ENERGY EFFICIENCY RESOURCE ASSESSMENT
WASHINGTON SERVICE TERRITORY

Prepared for

Cascade Natural Gas

Draft Report

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Project Overview

The goal of this project was to provide Cascade Natural Gas (CNG) with the amount and cost of potential energy efficiency and renewable energy measures that could provide electricity and natural gas demand-side savings for Washington consumers by 2025 within the territory they serve. To do so, we adapted a similar resource assessment developed for the Energy Trust of Oregon. This resource assessment is designed to inform the project development and selection process. By 2025, about 70 Million therms of potential gas savings were identified in this study. Of that potential, about 59 million therms are considered to be achievable by conservation programs. It is important to note that this study covers only “core” customers – transportation customers are not included.

Stellar Processes and Ecotope, Inc., reviewed existing demographic and energy efficiency measure data sources to identify and quantify the resource potential and created easily updateable planning tools. CNG is unique in that much of their customer base has not been growing. In part, this is due to “rate shock”. In part, it is due to large customers choosing to purchase commodity elsewhere and purchasing only transportation from Cascade. As a result, most of the industrial customer base is “non-core” and in not included in this study. Where industrial customers are served as “core” customers, the meter often serves only a few small space-heating applications. Thus, the industrial sector becomes very similar to the commercial sector – both are dominated by space-heating consumption with little application for large industrial processes.

In order to show a reasonable perspective for the opportunities in new construction, we estimated potential savings for the forecast year 2025. That is, the potential savings labeled “new” represent the cumulative amount in new construction and appliances up to the year 2025.

A method to evaluate the cost of individual measures and packages of measures that takes into account the measure life, equipment and installation, annual O&M expenses and the societal discount rate produces levelized cost results that enable comparison of widely different program options and conservation strategies.

While this project was not intended to provide program design, it does identify and provide quantitative estimates of gas and measures of activity (such as number and energy use of households or total floor space) in the target markets for the residential and commercial sectors. In order to provide information that can be applied to the Integrated Resource Plan (IRP) planning process, we have prepared an estimate of the year-by-year DSM that could be provided by conservation programs.

Residential savings potential is quantified by housing type for new and existing single family, multifamily, and manufactured homes. Commercial savings estimates are quantified on a square footage basis for typical business type designations such as retail, grocery, and large and small office spaces. Industrial savings potential is quantified by the therms sold.

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 utility 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.

Figure 1 summarizes the results of this analysis for 2025. We imposed an arbitrary measure cost threshold of $0.85/therm levelized to limit the savings opportunities to those which have a more reasonable chance of being cost effective when compared to avoided energy costs. Although the supply curves do not include the highest cost measures, the tables of measures results in Appendix B include all measures considered in this study.

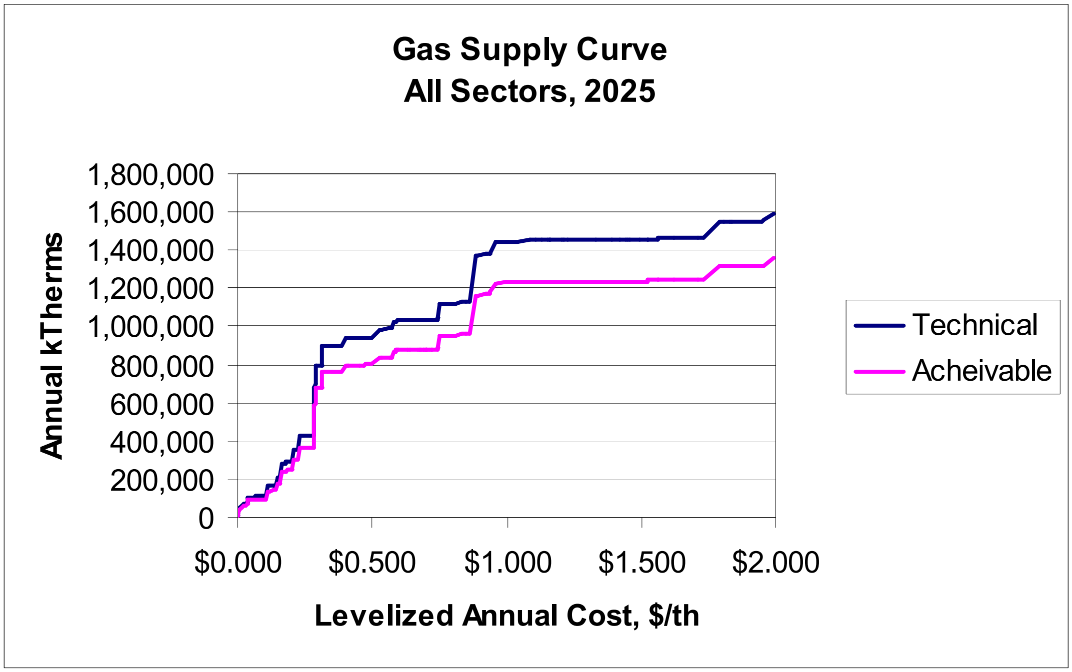

Figure 1. Natural Gas Supply Curve

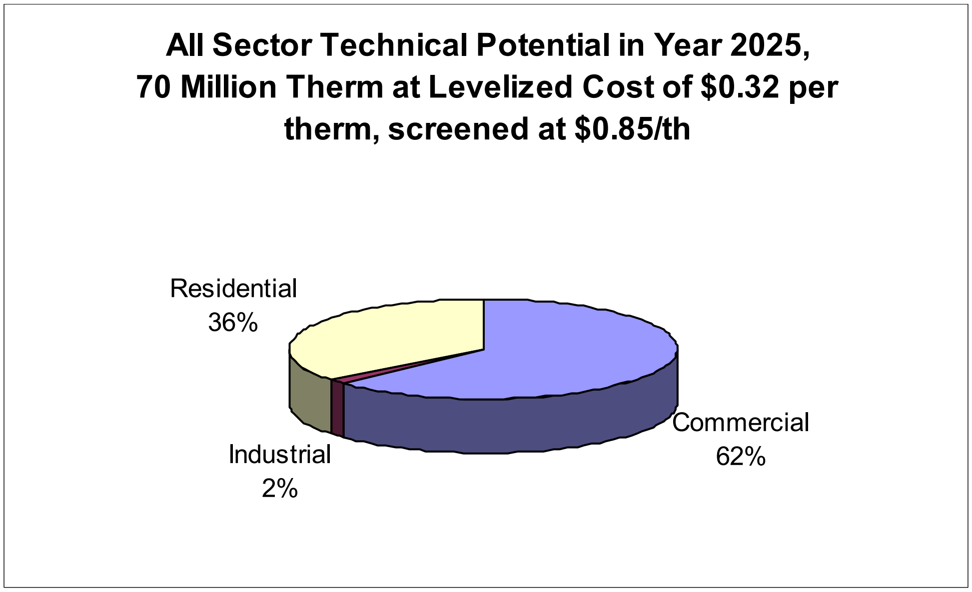

Figure 2. Natural Gas Technical Potential

Figure 2 shows the estimated savings from all measures would reduce year 2025 consumption by approximately 70 million therms at an average levelized cost of $0.32 per therm. While it may seem surprising that the industrial sector is so small, this is because most industrial customers choose to purchase natural gas as a transportation commodity, as will be discussed later.

Significant Conservation Efficiency Measures

Commercial Sector

Figure 3 shows the potential for groups of measures in the commercial sector with most significant savings grouped by applicability to existing stock as repair or replacement versus those specific to new construction. Table 13 lists details of the measures.

Potential gas conservation opportunities for 2025 are summarized in Figure 2 and Table 1. Opportunities are grouped by existing versus new building stock. Since space heating is the primary use, higher efficiency insulation for the building shell is a primary set of measures. Heat reclamation from refrigeration has emerged as significant due to recent regional market research. Otherwise, opportunities for savings are related to improved efficiency for equipment and systems.

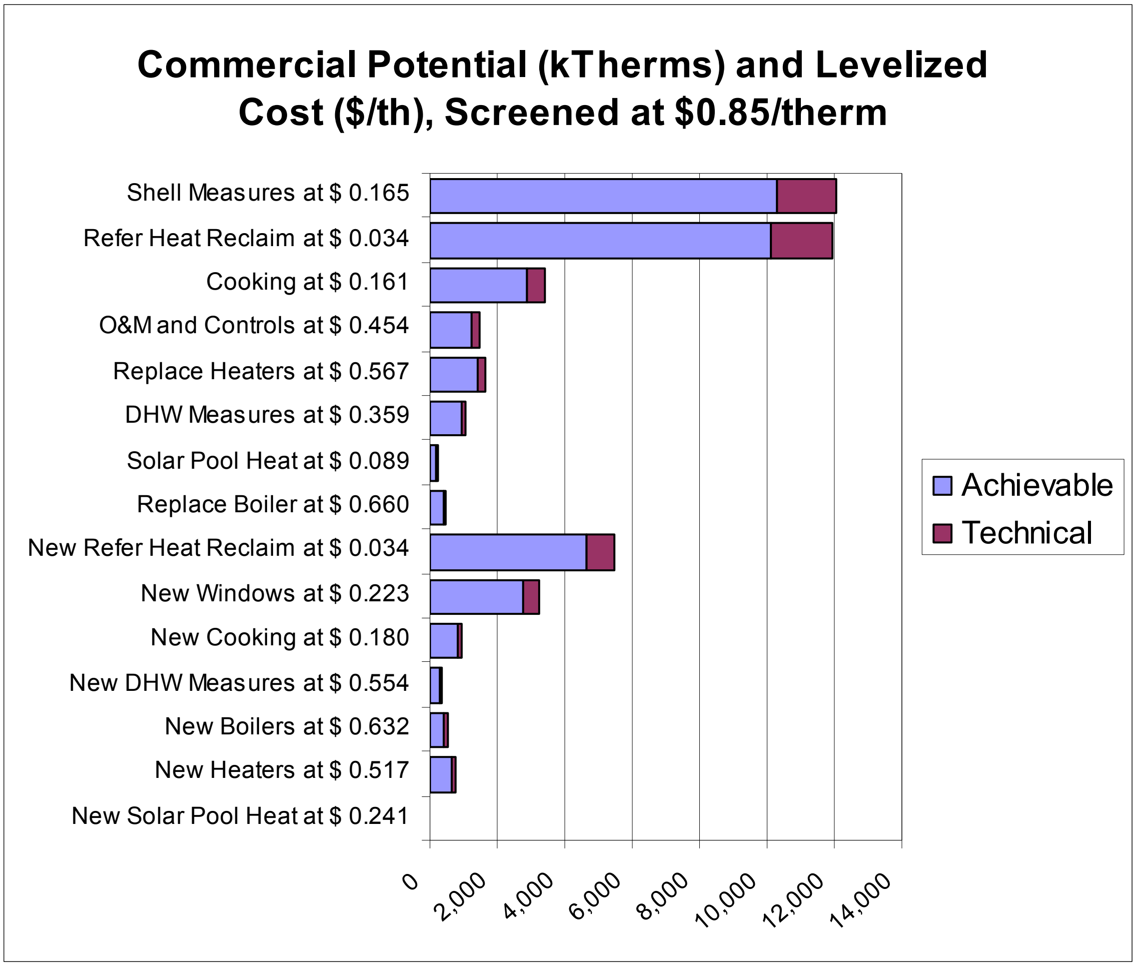

Figure 3. Major Commercial Sector Measures

Table 1. Commercial Sector 2025 Technical Potential Savings, Screened at $0.85/therm

Measure Category	Therms, thousands	$/th
Shell Measures	12,084	$0.165
Refer Heat Reclaim	11,926	$0.034
Cooking	3,399	$0.161
O&M and Controls	1,458	$0.454
Replace Heaters	1,660	$0.567
DHW Measures	1,076	$0.359
Solar Pool Heat	215	$0.089
Replace Boiler	491	$0.660
New Refer Heat Reclaim	5,471	$0.034
New Windows	3,264	$0.223
New Cooking	945	$0.180
New Heaters	737	$0.517
New DHW Measures	377	$0.554
New Boilers	514	$0.632
New Solar Pool Heat	32	$0.241
Total	**43,650**	**$0.167**

Residential Sector

For natural gas, the greatest opportunity lies new construction, including better insulation and windows, as well as heat recovery ventilation. Next in importance is weatherization of existing buildings, even though a substantial percentage of CNG's residential stock was likely to have been weatherized by an electric utility (pre-conversion) or the owner. Further opportunity lies in upgrading existing heating systems. Most measures are relatively expensive compared to the natural gas avoided cost although they could be cost effective over a long time frame.

Table 2. Residential Sector 2025 Technical Potential Savings, screened at $0.85/th

Measure Category	Therms, thousands	$/th
HVAC Retrofit	8,512	$0.454
Weatherization Retrofit	8,189	$0.726
New Construction	8,265	$0.600
Total	24,966	$0.592

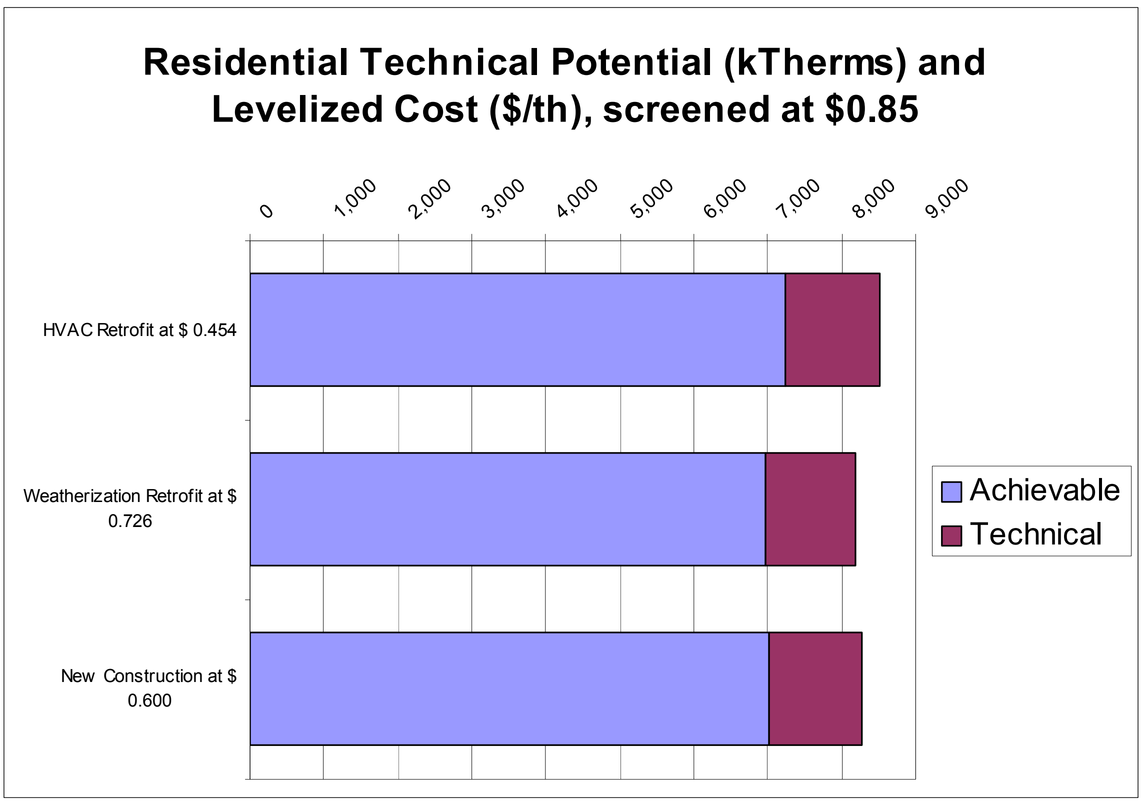

Figure 4. Major Residential Sector Measures

Industrial Sector

Characteristics of the industrial sector are quire different from what one might expect. Large industrial customers tend to purchase natural gas as a commodity; hence, they are “non-core” transportation customers only. Of some 89 million therms sold to non-residential customers, only about 10 million therms (11%) was supplied to customers with an industrial business. While one might expect that industrial process involve large applications of process heat, these same customers appear to often be limited to small space-heating applications. There is relatively little presence of what would usually be considered industrial processes – such as large furnaces or steam boilers. As a result, most of the conservation measures in the industrial sector are the same space-heating options that apply to commercial facilities.

Figure 5 shows the potential for groups of measures in the industrial sector with most significant savings grouped by applicability to existing stock as repair or replacement versus those specific to new construction. Table 3 lists details of these measures. Since space heating is the primary use, higher efficiency insulation and improvements to heating equipment are the primary measures.

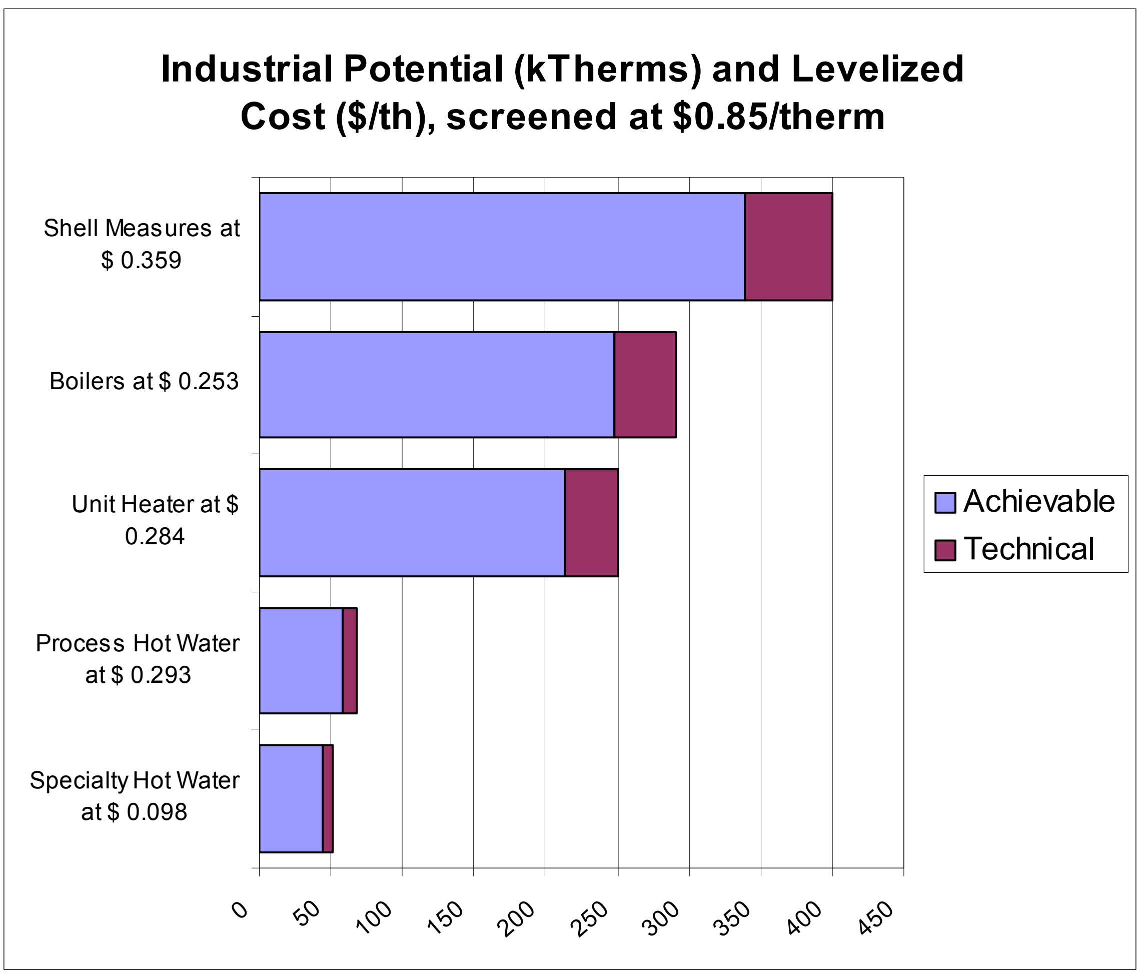

Figure 5. Major Industrial Sector Measures

Table 3. Industrial Sector 2025 Technical Potential Savings, screened at $0.85/th

Measure Category	Therms, thousands	$/th
Shell Measures	400	$0.359
Boilers	291	$0.253
Unit Heater	251	$0.284
Process Hot Water	68	$0.293
Specialty Hot Water	52	$0.098
Total	**1,061**	**$0.295**

Emerging Technology

Emerging technologies are those that show potential savings but are still not considered mainstream in the industry. A few measures in this category deserve discussion and possible support for demonstration.

Heat reclamation from commercial refrigeration has emerged as a new measure due to recent regional market research. Although still considered emerging, it's recognized as the second largest measure category for gas savings in this study. Heat recovery to DHW is low cost, easy to implement and enjoys wide market acceptance. Heat recovery for space heating is more complicated and, hence, more risky and less attractive to customers. It is one of relative few measures with large potential for gas conservation.

Similarly, Heat Recovery Ventilation (HRV) has a large technical potential in both the residential and the commercial sector. In this case, there are products available but local builders are reluctant to adopt them.

Technical Potential Savings Fraction

One perspective on the savings potential is to compare estimated savings to the amount of estimated consumption. Such a comparison may be presented as the expected fraction of savings. As a reality check, one would like to be comfortable that the expected savings represent a reasonable fraction of the expected consumption. For the current building stock, we estimate savings as shown in Table 4. The potential for commercial savings is relatively high because much weatherization remains undone.

Table 4. Technical Savings as Percent of Consumption in Existing Buildings

Commercial	31%
Industrial	14%
Residential	18%

Methodology

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

1. We quantified current energy use by sector unit (residential household, commercial square footage, and industrial by typical facility) and customer type within each sector (single family, small office, wood products, etc.).

It is important to understand how much energy is currently consumed for specific enduses and market segments so that the eventual savings estimates will be realistic. We utilized the utility estimates of sales by customer group and market segment and best estimates of Energy Use Index (EUI energy/sqft) factors to calibrate our estimates to match the actual utility sales data.

We reviewed several sources for utility sales data. One might think that this is a simple task, however the breakdown of customers into analysis categories is not the same as the way CNG defines business segments. Furthermore, there were a number of customers for which no business type had been assigned. Our assignment of business type matches utility records closely. Table 5 shows the sales data to which we calibrated our enduse models and assessments.

Table 5. 2004 Utility Sales for Calibration

	Consumption, ktherm
Commercial	74,165
Industrial	10,064
Residential	100,053
Total	**184,283**

2. We estimated energy consumption by end use for each customer type.

The methods varied by customer group. For the residential sector, we applied prototype models in three climate zones to estimate major enduse consumption, calibrated to actual sector consumption. For the commercial sector, the EUI factors provided consumption by enduses. For the industrial sector, we developed sharedown fractions that allocated therm sales to specific enduses.

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

We applied the same forecasted growth used by the utility in their planning to project future sales. In the case of CNG, it is important to recognize that much of the sales are predicted to decrease.

4. We reviewed information on specific measures for applicability to CNG-Washington customers.

This information includes estimates of incremental cost and savings but also assesses the market potential for specific measures. Applicability of some measures might depend on the fuel for space heating, for example. Also, the amount of remaining potential is affected by the extent to which the market for a specific product is currently saturated.

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 Planning Council's (NPPC) Regional Technical Forum (RTF) data was utilized in the residential sector to collect costs and energy benefits. In addition, the NPPC 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. 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 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.

Assessment of Potential Measures

In the commercial sector, we reviewed 93 measures. Of course, each measure is developed separately for 12 building types. In residential sector, we reviewed 20 measures. Each measure is developed separately for three building types.

The measures identified in the initial list of measures were then analyzed for cost and performance in the service territory. We collected data on measure costs, benefits, technological maturity, and applicability. We studied the 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.

The study is structured to present efficiency potential by measures directed to "New Construction", "Retrofit" or "At Replacement". "At 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 removing and replacing 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.

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 were 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, and over existing equipment for retrofit situations. These measures generally examine one-for-one equipment selections so all other costs are assumed to be the same. In cases where additional installation 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).

For the savings analysis, we assumed that the measure would be applied to 100% of situations for which it was applicable and for which no related measure was applied. For retrofit measures, we assumed that all the population would be addressed. 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, we assumed that all of the applicable new construction was treated every year. Growth rates were developed based on utility projections. Thus, for replacement and new measures it is important to specify a target year sufficiently into the future that significant new resource will be counted. We utilized the year 2025 as a target year for assessment.

Retrofit and Replacement can be in conflict – if one does a retrofit measure, it may eliminate the efficiency opportunity from a potential 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, but 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.

While we have developed a supply curve for only one fuel, we recognize that many measures save both electricity and gas on the same site (e.g., building energy management system). 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. In the case where the same measure saves both fuels, we compute the Net Present Value (NPV) of lifetime avoided cost for both fuels and use the ratio of the NPV's 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.

Tool Selection and Use

One of the primary goals of this project was to develop a method of analyzing measures across sectors and technology types that would provide a means of comparing anticipated costs and benefits associated with a variety of program options. A spreadsheet-based tool was adopted and modified for this purpose.

The Assessment Tool selected 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, 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.
- 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 Utility 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, subsector 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 we selected did not provide optimum flexibility to analyze measures by subsector or across subsectors 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.

Supply Curve of Conservation Measures

The results of our assessment are provided in the form of separate spreadsheets for the residential, commercial and industrial sectors (see end tables for the final lists of measures). For each measure or package of measures, we developed cost and savings estimates, as well as an estimate of overall achievable energy savings for the future. To generate both the costs 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

The levelized cost for each measure or package of measures can be used to compare and rank measures. The levelized cost calculation starts with the incremental capital cost of a given measure or package of measures over and above the cost of standard technologies. This cost is amortized over an estimated measure lifetime using an average societal discount rate (in this case a real discount rate of 5.17 percent per year). Cost includes any net annual operating and maintenance cost (or benefit). This annual net measure cost is then divided by the annual net energy savings from measure application (again relative to a standard technology) to produce the levelized cost estimate in dollars per therm saved, as illustrated in Formula 1.

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

The levelized cost is a figure that can be compared with the full cost of acquiring natural gas from other sources. The levelized cost approach was chosen as the most practical and useful method of comparing measures of various types and applications.

The final result of this analysis provides the cumulative amount of potential resource available at a given levelized cost, as shown in Figure 2.

Commercial Sector Resource Assessment

Commercial Segment Description

Cascade Natural Gas serves a wide variety of counties of suburban/urban settings throughout the state of Washington. Its service territory encompasses relatively little highly urbanized area -- though it does include smaller cities such as Yakima and Bellingham, and large amounts of rural areas in both eastern and western Washington. A total of sixteen counties are served in whole or in part, by CNG. For this analysis we collapse individual service territories into a single set of commercial buildings based on end use. From billing records that included all non-residential customers and various multi-family managed properties provided by CNG, industrial and multifamily residential customers were culled to leave an estimate of the commercial sector.

The billing records for these “non-residential” customers included a categorization for each billing record. CNG used this categorization to characterize the type of business and end use for each customer. Customers were divided into approximately twenty categories including nine commercial, eight industrial and three “other.” The process of culling out the industrial sector included reviewing categorizations of individual customers, determining which of those customers actually appeared in other categories besides industrial, and vice versa. The CNG’s “other/miscellaneous” categories were also reviewed in detail and individual customers were assigned to major building categories or to industrial categories as appropriate. Finally, individual company names and use patterns were reviewed and approximately twenty percent of CNG’s categorizations were re-classified to match the array of building types used in this resource assessment.

This process was in turn summarized into twelve building categories to correspond with the regional tools developed for assessment of both electrical and gas conservation opportunities throughout the region.

Table 6 summarizes the results of this effort. It includes 18,981 commercial sector customers. This accounting represents approximately 2000 customers less than the total non-residential customer records provided by the utility. These 2000 were largely the industrial sector although several of them were re-categorized as residential since they represented residential complexes.

Table 6. Cascade Natural Gas Commercial Sales (2004)

Building Type	Therms (thousands)	% Sales	Customers	% Customers
College	1,344	1.8%	94	0.5%
Grocery	4,038	5.3%	536	2.8%
Health	4,681	6.1%	1,123	5.9%
Hospital	858	1.1%	48	0.3%
Large Office	9,486	12.4%	538	2.8%
Lodging	3,301	4.3%	335	1.8%
Other	6,048	7.9%	1,069	5.6%
Restaurant	11,671	15.3%	2,026	10.7%
Retail	11,725	15.3%	5,994	31.6%
Small Office	7,140	9.3%	5,187	27.3%
School	10,403	13.6%	773	4.1%
Warehouse	5,832	7.6%	1,258	6.6%
Total	76,528		18,981	

A total of 76.5 million therms of sales were used as the basis for this allocation.

The commercial conservation resource assessment uses these twelve categories of buildings in order to assess the approximate saturation and impact of conservation programs based on components derived from survey information collected in Washington and Oregon. This information was not directly culled from CNG service territory, however it represents a similarity to the CNG service territory array of end-uses, building types and building sizes.

Building Type Definition

CNG provided a categorization for each customer based on end-use type. This needed to be adapted to include definitions more aligned to the conservation assessment tools. Each of the individual categories was re-defined using the combination of previously developed work for the resource assessments and information contained in CNG's categorization for these customers.

2.1. Small & Large Office Category

This category was, for the most part, derived from the "C8" category for CNG, which was, in turn separated into categories for small and large offices based on actual energy use. Earlier in the process it was determined that the customer square footage information in the CNG billing records was fairly unreliable and represented a poor relationship between the actual energy use and the reported building size. Thus, absolute therms consumption was used as the determining factor for office size. The division between small and large offices was set at about seven thousand therms, annually corresponding to roughly a 20,000 ft2 building. Customers with usage below this threshold were categorized as the small office sector. The remaining offices were categorized as large offices. Both these categories together were the office sector and represent about 22% of total commercial CNG sales.

2.2. Restaurant and Food Service Sector

This sector was well defined by CNG. However about fifteen percent of this category consists of additional restaurants identified while reviewing the billing records and company names in other CNG classifications (especially "O3" other commercial) categories of the commercial sector. About 200 of these customers were re-coded as restaurants. Approximately 15% of CNG commercial sales were in the restaurant sector.

2.3. Retail

The retail category was equally split between "other/miscellaneous" (O3) and "retail" categories (C7) used by CNG. As a result, the total retail sector used here is about double that from CNG's billing records. Using this re-coded definition, which includes individual stores, malls, and related commercial establishments, the total of 15% of commercial sales in the CNG commercial sector was used by the retail sector.

2.4. Groceries

This is a special type of use and is defined separately by both CNG and other resource assessments. This is special because of the large refrigeration loads that change the characteristics of energy use in these buildings loads are beyond that expected for the rest of the retail sector. For the most part, these categorizations are largely the same as described by CNG although we re-coded some mis-categorized customers. This sector accounts for about 5% of CNG commercial sector usage.

2.5. Warehouses

Like the grocery sector, the warehouse sector was well defined by the CNG utility. As with the other situations, additional warehouse uses were recognized and re-coded into this category especially form the O3 category that served as a catch-all in some localities in the CNG service territory. This re-assignment represents an eight percent increase in the total number of warehouse customers. The warehouse sector represents almost 8% of the commercial gas sales while it also represents the largest single category of square foot area served by CNG.

2.6. Schools

Schools are defined as K-12 grade educational institutions and they include church schools, day-care centers and other instructional facilities. This category was also defined this was by CNG although approximately twenty five percent of the total category consists of re-coded customers, especially from the CNG "Other/miscellaneous/undefined" (O3) category. Overall, this category accounts for about 13.5% of commercial sales and is fairly uniformly distributed throughout the service territory.

2.7. Colleges

This sector is constructed from customer name categories and is meant to characterize the central institutions throughout the service territory. These are thought to be areas where district heating and other centralized energy management may be present. Slightly less than one hundred separate college accounts were identified and had been spread throughout a number of CNG categorizations. Thus the "college" category is a construct of several of the CNG categories based on our review of all the accounts presented and because of this, the opportunity for mis-categorization is somewhat higher, especially for college categories that did not have a clearly defined account name. This is one of the smallest categories and represents slightly less than 2% of commercial sales.

2.8. Hospitals/Health

Hospitals have a specialized end-use and they represent specialized energy conservation and energy management problems. Thus, they are even separated from other medical and healthcare facilities and reflect a division of the "health" (C5) category used by CNG into a hospital subset. The remaining customers in this category were included as "health" and included clinics, doctor and dentist offices, and several uses involving skilled nursing such as nursing homes, assisted living centers, rehabilitation centers, retirement homes, etc. These two categories together represent approximately 7% of commercial CNG sales.

2.9. Lodging

This category describes commercial lodging in the form of hotels, motels, resorts, etc. In general, these facilities are scattered throughout the service territory but were categorized by the utility in a "lodging" category (C4). In our review, an additional twenty-five percent of this classification was added from other categories especially "other/miscellaneous". This category represents about 4% of CNG commercial sales.

2.10. Other

This group includes commercial customers that were not easily defined in any one of the other major categories. This included churches and other assembly buildings such as gymnasiums, theaters, etc. It also included buildings with specialized uses like casinos, jails, fire stations, etc. This category also included municipal uses that were not office spaces and might include swimming pools or other kinds of public activities. Efforts were made to re-categorized certain municipal facilities such as water-treatment plants as industrial. This category represents about 8% of commercial sales, the vast majority of which are churches.

A list of the major commercial measures, ranked by the levelized cost, is provided in Table 1 and Table 13. These lists present individual measures, with costs and benefits resulting from the applicable population.

Description of Commercial Measures

For this study, the detailed measure descriptions are included in Table 13. Significant changes from previous studies include a more thorough development of refrigeration measures that have impact on potential gas savings.

Large Refrigeration Energy Efficiency Measures

Energy efficiency measures were developed from Supermarket Energy Efficiency (NEEA, 2005) for large supermarket refrigeration systems. Refrigeration Heat Reclaim has large potential heating savings. 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.

Window Measures

Window energy savings were predicted with building energy simulation models. The window market was divided into vinyl and aluminum frame, and tinted versus untinted. 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 Washington code has low and high glazing fraction paths. The high glazing path requires maximum performance windows, which effectively 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.

Table 7. 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					
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

Residential Sector Resource Assessment

Residential Sector Characterization

For this analysis, three residential subsectors were considered: single family, manufactured homes and multi-family units. We further divided these subsectors into low income and all other income levels (see the CNGResPopulation.xls spreadsheet). 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 14. These tables provide results for the measures applied to the appropriate population. A short description of assumptions used to develop these measures follows.

HVAC

1. PTCS 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. 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%.

3. Gas Boiler Combo (with DHW)

For this measure, both the upgrade from a furnace with an AFUE of .8 to a boiler AFUE of .85 and a 15% duct leakage improvement were included.

Envelope

1. Window Upgrades (New/Replacement)

Improvement from U=.4 to U=.3.

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

Addition of heat recovery to ventilation system and whole house sealing.

3. Upgrade insulation to Energy Star levels (New). This measure was examined both as a stand-alone measure and combined with a PTCS-level duct system. For this measure, the base case 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.

4. Insulation improvements (Retrofit)

For the retrofit sector, the base cases were drawn from the existing building prototypes, weighted by vintage using data from the US Census, and adjusted to account for homes that have already been weatherized. 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 Rvalue. 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.

Domestic Hot Water

1. 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. Measures include a water tank upgraded from EF=.59 to EF=.65, as well as an upgrade to a condensing gas furnace with an EF of .86.

2. Solar Water Heater (New/Replacement)

This measure assumes that a gas water heater is replaced with a solar water heater with backup, reducing the water heating load by about 50%. Source for solar details was the Oregon Department of Energy.

3. Tankless Water Heater

A tankless gas water heater offers savings because it saves standby losses and has a high burner efficiency, increasing the EF rating from .65 to .85. We included these appliances as having a high technical potential. (Reference: Tankless Gas Water Heaters: Oregon Market Status, ETO, December 6, 2005.)

Industrial Sector Resource Assessment

Industrial Sector Characterization

As discussed earlier, the first issue was to separate commercial and industrial facilities. The types of business cannot always be determined from the rate schedule. That is, there are both industrial and commercial businesses within both 504 and 505 Rate Schedules. In most cases, Cascade Gas has described the appropriate business segment. However, a significant number of customers were not defined. For those customers, we made a determination of the business segment according to the customer's name and other characteristics. Figure 6 and Table 8 show 2005 consumption by industrial business segment.

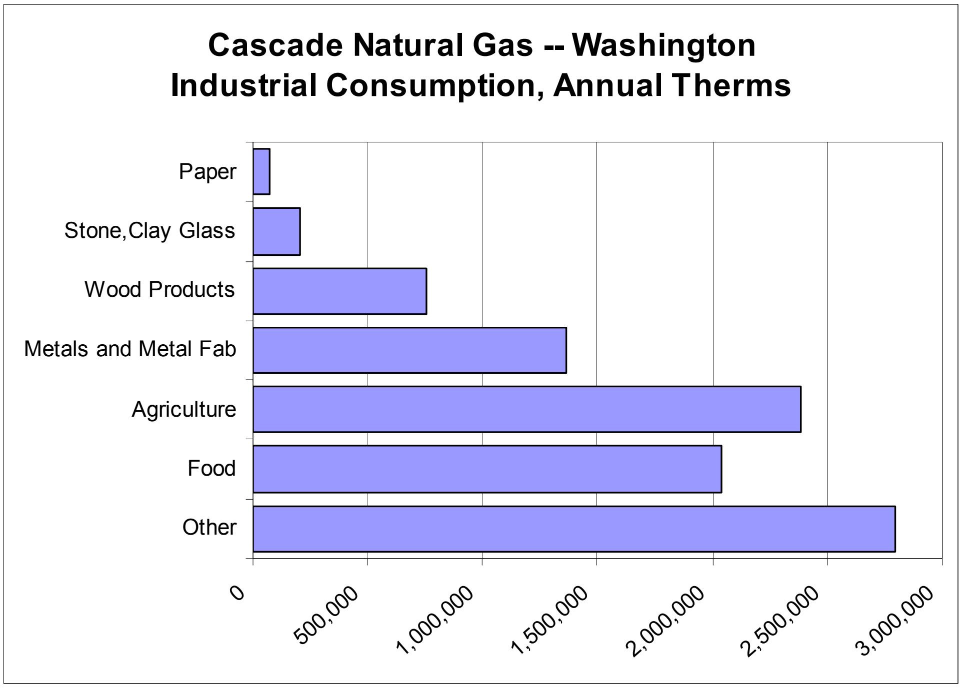

Figure 6. Industrial Consumption

Table 8. Cascade Natural Gas – Washington 2005 Consumption

Business Segment	Therms
Other	2,794,845
Food	2,041,703
Agriculture	2,472,598
Metals and Metal Fab	1,067,208
Wood Products	850,851
Stone,Clay, Glass	206,596
Paper	76,843
Total	10,269,144

Note that 10 million therms is a small amount of sales for the industrial sector – that is because most of the sales are transportation to “non-core” customers and “non-core” customers are not included in this study. The “core” sales to these customers appear to often be small space-heating applications with little that might be considered industrial processes – such as large furnaces or steam boilers.

As a result, most of the conservation measures are the same space-heating ones that apply to commercial facilities. The difference is that we have little information on the applicable square footage of industrial facilities so savings opportunities are computed from the total therm sales. As part of that procedure, we developed sharedowns that represent the fraction of therm sales applicable to specific enduses within the facility types.

Table 9. Industrial Process Sharedowns

Business Segment	Process Heating				Space Heat			Hot Water	
	Drying and Curing	Baking, Heat Treating	Melting and Casting	Process Boiler	Furnace	Unit Heater	SH Boiler	Specialty HW	HW
Agriculture	7%			8%	17%	35%	6%	5%	22%
Food	3%	1%		8%	24%	2%	12%		50%
Lumber	12%			4%	18%	43%	1%		23%
Paper	54%				31%	13%			2%
Stone,Clay Glass			22%		27%	27%			24%
Metals	9%	20%	23%		27%	18%			3%
Other	20%	17%			40%	17%		0%	6%
Total	10%	7%	3%	4%	25%	19%	4%	1%	20%

Table 9 shows the process shares. Space heating is relatively large and process heating relatively small. This would not usually be true of industrial customers but it reflects the fact that these meters tend to be atypically small, "core" customers. Unit heaters appear to be frequently used for space heating. Hot water is a major process load in many sectors. A few customers have steam boilers – in which case, the hot water is included under "Process Boiler". For the remaining customers, hot water is supplied using commercial scale water heaters. "Specialty Hot Water" represents hot water in dairies and commercial laundries -- for which we have identified specific conservation measures.

Industrial sector consumption is forecast to decline in several localities. Figure 7 shows forecasted consumption by industrial sectors.

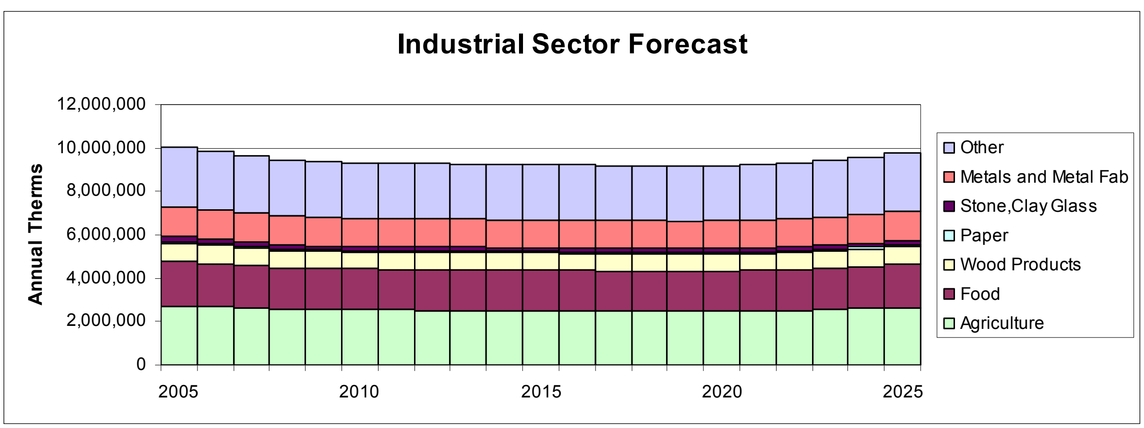

Figure 7. Industrial Forecast

Description of Industrial Measures

The majority of conservation measures are the same ones applicable to commercial businesses. These include insulation and space heater improvements to conserve on space heating, as well as commercial water heater, steam boiler measures and efficient clothes washer (applicable only to commercial laundries). Many of these measures could be deployed in the same manner as commercial measures – that is, either as a one-time retrofit or during an on-going program of upgrade during normal replacement. However, both approaches cannot be applied to the same conservation opportunity. We included a logic check to ensure that we did not double-count retrofit and replacement measures when both are applicable.

A few measures are specific to industrial processes – to the extent that furnaces or ovens are involved, there is opportunity to upgrade the efficiency of process heat. Details of this measure were developed from projects in California (CADMAC, 2006.). Heat recovery from refrigeration is a potential measure in dairies to supply hot water. Details for this measure were taken from a specific Oregon project (Hesse Dairy, 2001).

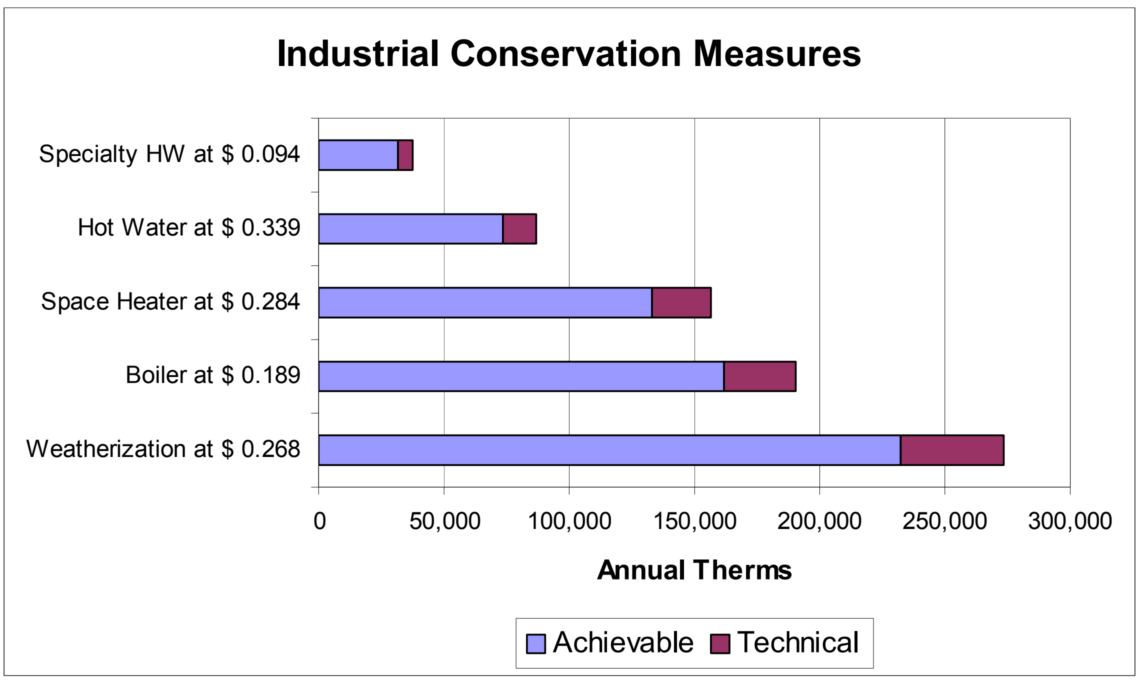

Figure 8. Major Industrial Measures

Table 10 shows a list of industrial sector measures. A levelized cost screen of $0.85 per therm is assumed to represent the cost-effectiveness limit.

Table 10 List of Industrial Measures

Measure Type	Savings Achievable Potential, therms	Levelized Cost, $/therm
Weatherization	232,500	$0.268
Boiler	161,698	$0.189
Space Heater	132,874	$0.284
Hot Water	73,594	$0.339
Specialty HW	31,629	$0.094

One test to verify the savings potential is to compare estimated savings to the amount of estimated consumption. Such a comparison may be presented as the expected fraction of savings. As a reality check, one would like to be comfortable that the expected savings represent a reasonable fraction of the expected consumption. Figure 9 shows that the technical potential savings fraction for industrial business segments tends to be about 15%. Note that this savings fraction has not been reduced be applying a cost-effectiveness screen. Only about half this amount of savings would be cost-effective at current avoided costs.

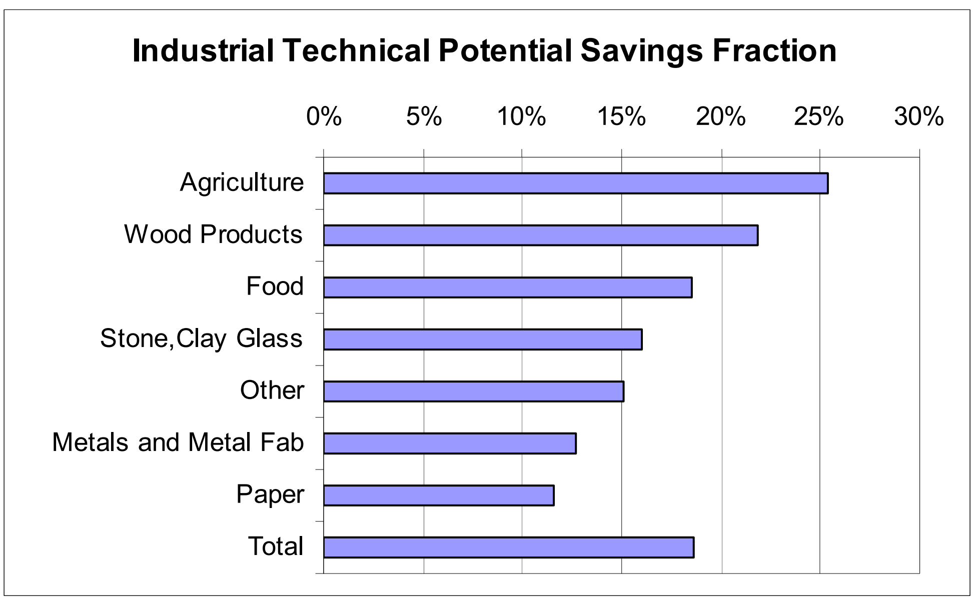

Figure 9. Savings Fractions for Industrial Subsectors

Deployment Scenario

In order to provide information that can be applied to the Integrated Resource Plan (IRP) planning process, we have prepared an estimate of the year-by-year DSM that could be provided by conservation programs. Results are presented in Figure 10 and described in more detail in Table 11.

The following deployment scenario is based on the following considerations:

1. Achievable Potential, screened at $0.85/therm levelized societal cost.
2. Replacement measures are included where practical, as these are generally more cost effective than retrofit measures. To avoid double-counting, retrofits are constrained to those measures where replacement options do not apply.
3. Annual DSM amounts include new construction and replacement of existing equipment as it occurs during each year. Retrofit amounts are assumed to reach the achievable potential over a ten-year time period, starting in 2007.
4. Most of the conservation measures have lifetimes longer than the planning horizon. For the few measures that do not (efficient furnace and duct sealing), we extend the lifetime and include the present value of replacement as an O&M cost. This has no effect on levelized cost but does assume that owners will replace to the same efficiency level.
5. It is beyond the scope of this project to design DSM programs. However, for purposes of the IRP planning process, one needs a rough estimate of the utility cost involved in implementing a resource acquisition. For planning purposes, we estimate that these programs will have a utility cost averaging 25% of the initial cost for incentives plus an additional 15% for program administration. The resulting costs have been computed as shown in Figure 11.

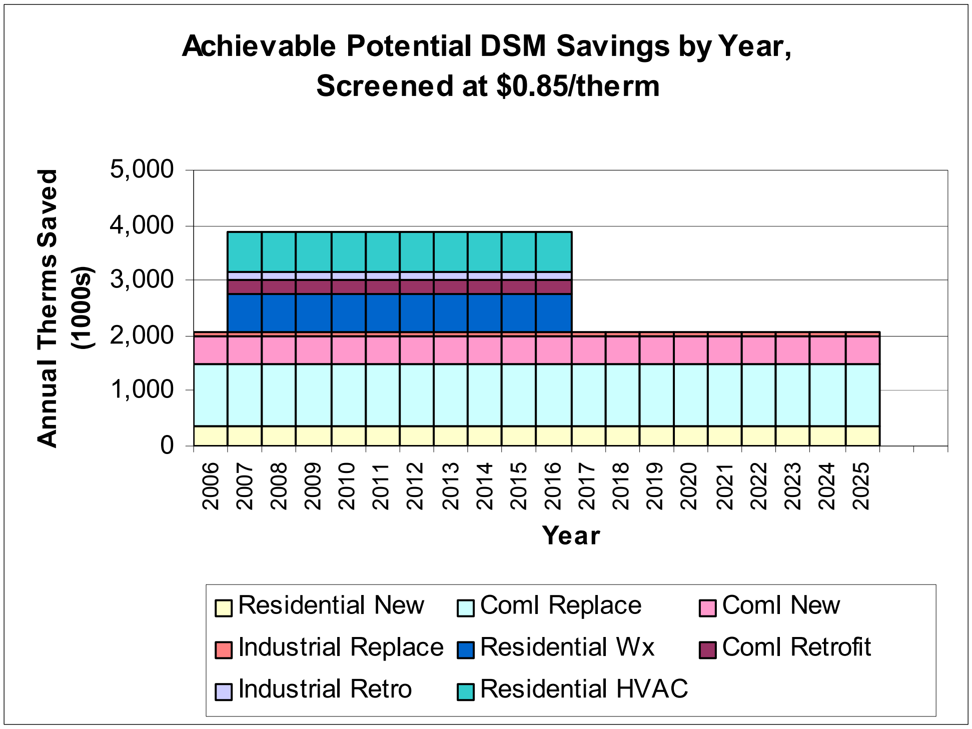

Figure 10. DSM Deployment Scenario

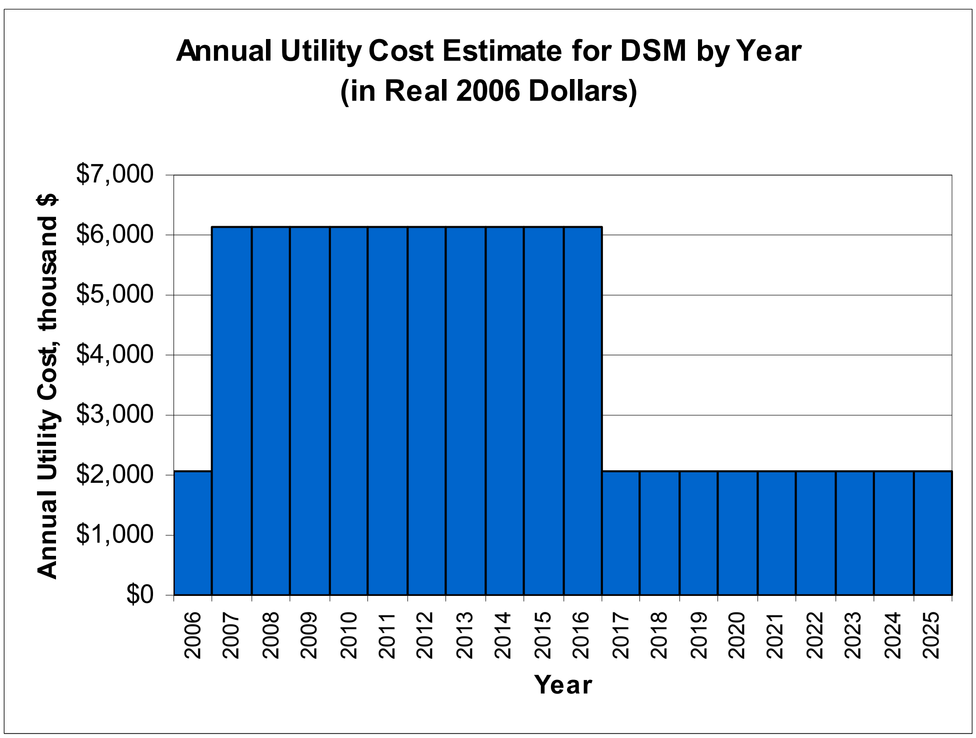

Figure 11. Estimate of Annual Utility Cost

Technical Appendix: Detailed Measure Descriptions

Table 11. DSM Deployment Scenario, Thousands of Annual Therm Saved by Year

Year	Levelized Utility Cost, $/th	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Residential Wx	$0.146	0	696	696	696	696	696	696	696	696	696	696	0	0	0	0	0	0	0	0	0
Residential HVAC	$0.194	0	724	724	724	724	724	724	724	724	724	724	0	0	0	0	0	0	0	0	0
Coml Retrofit	$0.067	0	229	229	229	229	229	229	229	229	229	229	0	0	0	0	0	0	0	0	0
Industrial Retro	$0.073	0	171	171	171	171	171	171	171	171	171	171	0	0	0	0	0	0	0	0	0
Residential New	$0.176	351	351	351	351	351	351	351	351	351	351	351	351	351	351	351	351	351	351	351	351
Coml Replace	$0.043	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144
Coml New	$0.051	482	482	482	482	482	482	482	482	482	482	482	482	482	482	482	482	482	482	482	482
Industrial Replace	$0.100	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88
Total	**$0.296**	**2,065**	**3,885**	**3,885**	**3,885**	**3,885**	**3,885**	**3,885**	**3,885**	**3,885**	**3,885**	**3,885**	**2,065**	**2,065**	**2,065**	**2,065**	**2,065**	**2,065**	**2,065**	**2,065**	**2,065**

Table 12. DSM Deployment Scenario, Annual Utility Cost, Thousands of Dollars

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Residential Wx	$0	$2,197	$2,197	$2,197	$2,197	$2,197	$2,197	$2,197	$2,197	$2,197	$2,197	$0	$0	$0	$0	$0	$0	$0	$0	$0
Residential HVAC	$0	$1,497	$1,497	$1,497	$1,497	$1,497	$1,497	$1,497	$1,497	$1,497	$1,497	$0	$0	$0	$0	$0	$0	$0	$0	$0
Coml Retrofit	$0	$382	$382	$382	$382	$382	$382	$382	$382	$382	$382	$0	$0	$0	$0	$0	$0	$0	$0	$0
Industrial Retro	$0	$4	$4	$4	$4	$4	$4	$4	$4	$4	$4	$0	$0	$0	$0	$0	$0	$0	$0	$0
Residential New	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030	$1,030
Coml Replace	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661	$661
Coml New	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371	$371
Industrial Replace	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5	$5
Total	$2,066	$6,147	$6,147	$6,147	$6,147	$6,147	$6,147	$6,147	$6,147	$6,147	$6,147	$2,066	$2,066	$2,066	$2,066	$2,066	$2,066	$2,066	$2,066	$2,066

Note: Costs are shown in thousands of real, constant value, 2006 dollars. Neither inflation nor present valuing has been applied.

Table 13. Detailed Measure Table, Commercial Sector, 2025 Technical Potential

Measure Code	Measure Name	Measure Description	Construction Type	Measure End Use	Gas Impacts Therms	Levelized Cost, $/kWh	Levelized Cost, $/th
W123r	HiEff Clothes Washer	Install high performance commercial clothes washers - residential sized units	At Replacement	Water Heat	182	na	($0.3029)
W123	HiEff Clothes Washer	Install high performance commercial clothes washers - residential sized units	New	Water Heat	51	($0.0241)	($0.2985)
E114	Windows - Add Low E to Vinyl Tint	Windows - Add Low E to Vinyl Tint. Application: Old buildings	At Replacement	Heating	528	$0.0020	$0.0283
R101	Heat Reclaim with Floating Head Control	Large Grocery - Heat recovery to space heating with floating head control	New	Refrigeration	5,471	$0.0034	$0.0341
R101rep	Heat Reclaim with Floating Head Control	Large Grocery - Heat recovery to space heating with floating head control	At Replacement	Refrigeration	11,926	$0.0034	$0.0341
E115	Windows - Add Low E and Argon to Vinyl Tint	Windows - Add Low E and Argon to Vinyl Tint. Application: Old buildings	At Replacement	Heating	879	$0.0026	$0.0366
C116	Estar Steam Cooker	Install Energy Star Steam Cooker	New	Cooking	125	na	$0.0443
C116rep	Estar Steam Cooker	Install Energy Star Steam Cooker	At Replacement	Cooking	424	na	$0.0443
E121	Windows - Tinted AL Code to Class 40	Windows - Tinted AL Code to Class 40. Application: Old buildings	At Replacement	Heating	295	$0.0033	$0.0477
E123	Windows - Add Low E to Vinyl Tint	Windows - Add Low E to Vinyl Tint. Application: New Construction	New	Heating	200	$0.0041	$0.0594
E101	Wall Insulation - Blown R11	Wall Insulation - Blown R11. Application: Old buildings	Retrofit	Heating	1,981	$0.0043	$0.0701
E124	Windows - Add Low E and Argon to Vinyl Tint	Windows - Add Low E and Argon to Vinyl Tint. Application: New Construction	New	Heating	277	$0.0054	$0.0772
E111	Roof Insulation - Attic R0-30	Roof Insulation - Attic R0-30. Application: Buildings with uninsulated attics	Retrofit	Heating	121	$0.0049	$0.0798
C112	Infared Fryer	0	New	Cooking	494	na	$0.0871
C107	Infared Fryer	0	At Replacement	Cooking	2,051	na	$0.0881
M105r	Solar Pool Heaters	Install solar pool heaters in public, educational and other swimming pool	Retrofit	Misc.	215	na	$0.0887
H105	HW Boiler Tune	Tune up in accordance with	Retrofit	Heating	9	na	$0.0916

Measure Code	Measure Name	Measure Description	Construction Type	Measure End Use	Gas Impacts Therms	Levelized Cost, $/kWh	Levelized Cost, $/th
		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.					
E122	Windows - Tinted AL Code to Class 36	Windows - Tinted AL Code to Class 36. Application: Old buildings	At Replacement	Heating	696	$0.0066	$0.0941
E130	Windows - Tinted AL Code to Class 40	Windows - Tinted AL Code to Class 40. Application: New Construction	New	Heating	102	$0.0071	$0.1017
H104	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	284	na	$0.1154
E103	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	At Replacement	Heating	418	$0.0083	$0.1345
E102	Wall Insulation - Spray On for Metal Buildings	Wall Insulation - Spray On for Metal Buildings (Cellulose) Unfinished. Application: Old buildings	Retrofit	Heating	324	$0.0000	$0.1528
E125	Windows - Add	Windows - Add Argon to	New	Heating	527	$0.0000	$0.1586

Measure Code	Measure Name	Measure Description	Construction Type	Measure End Use	Gas Impacts Therms	Levelized Cost, $/kWh	Levelized Cost, $/th
	Argon to Vinyl Lowe	Vinyl Lowe. Application: New Construction					
H106	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	149	na	$0.1639
W127r	Waste Water Heat Exchanger	Install HX on waste water	Retrofit	Water Heat	76	na	$0.1687
E131	Windows - Tinted AL Code to Class 36	Windows - Tinted AL Code to Class 36. Application: New Construction	New	Heating	219	$0.0119	$0.1718
C111	Direct Fired Convection Oven	0	New	Cooking	140	na	$0.1772
E116	Windows - Add Argon to Vinyl Lowe	Windows - Add Argon to Vinyl Lowe. Application: Old buildings	At Replacement	Heating	1,645	$0.0000	$0.1777
C106	Direct Fired Convection Oven	0	At Replacement	Cooking	402	na	$0.1793
E119	Windows - Non-Tinted AL Code to Class 36	Windows - Non-Tinted AL Code to Class 36. Application: Old buildings	At Replacement	Heating	921	$0.0000	$0.1856
E127	Windows - Non-Tinted AL Code to Class 40	Windows - Non-Tinted AL Code to Class 40. Application: New Construction	New	Heating	673	$0.0000	$0.2000
W101	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	25	na	$0.2016
E104	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	At Replacement	Heating	477	$0.0125	$0.2038

Measure Code	Measure Name	Measure Description	Construction Type	Measure End Use	Gas Impacts Therms	Levelized Cost, $/kWh	Levelized Cost, $/th
E118	Windows - Non-Tinted AL Code to Class 40	Windows - Non-Tinted AL Code to Class 40. Application: Old buildings	At Replacement	Heating	1,464	$0.0000	$0.2145
W102	DHW Shower Heads	Install low flow shower heads (2.0 gallons per minute) to replace 3.4 GPM shower heads.	Retrofit	Water Heat	134	na	$0.2177
H119	HiEff Unit Heater (new)	Install power draft units (80% seas. Eff) in place of natural draft (64% seas. Eff)	New	Heating	270	na	$0.2212
M105	Solar Pool Heaters	Install solar pool heaters in public, educational and other swimming pool	New	Misc.	32	na	$0.2412
H114	Hi Eff Unit Heater (replace)	Install power draft units (80% seas. Eff) in place of natural draft (64% seas. Eff)	At Replacement	Heating	607	na	$0.2424
E107	Roof Insulation - Blanket R0-19	Roof Insulation - Blanket R0-19. Application: Buildings with open truss unfinished interior	Retrofit	Heating	303	$0.0164	$0.2665
E112	Roof Insulation - Attic 11-30	Roof Insulation - Attic 11-30. Application: Buildings with partially insulated attics	Retrofit	Heating	215	$0.0174	$0.2828
E108	Roof Insulation - Blanket R0-30	Roof Insulation - Blanket R0-30. Application: Buildings with open truss unfinished interior	Retrofit	Heating	318	$0.0175	$0.2857
H101	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	280	na	$0.2928
W124r	Computerized Water Heater Control	Install intelligent controls on the hot water circulation loops.	Retrofit	Water Heat	163	na	$0.3109
E117	Windows - Non-Tinted AL Code to Class 45	Windows - Non-Tinted AL Code to Class 45. Application: Old buildings	At Replacement	Heating	593	$0.0000	$0.3228
E128	Windows - Non-Tinted AL Code to Class	Windows - Non-Tinted AL Code to Class 36. Application: New	New	Heating	1,016	$0.0000	$0.3345

Measure Code	Measure Name	Measure Description	Construction Type	Measure End Use	Gas Impacts Therms	Levelized Cost, $/kWh	Levelized Cost, $/th
	36	Construction					
E105	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	At Replacement	Heating	905	$0.0215	$0.3502
E126	Windows - Non-Tinted AL Code to Class 45	Windows - Non-Tinted AL Code to Class 45. Application: New Construction	New	Heating	251	$0.0000	$0.3508
W121	Combo Hieff Boiler (new)	Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.	New	Heating	60	na	$0.3568
H107	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	40	na	$0.3635
E113	Roof Insulation - Roofcut 0-22	Roof Insulation - Roofcut 0-22. Application: Buildings with uninsulated flat roofs at reroofing time	At Replacement	Heating	2	$0.0227	$0.3704
C113	Convection Range/Oven	0	New	Cooking	30	na	$0.3757
C108	Convection Range/Oven	0	At Replacement	Cooking	86	na	$0.3768
W119	Combo Hieff Boiler (repl)	Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.	At Replacement	Heating	120	na	$0.3899
W103	DHW Faucets	Add aerators to existing faucets to reduce flow from 3.4 gallons per minute to 2.0 GPM.	Retrofit	Water Heat	18	na	$0.4064
H117	SPC Hieff Boiler (new)	Install near condensing boiler. Assumed seasonal combustion efficiency of 82% over base of 75%	New	Heating	117	na	$0.4545
C115	Power Range	0	New	Cooking	90	na	$0.4661

Measure Code	Measure Name	Measure Description	Construction Type	Measure End Use	Gas Impacts Therms	Levelized Cost, $/kWh	Levelized Cost, $/th
	Burner						
C110	Power Range Burner	0	At Replacement	Cooking	253	na	$0.4686
H111	SPC Hieff Boiler Replace	Install near condensing boiler. Assumed seasonal combustion efficiency of 82% over base of 75%	At Replacement	Heating	47	na	$0.4857
C114	Infared Griddle	0	New	Cooking	65	na	$0.6707
W109	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	176	na	$0.6802
C109	Infared Griddle	0	At Replacement	Cooking	184	na	$0.6805
H120a	Cond Unit Heater from Nat Draft(new)	Install condensing power draft units (90% seas. Eff) in place of natural draft (64% seas. Eff)	New	Heating	468	na	$0.6877
W108	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.	At Replacement	Water Heat	331	na	$0.6891
W127	Waste Water Heat Exchanger	Install HX on waste water	New	Water Heat	91	na	$0.6953
W115	DHW Hieff Boiler (new)	Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.	New	Water Heat	59	na	$0.7001
H102	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	287	$0.0629	$0.7106
W113	DHW Hieff Boiler (repl)	Replace existing boiler with unit meeting OR Code requirements of 85% combustion efficiency.	At Replacement	Water Heat	106	na	$0.7177

Measure Code	Measure Name	Measure Description	Construction Type	Measure End Use	Gas Impacts Therms	Levelized Cost, $/kWh	Levelized Cost, $/th
W122	Combo Cond Boiler (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).	New	Heating	117	na	$0.7220
H108	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	Heating	410	na	$0.7410
H118	SPC Cond Boiler (new)	Install condensing boiler. Assumed seasonal combustion efficiency of 88% over base of 75%	New	Heating	219	na	$0.7533
H115a	Cond Unit Heater from Nat draft(replace)	Install condensing power draft units (90% seas. Eff) in place of natural draft (64% seas. Eff)	At Replacement	Heating	1,053	na	$0.7536
W104	DHW Pipe Ins	Add 1" insulation to pipes used for steam or hydronic distribution; particularly effective when pipes run through unheated spaces.	Retrofit	Water Heat	40	na	$0.7746
W120	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).	At Replacement	Heating	235	na	$0.7800
H112	SPC Cond Boiler Replace	Install condensing boiler. Assumed seasonal combustion efficiency of 88% over base of 75%	At Replacement	Heating	88	na	$0.8042
W105	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	Retrofit	Water Heat	101	na	$0.9605

Measure Code	Measure Name	Measure Description	Construction Type	Measure End Use	Gas Impacts Therms	Levelized Cost, $/kWh	Levelized Cost, $/th
		from dropping below required levels).					
H123	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	1,426	$0.0786	$1.0012
W124	Computerized Water Heater Control	Install intelligent controls on the hot water circulation loops.	New	Water Heat	24	na	$1.0430
W116	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 90% efficiency for savings calculations).	New	Water Heat	116	na	$1.1088
H103	Ducts	Duct retrofit of both insulation and air sealing	Retrofit	Heating	126	$0.0950	$1.1265
W114	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% efficiency for savings calculations).	At Replacement	Water Heat	208	na	$1.1603
E106	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	At Replacement	Heating	331	$0.0745	$1.2141
H120b	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	120	na	$1.3915
W125r	Solar Hot Water	Install solar water heaters on large use facility such as multifamily or lodging	Retrofit	Water Heat	701	na	$1.4430

Measure Code	Measure Name	Measure Description	Construction Type	Measure End Use	Gas Impacts Therms	Levelized Cost, $/kWh	Levelized Cost, $/th
H129	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.	Retrofit	Heating	168	na	$1.4482
H121	Cond Furnace (new)	Condensing / pulse package or residential-type furnace with a minimum AFUE of 92%.	New	Heating	237	na	$1.5240
H115b	Cond Unit Heater from power draft (replace)	Install condensing power draft units (90% seas. Eff) in place of power draft (80% seas. Eff)	At Replacement	Heating	270	na	$1.5247
H116	Cond Furnace (repl)	Condensing / pulse package or residential-type furnace with a minimum AFUE of 92%.	At Replacement	Heating	525	na	$1.8091
E110	Roof Insulation - Blanket R11-41	Roof Insulation - Blanket R11-41. Application: Buildings with open truss unfinished interior	Retrofit	Heating	124	$0.1121	$1.8264
E109	Roof Insulation - Blanket R11-30	Roof Insulation - Blanket R11-30. Application: Buildings with open truss unfinished interior	Retrofit	Heating	104	$0.1194	$1.9450
H122	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 technology. Work done in Eugene (Davis, et al, 2002) suggests higher savings than the other documented commissioning on more complex systems.	New	Heating	815	$0.1788	$2.1287
W125	Solar Hot Water	Install solar water heaters on large use facility such as multifamily or lodging	New	Water Heat	222	na	$2.2496

Table 14. Detailed Measure Table, Residential Sector, 2025 Technical Potential

Measure Code	Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Gas Savings Therms	Level Cost, $/th
R-WG106	Wx insulation 1 added measure Zone 3	Weiss	45	1,130,134	0	467,920	$0.139
R-WG104	Wx insulation 1 added measure Zone 1	WxExist	45	762,226	0	276,226	$0.159
R-WG105	Wx insulation 1 added measure Zone 2	WxExist	45	1,537,588	0	539,741	$0.164
N-H103	E* Insulation, Ducts, Zone 3	NewPkg	45	28,644,770	0	3,488,895	$0.474
R-H115	Duct Sealing and AFUE 90+, Zone 3	HVACExist	20	1,343,411	0	225,677	$0.485
R-WG109	Window, replacement (U=.35) Zone 3	WxExist	45	10,409,052	0	1,206,318	$0.498
N-H105	Heating upgrade (AFUE 90), Zone 2	NewPkg	18	10,410,665	0	1,598,275	$0.565
R-WG107	Window, replacement (U=.35) Zone 1	WxExist	45	7,020,447	0	709,217	$0.571
R-H103	Duct Sealing, Zone 3	HVACExist	20	1,181,587	0	167,703	$0.574
N-H102	E* Insulation, Ducts, Zone 2	NewPkg	45	38,972,229	0	3,830,256	$0.587
R-H113	Duct Sealing and AFUE 90+, Zone 1	HVACExist	20	906,071	0	124,877	$0.591
R-WG108	Window, replacement (U=.35) Zone 2	WxExist	45	14,161,886	0	1,375,897	$0.594
R-WG103	Wx insulation 2 measures Zone 3	WxExist	45	7,910,938	0	766,849	$0.595
N-H101	E* Insulation, Ducts, Zone 1	NewPkg	45	19,319,635	0	1,765,328	$0.631
R-H114	Duct Sealing and AFUE 90+, Zone 2	HVACExist	20	1,827,758	0	233,830	$0.637
R-WG101	Wx insulation 2 measures Zone 1	WxExist	45	5,335,579	0	454,544	$0.677
N-H106	Heating upgrade (AFUE 90), Zone 3	NewPkg	18	7,651,887	0	951,793	$0.697
R-WG102	Wx insulation 2 measures Zone 2	WxExist	45	10,763,113	0	888,592	$0.699
R-H106	AFUE 90+ Furnace, Zone 3	HVACExist	18	11,247,109	0	1,375,074	$0.709
N-H115	E* Plus (FTC) Insulation, Zone 3	NewPkg	45	47,070,906	0	3,654,631	$0.743
R-H101	Duct Sealing, Zone 1	HVACExist	20	796,928	0	87,228	$0.744
N-H104	Heating upgrade (AFUE 90), Zone 1	NewPkg	18	5,160,861	0	600,917	$0.745
R-H112	Combo with Hot Water delivery, Zone 3	HVACExist	30	256,436	0	20,932	$0.813
R-H102	Duct Sealing, Zone 2	HVACExist	20	1,607,591	0	154,826	$0.846
R-H104	AFUE 90+ Furnace, Zone 1	HVACExist	18	7,585,680	0	763,055	$0.862

Measure Code	Measure Description	Program	Average Lifetime	Total Incremental Cost	Total O&M Impact ($)	Gas Savings Therms	Level Cost, $/th
R-H110	Combo with Hot Water delivery, Zone 1	HVACExist	30	172,955	0	12,853	$0.893
R-H111	Combo with Hot Water delivery, Zone 2	HVACExist	30	348,890	0	25,105	$0.922
R-H105	AFUE 90+ Furnace, Zone 2	HVACExist	18	15,302,092	0	1,424,214	$0.932
N-H114	E* Plus (FTC) Insulation, Zone 2	NewPkg	45	64,041,644	0	3,942,601	$0.937
N-H112	HRV, E*, Zone 3	NewPkg	45	12,751,020	0	784,651	$0.938
N-H113	E* Plus (FTC) Insulation, Zone 1	NewPkg	45	31,747,253	0	1,834,776	$0.998
R-WG112	Window upgrade (U=.4 to U=.35) Zone 3	WxExist	45	809,593	0	45,226	$1.033
N-H111	HRV, E*, Zone 2	NewPkg	45	17,348,217	0	921,123	$1.087
N-H110	HRV, E*, Zone 1	NewPkg	45	8,600,001	0	431,521	$1.150
N-H109	Window U=.3, Zone 3	NewPkg	45	11,522,330	0	571,549	$1.163
R-WG110	Window upgrade (U=.4 to U=.35) Zone 1	WxExist	45	546,035	0	26,206	$1.202
R-WG111	Window upgrade (U=.4 to U=.35) Zone 2	WxExist	45	1,101,480	0	51,659	$1.230
N-H108	Window U=.3, Zone 2	NewPkg	45	15,676,540	0	678,841	$1.333
N-H107	Window U=.3, Zone 1	NewPkg	45	7,771,304	0	308,263	$1.455
N-DG104	Tankless Gas heater	NewDHW	20	7,266,429	0	378,838	$1.562
R-DG104	Tankless Gas heater	DHWExist	20	6,320,173	0	329,504	$1.562
R-H109	AFUE 85 DHW combo, Zone 3	HVACExist	18	2,552,488	0	136,771	$1.618
R-H107	AFUE 85 DHW combo, Zone 1	HVACExist	18	1,721,540	0	87,415	$1.708
R-H108	AFUE 85 DHW combo, Zone 2	HVACExist	18	3,472,750	0	163,878	$1.838
R-WG115	HRV Zone 3	WxExist	18	2,602,263	0	99,315	$2.272
R-DG101	Tank upgrade (50 gal gas)	DHWExist	15	19,001,215	0	712,583	$2.599
N-DG101	Tank upgrade (50 gal gas)	NewDHW	15	21,846,076	0	819,271	$2.599
R-WG113	HRV Zone 1	WxExist	18	1,755,112	0	58,417	$2.605
R-WG114	HRV Zone 2	WxExist	18	3,540,472	0	113,473	$2.706
N-DG103	Solar hot water heater (50 gal) - Solar Zone 2. With gas backup.	NewDHW	20	34,962,954	0	976,790	$2.915
R-DG103	Solar hot water heater (50 gal) - Solar Zone 2. With gas backup.	DHWExist	20	30,409,974	0	849,590	$2.915
R-DG102	Tank upgrade (50 gal gas) condensing	DHWExist	15	28,460,277	0	754,072	$3.679
N-DG102	Tank upgrade (50 gal gas) condensing	NewDHW	15	32,721,348	0	866,971	$3.679

Table 15. Detailed Measure Table, Industrial Sector, 2025 Technical Potential

Measure Name	Incremental Cost($/Unit)	O&M Cost($/Yr)	Potential Savings (Therm)	Cost of Saved Energy($/th)	Initial Cost, k$
HiEff Clothes Washer (repl)	$5.935	($1.786)	323	($1.207)	$2
HiEff Clothes Washer (retro)	$8.503	($1.786)	323	($0.957)	$3
DHW Wrap	$0.002	$0.000	8,085	$0.000	$0
Process Boiler Maintenance	$0.000	$0.001	4,836	$0.001	$0
Process Boiler Water Treatment	$0.007	$0.000	2,418	$0.001	$0
Process Boiler Controls	$0.013	$0.000	4,280	$0.001	$0
Process Boiler Load Control	$0.015	$0.000	9,672	$0.001	$0
Process Boiler Insulation	$0.064	$0.001	19,345	$0.007	$1
DHW Pipe Ins	$0.169	$0.000	18,191	$0.016	$3
DHW Condensing Tank (repl)	$0.220	$0.000	3,115	$0.021	$1
Process Boiler Steam Trap Maintenance	$0.000	$0.035	15,718	$0.035	$0
DHW Hieff Boiler (repl)	$0.503	$0.000	2,169	$0.041	$1
DHW Condensing Tank (retro)	$0.988	$0.000	0	$0.096	$0
Dairy Heat Recovery	$2.483	($0.130)	51,232	$0.113	$127
DHW Cond Boiler (repl)	$1.608	$0.000	3,630	$0.131	$6
HW Boiler Tune	$0.640	$0.000	40,623	$0.149	$26
Hot Water Temperature Reset	$1.232	$0.000	73,860	$0.161	$91
DHW Std. Boiler (retro)	$2.364	$0.000	2,695	$0.192	$6
Wall Insulation - Blown R11	$3.167	$0.000	64,735	$0.210	$205
Wall Insulation - Spray On for Metal Buildings	$3.526	$0.000	71,076	$0.234	$251
Hi Eff Unit Heater (replace)	$3.279	$0.000	251,009	$0.284	$823
Combo Hieff Boiler (repl)	$3.529	$0.000	21,523	$0.287	$76
Roof Insulation - Blanket R0-19	$4.372	$0.000	92,161	$0.290	$403
Steam Balance (Wood Prod)	$3.187	$0.000	546	$0.311	$2
Roof Insulation - Blanket R0-30	$4.688	$0.000	96,694	$0.311	$453
DHW Hieff Boiler (retro)	$3.935	$0.000	210	$0.320	$1
Vent Damper	$3.511	$0.000	40,623	$0.400	$143
DHW Cond Boiler (retro)	$5.039	$0.000	273	$0.410	$1
Combo Cond Boiler (repl)	$6.492	$0.000	42,022	$0.529	$273
Steam Trap Maint (Wood Prod)	$4.117	$0.000	622	$0.538	$3
Waste Water Heat Exchanger	$7.133	$0.000	31,442	$0.581	$224
SPC Hieff Boiler Replace	$7.252	$0.000	3,955	$0.591	$29
Roof Insulation - Rigid R11-22	$11.338	$0.000	75,018	$0.752	$851
Upgrade Process Heat	$8.570	$0.000	8,854	$0.835	$76
Cond Unit Heater from Nat draft(replace)	$10.197	$0.000	241,722	$0.884	$2,465
SPC Cond Boiler Replace	$11.312	$0.000	6,840	$0.921	$77
Power burner	$8.396	$0.000	59,878	$0.957	$503

Measure Name	Incremental Cost($/Unit)	O&M Cost($/Yr)	Potential Savings (Therm)	Cost of Saved Energy($/th)	Initial Cost, k$
Combo Cond Boiler (retro)	$17.456	$0.000	3,160	$1.422	$55
Combo Hieff Boiler (retro)	$18.376	$0.000	2,081	$1.496	$38
Hi Eff Unit Heater (retro)	$19.966	$0.000	0	$1.731	$0
Cond Unit Heater from power draft (replace)	$20.631	$0.000	92,873	$1.789	$1,916
SPC Cond Boiler Retro	$24.006	$0.000	511	$1.955	$12
Roof Insulation - Blanket R11-41	$30.000	$0.000	40,289	$1.990	$1,209
SPC Hieff Boiler Retro	$25.363	$0.000	370	$2.065	$9
Roof Insulation - Blanket R11-30	$32.000	$0.000	33,574	$2.123	$1,074
Roof Insulation - Rigid R11-33	$34.483	$0.000	36,999	$2.288	$1,276
Cond Furnace (repl)	$23.629	$0.000	137,895	$2.303	$3,258
Ducts	$26.316	$0.000	206,895	$2.565	$5,445
Solar Hot Water	$47.835	$0.000	22,009	$3.895	$1,053