap preheating (Greissel 2000, IISI 2000b). The aim is to produce a semi-continuous process with enhanced productivity through reduced resource use (e.g. refractories, electrodes) and reduced tap-to-tap times. At the same time increased product quality also demands increased feedstock flexibility (e.g. scrap, DRI or pig iron). Different developers are involved in new EAF-process design, the most important being the Twin Electrode DC (IHI, Japan), Comelt (Voest Alpine, Austria) and Contiarc and Conarc (SMS Demag, Germany). The production costs are expected to be $9-13 lower per ton steel produced (Reichelt and Hofman 1996; Mannesmann 1998), or up to a 20 percent reduction. Given the narrow application (only one plant in the territory), we assume a low achievable potential.

Food Segment

Refrigeration in the food segment is a large energy consumer and is mainly used for freezing of vegetables. Many options exist to improve the performance of industrial refrigeration systems. System optimization and control strategies combined show a large potential for energy efficiency improvement of up to 30 percent (Brownell 1998). Opportunities include system design, component design (e.g. adjustable speed drives), as well as improved operation and maintenance practices. We focus on new system designs. Adjustable speed drives and process control systems have been discussed elsewhere. New system designs include the use of adsorption heat pumps, gas engine driven adsorption cooling, new working fluids (e.g. ammonia, CO_2) and alternative approaches (e.g. thermal storage). Due to the wide variety, we focus on selected technology developments in the areas of gas engines, thermal storage and new working fluids. Because these are new technologies, we assume a low achievable potential.

Food: Refrigerated Storage

Although the processing of frozen food tends to be seasonal, the product is stored throughout the year in refrigerated warehouses. This application is a large consumer of energy within the food segment. Simple O&M practices have been identified as providing savings. Such measures include tune-up and cleaning of compressor systems and control sensors (DEER, 2005). Due to ease of implementation, we assume a high achievable potential.

Agriculture Segment

Agriculture is important to the rural economy but a difficult segment for the utility to serve. That is because these loads tend to be highly seasonal. By far the largest agricultural use is for irrigation pumping. However, the pumping season lasts for only a few months, resulting in poor utilization of the capital investment. Nursery stock has become a major part of the local economy and consumes electricity for cooling. Animal production of poultry and containment livestock is a small segment with year-round requirement for ventilation and lighting.

Irrigation: Ditch to Pipe Conversion

PacifiCorp's IRP previously identified a narrow niche for this measure. A small amount of irrigation involves the pumping of water from unlined ditches. If the ditches are replaced with a piped system, there is sufficient gravity head that pumping is no longer needed. More importantly, the conversion saves water that would otherwise have leaked from the ditch. The saved water is a valuable commodity that can be used by the farmer or resold for wildlife or other users. While the applicability is small, the non-energy benefits can be large. We assume a high achievable where potential exists.

Irrigation: Pump Systems

The industry consists of multiple pump users including both farmers and water suppliers, such as irrigation districts. Irrigation is a difficult industry target for energy efficiency initiatives. However, there is inefficiency due to the fragmented nature. For instance, 80% of pumps in this industry are older than 15 years, resulting in poor efficiency. Pump efficiency tests performed by utilities were discontinued in the early 1990s due to budget constraints. As a result, awareness of energy efficiency and operating cost savings as well as knowledge of new technologies has decreased. Efficiency initiatives could be targeted at creating awareness of such practices as properly sizing pumps and replacing older equipment (NEEA). Pump efficiency testing and impeller improvements have long been part of program in the Northwest. Net savings from pump testing and impeller improvements are unclear, difficult to verify and not long-lived. We considered these savings to be moderately achievable.

Irrigation: Water Management

Scientific scheduling of irrigation utilizes direct measurement of soil moisture combined with local meteorological forecasts of crop transpiration. The result is a way of determining the proper amount of water to apply at just the right time. Net savings are unclear, difficult to verify and not long-lived. We considered them to be moderately achievable.

Paper Segment

Paper manufacture is one of the largest industrial consumers. Trust territory includes only a few firms but they have been actively participating in the efficiency program. For the most part, these firms produce different products and do not compete with each other. That also means that conservation measures appropriate to one plant are probably not transferable to other plants.

There is one exception in two plants that come close to similar operations. Both produce newsprint using primarily recycled paper fiber. However, the first plant produces coated paper such as is used in the advertising supplements. The second produces unfinished newsprint. The first plant has utilized Trust incentives for a major retrofit of their fiber refining process that provided large energy savings. It is possible that a similar retrofit could benefit the second plant.

Measures are broken into segments for kraft and bleached paper products. Prototype measures were applied based on a study by Marbek Associates for the British Columbia paper industry.

Wood Products Segment

Measures were broken into segment that correspond to plywood veneer, dimension lumber and other wood products. Improved material handling, in particular replacing pneumatic transfer, is an important set of measures. Conveyor systems are broadly defined as a piece of equipment moving material from one place to another. There are multiple types including blowers and pumps. Together they account for one of the largest energy uses within these facilities. The industry is fragmented with many smaller vendors. As a result, this is a difficult market to pursue energy efficiency initiatives. However, there are areas of improvement for the use of conveyor systems. These include: regular maintenance of the conveyor, installation of a VSD where loads vary significantly and replacement of inefficient pneumatic conveyors.

The Wood Products segment is large and diverse. It includes facilities that mill and cure lumber or veneer. It also includes facilities that process these products into chipboard, plywood and manufactured lumber. This segment is unique in that current Trust programs have already captured part (3%) of the opportunity for process improvements. We adjusted applicability for this fact.

Street and Traffic Lights

Since these loads are not associated with space heating, they have been included in the industrial sector. Measures are based on the latest set of measures from the Northwest Power Planning and Conservation Council.

Electronics Segment

This segment is one of the largest, accounting for 40% of PGE's industrial sales. This industry segment is comprised of a small number of companies, whose facilities are known to exhibit a wide variation in energy use, depending on their design, vintage and management philosophy. Most of these firms are self- directors.

There is an understandable reluctance to make changes in their process equipment (also known as "tools") because the processes are finely tuned to produce specific, repeatable results within extremely tight tolerances, and are sensitive to contamination. These process tool sets are persistent. For example, a manufacturer is still making 386 and 486 computer chips. Although these chips may be 20 years obsolete for desktop computers, they are still in demand for "smart appliances" or other applications. So the original process and facility is still in operation.

There may be an opening to address new measures to both tools and facility loads during the design of new facilities. However, existing facilities may operate for a long time without permitting any major overhaul. Thus, while there is large technical potential, the reluctance to participate is shown by a low achievable potential for these sorts of measures.

Table 13: Electronics Segment Process Shares

Electricity Process Shares	Total	Facility	Process
Pumps	27%	2%	25%
Fans	10%	10%	
Air Compressor	5%	5%	
Material Handling	3%	3%	
Material Processing	10%	5%	5%
Refrigeration	5%	5%	
Pollution Control	3%	3%	
Drying	0%		
Heating	5%		5%
HVAC	25%	25%	
Lighting	3%	2%	1%
Other Process	4%		4%
All Electric	100%	60%	40%
All Motors	83%		

Process Shares

The industry in Oregon differs from national averages. There is no longer any silicon melt operation in Oregon. Instead, the plants focus on wafer and chip production. Opportunities in the new solar cell manufacturing facilities are unknown but are assumed here to be represented by the measures that apply to chip production. While the MWh data include a small amount of instrument assembly and compressed gas production, chip plants dominate and require clean rooms with high HVAC consumption. Solar photovoltaic manufacturer is included with chip plants. Table 13 shows process shares for this segment. Note that the shares are split into those at the process line and those treated as part of the central facility. That is because the process lines may be more difficult for the program to access.

Specific Measures

We applied a higher achievable potential to measures that could be implemented without disruption of the process line. There are two potential openings here. To the extent that central facility operations (e.g. chiller plant) could be changed without disrupting a process line, those operations are moderately achievable. We also identified a few replacement opportunities for smaller equipment that would be achievable without disruption of processes.

Even so, it must be recognized that replacement of some parts of the process support equipment (for example, vacuum pumps) requires “re-qualifying” the process line. That is, it takes staff days to properly tune and calibrate all the mass flow, heating and cooling operations in a process tool – every time something changes they have to go through the calibration again. Of course, the same problem occurs if any equipment breaks or fails so there are continual replacement openings, albeit they cannot be scheduled.

Highly Achievable

We focused on etch tools and wet benches processes that etch and clean the wafers. This equipment runs continuously, with little electric load variation during times it is processing wafers. The equipment is so difficult to properly set up and calibrate that engineers are reluctant to let it go idle. We estimate there are about 5000 of these “benches” in Oregon. Components include 4 kW of vacuum pumps, the treatment equipment and trim chillers. The trim chiller consumes about 4.5 kW of electricity. Its role is to adjust the process cooling water temperature to that required by the process tool. The fabricating process produces dangerously reactive gases that are collected in a powered exhaust system.

Upgrade vacuum pump

The vacuum pumps are rebuilt periodically but slow to be replaced. Current units are 50% more efficient than the old units still in place. Replacement is not welcome since the process line must be “re-qualified” with every change. An efficiency incentive would encourage new replacement rather than re-build of older units. However, given that the units will eventually be replaced anyway, accelerating the upgrade is not cost effective.

Alternative Chiller

The trim chillers are large and inefficient and lack effective feedback controls. They can be replaced by a smaller, thermoelectric system that incorporates more effective feedback, does a better job of controlling temperature and increase throughput. Electricity savings are 90%. The thermoelectric system also saves about $5000 annually on decreased maintenance. There is another significant benefit in that the smaller unit has a much smaller footprint. We did not attempt to quantify the value of clean room floor space savings but it is considerable. Nor did we quantify the value of increased process throughput. The thermoelectric system permits more usable wafers per batch; better feedback controls decrease the risk of process flaws. Estimates derived from industry data sources.

Alternative Exhaust Injector

Etch tools use a point of use (POU) exhaust system to pre-treat the etch effluent before it enters the house exhaust system. The POU exhaust system consumes process gases and cleaned makeup air. It requires resistance heating and needs periodic maintenance. The alternative system uses a jet of nitrogen gas to flush (or "inject") the exhaust from the etch tool into the house exhaust header. It saves 100% of the resistance heat as well as about $6000 annually in process gases. We estimate there about 400 applications in Oregon. Estimates derived from industry data sources.

Reduce Pressure of Process Gases (Dry Air and Nitrogen)

This is a no-cost O&M measure. Sematech survey indicated that most tools could operate at 80 psi or less but that 100 psi is routinely provided. Reducing pressure by 20 psi is estimated to save 10% in compressor energy as well as reduce consumption of process gases.

Moderately Achievable

We consider the next set of measures to be moderately achievable because central facility operations (e.g. chiller plant) could be changed without disrupting a process line. The barriers here are the usual ones of reluctance to invest capital in major changes. In many cases, the cost and savings of the measures came from a Supersymmetry report on a typical facility. Many of these measures are specific opportunities that correct operations and design problems at Supersymmetry's case example. While Oregon facilities will not be identical, we assume that the measures identified by Supersymmetry are proxies for similar opportunities that exist in Oregon plants.

Electronics: Chiller optimize

Based on audit of a typical plant, Supersymmetry suggested a variety of simple changes to improve the overall system performance. These included elimination of unnecessary chillers, reset of CW temperature, combining pipe runs and controls for parallel operation of multiple chillers.

Electronics: Change filter strategy

New immerging filter technologies (HEPA/ULPA filters) offer the opportunity to significantly reduce filter energy use by reducing filter pressure drops (Tschudi 2000). Supersymmetry noted for their case example that less expensive filters could be used in part of the operations in order to offset the cost of more expensive filters in other operations.

Electronics: Clean Room HVAC

Several HVAC technologies that have emerged recently which when combined, can achieve significant energy savings. Currently a large amount of energy is expended in heating, cooling, and filtering air that is then exhausted. Air re-circulation is another large HVAC energy user. Recirculation air velocity can be turned down (from, say, 90 fpm to 80) without affecting cleanliness levels. Sensors and the use of laser-based particle counters are both technologies that can be applied to more efficiently moderate airflow. Additionally, more efficient airflow equipment that is near commercial (e.g. low face velocity fans, efficient duct systems, more efficient filter units) could be combined to further reduce recirculation fan energy requirements. Existing practices can also be applied in conjunction with these technologies to further enhance energy savings, such as "right-sizing" of exhaust air flow for each specific tool, improved design guidance for ducting and other systems, and limiting the floor area that requires clean air flow to a smaller "micro" environment. This measure has been screened to avoid double counting with other HVAC measures. Combined with the other HVAC measures, clean room technologies have the potential to reduce electricity consumption of the average clean-room facility by 25-30 percent, or an average of 145 kWh/sq. ft. Additionally, they are accompanied by several additional non-energy benefits including improved productivity and a reduction in emissions without sacrificing any product quality.

Electronics: Eliminate exhaust

Minimizing exhaust flow reduces the amount of make up air that needs to be reconditioned. Ultra low fume hoods, a technology developed at Lawrence Berkeley National Laboratory, require 25 percent of normal exhaust flow. This technology is now being piloted in field trials (Tschudi 2000). Supersymmetry's audit noted that full exhaust is required for only 50% of operating hours. Use of controllers and VSD fans would reduce unneeded exhaust with significant savings on makeup air. Phil Naughton, SEMATECH, noted that various process tools could be reduced by about 30% of the exhaust requirement.

Electronics: Reduce pressure, reset CHW

In their audit, Supersymmetry notes that the existing tower experiences poor flow. The plant staff expected to increase pumping power to compensate. Instead, Supersymmetry suggested a number of ways to remove flow obstructions and lower pumping power. Also, they suggested reset of CW temperature to lower flow rate.

Electronics: VSD Tower Pumps

In their audit, Supersymmetry notes that tower pumps are staged off and on which results in unequal pressure drops to the different pumps. Use of VSD drives would allow for even distribution of flows and saved pump energy.

Electronics: Wastewater Preheat Of OSA

Conditioning of makeup air is a major HVAC energy requirement whether for heating in the winter or cooling in the summer. Supersymmetry noted that preconditioning with the plant wastewater would provide savings in both seasons.

Low Achievable

These measures are considered unlikely to be achievable either because they require a major re-investment in plant capital or a major re-design in handling processes. Facility operators may be reluctant for both reasons.

Electronics: CW to gas plant

In their audit, Supersymmetry noted the opportunity to provide more efficient cooling to the compressors that provide cleaned air and process gases to the process line.

Electronics: Chiller heat recovery

In their audit, Supersymmetry noted opportunities to recover waste heat from the chillers. The waste heat can be used for pre-conditioning makeup air or other low temperature applications. The savings quantified here are primarily due to improving chiller performance by better heat removal.

Electronics: New air compressor

In their audit, Supersymmetry noted that two large air compressors were scheduled for replacement with an existing used compressor. Replacement with new, efficient compressors would provide savings. Cost would be the incremental cost over the planned replacement.

Electronics: New chiller/tower, 2 loops

In their audit, Supersymmetry noted the opportunity to replace the chiller system with a better designed new one. The new system would be designed to maximize free cooling, a VSD chiller and would include splitting the CW system into two pipe loops – one cold and one moderate loop. The overall system performance would be improved by utilizing two loop temperatures. While savings are considerable, this would be a major capital investment.

Table 14: Summary of Measures -- Electronics Segment

Opportunity	Measure Name	Cost	Savings, kWh	O&M/yr	Life	LC in 2008$
Highly	Thermoelectric Chiller	$20,000	40,571	-$5000	10	($0.071)
Achievable	Exhaust Injector	$20,000	45,815	-$6170	10	($0.073)
	Reduce Gas Pressure	$0	3,260	-$46	10	($0.001)
	Vacuum pump, incremental over rebuild	$51,000	63,072		5	$0.972
Moderately	Chiller optimize	$50,000	1,736,000		10	$0.037
Achievable	Change filter strategy	$9,200	1,463,000		1	$0.054
	Clean Room HVAC	$20/sqft	144/sqft		20	$0.011
	Eliminate exhaust	$80,000	442,000		10	$0.026
	Reduce pressure, reset CHW	$40,000	81,000		10	$0.070
	VSD tower pumps	$50,000	187,000		10	$0.028
	Wastewater preheat of OSA	$325,000	776,000	-$180,000	10	($0.173)
Low	CW to gas plant	$40,000	245,000		10	$0.023
Achievable	Chiller heat recovery	$30,000	28,000		10	$0.152
	New air compressor	$50,000	273,000		10	$0.026
	New chiller/tower, 2 loops	$800,000	4,539,000		10	$0.025

Industrial Natural Gas Conservation Measures

As discussed, the gas customers included in this study are only those in the Industrial Firm tariff, corresponding to perhaps 10% of commercial and industrial customers. Those on the firm rate are generally small facilities or adjunct meters to larger facilities. As such, the end uses are more similar to other small commercial customers than to what would be expected for large industrial facilities. The primary application of gas is for boilers –either for process steam or for space heating. As a result, the opportunity is dominated by various measures to improve boiler efficiency.

The following measures are included:

- Chiller heat recovery (Electronics Segment)
- Utilize heat recovery where option exists
- Combo Cond Boiler (Replace and Retrofit)
- Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90% efficiency for savings calculations).
- Combo Hieff Boiler (Replace and Retrofit)

- Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.
- Condensing Furnace (Replace)
- Condensing / pulse package or residential-type furnace with a minimum AFUE of 92%.
- Condensing Unit Heater from Nat draft or power draft (Replace)
- Install condensing power draft units (90% seasonal efficiency) in place of natural draft (64% seasonal efficiency)
- Heat Recovery to HW
- Utilize heat recovery where option exists
- DHW Condensing Boiler (Replace and Retrofit)
- Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90% efficiency for savings calculations).
- DHW Condensing Tank (Replace and Retrofit)
- Costs and savings are incremental over a Code-rated tank (combustion efficiency of 80%) for a condensing tank with a minimum combustion efficiency of 94% and an R-16 tank wrap.
- DHW Hieff Boiler (Replace and Retrofit)
- Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.
- DHW Pipe Insulation
- Add 1" insulation to pipes used for steam or hydronic distribution; particularly effective when pipes run through unheated spaces.
- DHW Standard Boiler (Retrofit)
- Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.
- DHW Wrap
- Insulate the surface of the storage water heater or an unfired storage tank to R-5 to reduce standby losses.
- Ducts
- Duct retrofit of both insulation and air sealing
- Hi Eff Unit Heater (Replace and Retrofit)
- Install power draft units (80% seas. Eff) in place of natural draft (64% seasonal efficiency)
- HiEff Clothes Washer (Replace and Retrofit)

- Install high performance commercial clothes washers - residential sized units
- Hot Water Temperature Reset
- Controller automatically resets the delivery temperature in a hot water radiant system based on outside air temperature. The reset reduces the on-time of the heating equipment and the occurrence of simultaneous heating and cooling through instantaneous adjustments.
- HW Boiler Tune Tune up in accordance with Minneapolis Energy Office protocol.

  Can include derating the burner, adjusting the secondary air, adding flue restrictors, cleaning the fire-side of the heat exchanger, cleaning the water side, or installing turbulators. Other modifications may include uprating the burner to reduce oxygen or derating the burner to reduce stack temperature.

  Note: In gas systems, excess air and stack temperatures are often within reasonable ranges, so the technical potential for this measure is limited. Combining this measure with the vent damper and power burner measures increases both applicability and cost effectiveness, and was assumed for this analysis.
- Power burner

  Replace standard burner with a power burner to optimize combustion and reduce standby losses in the stack.

  Note: Costs and savings assume that this measure will be performed in conjunction with a boiler tune up when appropriate.
- Process Boiler Controls
- Process Boiler Insulation
- Process Boiler Load Control
- Process Boiler Maintenance
- Process Boiler Steam Trap Maintenance
- Process Boiler Water Treatment
- Roof Insulation - Blanket R0-19

  Application: Buildings with open truss unfinished interior
- Roof Insulation - Blanket R0-30

  Application: Buildings with open truss unfinished interior
- Roof Insulation - Blanket R11-30

  Application: Buildings with open truss unfinished interior
- Roof Insulation - Blanket R11-41

  Application: Buildings with open truss unfinished interior
- Roof Insulation - Rigid R11-22 (Replace)

2" rigid added to an existing foam roof insulation at re-roof, includes some surface prep. Application: Old buildings with flat roofs, no attics, and some insulation

- Roof Insulation - Rigid R11-33 (Replace)
- Roof Insulation - Rigid R11-33: add 4' of insulation at reroof. Application: Old buildings with flat roofs, no attics, and some insulation
- Solar Hot Water

  Install solar water heaters on large use facility such as multifamily or lodging
- SPC Condensing Boiler (Replace)

  Install condensing boiler. Assumed seasonal combustion efficiency of 88% over base of 75%
- SPC Condensing Boiler (Retrofit)

  Install condensing boiler. Assumed seasonal combustion efficiency of 88% over base of 69.5%
- SPC High Efficiency Boiler (Replace)

  Install near condensing boiler. Assumed seasonal combustion efficiency of 82% over base of 75%
- SPC High Efficiency Boiler (Retrofit)

  Install near condensing boiler. Assumed seasonal combustion efficiency of 82% over base of 69.5%
- Steam Balance (Wood Prod)

  Single-pipe steam systems are notorious for uneven heating, which wastes energy because the thermostat must be set to heat the coldest spaces and overheating other spaces. Steam balances corrects these problems by: 1) Adding air venting on the main line or at the radiators; 2) Adding boiler cycle controls; 3) Adding or subtracting radiators. Energy savings accrue from lowering the overall building temperature.
- Steam Trap Maint (Wood Prod)

  Set up a in-house steam trap maintenance program with equipment, training, and trap replacement. An alternative procedure is to just pay for an outside contractor to conduct a steam survey.
- Upgrade Process Heat

  Replace furnace, re-heaters
- Vent Damper

  Install vent damper downstream of the draft relief to prevent airflow up the stack, while allowing warm air from the boiler to spill into the conditioned space as heat or into the boiler room to reduce jacket losses. This measure is most cost-effective when combined with the boiler tune up and power burner measures.
- Wall Insulation - Blown R11

Application: Old buildings

- Wall Insulation - Spray On for Metal Buildings
- Wall Insulation (Cellulose) unfinished. Application: Old buildings
- Waste Water Heat Exchanger

  Install heat exchanger where copious warm water is discarded

Commercial Sector Resource Assessment

A list of the major commercial measures, listed by the levelized cost, is provided in Table 18 and Table 19. These lists present individual measures, with costs and benefits resulting from the applicable population.

Commercial Sector Characterization

Characterizing the commercial segment reveals certain difficulties. For example, industrial customers often have a relatively large percentage of overall floor space devoted to end uses that would typically be thought of as commercial. We included a portion of "industrial" sales as really belonging to commercial uses. New construction square footage estimates were also developed using utility estimates although these appear to assume optimistic growth.

On particular problem lies with the growth of large data server "farms". Several of these facilities have located in the Northwest and their energy consumption can be prodigious. A variety of conservation measures are available for these facilities. However, quantifying the impact is difficult. Problems occur with:

- Forecasting – specific facilities are not included in the utility forecasts.
- Baseline – computer technology changes rapidly and baseline consumption is not clear
- Current practice – the extent to which HVAC and software management measures are already adopted is not clear.

As a result, although one can anticipate significant opportunities regarding data servers, we have not attempted to quantify them.

Description of Commercial Measures

Measures were previous described in the 2007 report. For this study, the detailed measure descriptions are included in Table 18 and Table 19.

Lighting Measures

The new assessment has made several adjustments to the cost and savings assumptions and the calculation methods used in the lighting assessment.

Lighting equipment cost data were reviewed and adjusted to agree with the latest set of measures from the Northwest Power and Conservation Council.

Overall, high performance T8 technology is highly attractive and should be pursued aggressively. The high/low bay lighting is much less clear. Further evaluation of this niche is warranted. Hours of operation and available control strategies will have a large impact on savings and, as such, solutions most likely need to be evaluated on a case by case basis. Ceramic metal halide remains a highly attractive but expensive option for display light situations. It definitely delivers same to better quality light and less frequent bulb changes and, as such, is an upgrade in most situations. Even though this fixture is not cost effective in most situations, it should be evaluated on a situation-by-situation basis.

Lighting measures:

- CFL 9W to 39W hardwired
- High Efficacy LED Display
- T8 to HP T8
- T12 to HP T8
- High Bay HID Medium to T8 (Retrofit and New)
- High Bay HID Large to T5 (Retrofit and New)
- Daylight Control (overhead)
- Sweep Control
- Daylight perimeter zone
- Occupancy Sensors
- Exit signs
- Ceramic Metal Halide (Retrofit and New)
- Daylighting Overhead (New)
- Daylight control with skylight

HVAC Measures

Economizer Diagnostic, Damper Repair & Reset

Applicable to single zone packaged systems. The outdoor make-up air damper and control are often set incorrectly or not functioning. Savings derive from reduced cooling due to restored economizer function and reduced heating from reduced minimum outdoor air.

Warm Up Control

This measure is designed to implement a shut down of outside air when the building is coming off night setback. Usually the capability for this is available in a commercial t-stat but either the extra control wire is not attached or the unit itself has not been set up to receive the signal. Cost is based on labor cost to enable this ability in existing controllers.

Rooftop Condensing Burner

Prototype units of condensing natural gas packaged heaters have been demonstrated in Canada. However, the condensing feature of these units was not the primary source of their savings – rather it was the fact that exposed ductwork was better insulated.

Demand Controlled Ventilation (DCV)

Applicable to single zone packaged systems with large make -up air fractions either because of intermittent occupancy or because of code requirements. In most cases the outdoor air is reset to 5% or less with CO_2 build-up modulating ventilation.

Ducts

Duct retrofit of both insulation and air sealing

Hot Water Temperature Reset

Controller automatically resets the delivery temperature in a hot water radiant system based on outside air temperature. The reset reduces the on-time of the heating equipment and the occurrence of simultaneous heating and cooling through instantaneous adjustments.

HW Boiler Tune

Tune up in accordance with Minneapolis Energy Office protocol. Can include de-rating the burner, adjusting the secondary air, adding flue restrictors, cleaning the fire-side of the heat exchanger, cleaning the water side, or installing turbulators. Other modifications may include up-rating the burner to reduce oxygen or de-rating the burner to reduce stack temperature. Note: In gas systems, excess air and stack temperatures are often within reasonable ranges, so the technical potential for this measure is limited. Combining this measure with the vent damper and power burner measures increases both applicability and cost effectiveness, and was assumed for this analysis.

Steam Balance

Single-pipe steam systems are notorious for uneven heating, which wastes energy because the thermostat must be set to heat the coldest spaces and overheating other spaces. Steam balances corrects these problems by: 1) Adding air venting on the main line or at the radiators; 2) Adding boiler cycle controls; 3) Adding or subtracting radiators. Energy savings accrue from lowering the overall building temperature.

Steam Trap Maintenance

Set up a in-house steam trap maintenance program with equipment, training, and trap replacement. An alternative procedure is to just pay for an outside contractor to conduct a steam survey.

Vent Damper

Install vent damper downstream of the draft relief to prevent airflow up the stack, while allowing warm air from the boiler to spill into the conditioned space as heat or into the boiler room to reduce jacket losses. This measure is most cost-effective when combined with the boiler tune up and power burner measures.

Power burner

Replace standard burner with a power burner to optimize combustion and reduce standby losses in the stack. Note: Costs and savings assume that this measure will be performed in conjunction with a boiler tune up when appropriate.

Space Conditioning Hieff Boiler (Retro and Replace)

Boiler costs for near condensing boiler. Assumed seasonal combustion efficiency of 82% over base of 69.5%

Space Conditioning Cond Boiler (Retro and Replace)

Boiler costs for condensing boiler. Assumed seasonal combustion efficiency of 88% over base of 69.5%

Hi Eff Unit Heater (New, Retro and Replace)

Base efficiency has gone up. Install power draft units (80% seasonal eff) in place of natural draft (64% seasonal eff)

Cond Unit Heater from Natural draft (New and Replace)

Install condensing power draft units (90% seasonal eff) in place of natural draft (64% seasonal eff)

Cond Unit Heater from Power draft (New and Replace)

Install condensing power draft units (90% seasonal eff) in place of power draft (80% seasonal eff)

Cond Furnace (New and Replace)

Condensing / pulse package or residential-type furnace with a minimum AFUE of 92%.

Space Conditioning Hieff Boiler (New)

Install near condensing boiler. Assumed seasonal combustion efficiency of 82% over base of 75%

Space Conditioning Cond Boiler (New)

Install condensing boiler. Assumed seasonal combustion efficiency of 88% over base of 75%

Water Heating Measures

DHW Wrap

Insulate the surface of the storage water heater or an unfired storage tank to R-5 to reduce standby losses.

DHW Shower Heads

Install low flow shower heads (2.0 gallons per minute) to replace 3.4 GPM shower heads.

DHW Faucets

Add aerators to existing faucets to reduce flow from 3.4 gallons per minute to 2.0 GPM.

DHW Pipe Ins

Add 1" insulation to pipes used for steam or hydronic distribution; particularly effective when pipes run through unheated spaces.*DHW Recirc Controls*

Install electronic controller to hot water boiler system that turns off the boiler and circulation pump when the hot water demand is reduced (usually in residential type occupancies) or can be reset to meet the hot water load. (Steel boilers also require a mixing valve to prevent water temperatures from dropping below required levels).

DHW Std. Tank (Retro)

This measure would replace existing DHW tank with equipment meeting current Oregon Energy Code requirements (thermal efficiency of 78% or better).

DHW Condensing Tank (Retro)

Replace older tanks with condensing tanks with combustion efficiency of 94% and tank insulation with an R-value of 16 or greater.

DHW Condensing Tank (Replace)

Costs and savings are incremental over a Code-rated tank (combustion efficiency of 80%) for a condensing tank with a minimum combustion efficiency of 94% and an R-16 tank wrap.

DHW Condensing Tank (New)

Costs and savings are incremental over a Code-rated tank (combustion efficiency of 80%) for a condensing tank with a minimum combustion efficiency of 94% and an R-16 tank wrap.

DHW Std. Boiler (Retro)

Replace existing boiler with unit meeting OR Code requirements of 80% combustion efficiency.

DHW Hieff Boiler (Retro)

Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.

DHW Cond Boiler (Retro)

Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90% efficiency for savings calculations).

DHW Hieff Boiler (Replace and New)

Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.

DHW Cond Boiler (Replace and New)

Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90% efficiency for savings calculations).

Combo Hieff Boiler (Retro)

Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.

Combo Cond Boiler (Retro)

Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90% efficiency for savings calculations).

Combo Hieff Boiler (Replace and New)

Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.

Combo Cond Boiler (Replace and New)

Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90% efficiency for savings calculations).

Solar Hot Water (New and Retrofit)

Install solar water heaters on large use facility such as multifamily or lodging New

Heat Pump Water Heat (New and Retrofit)

Waste Water Heat Exchanger (New and Retrofit)

Install HX on waste water

Hi Eff Clothes Washer (Replace)

Install high performance commercial clothes washers – for residential units

Computerized Water Heater Control (New and Retrofit)

Install intelligent controls on the hot water circulation loops.

Cooking Measures

Cooking measures with primarily gas savings include Energy Star applications for Convection Oven, Fryer, Griddle, and Hot Food Holding Cabinet. These apply to both electricity and gas appliances.

Shell Measures

Insulation measures:

Wall Insulation - Blown R11

Application: Old buildings

Wall Insulation - Spray On for Metal Buildings

Spray On for Metal Buildings (Cellulose) Unfinished. Application: Old buildings

Roof Insulation - Rigid R0-11

Rigid R0-11-not including re-roofing costs but including deck preparation. Application: Old buildings with flat roofs and no attics

Roof Insulation - Rigid R0-22

Rigid R0-22-- not including re-roofing costs but including deck preparation and ~4" rigid.. Application: Old buildings with flat roofs and no attics

Roof Insulation - Rigid R11-22

Rigid R11-22 2" rigid added to an existing foam roof insulation at re-roof, includes some surface prep. Application: Old buildings with flat roofs, no attics, and some insulation

Roof Insulation - Rigid R11-33

Rigid R11-33: add 4' of insulation at time of reroofing. Application: Old buildings with flat roofs, no attics, and some insulation

Roof Insulation - Blanket R0-19

Blanket R0-19. Application: Buildings with open truss unfinished interior

Roof Insulation - Blanket R0-30

Blanket R0-30. Application: Buildings with open truss unfinished interior

Roof Insulation - Blanket R11-30

Blanket R11-30. Application: Buildings with open truss unfinished interior

Roof Insulation - Blanket R11-41

Blanket R11-41. Application: Buildings with open truss unfinished interior

Roof Insulation - Attic R0-30

Attic R0-30. Application: Buildings with uninsulated attics

Roof Insulation - Attic 11-30

Attic 11-30. Application: Buildings with partially insulated attics

Roof Insulation - Roofcut 0-22

Roofcut 0-22. Application: Buildings with uninsulated flat roofs at reroofing time

Window Measures

Window energy savings were predicted with building energy simulation models for the 2004 ETO evaluation. The window market was divided into vinyl and aluminum frame, and tinted versus non-tinted. The tinted versus un-tinted is significant because without tint windows must be include a low emissivity coating to pass the SHGC code requirement. This generally brings the window SHGC and U-value below the code requirements by a significant margin, reducing savings available.

The Oregon code has low and high glazing fraction paths. The high glazing path requires maximum performance windows, which pretty much excludes them from utility programs. Therefore, we limited this evaluation to the lower glazing path and window populations (application factor) were reduced by 40% to remove the high glazing buildings (>30% in zone 1 and >25% in zone 2) from the target population.

For each of these cases, savings were predicted for various measures. For the aluminum frames, several U-value targets were established with the assumption that the target buildings would evenly divide into these groups.

Categories of retrofit windows include: Windows – Single or Double to Class 45, 40, 36 or VEA. Details of window assumptions are listed in Table 15.

Table 15: Window Measure Details

Window	SHGC	U-Value	Measure Code, At Replacement	Measure Code, New	Measure Name
Code Requirement	0.57	Z1 0.54 Z2 0.50			
Aluminum, tinted					
Model Base	0.52	0.50			
Class 45 tint	0.35	0.45	E120	E129	Windows - Tinted AL Code to Class 45
Class 40 tint	0.35	0.40	E121	E130	Windows - Tinted AL Code to Class 40
Class 36 tint	0.35	0.36	E122	E131	Windows - Tinted AL Code to Class 36
Aluminum, not tinted					

Window	SHGC	U-Value	Measure Code, At Replacement	Measure Code, New	Measure Name
Model Base	0.43	0.48			
Class 45	0.43	0.45	E117	E126	Windows - Non-Tinted AL Code to Class 45
Class 40	0.43	0.40	E118	E127	Windows - Non-Tinted AL Code to Class 40
Class 36	0.43	0.36	E119	E128	Windows - Non-Tinted AL Code to Class 36
Vinyl, tinted					
Model Base	0.54	0.50			
Add Low E	0.35	0.35	E114	E123	Windows - Add Low E to Vinyl Tint
Add Low E + Argon	0.35	0.31	E115	E125	Windows - Add Low E and Argon to Vinyl Tint
Vinyl, not tinted					
Model Base	0.43	0.35			
Add Argon	0.43	0.31	E116	E124	Windows - Add Argon to Vinyl Lowe

Cooling and HVAC Controls Measures

CEE Tier 2 3 ton (New and Replacement)

Install high efficiency cooling equipment complying with CEE Tier 2.

CEE Tier 2 7.5 ton (New and Replacement)

Install high efficiency cooling equipment complying with CEE Tier 2.

CEE Tier 2 15 ton (New and Replacement)

Install high efficiency cooling equipment complying with CEE Tier 2.

CEE Tier 2 25 ton (New and Replacement)

Install high efficiency cooling equipment complying with CEE Tier 2.

HVAC System Commissioning (New)

Commissioning includes testing and balancing, damper settings, economizer settings, and proper HVAC heating and compressor control installation. This measure includes the proper set-up of single zone package equipment in simple HVAC systems. The majority of the Commercial area is served by this technology. Work done in Eugene (Davis, et al, 2002) suggests higher savings than the other documented commissioning on more complex systems.

HVAC controls (New)

Set up control algorithms. This assumes the development of an open source control package aimed at describing scheduling and control points throughout the HVAC system, properly training operators so that scheduling can be maintained and adjusted as needed, and providing operator back up so that temperature reset, pressure reset, and minimum damper settings are set at optimum levels for the current occupancy.

Lighting Scheduling/Controls (New)

This measure includes the commissioning of any occupancy and sweep controls and the review and proper setting of daylighting controls. Since these are largely a function of schedule settings (except in cases where daylighting controls are integrated into the energy management software), we have included only the impact of properly controlled lighting and occupancy.

PCs and Monitors - Energy Management Software (New and Replacement)

There is a solution to automate the enabling of Power Management in commercial computers and monitor/displays called Surveyor by EZConserve.

LCD Monitors (New and Replacement)

Replace CRT with LCD monitor at replacement time. This measure is zeroed out as being current practice.

High Efficiency Chiller (Replace)

Replace chillers or installing new chillers to purchase units with efficiencies averaging 0.51kW/ton air conditioning (AC), rather than the standard new unit, which has an efficiency of 0.65 kW/ton. In practice, some fraction of chiller replacements may involve the early retirement of units with lower efficiencies (perhaps 0.90 kW/ton), and thus achieve higher savings in the first few years of the measure installation.

Chiller System Optimization (Replace)

Includes improvements in efficiency and reduction in parasitic losses in pumps, fans, and other (non-chiller) electric motor-driven systems associated with chillers.

Chiller Tower 6F approach (Replace)

Install low approach cooling tower

Transformers (Retrofit)

Savings apply at service entry for all electric usage

EMS Retrofit for Restaurants (Retrofit)

Many commercial establishments have no means of operating facility lighting, heating, air conditioning, refrigeration, etc., except to rely upon employees to manually switch equipment on/off before, during and after a typical work day. This is especially true in restaurants. A proper EMS installation in such facilities can reduce existing gas and electric energy usage by about 10% or more.

ECM Fan Powered Boxes (New)

Install ECM motors in VAV fan powered terminals with PSC motors

Indirect/Direct Evaporative Cooling ~20 ton (New and Replacement)

Install indirect/direct evaporative cooling in commercial building HVAC system in 20 to 60 ton range

Indirect/Direct Evaporative Cooling >60 ton (New and Replacement)

Install indirect/direct evaporative cooling in commercial building HVAC system in large systems <60 ton range. Original ETO evaluation evaluated at 20, 150 and 300tons with all being essentially equivalent

Ground Source Heat Pump - Air Source HP Base (Replacement)

Install GSHP in place of air source heat pumps.

Refrigeration Measures

Four energy efficiency measures were developed from Supermarket Energy Efficiency (NEEA, 2005) for large supermarket refrigeration systems.

Floating heat pressure has very large energy savings and a relatively high current saturation. It includes floating head pressure controls with variable set-point control to maintain a 10F delta T to a minimum coil temperature of 70F.

Heat Reclaim has huge savings for the heating fuel but a significant electric interaction penalty with floating head pressure. Currently, heat reclaim is most common in the limited form of heating service hot water with refrigeration superheat. This measure is the use of condenser heat in a heat reclaim coil installed in the space heating system.

This measure assumes that floating head pressure is installed and heat reclaim holdback valves are used to maintain the refrigerant's SCT in the reclaim coil, regardless of the SCT at the condenser, thereby allowing the condenser to "float" with ambient. This greatly reduces the savings from floating head pressure and is accounted for as a negative electric savings for this measure.

Other refrigeration measures:

Refrigeration Case Package

This measure includes efficient evaporator fans, case lighting, and low energy anti-sweat heaters.

Efficient Refrigeration Systems

This measure includes efficient compressor, efficient condenser fans, mechanical sub-cooling, and controls.

Package Refrigeration - Icemakers, Vending machines (New and Replacement)

Install machines with package of measures akin to ADL low cost

Efficient Standalone Refrigeration Cases (New and Replacement)

Install efficient stand-alone cases. This measure is based upon current rebates and SAIC savings numbers

Residential Sector Resource Assessment

Sector Characterization

For this analysis, three residential segments were considered: single family, manufactured homes and multi-family units. We further divided these segments, at the request of the Energy Trust, into low income, medium low income, and all other income levels (see the ResSectorChar.xls spreadsheet). For this analysis, both electricity and fuel savings are considered. In cases where the nature of the measure limits its applicability to a portion of the homes (for example, duct measures exclude homes with basements), adjustments to the technical potential are contained in the workbook for that measure.

Description of Residential Measures

Detailed list of measures in included as Table 20 and Table 21. These tables provide results for the measures applied to the appropriate population. A short description of assumptions used to develop these measures follows. Savings estimates for heating consumption are based on simulations by Ecotope's SEEM model, which is specifically designed to include effects of duct distribution losses and other regional measures.

HVAC Measures

1. Duct Sealing (New/Replacement)

Duct sealing in accordance with PTCS standards for new construction. The distribution efficiency associated with the duct sealing measure is .85.

2. Duct Repair (Retrofit)

Duct sealing in accordance with PTCS standards for existing construction, requiring a 50% reduction in leakage, was examined for several heating system types.

3. Heat Pump Upgrade (New/Replacement/Retrofit)

Heat pump upgrade from HSPF 7.7 to 9.5, with PTCS-level commissioning and duct sealing. For the retrofit sector, the efficient heat pump was examined both as a retrofit from an older, working heat pump and from an electric furnace base case.

4. Ground Source Heat Pumps (New)

Install Ground Source heat pump (GSHP) in lieu of standard air source heat pump.

5. High Efficiency AC (New/Replacement)

We examined a measure to upgrade a central forced air AC system to SEER 15 from SEER 13. Some additional savings from proper commissioning are included in the total. We also examined a measure to upgrade a standalone window unit to Energy Star levels (base case EER 9.7 upgraded to 10.7).

6. Diagnostic Heat Pump tune-up (Retrofit)

A program based on field visits that offers minor adjustments to HVAC equipment (adjust charge, clean filters, check settings, install cutout thermostat) to optimize efficiency. The requirements for each system will vary, but cost and savings are based on overall expectations if a large population is treated.

7. Evaporative Cooling (New/Replacement/Retrofit)

Install a direct/indirect evaporative cooler for new and replacement models. Savings for the retrofit sector are from in lieu of a SEER 13 central AC.

8. High Efficiency Gas Furnace (New/Replacement)

This measure describes an upgraded gas furnace from AFUE .8 to .9. A separate measure adds duct leakage improvements of 15%.

9. Ductless Mini-split Heat Pump

Current models are small in capacity, which limits their retrofit potential. They are suggested for homes with electric baseboard heating – which makes them one of the few retrofit equipment measures possible for older homes with baseboard heating. In multi-family housing where they would provide the equivalent of an efficient through-the-wall heat pump. The cost estimate gives credit for the fact that a window air conditioner would otherwise have to be included to provide a similar cooling benefit.

Envelope Measures

1. Energy Star building package (New)

The Energy Star package is continuingly evolving. As new efficiency levels are implemented in codes and standards, Energy Star must develop new measures that provide a further level of energy savings. It becomes more difficult to find further measures that are cost-effective and provide sufficient savings. The current Energy Star package includes insulation, windows, duct sealing, efficient hot water and lights, as well as high efficiency heating/cooling equipment.

2. Window Upgrades (New/Replacement/Retrofit)

Improvement from U=.35 to U=.30. This measure is applicable to both electrically heated and gas heated homes.

2. Heat Recovery Ventilation, including infiltration reduction (New)

Addition of heat recovery to ventilation system and whole house sealing. This measure is applicable to both electrically heated and gas heated homes.

3. Standalone shell measures to Energy Star levels (New).

Window and insulation as a stand-alone measures. Basecase was R-21 in the floor and walls, and R-38 insulation in the attic. The Energy Star package requires the same wall and attic insulation performance, but also requires advanced framing for the walls and R-30 insulation in the floor. This measure is applicable to both electrically heated and gas heated homes.

4. Insulation improvements (Retrofit)

For the retrofit segment, the base cases were drawn from the existing building prototypes, weighted by vintage using data from the US Census. For these measures, the candidate home must have no existing wall insulation, ceiling insulation of R-11 or less, and floor insulation of R-19 or less. All measures utilize blown-in or batt insulation to achieve the increased R-value. The measure assumes that the home will be treated with the two most cost-effective measures (floor, wall or attic insulation), based on the specific characteristics of each home. This measure applies to both electrically heated and gas heated homes.

4. Bring Ducts Indoors. (New)

Locating ductwork within the heated space accomplished the benefits of duct sealing at low cost. Thus, it provides an alternative path to achieve similar savings to the Energy Star package. We include an alternative package with Indoor Ducts, DHW and Lights that would be the uncertified equivalent of Energy Star.

5. Weatherization Envelope Sealing (Retrofit)

Blower-door assisted sealing has been a popular measure within the program. It applies to both electric and gas heated homes.

Lighting Measures

1. Efficient fluorescent bulbs and fixtures (New/Replacement/Retrofit)

Lighting measures are difficult to categorize because new Federal standards will occur. We assume that the current Energy Star Lighting measure requires installation of 18 CFL lamps (20% reduction in LPD) or full replacement (30% reduction). However, the opportunity for this measure is short-lived. By 2015, new Federal standards will require that new lighting product meet an equivalent efficiency standard. We propose that a new set of emerging technology lighting products, based on LED lights, will become available starting in 2015 to provide efficiency beyond code minimum requirements. These proposed measures are described as:

- Add 6 LED lamps (using incandescent base) aft 2015 (65% reduction in LPD using both fixtures and lamps)
- Add 6 LED lamps (using CFL base) after 2015
- Add 16 LED lamps (using incandescent base) after 2015
- Add 16 LED lamps (using CFL base) after 2015
- All LED (from 2020 base) after 2020

Similarly for retrofit lighting measures, CFL replacements may occur up until year 2015 but then we anticipate emerging technology be based on high efficiency LED lights. These are proposed as:

- 50% LED after 2020
- 100% LED after 2020

Domestic Hot Water Measures

1. Tank wrap (Retrofit)

This measure assumes an R-6 tank wrap is installed in water heaters older than 5 years, and applies to both gas and electric units.

2. Hot water pipe wrap (Retrofit)

This measure assumes that the hot and cold water pipes are insulated with an R-2 wrap, and applies to both gas and electric water heat.

3. Water Heater Upgrade (New/Replacement)

Two water heater upgrade measures were examined for the new and replacement markets. The primary difference is in the quality of the unit. For electric water heat, the first measure upgrades the water heater from an EF of .90 to .93, with a 20 year warrantee. The second measure costs less for a unit with a 10 year warrantee. The efficiency improvement for that measure is from an EF of .90 to .94.

For the gas segment, the measures includes a water tank upgrade from EF=.59 to EF=.62. An emerging efficient option is upgrading to EF=.70. Tankless water heaters provide an EF= .85 and an incremental improvement to and efficient model with EF= .89.

4. Heat Pump Water Heater (New/Replacement)

This measure assumes that an electric water heater is replaced with a heat pump water heater (EF from .90 to 2.0).

6. Combined Space and Water Heating

We examined a variety of system that combine gas space and water heating. Although these systems have some appeal in providing radiant slab heating, there is a question about the appropriate baseline. Compared to a hydronic system that would provide similar radiant heating, there is little or no energy saving. One combination option appears to be currently cost-effective – that would be a combination involving a low-cost hydrocoil applied to an air distribution system. We also include a high efficiency combination system based on the Polaris water heater.

7. Solar Water Heater (New/Replacement)

This measure assumes that an electric or gas water heater is replaced with a solar water heater with backup, reducing the water heating load by about 60%. Cost estimates come from the current program.

Appliance Measures

1. Low Power Mode Appliances

These measures were changed to follow the latest set of measures from the Northwest Power Planning and Conservation Council. Specific measures are low-power mode PCs, televisions, monitors and setup boxes. These products have a high turnover rate and are being upgraded continually. Hence, the opportunity for long-term savings is limited.

2. EStar Refrigerator assumes a unit 15% more efficient than Federal standard.

3. Two clothes washers are considered. The MEF 2.0 Washer is only a modest improvement over the minimum standard. The high efficiency washer is MEF 2.2. It should be mentioned that units with even higher MEF ratings occur in the current program.

4. EStar Dishwasher is based on a unit rated at .68 (higher than Energy Star minimum) over a market baseline rated .52 (slightly higher than Federal minimum standard).

5. Home Energy Monitor is a device than offers direct feedback to consumers regarding their energy consumption. With the feedback, customers are expected to better control their energy usage. Estimates are based on the BC Hydro study that estimated a 6.5% reduction in electric load. To be conservative and because we are not in Canada we used 5%.

6. Solar Water Heater (New/Replacement)

This measure assumes that an electric or gas water heater is replaced with a solar water heater with backup, reducing the water heating load by about 60%.

Appendix: Detailed Measure Descriptions

Table 16: Detailed Measure Description, Industrial Electricity

Conservation Measure	First Cost ($/ kWh)	Deploy-ment	Sector	Enduse App	% Savings	Measure Applica-bility	Achiev. Potential	Lifetime	Annual Fuel Impact, therm/ kWh	Annual O&M Cost	Annual Non-Energy Benefit	Level Cost ($/kWh)	BCR	Source
Air Compressor Demand Reduction	$0.060	Retrofit	All Except Cold Storage	Air Comp	20%	26%	100%	10		$0.027		$0.039	2.42	SEG, Systems Optimization R4. xls
Air Compressor Equipment1	$0.124	Retrofit	Sugar, Wood, Paper, Metal, Equipment, Refinery	Air Comp	35%		100%	10		$0.027		$0.051	1.95	Ibid.
Air Compressor Equipment2	$0.048	Replace	Sugar, Wood, Paper, Metal, Equipment, Refinery	Air Comp	35%	17%	100%	10		$0.027		$0.036	2.53	Ibid.
Air Compressor Optimization	$0.150	Retrofit	Sugar, Wood, Paper, Metal, Equipment, Refinery	Air Comp	50%	36%	100%	10		$0.027	$0.059	($0.003)	3.07	Ibid.
HighBay Lighting 1 Shift	$0.181	Replace	Food, Wood, Metal Fab, Other	Lights	51%	varies by sector	100%	10				$0.034	3.79	Ecotope RA for ETO
HighBay Lighting 2 Shift	$0.106	Replace	Food, Wood, Metal Fab, Other	Lights	51%		100%	10				$0.020	6.37	Ibid.
HighBay Lighting 3 Shift	$0.059	Replace	All	Lights	51%		100%	10				$0.011	10.94	Ibid.
Efficient Lighting 1 Shift	$0.058	Replace	Food, Wood, Metal Fab, Other	Lights	70%	varies by sector	100%	10				$0.011	11.86	Ibid.
Efficient Lighting 2 Shift	$0.034	Replace	Food, Wood, Metal Fab, Other	Lights	70%		100%	10				$0.006	19.94	Ibid.
Efficient Lighting 3 Shift	$0.019	Replace	All	Lights	70%		100%	10				$0.004	34.23	Ibid.

Conservation Measure	First Cost ($/ kWh)	Deploy-ment	Sector	Enduse App	% Savings	Measure Applica-bility	Achiev. Potential	Lifetime	Annual Fuel Impact, therm/ kWh	Annual O&M Cost	Annual Non-Energy Benefit	Level Cost ($/kWh)	BCR	Source
Lighting Controls	$0.147	Replace	All	Lights	28%	15%	100%	10				$0.028	4.41	Ibid.
Motors: Rewind 20-50 HP	$0.270	Replace	Food, Wood, Paper, Metal, Metal Fab, Refinery	All Motors	0.9%	varies by sector	100%	10				$0.051	2.40	Dennis Brown, "Quality Motor Rewinding", submittal to RTF, 2008.
Motors: Rewind 51-100 HP	$0.232	Replace	Food, Wood, Paper, Metal, Metal Fab, Refinery	All Motors	0.50%		100%	10				$0.044	2.79	Ibid.
Motors: Rewind 101-200 HP	$0.172	Replace	Food, Wood, Paper, Metal, Metal Fab, Refinery	All Motors	0.50%		100%	10				$0.033	3.76	Ibid.
Motors: Rewind 201-500 HP	$0.112	Replace	Food, Wood, Paper, Metal, Metal Fab, Refinery	All Motors	0.50%		100%	10				$0.021	5.76	Ibid.
Motors: Rewind 501-5000 HP	$0.082	Replace	Food, Wood, Paper, Metal, Metal Fab, Refinery	All Motors	0.50%		100%	10				$0.016	7.86	Ibid.
Efficient Centrifugal Fan	$0.136	Retrofit	Pulp, Paper, Wood	Material Handling	20%	11%	100%	10				$0.026	4.76	Marbek Resource Consultants, 2008
Fan Energy Management		Retrofit	All Except Cold Storage	Fan	10%	27%	100%	10		$0.033		$0.033	2.63	SEG, Systems Optimization R4. xls
Fan Equipment Upgrade	$0.064	Retrofit	Paper, Wood	Fan	35%	23%	100%	10		$0.033		$0.045	2.07	Ibid.
Fan System Optimization	$0.090	Retrofit	Paper, Wood	Fan	50%	30%	100%	10		$0.039	$0.042	$0.014	2.51	Ibid.
Pump Energy Management		Retrofit	All Except Cold Storage	Pump	8%	31%	100%	10		$0.033		$0.033	2.61	Ibid.

Conservation Measure	First Cost ($/ kWh)	Deploy-ment	Sector	Enduse App	% Savings	Measure Applica-bility	Achiev. Potential	Lifetime	Annual Fuel Impact, therm/ kWh	Annual O&M Cost	Annual Non-Energy Benefit	Level Cost ($/kWh)	BCR	Source
Pump Equipment Upgrade	$0.094	Retrofit	Paper, Wood	Pump	20%	34%	100%	10		$0.033		$0.050	1.89	Ibid.
Pump System Optimization	$0.190	Retrofit	Paper, Wood	Pump	50%	15%	100%	12		$0.046	$0.111	($0.034)	2.96	Ibid.
Transformers-Retrofit	$0.524	Retrofit	All	All Electric	1.6%	17%	100%	10				$0.099	1.23	NWPPC, Transformers\PC-Transformer-Liquid--D1.xls
Transformers-New	$0.569	Replace	All	All Electric	0.4%	37%	100%	32				$0.053	2.73	Ibid.
Synchronous Belts	$0.160	Retrofit	All Except Cold Storage, Electronics	All Motors	2.0%	21%	100%	10				$0.030	4.04	Marbek Resource Consultants, 2008
Elec Chip Fab: Eliminate Exhaust	$0.140	Retrofit	Chip Fab portion of Electronic Fab	HVAC	5%	80%	100%	10				$0.027	4.63	Phil Naughton, 2005, NEEA Chiller
Elec Chip Fab: Exhaust Injector	$0.338	Retrofit	Chip Fab portion of Electronic Fab	Heat	100%	35%	100%	10			$0.151	($0.087)	5.34	Paragon
Elec Chip Fab: Solidstate Chiller	$0.381	Retrofit	Chip Fab portion of Electronic Fab	HVAC	90%	20%	100%	10			$0.138	($0.066)	4.47	Solid State
Elec Chip Fab: Reduce Gas Pressure		Retrofit	Chip Fab portion of Electronic Fab	Refrig, Air Comp	10%	50%	100%	10			$0.016	($0.016)	100.00	Phil Naughton, 2005
Clean Room: Change Filter Strategy	$0.005	Retrofit	Electronic Fab, Other Clean Rooms	HVAC	40%	10%	100%	1				$0.007	16.20	ACEEE,2001, NEEA Chiller
Clean Room: Clean Room HVAC	$0.121	Retrofit	Electronic Fab, Other Clean Rooms	HVAC	9%	30%	100%	20				$0.014	9.66	Ibid.
Clean Room: Chiller Optimize	$0.061	Retrofit	Electronic Fab, Other Clean Rooms	HVAC	15%	28%	100%	10				$0.012	10.61	Ibid.
Food: Cooling and Storage	$0.225	Retrofit	Food	Refer	15%	100%	100%	10				$0.043	2.91	*Cascade Engineering, NW*

Conservation Measure	First Cost ($/ kWh)	Deploy-ment	Sector	Enduse App	% Savings	Measure Applica-bility	Achiev. Potential	Lifetime	Annual Fuel Impact, therm/ kWh	Annual O&M Cost	Annual Non-Energy Benefit	Level Cost ($/kWh)	BCR	Source
														Refrigeration Savings Potential.xls, 2008.
Food: Refrig Storage Tuneup	$0.052	Retrofit	Food	Refer	8%	100%	100%	3				$0.028	4.39	Ibid.
Metal: New Arc Furnace	$0.069	Retrofit	Metal	Process Heat	45%	10%	100%	10			$2.000	($1.987)	230.31	ACEEE, 2004 Resource Assessment for Energy Trust
Kraft: Effluent Treatment System	$0.056	Retrofit	Kraft Pulp	Pump	15%	10%	100%	10				$0.011	11.65	Marbek Resource Consultants, 2008
Kraft: Efficient Agitator	$0.063	Replace	Kraft Pulp	Process	50%	14%	100%	10				$0.012	10.32	Ibid.
Paper: Efficient Pulp Screen	$0.136	Retrofit	Paper	Process	15%	14%	100%	10				$0.026	4.78	Ibid.
Paper: Premium Fan	$0.136	Retrofit	Paper	Fan	20%	25%	100%	10				$0.026	4.75	Ibid.
Paper: Material Handling	$0.482	Replace	Paper	Material Handling	13%	25%	100%	10				$0.091	1.34	Ibid.
Paper: Large Material Handling	$0.576	Replace	Mech Pulp, Kraft, Paper	Material Handling	10%	25%	100%	10				$0.109	1.12	Ibid.
Paper: Premium Control Large Material	$0.330	Replace	Mech Pulp, Kraft, Paper	Material Handling	19%	25%	100%	10				$0.062	1.96	Ibid.
Material Handling1	$0.560	Retrofit	Other, Wood	Material Handling	5%		100%	10				$0.106	1.17	Ibid.
Material Handling2	$0.350	Replace	Other, Wood	Material Handling	5%	53%	100%	10				$0.066	1.87	Ibid.
Material Handling VFD1	$0.449	Retrofit	Other, Wood	Material Handling	19%		100%	10				$0.085	1.45	Ibid.
Material Handling VFD2	$0.225	Replace	Other, Wood	Material Handling	19%	53%	100%	10				$0.043	2.91	Ibid.
Wood: Replace Pneumatic Conveyor	$0.010	Replace	Wood	Material Handling	29%	50%	100%	10			$0.066	($0.064)	115.51	NEEA, Just Enough Air
Panel: Hydraulic Press	$0.138	Replace	Panel	Process	28%	28%	100%	10				$0.026	4.72	ETO Program Files
Plant Energy Management	$0.016	Retrofit	All	All Motors	12%	27%	100%	10		$0.031		$0.033	2.55	SEG, Systems Optimization R4. xls
Energy Project Management	$0.092	Retrofit	Wood, Paper, Metal	All Motors	29%	27%	100%	11		$0.031		$0.048	2.01	SEG, Systems Optimization R4. xls

Conservation Measure	First Cost ($/ kWh)	Deploy-ment	Sector	Enduse App	% Savings	Measure Applica-bility	Achiev. Potential	Lifetime	Annual Fuel Impact, therm/ kWh	Annual O&M Cost	Annual Non-Energy Benefit	Level Cost ($/kWh)	BCR	Source
Integrated Plant Energy Management	$0.148	Retrofit	Wood, Paper, Metal	All Motors	50%	22%	100%	11		$0.039	$0.082	($0.017)	2.94	SEG, Systems Optimization R4. xls
Irrigation: Ditch > Pipe	$0.059	Retrofit	Agriculture	Pump	60%	1%	100%	10		($1.010)	($1.002)	($1.002)	1.09	ETO Program Files
Irrigation: Nozzles	$0.177	Retrofit	Agriculture	Pump	0%	28%	100%	3			$0.065	$0.065	2.34	Ibid.
Irrigation: Pump Systems Repair	$1.354	Retrofit	Agriculture	Pump	0%	28%	100%	7		($0.010)	$0.226	$0.226	1.36	Ibid.
Irrigation: Pump Systems Adjust	$0.172	Retrofit	Agriculture	Pump	2%	28%	100%	3		($0.048)	$0.016	$0.016	2.38	Ibid.
Irrigation: Water Management	$0.144	Retrofit	Agriculture	Pump	1%	28%	100%	5		$0.067	$0.100	$0.100	1.86	Ibid.
Rural Area Lights	$1.231	Replace	Lighting	Lighting	55%	1%	100%	23		($0.061)		$0.032	1.67	Ibid.
Replace Traffic Light: Red Ball 8-inch	$0.102	Replace	Lighting	Lighting	91%	0%	100%	6		($0.033)		($0.013)	5.76	NWPPC 6th Plan, PC-StreetRoadway-6P-D2.xls
Replace Traffic Light: Red Ball 12-inch	$0.076	Replace	Lighting	Lighting	93%	0%	100%	6		($0.018)		($0.003)	6.79	Ibid.
Replace Traffic Light: Yellow Ball 8-inch	$4.164	Replace	Lighting	Lighting	91%	0%	100%	6		($0.604)		$0.222	0.83	Ibid.
Replace Traffic Light: Yellow Ball 12-inch	$2.786	Replace	Lighting	Lighting	93%	0%	100%	6		($0.336)		$0.216	0.76	Ibid.
Replace Traffic Light: Green Ball 8-inch	$0.179	Replace	Lighting	Lighting	91%	0%	100%	6		($0.043)		($0.008)	3.59	Ibid.
Replace Traffic Light: Green Ball 12-inch	$0.133	Replace	Lighting	Lighting	93%	0%	100%	6		($0.024)		$0.002	4.10	Ibid.
Replace Traffic Light: Red Arrow	$0.271	Replace	Lighting	Lighting	95%	0%	100%	6		($0.098)		($0.044)	3.39	Ibid.
Replace Traffic Light: Green Arrow	$0.275	Replace	Lighting	Lighting	93%	0%	100%	6		($0.100)		($0.045)	3.37	Ibid.
Replace Traffic Light: Yellow Bi-Modal Arrow	$0.494	Replace	Lighting	Lighting	91%	0%	100%	6		($0.102)		($0.004)	1.90	Ibid.
Replace Traffic Light: Green Bi-Modal Arrow	$0.344	Replace	Lighting	Lighting	93%	0%	100%	6		($0.100)		($0.032)	2.69	Ibid.
Replace Traffic Light: White Walking Person	$0.205	Replace	Lighting	Lighting	94%	0%	100%	6		($0.030)		$0.011	2.80	Ibid.
Replace Traffic Light: Orange Hand	$0.207	Replace	Lighting	Lighting	93%	0%	100%	6		($0.030)		$0.011	2.78	Ibid.

Conservation Measure	First Cost ($/ kWh)	Deploy-ment	Sector	Enduse App	% Savings	Measure Applica-bility	Achiev. Potential	Lifetime	Annual Fuel Impact, therm/ kWh	Annual O&M Cost	Annual Non-Energy Benefit	Level Cost ($/kWh)	BCR	Source
Replace Traffic Light: Orange Countdown	$0.553	Replace	Lighting	Lighting	93%	0%	100%	6		($0.080)		$0.029	1.50	Ibid.
Replace Streetlight: 100WHPS>LED78W	$1.141	Replace	Lighting	Lighting	50%	22%	100%	17		($0.052)		$0.050	1.35	Ibid.
Replace Streetlight: 100WHPS>LED60W	$1.037	Replace	Lighting	Lighting	64%	2%	100%	23		($0.077)		$0.001	2.19	Ibid.
Replace Streetlight: 150HPS>LED117W	$1.231	Replace	Lighting	Lighting	55%	5%	100%	23		($0.061)		$0.032	1.67	Ibid.
Replace Streetlight: 150HPS>LED111W	$0.978	Replace	Lighting	Lighting	50%	3%	100%	14		($0.062)		$0.038	1.49	Ibid.
Retro Streetlight: 100WHPS>LED78W	$1.898	Retrofit	Lighting	Lighting	50%		100%	17		($0.052)		$0.118	0.81	Ibid.
Retro Streetlight: 100WHPS>LED60W	$2.110	Retrofit	Lighting	Lighting	64%		100%	23		($0.077)		$0.082	1.07	Ibid.
Retro Streetlight: 150HPS>LED117W	$2.115	Retrofit	Lighting	Lighting	55%		100%	23		($0.061)		$0.098	0.97	Ibid.
Retro Streetlight: 150HPS>LED111W	$1.773	Retrofit	Lighting	Lighting	50%		100%	14		($0.062)		$0.120	0.82	Ibid.

Industrial Sources and References:

ACEEE, 2001, Martin, N., Worrell, E., Ruth, M., Price, L., Elliott, R.N., Shipley, A.M., and J. Thorne. 2001. Emerging Energy Efficient Technologies. Washington, D.C.

ACEEE, 2004 Resource Assessment for Energy Trust

Cascade Engineering, NW Refrigeration Savings Potential.xls, 2008.

DEER, 2008, CPUC

Dennis Brown, "Quality Motor Rewinding", submittal to RTF, 2008. www.greenmotors.org

Distributed Generation in Oregon: Overview, Regulatory Barriers and Recommendations, Lisa Schwartz, Public Utility Commission Staff, February 2005

Ecotope, resource assessment for Energy Trust of Oregon, 2008.

ETO Program Files

Marbek Resource Consultants, BC Hydro 2007 Conservation Potential Review, 2008.

NEEA Chiller Efficiency Study, NEEA, 12/15/3

NEEA, Just Enough Air

Paragon Exhaust Injector system, 2005, vendor information for electronic clean rooms, supplied by Chris Robertson.

Phil Naughton, Project Manger, International SEMATECH Manufacturing Initiative, Austin TX, "Fab Energy Trends and Key Areas for Equipment Improvement", 2005.
SEG, Systems Optimization R4. xls
Solid State Cooling Systems, 2005, vendor information on thermoelectric chiller for electronic clean rooms.
Supersymmetry USA, Proprietary report on specific site,1998, "Report on Suggested Energy Efficiency". USDOE, United States Industrial Electric Motor Systems Market Opportunities Assessment, Xenergy, 1998.
http://www1.eere.energy.gov/industry/bestpractices/pdfs/replace_vbelts_motor_systemts5.pdf

Table 17: Detailed Measure Description, Industrial Natural Gas

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
Chiller heat recovery (Electronics)	Utilize heat recovery where option exists	Retrofit	$12.129	SHBoiler	30%	10%	25%	10		$1.581	0.69	Supersymmetry
Combo Cond Boiler (repl)	Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90% efficiency for savings calculations).	Replacement	$7.525	SHBoiler, Process Boiler	16%	35%	85%	20		$0.611	1.91	WNG 1995
Combo Cond Boiler (retro)	Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90% efficiency for savings calculations).	Retrofit	$20.234	SHBoiler, Process Boiler	22%	0%	85%	20		$1.643	0.71	WNG 1996
Combo Hieff Boiler (repl)	Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.	Replacement	$4.091	SHBoiler, Process Boiler	8%	35%	85%	20		$0.332	3.51	WNG 1997

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
Combo Hieff Boiler (retro)	Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.	Retrofit	$21.299	SHBoiler, Process Boiler	15%	0%	85%	20		$1.729	0.67	WNG 1998
Cond Furnace (repl)	Condensing / pulse package or residential-type furnace with a minimum AFUE of 92%.	Replacement	$27.389	SHFurn	13%	40%	85%	15		$2.664	0.42	WNG 1995
Cond Unit Heater from Nat draft (replace)	Install condensing power draft units (90% seas. Eff) in place of natural draft (64% seas. Eff)	Replacement	$11.820	SHUnit		40%	85%	18		$1.022	1.13	WNG 1995
Cond Unit Heater from power draft (replace)	Install condensing power draft units (90% seas. Eff) in place of power draft (80% seas. Eff)	Replacement	$23.914	SHUnit	11%	40%	85%	18		$2.068	0.56	WNG 1995
Heat Recovery to HW	Utilize heat recovery where option exists	Retrofit	$2.878	Specialty HW	64%	60%	85%	15	($0.130)	$0.150	11.28	Hesse Dairy, 2001
DHW Cond Boiler (repl)	Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90%	Replacement	$1.863	Process Boiler	16%	6%	85%	20		$0.151	7.70	WNG 1995

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
	efficiency for savings calculations).											
DHW Cond Boiler (retro)	Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 90% efficiency for savings calculations).	Retrofit	$5.841	Process Boiler	22%	0%	85%	20		$0.474	2.46	WNG 1995
DHW Condensing Tank (repl)	Costs and savings are incremental over a Code-rated tank (combustion efficiency of 80%) for a condensing tank with a minimum combustion efficiency of 94% and an R-16 tank wrap.	Replacement	$0.255	Process Boiler	13%	6%	85%	15		$0.025	45.69	WNG 1995
DHW Condensing Tank (retro)	Replace older tanks with condensing tanks with combustion efficiency of 94% and tank insulation with an R-value of 16 or greater.	Retrofit	$1.146	Process Boiler	29%	0%	85%	15		$0.111	10.15	WNG 1995
DHW Hieff	Replace existing boiler with unit	Replacement	$0.583	Process	8%	7%	85%	20		$0.047	24.60	WNG 1995

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
Boiler (repl)	meeting OR Code requirements of 85% combustion efficiency.			Boiler								
DHW Hieff Boiler (retro)	Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.	Retrofit	$4.561	Process Boiler	15%	0%	85%	20		$0.370	3.14	WNG 1995
DHW Pipe Ins	Add 1" insulation to pipes used for steam or hydronic distribution; particularly effective when pipes run through unheated spaces.	Retrofit	$0.196	HW	2%	45%	85%	15		$0.019	59.46	WNG 1995
DHW Std. Boiler (retro)	Replace existing boiler with unit meeting OR Code requirements of 80% combustion efficiency.	Retrofit	$2.740	HW	7%	2%	85%	20		$0.222	5.23	WNG 1995
DHW Wrap	Insulate the surface of the storage water heater or an unfired storage tank to R-5 to reduce standby losses.	Retrofit	$0.003	HW	2%	20%	85%	7		$0.000	100.00	WNG 1995

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
Ducts	Duct retrofit of both insulation and air sealing	Retrofit	$30.503	SHFurn	10%	80%	85%	15		$2.967	0.38	ETO 2003
Hi Eff Unit Heater (replace)	Install power draft units (80% seas. Eff) in place of natural draft (64% seas. Eff)	Replacement	$3.801	SHUnit	20%	60%	85%	18		$0.329	3.50	WNG 1995
Hi Eff Unit Heater (retro)	Install power draft units (80% seas. Eff) in place of natural draft (64% seas. Eff)	Retrofit	$23.143	SHUnit	20%	0%	85%	18		$2.002	0.58	WNG 1995
HiEff Clothes Washer (retro)	Install high performance commercial clothes washers - residential sized units	Retrofit	$7.572	Specialty HW	15%	8%	85%	15	($11.710)	($10.974)	6.29	ETO2010, DOE Clotheswasher
HiEff Clothes Washer (repl)	Install high performance commercial clothes washers - residential sized units	Replacement	$7.572	Specialty HW	15%	8%	85%	15	($11.710)	($10.974)	6.29	ETO2010, DOE Clotheswasher
Hot Water Temperature Reset	Controller automatically resets the delivery temperature in a hot water radiant system based on outside air temperature. The reset reduces the on-time of the heating equipment and the occurrence	Retrofit	$1.428	SHBoiler	9%	80%	85%	10		$0.186	5.82	WNG 1995

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
	of simultaneous heating and cooling through instantaneous adjustments.											
HW Boiler Tune	Tune up in accordance with Minneapolis Energy Office protocol. Can include derating the burner, adjusting the secondary air, adding flue restrictors, cleaning the fire-side of the heat exchanger, cleaning the water side, or installing turbulators. Other modifications may include uprating the burner to reduce oxygen or derating the burner to reduce stack temperature. Note: In gas systems, excess air and stack temperatures are often within reasonable ranges, so the technical potential for this measure is limited. Combining this measure with	Retrofit	$0.742	SHBoiler, Process Boiler	5%	80%	85%	5		$0.172	5.90	WNG 1995

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
	the vent damper and power burner measures increases both applicability and cost effectiveness, and was assumed for this analysis.											
Power burner	Replace standard burner with a power burner to optimize combustion and reduce standby losses in the stack. Note: Costs and savings assume that this measure will be performed in conjunction with a boiler tune up when appropriate.	Retrofit	$9.732	SHBoiler, Process Boiler	7%	80%	85%	12		$1.107	1.00	WNG 1995
Process Boiler Controls		Retrofit	$0.015	Process Boiler	3%	35%	85%	15	$0.000	$0.001	100.00	CADMAC 2007
Process Boiler Insulation		Retrofit	$0.074	Process Boiler	8%	60%	85%	15	$0.001	$0.008	0.81	CADMAC 2007
Process Boiler Load Control		Retrofit	$0.017	Process Boiler	4%	60%	85%	15	$0.000	$0.002	100.00	CADMAC 2007
Process Boiler Maintenance		Retrofit	$0.000	Process Boiler	10%	12%	85%	15	$0.001	$0.001	0.82	CADMAC 2007
Process Boiler Steam Trap Maintenance			Retrofit	$0.000	Process Boiler	13%	30%	85%	15	$0.035	$0.035	0.82
Process Boiler Water Treatment		Replacement	$0.008	Process Boiler	1%	60%	85%	15	$0.000	$0.001	100.00	CADMAC 2007

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
Roof Insulation - Blanket R0-19	Roof Insulation - Blanket R0-19. Application: Buildings with open truss unfinished interior	Retrofit	$5.067	SH	60%	3%	85%	30		$0.335	3.58	ETO 2003
Roof Insulation - Blanket R0-30	Roof Insulation - Blanket R0-30. Application: Buildings with open truss unfinished interior	Retrofit	$5.433	SH	63%	3%	85%	30		$0.359	3.34	ETO 2003
Roof Insulation - Blanket R11-30	Roof Insulation - Blanket R11-30. Application: Buildings with open truss unfinished interior	Retrofit	$37.092	SH	8%	8%	85%	30		$2.452	0.49	ETO 2003
Roof Insulation - Blanket R11-41	Roof Insulation - Blanket R11-41. Application: Buildings with open truss unfinished interior	Retrofit	$34.774	SH	10%	8%	85%	30		$2.298	0.52	ETO 2003
Roof Insulation - Rigid R11-22 repl	Roof Insulation - Rigid R11-22 2" rigid added to an existing foam roof insulation at re-roof, includes some surface prep. Application: Old buildings with flat roofs,	Replacement	$13.142	SH	29%	6%	85%	30		$0.869	1.38	ETO 2003

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
	no attics, and some insulation											
Roof Insulation - Rigid R11-33 repl	Roof Insulation - Rigid R11-33: add 4' of insulation at reroof. Application: Old buildings with flat roofs, no attics, and some insulation	Replacement	$39.970	SH	14%	6%	85%	30		$2.642	0.45	ETO 2003
Solar Hot Water	Install solar water heaters on large use facility such as multifamily or lodging	Retrofit	$55.447	Specialty HW	16%	7%	85%	20		$4.502	0.26	ETO2003
SPC Cond Boiler Replace	Install condensing boiler. Assumed seasonal combustion efficiency of 88% over base of 75%	Replacement	$13.113	SHBoiler, Process Boiler	15%	6%	85%	20		$1.065	1.09	WNG 1995
SPC Cond Boiler Retro	Install condensing boiler. Assumed seasonal combustion efficiency of 88% over base of 69.5%	Retrofit	$27.825	SHBoiler, Process Boiler	21%	0%	85%	20		$2.259	0.52	WNG 1995
SPC Hieff Boiler Replace	Install near condensing boiler. Assumed seasonal combustion efficiency of	Replacement	$8.405	SHBoiler, Process Boiler	9%	6%	85%	20		$0.682	1.71	WNG 1995

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
	82% over base of 75%											
SPC Hieff Boiler Retro	Install near condensing boiler. Assumed seasonal combustion efficiency of 82% over base of 69.5%	Retrofit	$29.399	SHBoiler, Process Boiler	15%	0%	85%	20		$2.387	0.49	WNG 1995
Steam Balance (Wood Prod)	Single-pipe steam systems are notorious for uneven heating, which wastes energy because the thermostat must be set to heat the coldest spaces and overheating other spaces. Steam balances corrects these problems by: 1) Adding air venting on the main line or at the radiators; 2) Adding boiler cycle controls; 3) Adding or subtracting radiators. Energy savings accrue from lowering the overall building temperature.	Retrofit	$3.694	Process Boiler	10%	8%	85%	15		$0.359	3.15	WNG 1995
Steam Trap Maint (Wood Prod)	Set up a in-house steam trap	Retrofit	$4.772	Process Boiler	14%	7%	85%	10		$0.622	1.74	FEMP - Steam Trap Alert

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
	maintenance program with equipment, training, and trap replacement. An alternative procedure is to just pay for an outside contractor to conduct a steam survey.											
Upgrade Process Heat	Replace furnace, reheaters	Retrofit	$9.934	Melt, Heat Oven	17%	7%	85%	15		$0.966	1.17	CADMAC
Vent Damper	Install vent damper downstream of the draft relief to prevent airflow up the stack, while allowing warm air from the boiler to spill into the conditioned space as heat or into the boiler room to reduce jacket losses. This measure is most cost-effective when combined with the boiler tune up and power burner measures.	Retrofit	$4.069	SHBoiler, Process Boiler	5%	80%	85%	12		$0.463	2.39	WNG 1995
Wall Insulation - Blown R11	Wall Insulation - Blown R11. Application: Old buildings	Retrofit	$3.671	SH	64%	2%	85%	30		$0.243	4.95	ETO 2003

Conservation Measure	Description	Construction	First Cost ($/th)	Enduse App	% Savings	Measure Accept	Achiev. Potential	Lifetime	Annual O&M Cost	Levelized Cost ($/th)	BCR	Source
Wall Insulation - Spray On for Metal Buildings	Wall Insulation - Spray On for Metal Buildings (Cellulose) Unfinished. Application: Old buildings	Retrofit	$4.087	SH	35%	4%	85%	30		$0.270	4.44	ETO 2003
Waste Water Heat Exchanger	Install heat exchanger where copious warm water is discarded	Retrofit	$8.268	HW	16%	10%	85%	20		$0.671	1.73	ETO2003
Ozone Treated Laundry	Use of O3 allows less hot water	Retrofit	$2.460	Laundry HW, dryer	49%	11%	85%	15	($0.068)	$0.171	13.17	ETO2010

Note: Costs in this table do not include the cost reduction due to the BETC tax credit although those credits are included in the BCR.

Table 18: Detailed Measure Table, Commercial Sector, Electricity Savings, 2030 Technical Potential

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
Estar Commercial Clothes Washer	Install high performance commercial clothes washers - coin op	New	Water Heat	10	198,575	-1,848,900	870	0.10	0.10	-$0.248	11.96
Estar Commercial Clothes Washer	Install high performance commercial clothes washers - coin op	Replace	Water Heat	10	6,356,638	-59,104,277	27,801	3.27	3.27	-$0.248	11.94
EStar Fryer	Install EStar in place of conventional	New	Cooking	8	21,621	0	5,652	0.66	0.66	$0.001	126.07
Ozone Laundry Treatment	Ozone treatment allows use of cold water	Retrofit	Water Heat	10	316,941	-30,138	21,294	2.51	2.51	$0.002	40.67
EStar Fryer	Replace with EStar in place of conventional	Replace	Cooking	8	411,313	0	33,365	3.93	3.93	$0.002	39.12
Estar Convection Oven	Replace with EStar in place of conventional	Replace	Cooking	12	587,055	0	17,289	2.03	2.03	$0.004	21.31
Waste Water Heat Exchanger	Install HX on waste water	Retrofit	Water Heat	15	90,338	0	1,995	0.23	0.23	$0.004	19.85
Floating Head Control	Large Grocery - Add floating head control. This is considered measure for the independent grocery chains that are less likely to implement this feature.	New	Refrigeration	18	473,891	0	8,945	1.22	1.61	$0.005	20.17
Floating Head Control	Large Grocery - Add floating head control. This is considered measure for the independent grocery chains that are less likely to implement this feature.	Replace	Refrigeration	18	1,490,386	0	28,131	3.85	5.05	$0.005	20.17

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
DHW Shower Heads	Install low flow shower heads (2.0 gallons per minute) to replace 3.4 GPM shower heads.	Retrofit	Water Heat	8	78,408	0	2,278	0.27	0.27	$0.005	14.01
Chiller System Optimization	The "chiller system optimization" measure includes improvements in efficiency and reduction in parasitic losses in pumps, fans, and other (non-chiller) electric motor-driven systems associated with chillers.	Replace	Cooling	15	787,078	0	14,206	3.52	3.07	$0.005	16.39
Roof Insulation - Attic R0-30	Roof Insulation - Attic R0-30. Application: Buildings with uninsulated attics	Retrofit	Heating	45	190,733	0	2,032	0.70	0.06	$0.005	19.76
Heat Pump Water Heat	0	Retrofit	Water Heat	15	3,374,420	201,618	50,249	5.91	5.91	$0.007	12.63
Efficient Refrigeration systems	Large Grocery - Efficient Comp, Sub-cooling, controls	New	Refrigeration	18	4,151,281	0	48,367	6.62	8.69	$0.007	12.45
Efficient Refrigeration systems	Large Grocery - Efficient Comp, Sub-cooling, controls	Replace	Refrigeration	18	13,055,779	0	152,114	20.83	27.33	$0.007	12.45
Transformers	0	Retrofit	Total	20	3,782,545	0	37,475	4.41	4.41	$0.008	11.49
Wall Insulation - Blown R11	Wall Insulation - Blown R11. Application: Old buildings	Retrofit	Heating	45	1,750,492	0	11,569	3.97	0.36	$0.009	12.26
Roof Insulation - Rigid R0-11	Roof Insulation - Rigid R0-11-not including re-roofing costs but including deck preparation. Application: Old	Replace	Heating	45	779,541	0	4,816	1.65	0.15	$0.009	11.46

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	buildings with flat roofs and no attics										
DHW Wrap	Insulate the surface of the storage water heater or an unfired storage tank to R-5 to reduce standby losses.	Retrofit	Water Heat	7	36,898	0	684	0.08	0.08	$0.009	7.85
Wall Insulation - Spray On for Metal Buildings	Wall Insulation - Spray On for Metal Buildings (Cellulose) Unfinished. Application: Old buildings	Retrofit	Heating	45	241,833	0	1,444	0.50	0.04	$0.010	11.07
Computerized Water Heater Control	Install intelligent controls on the hot water circulation loops.	Retrofit	Water Heat	15	534,130	0	5,048	0.59	0.59	$0.010	8.50
Estar Convection Oven	Install EStar in place of conventional	New	Cooking	12	616,319	0	5,918	0.70	0.70	$0.012	6.95
Roof Insulation - Blanket R0-19	Roof Insulation - Blanket R0-19. Application: Buildings with open truss unfinished interior	Retrofit	Heating	45	413,260	0	2,008	0.69	0.06	$0.012	9.01
DCV	Applicable to single zone packaged systems with large make -up air fractions either because of intermittent occupancy or because of code requirements. In most cases the outdoor air is reset to 5% or less with CO2 build-up modulating ventilation.	Retrofit	Heating	15	3,821,646	0	21,792	5.40	4.71	$0.012	5.11
Roof Insulation -	Roof Insulation - Blanket R0-30.	Retrofit	Heating	45	464,918	0	2,107	0.72	0.07	$0.013	8.40

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
Blanket R0-30	Application: Buildings with open truss unfinished interior										
High Bay HID Medium to T8	458W> 224W, 1 lamp HID to 6 Lamp HPT8	New	Lighting	21	29,439	1,383,627	25,633	3.51	4.61	$0.014	7.11
Roof Insulation - Rigid R0-22	Roof Insulation - Rigid R0-22-- not including re-roofing costs but including deck preparation and ~4" rigid.. Application: Old buildings with flat roofs and no attics	Replace	Heating	45	1,346,480	0	5,498	1.89	0.17	$0.014	7.57
Hot Food Holding Cabinet	Install EStar in place of conventional	New	Cooking	8	41,080	0	352	0.04	0.04	$0.018	4.13
Roof Insulation - Rigid R11-22	Roof Insulation - Rigid R11-22 2" rigid added to an existing foam roof insulation at re-roof, includes some surface prep. Application: Old buildings with flat roofs, no attics, and some insulation	Replace	Heating	45	2,853,681	0	8,911	3.06	0.28	$0.019	5.79
T12 to HP T8	162W> 49W	Retrofit	Lighting	21	22,218,999	10,472,042	240,700	32.96	43.25	$0.019	5.25
Roof Insulation - Attic 11-30	Roof Insulation - Attic 11-30. Application: Buildings with partially insulated attics	Retrofit	Heating	45	1,190,377	0	3,457	1.19	0.11	$0.020	5.38
Windows - Add Low E to Vinyl Tint	Windows - Add Low E to Vinyl Tint. Application: Old buildings	Replace	Heating	20	1,119,562	0	4,446	1.53	0.14	$0.021	4.76
Hot Food Holding	Install EStar in place	Replace	Cooking	8	269,315	0	2,043	0.24	0.24	$0.021	3.66

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
Cabinet	of conventional										
Heat Reclaim	Large Grocery - Heat recovery to space heating. Assumes floating head control exists and must be changed to allow HR.	Replace	Refrigeration	18	4,183,121	0	10,630	1.46	1.91	$0.021	4.51
Economizer Diagnostic, Damper Repair & Reset	Applicable to single zone packaged systems. The outdoor make-up air damper and control are often set incorrectly or not functioning. This measure is the general checking . . . Savings derive from reduced cooling due to restored economizer function and reduced heating from reduced minimum outdoor air.	Retrofit	Cooling	10	18,978,703	0	82,456	20.45	17.81	$0.021	3.74
Waste Water Heat Exchanger	Install HX on waste water	New	Water Heat	15	1,151,237	0	5,139	0.60	0.60	$0.022	4.01
High Bay HID Medium to T8	458W> 224W, 1 lamp HID to 6 Lamp HPT8	Retrofit	Lighting	21	11,381,022	3,375,619	90,112	12.34	16.19	$0.023	4.47
Heat Reclaim	Large Grocery - Heat recovery to space heating. Assumes floating head control exists and must be changed to allow HR.	New	Refrigeration	18	920,622	0	1,888	0.26	0.34	$0.024	3.84
ECM Fan Powered Boxes	Install ECM motors in VAV fan powered terminals with PSC motors	New	Ventilation	20	2,516,868	0	11,964	2.97	2.58	$0.025	3.86
Exit signs	20W> 1 W, switch to LED sign (not	Retrofit	Lighting	21	4,275,770	0	21,255	2.50	2.50	$0.025	3.85

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	photoluminescent b/c of cost)										
Windows - Add Low E and Argon to Vinyl Tint	Windows - Add Low E and Argon to Vinyl Tint. Application: Old buildings	Replace	Heating	20	1,750,895	0	5,393	1.85	0.17	$0.026	3.70
T8 to HP T8	58W> 49W	Retrofit	Lighting	21	22,218,999	6,076,153	116,922	16.01	21.01	$0.027	3.69
T8 to HP T8	58W> 49W	Replace	Lighting	21	34,288,604	40,902,481	311,270	42.62	55.93	$0.028	3.65
T8 to HP T8	58W> 49W	New	Lighting	21	16,661,466	19,652,241	145,369	19.91	26.12	$0.028	3.58
High Efficiency Chiller	Replace chillers or installing new chillers to purchase units with efficiencies averaging 0.51kW/ton air conditioning (AC), rather than the standard new unit, which has an efficiency of 0.65 kW/ton. In practice, some fraction of chiller replacements may involve the early retirement of units with lower efficiencies (perhaps 0.90 kW/ton), and thus achieve higher savings in the first few years of the measure installation.	Replace	Cooling	24	6,549,282	0	17,062	2.01	2.01	$0.028	3.45
CFL 9W to 39W hardwired	75W> 18W	New	Lighting	21	967,448	35,745,456	145,178	19.88	26.09	$0.029	3.42
EStar Griddle	Install EStar in place of conventional	New	Cooking	12	341,484	0	1,312	0.15	0.15	$0.030	2.78
Solar Hot Water	Install solar water heaters on large use facility such as multifamily or	Retrofit	Water Heat	15	7,611,379	673,810	26,777	3.62	11.38	$0.030	2.98

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	lodging										
DHW Faucets	Add aerators to existing faucets to reduce flow from 2.2 gallons per minute to 1.5 GPM.	New	Water Heat	8	42,894	0	220	0.03	0.03	$0.030	2.47
DHW Faucets	Add aerators to existing faucets to reduce flow from 2.2 gallons per minute to 1.5 GPM.	Retrofit	Water Heat	8	30,345	0	152	0.02	0.02	$0.031	2.41
Exterior LED Lighting	30% savings	New	Lighting	21	154,706,094	-69,689,634	208,621	-	-	$0.032	1.98
EStar Griddle	Replace with EStar in place of conventional	Replace	Cooking	12	1,384,580	0	4,870	0.57	0.57	$0.032	2.55
Sweep Control	25% savings	New	Lighting	21	21,446,386	0	65,315	-	-	$0.033	2.74
Computerized Water Heater Control	Install intelligent controls on the hot water circulation loops.	New	Water Heat	15	822,397	0	2,447	0.29	0.29	$0.033	2.68
High Bay HID Large to T5	1080W> 701W	New	Lighting	21	1,783,455	670,583	8,384	1.15	1.51	$0.033	3.05
Ducts	Duct retrofit of both insulation and air sealing	Retrofit	Heating	15	1,161,607	0	3,307	0.82	0.71	$0.034	2.58
Heat Pump Water Heat	0	New	Water Heat	15	2,305,449	137,748	6,939	0.82	0.82	$0.034	2.55
DHW Pipe Ins	Add 1" insulation to pipes used for steam or hydronic distribution; particularly effective when pipes run through unheated spaces.	New	Water Heat	15	497,104	0	1,411	0.17	0.17	$0.034	2.55
EMS Retrofit for Restaurants	Many commercial establishments have no means of operating facility lighting, heating, air	Retrofit	Total	20	20,394,536	0	47,987	5.65	5.65	$0.035	2.73

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	conditioning, refrigeration, etc., except to rely upon employees to manually switch equipment on/off before, during and after a typical work day. This is especially true in restaurants. A proper EMS installation in such facilities can reduce existing gas and electric energy usage by about 10% or more.										
Refrigeration Case Package	Efficient Evap Fans, case lighting, low energy anti-sweat heaters	New	Refrigeration	18	4,500,444	0	10,685	1.46	1.92	$0.037	2.54
Refrigeration Case Package	Efficient Evap Fans, case lighting, low energy anti-sweat heaters	Replace	Refrigeration	18	14,153,895	0	33,603	4.60	6.04	$0.037	2.54
2010 CEE Tier 1 - 3 ton (at rep)	Install high efficiency cooling equipment complying with 2010 CEE Tier 1 rather than 2010 code equipment. Costing in 6th plan showed 2010 Tier 2 equipment was 6 times more expensive and therefor is not included here. Tier 2 costs should be tracked.	Replace	Cooling	20	4,639,303	0	9,751	2.42	2.11	$0.039	2.46
Chiller Tower 6F approach	Install low approach cooling tower	Replace	Cooling	15	4,366,188	0	10,920	2.71	2.36	$0.039	2.27
High Bay HID Large to	1080W> 701W	Retrofit	Lighting	21	9,647,118	1,636,014	29,473	4.04	5.30	$0.040	2.52

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
T5											
Roof Insulation - Roofcut 0-22	Roof Insulation - Roofcut 0-22. Application: Buildings with uninsulated flat roofs at reroofing time	Replace	Heating	45	5,701	0	8	0.00	0.00	$0.040	2.68
2010 CEE Tier 1 - 25 ton (at rep)	Install high efficiency cooling equipment complying with 2010 CEE Tier 1 rather than 2010 code equipment. Costing in 6th plan showed 2010 Tier 2 equipment was 6 times more expensive and therefor is not included here. Tier 2 costs should be tracked.	Replace	Cooling	20	7,979,145	0	15,653	3.88	3.38	$0.042	2.30
PCs and Monitors - Energy Management Software	There is a solution to automate the enabling of Power Management in commercial computers and monitor/displays called Surveyor by EZConserve.	Replace	Misc.	4	62,526,349	0	474,473	55.82	55.82	$0.045	1.47
2010 CEE Tier 1 - 3 ton (new)	Install high efficiency cooling equipment complying with 2010 CEE Tier 1 rather than 2010 code equipment. Costing in 6th plan showed 2010 Tier 2 equipment was 6 times more expensive and therefor is not included here. Tier 2 costs should be	New	Cooling	20	2,284,294	0	4,105	1.02	0.89	$0.045	2.10

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	tracked.										
2010 CEE Tier 1 - 15 ton (at rep)	Install high efficiency cooling equipment complying with 2010 CEE Tier 1 rather than 2010 code equipment. Costing in 6th plan showed 2010 Tier 2 equipment was 6 times more expensive and therefor is not included here. Tier 2 costs should be tracked.	Replace	Cooling	20	4,639,303	0	8,309	2.06	1.79	$0.046	2.10
PCs and Monitors - Energy Management Software	There is a solution to automate the enabling of Power Management in commercial computers and monitor/displays called Surveyor by EZConserve.	New	Misc.	4	5,774,710	0	43,681	5.14	5.14	$0.046	1.45
Windows - Tinted AL Code to Class 40	Windows - Tinted AL Code to Class 40. Application: Old buildings	Replace	Heating	20	775,534	0	1,343	0.46	0.04	$0.047	2.08
Daylighting Overhead	Daylight control with skylite	New	Lighting	21	84,453,932	0	217,981	29.85	39.17	$0.048	2.10
2010 CEE Tier 1 - 25 ton (new)	Install high efficiency cooling equipment complying with 2010 CEE Tier 1 rather than 2010 code equipment. Costing in 6th plan showed 2010 Tier 2 equipment was 6 times more expensive and therefor is not included here. Tier 2	New	Cooling	20	3,928,761	0	6,589	1.63	1.42	$0.049	1.96

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	costs should be tracked.										
Windows - Tinted AL Code to Class 45	Windows - Tinted AL Code to Class 45. Application: Old buildings	Replace	Heating	20	515,730	0	813	0.28	0.03	$0.052	1.89
Lighting Scheduling/Controls	Lighting scheduling and control. This measure includes the commissioning of any occupancy and sweep controls, and the review and proper setting of daylighting controls. Since these are largely a function of schedule settings (except in cases where daylighting controls are integrated into the energy management software), we have included only the impact of properly controlled lighting and occupancy.	New	lighting	15	26,239,607	0	49,375	5.81	5.81	$0.052	1.69
2010 CEE Tier 1 - 15 ton (new)	Install high efficiency cooling equipment complying with 2010 CEE Tier 1 rather than 2010 code equipment. Costing in 6th plan showed 2010 Tier 2 equipment was 6 times more expensive and therefor is not included here. Tier 2 costs should be tracked.	New	Cooling	20	2,284,294	0	3,498	0.87	0.76	$0.053	1.79
HVAC controls	Control set up and algorithm. This	New	Heating	5	10,569,782	0	42,715	10.59	9.23	$0.057	1.23

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	assumes the development of an open source control package aimed at describing scheduling and control points throughout the HVAC system, properly training operators so that scheduling can be maintained and adjusted as needed, and providing operator back up so that temperature reset, pressure reset, and minimum damper settings are set at optimum levels for the current occupancy.										
Windows - Add Argon to Vinyl Lowe	Windows - Add Argon to Vinyl Lowe. Application: Old buildings	Replace	Heating	20	3,346,255	0	4,600	1.58	0.14	$0.059	1.65
Windows - Tinted AL Code to Class 40	Windows - Tinted AL Code to Class 40. Application: New Construction	New	Heating	20	609,289	0	790	0.27	0.02	$0.063	1.56
2010 CEE Tier 1 - 7.5 ton (at rep)	Install high efficiency cooling equipment complying with 2010 CEE Tier 1 rather than 2010 code equipment. Costing in 6th plan showed 2010 Tier 2 equipment was 6 times more expensive and therefor is not included here. Tier 2 costs should be	Replace	Cooling	20	4,639,303	0	5,935	1.47	1.28	$0.064	1.50

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	tracked.										
Roof Insulation - Rigid R11-33	Roof Insulation - Rigid R11-33: add 4' of insulation at reroof. Application: Old buildings with flat roofs, no attics, and some insulation	Replace	Heating	45	4,280,521	0	3,604	1.24	0.11	$0.069	1.56
Rooftop Condensing Burner	Install condensing burner	New	Heating	10	3,962,533	0	7,316	1.81	1.58	$0.071	1.06
2010 CEE Tier 1 - 7.5 ton (new)	Install high efficiency cooling equipment complying with 2010 CEE Tier 1 rather than 2010 code equipment. Costing in 6th plan showed 2010 Tier 2 equipment was 6 times more expensive and therefor is not included here. Tier 2 costs should be tracked.	New	Cooling	20	2,284,294	0	2,499	0.62	0.54	$0.075	1.28
Roof Insulation - Blanket R11-41	Roof Insulation - Blanket R11-41. Application: Buildings with open truss unfinished interior	Retrofit	Heating	45	1,162,295	0	824	0.28	0.03	$0.082	1.31
Windows - Tinted AL Code to Class 36	Windows - Tinted AL Code to Class 36. Application: Old buildings	Replace	Heating	20	1,938,835	0	1,832	0.63	0.06	$0.086	1.13
Roof Insulation - Blanket R11-30	Roof Insulation - Blanket R11-30. Application: Buildings with open truss unfinished interior	Retrofit	Heating	45	1,033,151	0	687	0.24	0.02	$0.087	1.23

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
Windows - Non-Tinted AL Code to Class 40	Windows - Non-Tinted AL Code to Class 40. Application: Old buildings	Replace	Heating	20	2,541,055	0	2,258	0.78	0.07	$0.092	1.07
Install Economizer	Economizer retrofit on unit with no economizer	Retrofit	Cooling	15	8,912,797	0	9,140	2.27	1.97	$0.095	0.93
Windows - Non-Tinted AL Code to Class 40	Windows - Non-Tinted AL Code to Class 40. Application: New Construction	New	Heating	20	1,944,529	0	1,626	0.56	0.05	$0.098	1.00
Warm Up Control	This measure is designed to implement a shut down of outside air when the building is coming off night setback. Usually the capability for this is available in a commercial t-stat but either the extra control wire is not attached or the unit itself has not been set up to receive the signal. Cost is based on labor cost to enable this ability in existing controllers	Retrofit	Heating	10	4,141,102	0	4,876	-	-	$0.111	0.67
Windows - Tinted AL Code to Class 36	Windows - Tinted AL Code to Class 36. Application: New Construction	New	Heating	20	1,523,222	0	1,097	0.38	0.03	$0.113	0.86
Daylight Control (overhead)	5% savings	New	Lighting	10	114,480,637	0	137,725	18.86	24.75	$0.118	0.71
HVAC System Commissioning	HVAC system commissioning. Includes testing and balancing, damper	New	Heating	15	31,407,353	0	24,408	6.05	5.27	$0.126	0.71

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	settings, economizer settings, and proper HVAC heating and compressor control installation. This measure includes the proper set-up of single zone package equipment in simple HVAC systems. The majority of the Commercial area is served by this technology. Work done in Eugene (Davis, et al, 2002) suggests higher savings than the other documented commissioning on more complex systems.										
Ceramic Metal Halide	100W> 44W	New	Lighting	21	16,184,156	21,283,688	24,569	3.36	4.41	$0.127	0.80
Ceramic Metal Halide	100W> 44W	Replace	Lighting	21	30,407,448	39,309,529	44,598	6.11	8.01	$0.130	0.77
Indirect/Direct Evaporative Cooling >60 ton	Install indirect/direct evaporative cooling in commercial building HVAC system in large systems <60 ton range. Original ETO evaluation evaluated at 20, 150 and 300tons with all being essentially equivalent	Replace	Cooling	18	52,727,509	0	31,305	7.76	6.76	$0.146	0.61
Windows - Non-Tinted AL Code to Class 36	Windows - Non-Tinted AL Code to Class 36. Application: Old buildings	Replace	Heating	20	6,352,637	0	3,442	1.18	0.11	$0.151	0.65
Solar Hot Water	Install solar water	New	Water Heat	15	7,061,316	625,115	4,700	0.64	2.00	$0.160	0.56

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
	heaters on large use facility such as multifamily or lodging										
Windows - Non-Tinted AL Code to Class 36	Windows - Non-Tinted AL Code to Class 36. Application: New Construction	New	Heating	20	4,861,323	0	2,428	0.83	0.08	$0.163	0.60
Windows - Non-Tinted AL Code to Class 45	Windows - Non-Tinted AL Code to Class 45. Application: Old buildings	Replace	Heating	20	1,689,802	0	803	0.28	0.02	$0.172	0.57
Indirect/Direct Evaporative Cooling >60 ton	Install indirect/direct evaporative cooling in commercial building HVAC system in large systems <60 ton range. Original ETO evaluation evaluated at 20, 150 and 300tons with all being essentially equivalent	New	Cooling	18	24,872,202	0	11,860	2.94	2.56	$0.182	0.49
Ground Source Heat Pump - Air Source HP Base	Install GSHP in place of air source heat pumps.	Replace	Heating	18	9,495,024	-315,150	4,333	1.07	0.94	$0.184	0.50
Occupancy Sensors	5% savings	New	Lighting	15	16,043,629	0	8,044	-	-	$0.206	0.40
Daylight perimeter zone	10% savings	New	Lighting	10	27,390,993	0	16,267	2.23	2.92	$0.231	0.36
High Efficacy LED Display	72W> 39W	New	Lighting	21	99,006	49,766,342	14,432	1.98	2.59	$0.280	0.36
Indirect/Direct Evaporative Cooling ~20 ton	Install indirect/direct evaporative cooling in commercial building HVAC system in 20 to 60 ton range	Replace	Cooling	18	124,286,306	0	31,305	7.76	6.76	$0.345	0.26

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Winter MW	Summer mW	Levelized Cost, $/kWh	BCR
Indirect/Direct Evaporative Cooling ~20 ton	Install indirect/direct evaporative cooling in commercial building HVAC system in 20 to 60 ton range	New	Cooling	18	54,407,943	0	11,860	2.94	2.56	$0.399	0.22
Package Refrigeration - Ice makers, Vending machines	Install machines with package of measures akin to ADL low cost	new	Misc.	9	48,238,499	0	5,861	0.69	0.69	$1.168	0.07
Package Refrigeration - Ice makers, Vending machines	Install machines with package of measures akin to ADL low cost	Replace	Misc.	9	160,201,414	0	19,443	2.29	2.29	$1.170	0.07
Efficient Standalone Refrigeration Cases	Install efficient stand alone cases. This measure is based upon current rebates and SAIC savings numbers	Replace	Misc.	9	3,305,925,711	0	166,815	19.62	19.62	$2.813	0.03
Efficient Standalone Refrigeration Cases	Install efficient stand alone cases. This measure is based upon current rebates and SAIC savings numbers	new	Misc.	9	465,718,200	0	23,480	2.76	2.76	$2.815	0.03

Note: Includes emerging technology measures

Table 19: Detailed Measure Table, Commercial Sector, Gas Savings, 2030 Technical Potential

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Estar Commercial Clothes Washer	Install high performance commercial clothes washers - coin op	New	Water Heat	10	1,097	-10,214	1	0	($4.4685)	10.70
Estar Commercial Clothes Washer	Install high performance commercial clothes washers - coin op	Replace	Water Heat	10	186,282	########	288	12	($2.9839)	7.58
EStar Steam Cooker	Install EStar in place of conventional	New	Cooking	10	24,554	-66,969	0	3	($1.6283)	3.52
EStar Steam Cooker	Replace with EStar in place of conventional	Replace	Cooking	10	132,794	-361,812	0	19	($1.6104)	3.52
EStar Fryer	Install EStar in place of conventional	New	Cooking	8	13,166	0	0	172	$0.0120	60.56
EStar Fryer	Replace with EStar in place of conventional	Replace	Cooking	8	238,145	0	0	1,140	$0.0326	22.23
Estar Convection Oven	Replace with EStar in place of conventional	Replace	Cooking	12	247,058	0	0	446	$0.0631	12.04
Roof Insulation - Attic R0-30	Roof Insulation - Attic R0-30. Application: Buildings with uninsulated attics	Retrofit	Heating	45	505,401	0	891	227	$0.0871	10.09
HW Boiler Tune	Tune up in accordance with Minneapolis Energy Office protocol. Can include derating the burner, adjusting the secondary air,	Retrofit	Heating	5	9,255	0	0	23	$0.0939	7.78

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
	adding flue restrictors, cleaning the fire-side of the heat exchanger, cleaning the water side, or installing turbulators. Other modifications may include uprating the burner to reduce oxygen or derating the burner to reduce stack temperature. Note: In gas systems, excess air and stack temperatures are often within reasonable ranges, so the technical potential for this measure is limited. Combining this measure with the vent damper and power burner measures increases both applicability and cost effectiveness, and was assumed for this analysis.									
DHW Shower Heads	Install low flow shower heads (2.0 gallons per minute) to replace 3.4 GPM shower heads.	Retrofit	Water Heat	8	88,072	0	0	116	$0.1181	6.13

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Hot Water Temperature Reset	Controller automatically resets the delivery temperature in a hot water radiant system based on outside air temperature. The reset reduces the on-time of the heating equipment and the occurrence of simultaneous heating and cooling through instantaneous adjustments.	Retrofit	Heating	10	747,573	0	0	750	$0.1304	5.97
Roof Insulation - Rigid R0-11	Roof Insulation - Rigid R0-11-not including re-roofing costs but including deck preparation. Application: Old buildings with flat roofs and no attics	Replace	Heating	45	2,642,731	0	3,599	627	$0.1435	6.13
Wall Insulation - Blown R11	Wall Insulation - Blown R11. Application: Old buildings	Retrofit	Heating	45	6,940,814	0	3,841	2,248	$0.1479	5.94

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Heat Reclaim	Large Grocery - Heat recovery to space heating. Assumes floating head control exists and must be changed to allow HR.	Replace	Refrigeration	18	5,031,683	0	15,292	1,054	$0.1544	5.17
Heat Reclaim	Large Grocery - Heat recovery to space heating. Assumes floating head control exists and must be changed to allow HR.	New	Refrigeration	18	1,672,412	0	5,056	349	$0.1551	5.15
Steam Balance	Single-pipe steam systems are notorious for uneven heating, which wastes energy because the thermostat must be set to heat the coldest spaces and overheating other spaces. Steam balances corrects these problems by: 1) Adding air venting on the main line or at the radiators; 2) Adding boiler cycle controls; 3) Adding or subtracting radiators. Energy savings accrue from lowering the overall building temperature.	Retrofit	Heating	15	734,199	0	0	391	$0.1834	4.43

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Waste Water Heat Exchanger	Install HX on waste water	Retrofit	Water Heat	15	118,429	0	0	59	$0.1961	3.97
DHW Wrap	Insulate the surface of the storage water heater or an unfired storage tank to R-5 to reduce standby losses.	Retrofit	Water Heat	7	16,216	0	0	14	$0.2043	3.48
Wall Insulation - Spray On for Metal Buildings	Wall Insulation - Spray On for Metal Buildings (Cellulose) Unfinished. Application: Old buildings	Retrofit	Heating	45	2,474,296	0	-58	702	$0.2131	4.13
Roof Insulation - Rigid R0-22	Roof Insulation - Rigid R0-22--not including re-roofing costs but including deck preparation and ~4" rigid.. Application: Old buildings with flat roofs and no attics	Replace	Heating	45	4,564,717	0	4,100	713	$0.2177	4.04
Estar Convection Oven	Install EStar in place of conventional	New	Cooking	12	211,131	0	0	102	$0.2366	3.21
Roof Insulation - Blanket R0-19	Roof Insulation - Blanket R0-19. Application: Buildings with open truss unfinished interior	Retrofit	Heating	45	4,228,239	0	106	967	$0.2499	3.52

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Roof Insulation - Blanket R0-30	Roof Insulation - Blanket R0-30. Application: Buildings with open truss unfinished interior	Retrofit	Heating	45	4,756,769	0	116	1,015	$0.2677	3.28
DHW Condensing Tank (repl)	Costs and savings are incremental over a Code-rated tank (combustion efficiency of 80%) for a condensing tank with a minimum combustion efficiency of 94% and an R-16 tank wrap.	Replace	Water Heat	15	5,608,629	0	0	1,870	$0.2929	2.66
DHW Condensing Tank (new)	Costs and savings are incremental over a Code-rated tank (combustion efficiency of 80%) for a condensing tank with a minimum combustion efficiency of 94% and an R-16 tank wrap.	New	Water Heat	15	1,940,952	0	0	638	$0.2968	2.62
DCV	Applicable to single zone packaged systems with large make -up air fractions either because of intermittent occupancy or because of code requirements. In most cases the	Retrofit	Heating	15	9,018,278	0	18,262	890	$0.3056	1.82

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
	outdoor air is reset to 5% or less with CO2 build-up modulating ventilation.									
Computerized Water Heater Control	Install intelligent controls on the hot water circulation loops.	Retrofit	Water Heat	15	803,151	0	0	252	$0.3115	2.50
Windows - Add Low E to Vinyl Tint	Windows - Add Low E to Vinyl Tint. Application: Old buildings	Replace	Heating	20	2,601,802	0	3,844	230	$0.3122	2.68
Roof Insulation - Attic 11-30	Roof Insulation - Attic 11-30. Application: Buildings with partially insulated attics	Retrofit	Heating	45	3,513,838	0	1,003	462	$0.3484	2.52
Roof Insulation - Rigid R11-22	Roof Insulation - Rigid R11-22 2" rigid added to an existing foam roof insulation at re-roof, includes some surface prep. Application: Old buildings with flat roofs, no attics, and some insulation	Replace	Heating	45	12,031,434	0	4,511	1,410	$0.3553	2.47
Hot Food Holding Cabinet	Install EStar in place of conventional	New	Cooking	8	25,015	0	0	10	$0.4011	1.80

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Hot Food Holding Cabinet	Install EStar in place of conventional	Replace	Cooking	8	166,263	0	0	65	$0.4014	1.80
Vent Damper	Install vent damper downstream of the draft relief to prevent airflow up the stack, while allowing warm air from the boiler to spill into the conditioned space as heat or into the boiler room to reduce jacket losses. This measure is most cost-effective when combined with the boiler tune up and power burner measures.	Retrofit	Heating	12	360,127	0	0	99	$0.4158	1.91
Windows - Add Low E and Argon to Vinyl Tint	Windows - Add Low E and Argon to Vinyl Tint. Application: Old buildings	Replace	Heating	20	4,068,983	0	3,894	323	$0.4267	1.96
EStar Griddle	Install EStar in place of conventional	New	Cooking	12	140,420	0	0	35	$0.4615	1.65
EStar Griddle	Replace with EStar in place of conventional	Replace	Cooking	12	519,617	0	0	128	$0.4635	1.64

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Waste Water Heat Exchanger	Install HX on waste water	New	Water Heat	15	404,081	0	0	82	$0.4806	1.62
SPC Hieff Boiler Replace	Install near condensing boiler. Assumed seasonal combustion efficiency of 85% over base of 80%	Replace	Heating	20	567,786	0	0	92	$0.5046	1.66
DHW Hieff Boiler (repl)	Replace existing boiler with unit meeting OR Code requirements of 80% combustion efficiency.	Replace	Water Heat	20	1,690,979	0	0	261	$0.5280	1.59
Combo Hieff Boiler (new)	Replace existing boiler with unit meeting OR Code requirements of 80% combustion efficiency.	New	Heating	20	468,922	0	0	72	$0.5284	1.52
Windows - Tinted AL Code to Class 45	Windows - Tinted AL Code to Class 45. Application: Old buildings	Replace	Heating	20	1,330,196	0	1,631	14	$0.5297	1.58
DHW Hieff Boiler (new)	Replace existing boiler with unit meeting OR Code requirements of 80% combustion efficiency.	New	Water Heat	20	626,309	0	0	96	$0.5337	1.50
Ducts	Duct retrofit of both insulation and air sealing	Retrofit	Heating	15	3,677,163	0	2,944	317	$0.5628	1.44

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Combo Hieff Boiler (repl)	Replace existing boiler with unit meeting OR Code requirements of 80% combustion efficiency.	Replace	Heating	20	1,497,659	0	0	217	$0.5634	1.49
Cond Furnace (new)	Condensing / pulse package or residential-type furnace with a minimum AFUE of 92%. Base case: AFUE 80	New	Heating	18	2,739,672	0	0	417	$0.5707	1.40
Roof Insulation - Roofcut 0-22	Roof Insulation - Roofcut 0-22. Application: Buildings with uninsulated flat roofs at reroofing time	Replace	Heating	45	10,067	0	2	1	$0.5987	1.47
Windows - Tinted AL Code to Class 40	Windows - Tinted AL Code to Class 40. Application: Old buildings	Replace	Heating	20	2,000,295	0	1,693	71	$0.6070	1.38
SPC Hieff Boiler (new)	Install near condensing boiler. Assumed seasonal combustion efficiency of 82% over base of 75%	New	Heating	20	988,174	0	0	123	$0.6533	1.24
DHW Recirc Controls	Install electronic controller to hot water boiler system that turns	Retrofit	Water Heat	10	730,193	0	0	142	$0.6711	1.11

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
	off the boiler and circulation pump when the hot water demand is reduced (usually in residential type occupancies) or can be reset to meet the hot water load. (Steel boilers also require a mixing valve to prevent water temperatures from dropping below required levels).									
DHW Faucets	Add aerators to existing faucets to reduce flow from 2.2 gallons per minute to 1.5 GPM.	New	Water Heat	8	14,670	0	0	3	$0.6842	1.06
DHW Faucets	Add aerators to existing faucets to reduce flow from 2.2 gallons per minute to 1.5 GPM.	Retrofit	Water Heat	8	34,128	0	0	8	$0.6863	1.05
SPC Cond Boiler Replace	Install condensing boiler. Assumed seasonal combustion efficiency of 92% over base of 80%	Replace	Heating	20	2,297,078	0	0	266	$0.7041	1.19

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Hi Eff Unit Heater (new)	Install power draft units (83% seas. Eff) in place of natural draft (80% seas. Eff) per ASHRAE 90.1-2007	New	Heating	18	1,114,946	0	0	126	$0.7678	1.04
DHW Cond Boiler (repl)	Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 92% efficiency for savings calculations).	Replace	Water Heat	20	5,473,743	0	0	580	$0.7708	1.09
Computerized Water Heater Control	Install intelligent controls on the hot water circulation loops.	New	Water Heat	15	292,751	0	0	37	$0.7732	1.01
DHW Cond Boiler (new)	Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 92% efficiency for savings calculations).	New	Water Heat	20	2,027,806	0	0	212	$0.7792	1.03
Power burner	Replace standard burner with a power burner to optimize combustion and reduce standby losses in the	Retrofit	Heating	12	7,437,584	0	0	1,020	$0.8323	0.95

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
	stack. Note: Costs and savings assume that this measure will be performed in conjunction with a boiler tune up when appropriate.									
SPC Cond Boiler (new)	Install condensing boiler. Assumed seasonal combustion efficiency of 88% over base of 75%	New	Heating	20	3,084,463	0	0	296	$0.8515	0.95
Cond Unit Heater From Power Draft (new)	Install condensing power draft units (90% seas. Eff) in place of power draft (80% seas. Eff)	New	Heating	18	3,114,289	0	0	310	$0.8720	0.92
Windows - Tinted AL Code to Class 40	Windows - Tinted AL Code to Class 40. Application: New Construction	New	Heating	20	938,064	0	465	29	$0.8932	0.90

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
DHW Pipe Ins	Add 1" insulation to pipes used for steam or hydronic distribution; particularly effective when pipes run through unheated spaces.	New	Water Heat	15	91,936	0	0	10	$0.9104	0.85
HVAC controls	Control set up and algorithm. This assumes the development of an open source control package aimed at describing scheduling and control points throughout the HVAC system, properly training operators so that scheduling can be maintained and adjusted as needed, and providing operator back up so that temperature reset, pressure reset, and minimum damper settings are set at optimum levels for the current occupancy.	New	Heating	5	21,153,361	0	24,673	2,902	$0.9109	0.77
Combo Cond Boiler (new)	Replace with boiler using condensing or pulse technology to achieve steady-state	New	Heating	20	1,865,757	0	0	161	$0.9482	0.85

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
	combustion efficiencies of 89% to 94% (this analysis used 92% efficiency for savings calculations).									
Combo Cond Boiler (repl)	Replace with boiler using condensing or pulse technology to achieve steady-state combustion efficiencies of 89% to 94% (this analysis used 92% efficiency for savings calculations).	Replace	Heating	20	5,850,328	0	0	481	$0.9925	0.84
Rooftop Condensing Burner	Install condensing burner	New	Heating	10	7,635,910	0	5,906	397	$0.9963	0.75
Roof Insulation - Rigid R11-33	Roof Insulation - Rigid R11-33: add 4' of insulation at reroof. Application: Old buildings with flat roofs, no attics, and some insulation	Replace	Heating	45	18,047,150	0	3,456	549	$1.0765	0.82
Cond Unit Heater from Nat Draft (new)	Install condensing power draft units (90% seas. Eff) in place of natural draft (80% seas. Eff)	New	Heating	18	6,009,369	0	0	465	$1.1218	0.71
Hi Eff Unit Heater (replace)	Install power draft units (83% seas. Eff) in place of natural	Replace	Heating	18	5,606,481	0	0	397	$1.2256	0.68

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
	draft (80% seas. Eff)									
Windows - Tinted AL Code to Class 36	Windows - Tinted AL Code to Class 36. Application: Old buildings	Replace	Heating	20	5,000,737	0	1,739	125	$1.2406	0.67
Windows - Add Argon to Vinyl Lowe	Windows - Add Argon to Vinyl Lowe. Application: Old buildings	Replace	Heating	20	10,132,890	0	-728	723	$1.2432	0.67
Cond Unit Heater from power draft (replace)	Install condensing power draft units (90% seas. Eff) in place of power draft (80% seas. Eff)	Replace	Heating	18	15,660,136	0	0	976	$1.3934	0.59
Ozone Laundry Treatment	Ozone treatment allows use of cold water	Retrofit	Water Heat	10	149,203	-9,844	8	12	$1.4330	0.55
Solar Hot Water	Install solar water heaters on large use facility such as multifamily or lodging	Retrofit	Water Heat	15	6,551,842	580,013	0	463	$1.5044	0.52
Steam Trap Maintenance	Set up a in-house steam trap maintenance program with equipment, training, and trap replacement. An alternative procedure is to just pay for an	Retrofit	Heating	10	1,071,732	4,459,777	0	442	$1.6373	0.48

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
	outside contractor to conduct a steam survey.									
Roof Insulation - Blanket R11-41	Roof Insulation - Blanket R11-41. Application: Buildings with open truss unfinished interior	Retrofit	Heating	45	11,891,923	0	53	396	$1.7097	0.51
Cond Unit Heater from Nat draft (replace)	Install condensing power draft units (90% seas. Eff) in place of natural draft (80% seas. Eff)	Replace	Heating	18	30,217,981	0	0	1,466	$1.7907	0.46
Windows - Tinted AL Code to Class 36	Windows - Tinted AL Code to Class 36. Application: New Construction	New	Heating	20	2,345,160	0	475	48	$1.8073	0.45

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
Roof Insulation - Blanket R11-30	Roof Insulation - Blanket R11-30. Application: Buildings with open truss unfinished interior	Retrofit	Heating	45	10,570,599	0	53	330	$1.8178	0.48
Windows - Non-Tinted AL Code to Class 40	Windows - Non-Tinted AL Code to Class 40. Application: Old buildings	Replace	Heating	20	7,664,277	0	-336	358	$1.8375	0.46
HVAC System Commissioning	HVAC system commissioning. Includes testing and balancing, damper settings, economizer settings, and proper HVAC heating and compressor control installation. This measure includes the proper set-up of single zone package equipment in simple HVAC systems. The majority of the Commercial area is served by this	New	Heating	15	62,855,700	0	14,099	1,658	$1.8869	0.42

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
	technology. Work done in Eugene (Davis, et al, 2002) suggests higher savings than the other documented commissioning on more complex systems.									
Warm Up Control	This measure is designed to implement a shut down of outside air when the building is coming off night setback. Usually the capability for this is available in a commercial t-stat but either the extra control wire is not attached or the unit itself has not been set up to receive the signal. Cost is based on labor cost to enable this ability in existing controllers	Retrofit	Heating	10	9,809,728	0	0	679	$1.8882	0.41
Windows - Non-Tinted AL Code to Class 40	Windows - Non-Tinted AL Code to Class 40. Application: New Construction	New	Heating	20	4,087,993	0	-169	177	$1.9730	0.41
Cond Furnace (repl)	Condensing / pulse package or residential-type furnace with a minimum AFUE	Replace	Heating	18	34,609,180	0	0	1,280	$2.3500	0.35

Measure Name	Measure Description	Construction Type	Measure End Use	Average Lifetime	Total Incremental Cost	Total O&M	Total MWh Savings	Gas Impacts kTherms	Levelized Cost, $/th	BCR
	of 92%.									
Windows - Non-Tinted AL Code to Class 36	Windows - Non-Tinted AL Code to Class 36. Application: Old buildings	Replace	Heating	20	19,160,692	0	-565	545	$2.9716	0.28
Windows - Non-Tinted AL Code to Class 45	Windows - Non-Tinted AL Code to Class 45. Application: Old buildings	Replace	Heating	20	5,096,744	0	-164	134	$3.2280	0.26
Windows - Non-Tinted AL Code to Class 36	Windows - Non-Tinted AL Code to Class 36. Application: New Construction	New	Heating	20	10,219,984	0	-331	268	$3.2280	0.25
Solar Hot Water	Install solar water heaters on large use facility such as multifamily or lodging	New	Water Heat	15	2,210,537	195,691	0	67	$3.5084	0.22

Table 20: Detailed Measure Table, Residential Sector, Electricity Savings, 2030 Technical Potential

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
Elec Hi-eff Washer	New Appl	12	9,364,706	-32,604,571	26,558,305	3,843	3,219	199,145	-$0.094	100.00	187,294
Elec MEF 2.0 Washer	New Appl	12	6,180,706	-21,230,884	17,774,211	2,572	2,154	152,975	-$0.090	100.00	187,294
Elec Hi-eff Washer	ReplaceAppl	12	46,013,321	-73,365,686	47,606,493	6,889	5,770	97,928	-$0.064	100.00	298,788
Elec ETO Dishwasher	ReplaceAppl	12	2,074,441	-3,640,238	2,939,959	425	356	13,228	-$0.058	100.00	38,416
Elec ETO Dishwasher	New Appl	12	1,300,356	-2,281,871	3,189,118	462	387	-4,549	-$0.034	3.66	24,081
Elec MEF 2.0 Washer	ReplaceAppl	12	33,763,021	-38,406,198	34,911,428	5,052	4,231	82,862	-$0.015	100.00	298,788
Common Area Lighting (MF Only)	Retro	7	0	0	54,725,937	6,438	6,438	1,095,061	$0.000	100.00	135,953
Heat Pump, (ER Base), Z B	Retro	18	0	107,562	4,054,956	678	170	0	$0.002	44.64	283
Hot water pipe wrap	Retro	10	215,203	0	6,756,705	795	795	128,175	$0.004	22.37	9,782
Tank wrap (in accordance with EWEB guidelines or equivalent)	Replace	10	82,168	0	1,430,785	168	168	27,172	$0.006	12.41	29,346
Window U=.3 (ER, Z B)	New	45	67,766	0	598,816	151	4	0	$0.007	17.63	479
Window U=.3 (HP, Z B)	New	45	39,975	0	336,760	56	14	0	$0.007	17.49	226
Window replace (U=.35), ER Z B	Replace	45	5,291,349	0	42,959,717	10,810	300	0	$0.007	16.20	15,118
Energy Star Television	New	10	1,072,452	0	18,838,358	2,216	2,216	0	$0.007	10.61	110,201
Window replace	Replace	45	1,637,447	0	11,559,807	1,932	484	0	$0.008	14.66	4,678

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
(U=.35), HP Z B											
Ducts Indoor, DHW, Lights (HP, Z2)	New	45	638,257	0	3,942,925	659	165	0	$0.009	12.82	824
Energy Star Computer Monitor	New	8	259,343	0	3,334,238	392	392	0	$0.012	6.20	110,614
Window replace (U=.35), ER Z A	Replace	45	12,972,503	0	61,383,286	15,446	429	0	$0.012	9.44	42,302
Energy Star Set Top Box	New	5	866,077	0	16,224,462	1,909	1,909	0	$0.012	5.66	119,715
Window U=.3 (ER, Z A)	New	45	228,780	0	976,822	246	7	0	$0.014	8.52	1,922
Ducts Indoor, DHW, Lights (HP, Z C)	New	45	223,390	0	943,593	158	40	0	$0.014	8.77	288
Window U=.3 (HP, Z A)	New	45	59,316	0	202,053	34	8	0	$0.017	7.07	374
Energy Star Computer Monitor	ReplaceAppl	8	2,557,252	0	43,190,135	5,081	5,081	-437,645	$0.017	7.29	888,671
Wx (ceiling,floor) ER, Z B	Retro	45	459,180	0	1,405,733	354	10	0	$0.019	6.11	242
Duct Sealing, Elect Resis, Z B	Retro	20	1,142,127	0	4,777,513	1,202	33	0	$0.020	5.43	1,845
Energy Star Insulation, Ducts, DHW, Lights (ER, Z B)	New	45	1,480,425	0	4,205,462	1,058	29	0	$0.020	5.67	1,306
Energy Star Insulation, Ducts, DHW, Lights (HP, Z B)	New	45	3,363,201	0	8,764,695	1,465	367	0	$0.022	5.41	2,120
Near Net Zero Zonal (Z B)	New	45	781,791	0	1,854,238	467	13	0	$0.024	4.73	176

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
Energy Star HP HSPF 7.7>9.5 (Z B) w. cx	New	15	317,609	0	1,193,582	200	50	0	$0.026	3.98	426
Energy Star Desktop Computer	New	5	1,781,901	0	15,839,988	1,863	1,863	0	$0.026	2.69	113,414
Energy Star Television	ReplaceAppl	10	12,963,912	0	145,097,771	17,069	17,069	-2,695,422	$0.026	5.52	972,223
Energy Star Set Top Box	ReplaceAppl	5	7,640,791	0	136,036,684	16,003	16,003	-2,321,422	$0.026	4.36	1,056,160
Wx Air Sealing, Z A	Retro	10	1,335,751	0	6,558,989	1,650	46	0	$0.027	3.38	9,869
Retail Lights (2 lamps)	Retro	7	3,621,803	0	19,422,331	2,285	2,285	400,401	$0.027	2.74	603,634
Wx (ceiling,floor) HP, Z B	Retro	45	157,083	0	337,029	56	14	0	$0.027	4.45	75
Wx (ceiling,floor) ER, Z A	Retro	45	13,283,855	0	27,378,686	6,889	191	0	$0.028	4.11	8,926
Duct Sealing, Heat Pump, Z B	Retro	20	1,164,797	0	3,356,992	561	141	0	$0.028	3.90	1,939
Ducts Indoor, DHW, Lights (HP, Z A)	New	15	765,067	0	2,552,436	427	107	0	$0.029	3.53	987
Duct Sealing, Elect Resis, Z A	Retro	20	17,536,821	0	46,357,344	11,665	324	0	$0.031	3.43	32,334
Energy Star Insulation, Ducts, DHW, Lights (HP, Z C)	New	45	1,224,630	0	2,292,092	383	96	0	$0.031	3.89	782
Tank upgrade (50 gal)-20 yr warranty	New	20	325,393	0	753,373	109	91	13,451	$0.031	3.29	3,264
Near Net Zero Zonal (Z C)	New	45	273,627	0	491,972	124	3	0	$0.032	3.59	62

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
Window replace (U=.35), HP Z A	Replace	45	13,115,723	0	23,151,080	3,870	970	0	$0.033	3.66	37,473
Add 16 LED lamps (using incand base) after 2015	New	10	3,111,782	0	20,578,246	2,421	2,421	-367,403	$0.034	3.29	24,311
Add 6 LED lamps (using incandesent base) aft 2015	New	10	2,031,003	0	12,523,439	1,473	1,473	-204,951	$0.034	3.12	42,313
Commissioning (HP), Z B	Retro	5	375,442	0	2,537,642	424	106	0	$0.034	2.44	1,707
Refrigerator Recycle	Retro	6	3,252,112	0	18,092,069	2,128	2,128	0	$0.036	2.03	32,521
Heat Pump, (HP Upgrade), Z B	Replace	18	1,881,739	0	4,498,615	752	189	0	$0.036	2.83	1,077
Energy Star Insulation, Ducts, DHW, Lights (ER, Z C)	New	45	735,959	0	1,167,319	294	8	0	$0.037	3.17	733
Near Net Zero Zonal (Z A)	New	45	901,835	0	1,380,234	347	10	0	$0.038	3.05	204
Energy Star Insulation, Ducts, DHW, Lights (HP, Z A)	New	45	4,859,320	0	7,392,191	1,236	310	0	$0.038	3.16	3,217
Commissioning (HP), Z A	Retro	5	6,448,074	0	37,519,201	6,272	1,572	0	$0.040	2.10	29,309
Window U=.3 (ER, Z C)	New	45	165,536	0	223,305	56	2	0	$0.043	2.69	346
Wx (ceiling, floor, wall) HP, Z B	Retro	45	365,735	0	475,707	80	20	0	$0.045	2.70	108
Energy Star HP HSPF 7.7>9.5 (Z C) w. cx	New	15	116,867	0	255,718	43	11	0	$0.045	2.32	158

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
Window U=.3 (HP, Z C)	New	45	59,230	0	75,203	13	3	0	$0.046	2.64	92
50% LED after 2020	Retro	10	23,707,897	0	56,529,352	6,650	6,650	1,180,011	$0.046	1.73	98,925
Heat pump water heater (80 gal)	New	15	2,582,703	1,085,058	7,508,675	1,087	910	0	$0.048	1.99	3,532
Heat pump water heater (80 gal)	ReplaceAppl	15	2,378,154	999,122	6,913,990	1,001	838	0	$0.048	1.99	3,252
Tank upgrade (50 gal)-10 yr warranty	ReplaceAppl	10	705,502	0	1,862,339	270	226	0	$0.050	1.73	20,157
Full lighting (all high efficacy)	New	7	2,189,898	0	9,101,654	1,071	1,071	-90,151	$0.050	1.58	19,553
Energy Star Insulation, Ducts, DHW, Lights (ER, Z A)	New	45	10,431,463	0	11,537,426	3,961	359	0	$0.052	1.96	10,989
ER> Mini-split ductless heat pump Z B	New	15	724,730	0	1,310,314	219	55	0	$0.054	1.91	259
Heat pump water heater (50 gal)	ReplaceAppl	15	24,213,044	8,369,072	53,957,456	7,809	6,540	0	$0.059	1.61	27,241
Wx (ceiling,floor) HP, Z A	Retro	45	2,124,396	0	2,086,601	349	87	0	$0.059	2.04	1,026
Energy Star HP HSPF 7.7>9.5 (Z A) w. cx	New	15	416,187	0	667,200	112	28	0	$0.061	1.70	569
Duct Sealing, Heat Pump, Z A	Retro	20	19,922,289	0	26,671,982	4,459	1,118	0	$0.061	1.81	33,306
Tank upgrade (50 gal)-20 yr warranty	ReplaceAppl	20	289,331	0	371,437	54	45	0	$0.064	1.61	2,903

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
Energy Star Desktop Computer	ReplaceAppl	5	19,294,417	0	95,770,205	11,266	11,266	-2,266,411	$0.065	1.11	1,000,573
ER> Mini-split ductless heat pump Z B-C	Retro	15	6,155,885	0	8,845,035	1,479	371	0	$0.068	1.52	1,620
100% LED after 2020	Retro	10	47,415,794	0	76,232,855	8,968	8,968	1,576,398	$0.068	1.16	88,261
Home Energy Monitor	New	3	1,045,287	0	5,532,756	651	651	0	$0.070	0.84	11,364
ER> Mini-split ductless heat pump Z C	New	15	253,656	0	350,775	59	15	0	$0.071	1.46	91
ER> Mini-split ductless heat pump Z A	New	15	841,929	0	1,125,042	283	8	0	$0.073	1.36	301
Wx (ceiling, floor, wall) ER, Z B	Retro	45	6,783,291	0	5,323,015	1,339	37	0	$0.074	1.57	3,145
All LED (from 2020 base) after 2020	New	10	6,320,807	0	12,248,956	1,441	1,441	-218,692	$0.081	0.96	24,311
Heat Pump, (HP Upgrade), Z A	Replace	18	4,769,293	0	5,049,640	844	212	0	$0.082	1.25	2,741
Windows U-.30, HP, Z A	Retro	45	482,920	0	330,701	55	14	0	$0.085	1.42	126
Heat pump water heater (50 gal)	New	15	51,670,935	17,579,404	77,327,128	11,191	9,372	0	$0.087	1.09	57,220
ER> Mini-split ductless heat pump Z A	Retro	15	102,594,743	0	113,394,190	18,956	4,752	0	$0.088	1.17	26,999
Common Area Lighting (MF Only)	New	7	1,582,628	0	2,719,162	320	320	9,298	$0.098	0.75	98,914
Wx (ceiling,	Retro	45	4,457,324	0	2,631,878	440	110	0	$0.098	1.23	1,332

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
floor, wall) HP, Z A											
Room AC (Z B)	Retro	18	399,552	0	351,758	0	160	0	$0.099	0.99	10,413
Windows U=.30, ER, Z A	Retro	45	43,573,221	0	25,498,403	6,416	178	0	$0.099	1.17	16,138
Room AC (Z A)	New	18	126,898	0	109,230	0	50	0	$0.101	0.97	3,172
HRV ER, Z B	Retro	18	49,462,424	0	42,301,109	10,644	296	0	$0.102	0.97	25,815
Energy Star lighting (18 lamps)	New	7	3,750,604	7,051,407	19,366,972	2,278	2,278	-220,943	$0.106	0.67	68,193
Tank upgrade (50 gal)-10 yr warranty	New	10	1,850,994	0	1,939,927	281	235	33,203	$0.109	0.79	52,886
Wx (ceiling, floor, wall) ER, Z A	Retro	45	60,163,084	0	31,141,246	7,836	218	0	$0.112	1.03	27,398
Estar Refrigerator	ReplaceAppl	12	25,968,609	0	22,282,698	2,621	2,621	364,509	$0.115	0.72	350,927
Heat Pump, (ER Base), Z A	Retro	18	198,216,860	13,125,841	158,700,068	39,933	1,109	0	$0.116	0.85	34,560
Solar hot water heater (50 gal) With electric backup.	ReplaceAppl	20	211,408,965	0	132,113,559	17,882	56,127	0	$0.131	0.75	51,221
HRV, Energy Star (ER Z C)	New	15	180,153	0	127,242	21	5	0	$0.138	0.75	209
Add 6 LED lamps (using CFL base) after 2015	New	10	1,166,918	0	1,224,896	144	144	-21,869	$0.138	0.52	24,311
Add 16 LED lamps (using CFL base) after 2015	New	10	3,111,782	0	3,184,729	375	375	-56,860	$0.142	0.51	24,311
HRV, Energy	New	15	721,500	0	466,187	78	20	0	$0.151	0.68	343

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
Star (ER Z B)											
Room AC (Z A)	Retro	18	1,043,487	0	571,919	0	261	0	$0.159	0.62	26,087
HRV, Energy Star (HP Z B)	New	15	533,340	0	309,340	52	13	0	$0.168	0.61	217
HRV HP Z B	Retro	18	41,986,466	0	20,302,954	3,394	851	0	$0.180	0.57	20,993
Evaporative Cooling (Direct/indirect) (Z A)	New	18	6,568,122	0	2,709,369	0	1,236	0	$0.211	0.47	8,210
HRV ER, Z A	Retro	18	102,228,241	0	39,908,681	10,042	279	0	$0.223	0.44	61,754
Evaporative Cooling (Direct/indirect) (Z A)	Retro	18	13,234,158	0	5,089,175	0	2,321	0	$0.226	0.43	16,543
HRV, Energy Star (HP Z C)	New	15	180,153	0	74,799	13	3	0	$0.235	0.44	83
Estar Refrigerator	New	12	23,020,024	0	10,480,014	1,233	1,233	-91,078	$0.257	0.30	163,263
AC Tune - up (Z B)	Retro	18	1,773,043	0	587,360	0	268	0	$0.262	0.37	11,820
Energy Star GSHP HSPF 12 (Z B)	New	15	2,985,394	0	1,099,714	184	46	0	$0.265	0.39	206
Wx Air Sealing, Z B	Retro	10	176,150	0	84,850	21	1	0	$0.271	0.33	406
Evaporative Cooling (Direct/indirect) (Z B)	Retro	18	7,991,038	7,790,119	4,592,401	0	2,094	0	$0.299	0.33	10,413
Solar hot water heater (50 gal) - With electric backup.	New	20	441,532,385	0	119,775,822	16,212	50,886	0	$0.301	0.33	68,665
ER> Mini-split ductless heat	New	15	7,435,423	0	2,336,847	588	16	0	$0.311	0.32	4,426

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
pump Z B in MF											
HRV HP Z A	Retro	18	17,258,740	0	4,121,654	689	173	0	$0.364	0.28	8,957
HRV, Energy Star (HP Z A)	New	15	800,932	0	211,949	35	9	0	$0.369	0.28	367
AC Tune - up (Z A)	Retro	18	5,815,065	0	1,267,361	0	578	0	$0.399	0.25	38,767
ER> Mini-split ductless heat pump Z A in MF	New	15	4,289,667	0	1,036,670	261	7	0	$0.404	0.25	2,553
Energy Star GSHP HSPF 12 (Z C)	New	15	1,044,888	0	238,774	40	10	0	$0.427	0.24	72
HRV, Energy Star (ER Z A)	New	15	1,867,679	0	405,945	102	3	0	$0.449	0.22	1,084
Energy Star GSHP HSPF 12 (Z A)	New	15	3,469,537	0	631,158	106	26	0	$0.537	0.19	239
Evaporative Cooling (Direct/indirect) (Z B)	New	18	3,573,289	0	549,870	0	251	0	$0.565	0.17	4,467
High SEER CAC, (SEER 15) (Z B)	Retro	18	11,613,021	0	1,664,658	0	759	0	$0.606	0.16	13,298
High SEER CAC, (SEER 15) (Z A)	New	18	69,356,751	0	9,456,652	0	4,313	0	$0.637	0.15	99,081
Room AC (Z B)	New	18	2,315,593	0	280,161	0	128	0	$0.718	0.14	57,890
High SEER CAC, (SEER 15) (Z A)	Retro	18	30,452,055	0	3,535,530	0	1,612	0	$0.748	0.13	33,836
ER> Mini-split ductless heat pump Z C in MF	New	15	4,289,667	0	554,593	140	4	0	$0.755	0.13	1,532
Home Energy	Replace	3	83,195,412	0	40,802,080	4,800	4,800	-897,046	$0.769	0.05	792,337

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Total KWh Savings	Winter Peak Savings, kW	Summer Peak Savings, kW	Gas Savings Therms	Level Cost, $/kWh	BCR	No. Units
Monitor											
High SEER CAC, (SEER 15) (Z B)	New	18	31,389,131	0	2,112,386	0	963	0	$1.291	0.08	44,842

Table 21: Detailed Measure Table, Residential Sector, Gas Savings, and 2030 Technical Potential

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Gas Savings Therms	Level Cost, $/th	BCR	No. Units
Low Flow Shower	Retro Gas	10	1,222,788	-3,181,526	12,113	-$21.145	100.00	38,069
Gas Hi-eff Washer	New Appl	12	-2,496,201	-4,369,577	88,046	-$1.911	100.00	25,101
Gas Hi-eff Washer	ReplaceAppl	12	-31,564,550	-59,619,232	661,514	-$1.872	100.00	242,804
Gas MEF 2.0 Washer	New Appl	12	-199,642	-252,916	6,622	-$1.833	100.00	2,231
Gas ETO Dishwasher	ReplaceAppl	12	-4,298,928	-16,558,780	114,745	-$1.436	100.00	174,745
Gas ETO Dishwasher	New Appl	12	-66,547	-317,136	2,829	-$1.416	100.00	3,347
Gas MEF 2.0 Washer	ReplaceAppl	12	-2,002,739	-2,200,275	38,831	-$1.235	100.00	17,117
Heating upgrade (AFUE 95) (Z A)	New Gas	15	-380,048	0	45,712	-$0.793	100.00	2,771
Heating upgrade (AFUE 95) (Z C)	New Gas	15	-71,202	0	9,721	-$0.715	100.00	479
Heating upgrade (AFUE 95) (Z B)	New Gas	15	-71,202	0	13,874	-$0.501	100.00	479
MF Corridor Ventilation	New Gas	15	0	0	483,536	$0.000	100.00	15,350
AFUE 92 to condensing combo hydrocoil, Z C	New Gas	45	17,953	0	24,026	$0.043	20.32	264
AFUE 92 to condensing combo hydrocoil, Z B	New Gas	45	17,953	0	21,650	$0.048	18.31	264
Window, retro (U=.35), Z B	Retro Gas	45	599,471	0	694,784	$0.050	17.59	4,867
AFUE 92 to condensing combo hydrocoil, Z A	New Gas	45	121,107	0	138,917	$0.050	17.41	1,781
Window, retro (U=.35), Z C	Retro Gas	45	615,179	0	499,806	$0.071	12.33	4,867
AFUE 95 Furnace, Z B	Replace Gas	18	789,914	317,173	984,463	$0.098	8.47	7,899
Window, retro (U=.20), Z B	Retro Gas	45	693,318	0	387,586	$0.104	8.49	1,521
Window, retro (U=.35), Z A	Retro Gas	45	6,224,460	0	3,281,961	$0.110	8.00	51,346
AFUE 95 Furnace, Z C	Replace Gas	18	776,894	317,173	704,387	$0.135	6.13	7,899
Window, retro (U=.20), Z C	Retro Gas	45	768,974	0	233,490	$0.191	4.61	1,521
Duct Sealing, Z B	Retro Gas	20	186,492	0	57,164	$0.266	3.14	594
E* Insulation, Ducts, DHW, Lights (Gas Z B)	New Gas	45	11,720,299	0	2,384,201	$0.278	3.17	16,448
Tankless Gas heater replace after 2015	Replace Gas	20	15,826,148	0	4,524,336	$0.285	2.81	16,448
Tankless Gas heater after 2015	New Gas	20	9,832,600	0	2,807,533	$0.286	2.80	79,131
Solar hot water heater (50 gal) - With gas backup.	New Gas	20	22,401,329	-19,953,670	697,771	$0.286	1.18	49,163

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Gas Savings Therms	Level Cost, $/th	BCR	No. Units
Solar hot water heater (50 gal) - With gas backup.	Retro Gas	20	60,015,479	-53,452,671	1,858,558	$0.288	1.18	5,428
E* Insulation, Ducts, DHW, Lights (Gas Z C)	New Gas	45	11,720,299	0	1,747,428	$0.290	3.04	14,541
E* Insulation, Ducts, DHW, Lights (Gas Z A)	New Gas	45	77,210,291	0	10,261,732	$0.297	2.97	111,960
Window, retro (U=.20), Z A	Retro Gas	45	7,652,950	0	1,489,220	$0.298	2.95	16,046
Duct Sealing, Z C	Retro Gas	20	193,859	0	52,961	$0.299	2.80	594
Tankless Gas heater replace	Replace Gas	20	54,891,879	0	13,413,665	$0.334	2.40	182,973
Tankless Gas heater	New Gas	20	2,674,065	0	652,585	$0.334	2.40	8,914
AFUE 95 Furnace, Z A	Replace Gas	18	6,907,414	2,773,525	2,340,995	$0.359	2.30	69,074
Upgrade Gas Hearth	Replace Gas	10	462,196	0	131,437	$0.460	1.69	28,887
Near Net Zero (Gas Z B)	New Gas	45	11,080,486	0	1,310,649	$0.485	1.82	2,501
HRV, Z B	Retro Gas	18	934,154	267,629	196,522	$0.531	1.56	1,868
Solar hot water heater (50 gal) - With gas aft 2015	New Gas	20	185,945,835	-148,133,828	5,160,721	$0.598	1.05	46,175
Tank upgrade (50 gal gas)	New Gas	15	2,784,067	0	450,096	$0.604	1.29	27,841
Near Net Zero (Gas Z C)	New Gas	45	3,077,913	0	281,389	$0.610	1.45	695
Condensing Tankless Gas heater	Replace Gas	20	16,852,696	0	2,254,012	$0.610	1.31	27,627
Condensing Tankless Gas heater	New Gas	20	1,212,543	0	161,958	$0.611	1.31	1,988
Solar hot water heater (50 gal) - With gas backup aft 2015	Replace Gas	20	45,372,149	-35,266,425	1,232,808	$0.669	1.03	10,993
Near Net Zero (Gas Z A)	New Gas	45	71,007,947	0	5,674,224	$0.725	1.22	16,029
HRV, Z C	Retro Gas	18	680,076	194,837	99,779	$0.762	1.09	1,360
Window U=.2 (Gas Z B)	New Gas	45	923,089	0	68,085	$0.785	1.12	1,267
Condensing Tankless Gas heater after 2015	New Gas	20	16,906,917	0	1,654,263	$0.834	0.96	33,151
HRV, E* (Gas Z B)	New Gas	15	3,518,829	0	394,464	$0.871	0.94	6,289
MF Corridor Ventilation	Retro Gas	15	2,773,077	0	291,173	$0.930	0.87	9,244
Window U=.2 (Gas Z C)	New Gas	45	922,490	0	56,676	$0.943	0.93	1,267
Wx insulation (ceiling, floor, walls), Z B	Retro Gas	45	8,188,487	0	451,759	$1.050	0.84	1,546
Window U=.2 (Gas Z A)	New Gas	45	6,026,665	0	320,825	$1.088	0.81	8,500
HRV, E* (Gas Z C)	New Gas	15	3,501,734	0	297,421	$1.150	0.71	6,289

Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Gas Savings Therms	Level Cost, $/th	BCR	No. Units
Move Ducts Inside, E* lights , Z A	New Gas	18	15,387,727	0	1,082,428	$1.235	0.67	9,617
HRV, E* (Gas Z A)	New Gas	15	22,440,837	0	1,683,065	$1.302	0.63	40,073
Move Ducts Inside, E* lights , Z B	New Gas	20	2,401,189	0	148,137	$1.323	0.63	1,501
HRV, Z A	Retro Gas	36	15,137,430	6,078,114	943,858	$1.393	0.63	30,275
Wx insulation (ceiling, floor, walls), Z C	Retro Gas	45	5,954,640	0	237,077	$1.455	0.60	1,124
Tank upgrade (50 gal gas) after 2015	New Gas	15	3,146,713	0	193,202	$1.590	0.49	17,879
Upgrade to forced draft tank	New Gas	20	3,595,132	0	168,464	$1.742	0.46	2,971
Duct Sealing, Z A	Retro Gas	20	896,539	0	39,971	$1.830	0.46	2,708
Move Ducts Inside, E* lights , Z C	New Gas	20	2,401,189	0	101,376	$1.933	0.43	1,501
Wx insulation (ceiling, floor), Z B	Retro Gas	45	10,196,220	0	305,476	$1.933	0.45	3,337
Upgrade to forced draft tank	Replace Gas	15	34,836,660	0	1,635,294	$2.204	0.35	28,791
Wx insulation (ceiling, floor), Z C	Retro Gas	45	7,593,608	0	174,141	$2.526	0.35	2,461
Wx Air Sealing, Z B	Retro Gas	10	209,107	0	9,850	$2.776	0.28	482
Wx Air Sealing, Z C	Retro Gas	10	335,530	0	15,786	$2.779	0.28	773
Wx insulation (ceiling, floor, walls), Z A	Retro Gas	45	123,705,281	0	2,572,669	$2.785	0.32	23,359
Upgrade to forced draft tank after 2015	New Gas	15	65,527,784	0	2,391,017	$2.849	0.27	59,034
Wx insulation (ceiling, floor), Z A	Retro Gas	45	145,192,683	0	1,880,950	$4.471	0.20	48,664
Wx Air Sealing, Z A	Retro Gas	10	10,558,357	0	197,803	$6.980	0.11	24,332