

Appendix E: Conservation Supply Curve Development

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OVERVIEW

This Appendix provides an overview of the Council general methodology for estimating the conservation resource potential in the region and describes the major sources of information used to prepare that analysis. It also provides links to spreadsheets containing the detailed input assumptions and specific source data used for each of the measures in the Council's conservation supply curves.

The Council estimates costs and savings for over 1400 measures. These costs and savings are used to develop supply curves of conservation potential available by year. The supply curves represent the amount of conservation available at different cost levels. Costs are expressed as TRC Net levelized costs so they can be compared to the costs of power purchases and the costs of new resource development.¹ The Council uses an in-house model called ProCost to calculate TRC Net levelized cost. The following sections describe the "global" inputs and methodology used by the Council in its assessment of regional conservation resource potential.

Cost-Effectiveness Methodology Used in the Portfolio Analysis Model

As with all other resources, the Council uses its Resource Portfolio Model (RPM) to determine how much conservation is cost-effective to develop.² The RPM is designed to compare resources, including conservation on a "generic" level. That is, it does not model a specific combined cycle gas or wind project nor does it model specific conservation measures or programs. In the case of conservation, the model uses two separate supply curves. These supply curves, one for discretionary resources and a second for lost opportunity resources, depict the amount of savings achievable at varying costs. The savings in these two supply curves are allocated to "on-peak" and "off-peak" periods for each quarter of the year to capture the daily and seasonal effect of changes in wholesale market prices on the value of conservation. This allocation of savings to time periods is a summation of the time-based shape of the collective savings of the individual measures in each of these supply curves.

The cost-effectiveness methodology used in the conservation assessment considers the time-based value of the savings, and the non-power system costs and benefits of each conservation measure to estimate how much of the identified savings potential is cost-effective based on an estimate of forecast power prices and forecast value of transmission and distribution capacity deferred. Run time constraints limit the number of conservation programs the RPM can

¹ "TRC Net Levelized Cost" is computed based on all costs minus all benefits regardless of which sponsor incurs the cost or accrues the benefits. TRC Net Levelized Cost includes all applicable costs and all benefits. In addition to energy system costs and benefits, TRC Net Levelized Cost includes non-energy, other-fuel, O&M, periodic-replacement and risk-mitigation benefits and costs. TRC Net Levelized Cost corresponds to TRC B/C ratios with regard to the costs and benefits included. Benefits are subtracted from costs, then levelized over the life of the program.

² The Act defines regional cost-effectiveness as follows: "Cost-effective", when applied to any measure or resource referred to in this chapter, means that such measure or resource must be forecast to be reliable and available within the time it is needed, and to meet or reduce the electric power demand, as determined by the Council or the Administrator, as appropriate, of the consumers of the customers at an estimated incremental system cost no greater than that of the least-cost similarly reliable and available alternative measure or resource, or any combination thereof. (Emphasis added). Under the Act the term "system cost" means an estimate of all direct costs of a measure or resource over its effective life, including, if applicable, the cost of distribution and transmission to the consumer and such quantifiable environmental costs and benefits as are directly attributable to such measure or resource. The Council has interpreted the Act's provisions to mean that in order for a conservation measure to be cost-effective the discounted present value of all of the measure's benefits should be compared to the present value of all of its costs.

consider. The RPM cannot consider individual programs for every measure and every specific load shape, and perform a measure-specific benefit-cost ratio for each sub-component of conservation. So the Council simplifies the set of conservation measures available to the portfolio model. The Council uses “adjusted” levelized costs to incorporate the transmission and distribution system benefits for the aggregate benefits of the collective set of conservation measures. The Council adjusts the levelized costs of the measures to reflect the transmission and distribution value of the collective savings in both the lost-opportunity and discretionary supply curves. The RPM compares this supply curve of available conservation and adjusted levelized costs to the model’s “estimates” of forecast short-term power market prices. The RPM then tests how much conservation to develop, along with other resources, that provides least-cost and least risk plans.

The Costs of Conservation

The costs included in the Council’s analyses are the sum of the total installed cost of the measure, and any operation and maintenance costs, or savings, associated with ensuring the measure’s proper functioning over its expected life. If the use of an electric efficiency measure increases or decreases the use of another fuel, such as improving the efficiency of lighting in a commercial building may increase the use of natural gas for heating, the cost or savings of these impacts are included in the analysis.

The Value of Conservation

Part of the value of a kilowatt-hour saved is the value it would bring on the wholesale power market and part of its value comes from deferring the need to add distribution and/or transmission system capacity. This means that the marginal “avoided cost” varies not only by the time of day and the month of the year, but also through time as new generation, transmission and distribution equipment is added to the power system. The Council’s cost-effectiveness methodology starts with detailed information about when the conservation measure produces savings and how much of these savings occur when distribution and transmission system loads are at their highest. That is, each measure’s annual savings are evaluated for their effects on the power system over the 8760 hours in a year.³

The Northwest’s highest demand for electricity occurs during the coldest winter days, usually during the early morning or late afternoon. Savings during these peak periods reduce the need for distribution and transmission system expansion. Electricity saved during these periods is also more valuable than savings at night during spring when snow melt is filling the region’s hydroelectric system and the demand for electricity is much lower. However, since the Northwest electric system is linked to the West Coast wholesale power market, the value of the conservation is no longer determined solely by regional resource cost and availability.

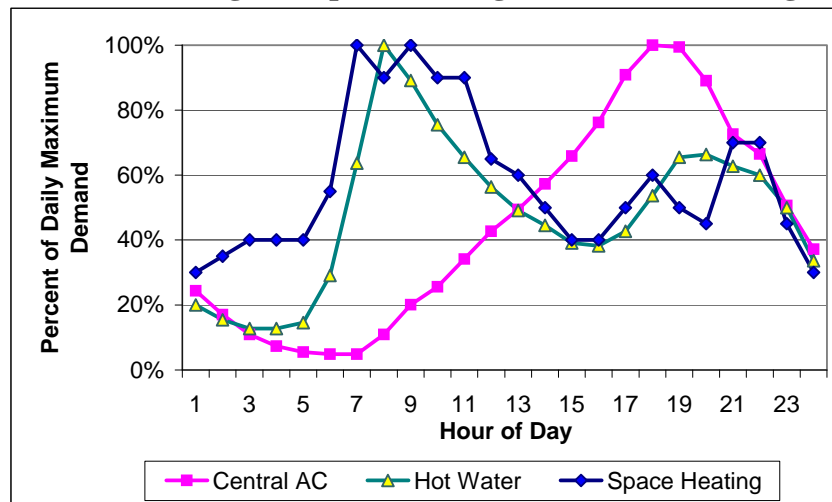
³ To simplify this analysis the Council divides each day and week into four time segments representing high, medium high, medium and low demand hours, resulting in four price “periods” per day for each month for a total of 48 prices per year.

Value of Energy Saved

Given the interconnected nature of the West, regional wholesale power prices reflect the significant demand for summer air conditioning in California, Nevada and the remainder of the desert Southwest. Consequently, wholesale power prices are as high as or higher during the peak air conditioning season in July and August than they are when the Northwest system peak demand occurs in the winter. Consequently, a kilowatt-hour saved in a commercial building in the afternoon in the Pacific Northwest may actually displace a kilowatt-hour of high-priced generation in Los Angeles on a hot August day. Whereas a kilowatt-hour saved in street lighting might displace a low-cost imported kilowatt-hour on a night in November.

As noted previously, in addition to its value in offsetting the need for generation during the hours it occurs, conservation also reduces the need to expand local power distribution system capacity. Figure E-1 shows typical daily load shape of conservation savings for measures that improve the efficiency of space heating, water heating and central air conditioning in typical new home built in Boise. The vertical axis indicates the ratio (expressed as a percent) of each hour's electric demand to the maximum demand for that end use during over the course of the entire day. The horizontal axis shows the hour of the day, with hour "0" representing midnight.

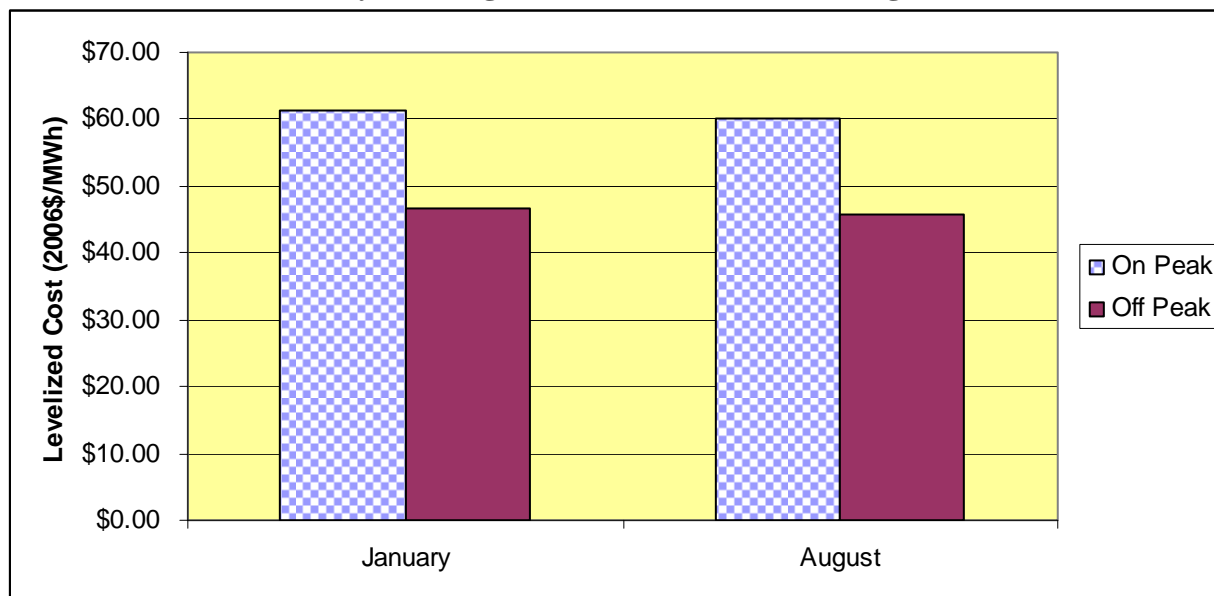
Figure E-1: Hour Load Profile for Residential Central Air Conditioning Water Heating and Space Heating Conservation Savings



As can be seen from inspecting Figure E-1, water heating savings increase in the morning when occupants rise to bathe and cook breakfast, then drop while they are away at work and rise again during the evening. Space heating savings also exhibit this “double-hump” pattern. In contrast, central air conditioning savings increase quickly beginning in the early afternoon, peaking in late afternoon and decline again as the evening progresses and outside temperatures drop.

The Council’s forecast of future hourly wholesale market power prices vary over the course of typical summer and winter days. Figure E-2 shows the average levelized “on peak” and “off peak” wholesale market prices at Mid-C for January and August. As can be seen from Figure E-2, “on-peak” savings are far more valuable than those that occur “off-peak” during the summer or during the winter.

Figure E-2: Forecast Levelized “On” and “Off-Peak” Wholesale Power Market Prices for January and August at Mid Columbia Trading HUB



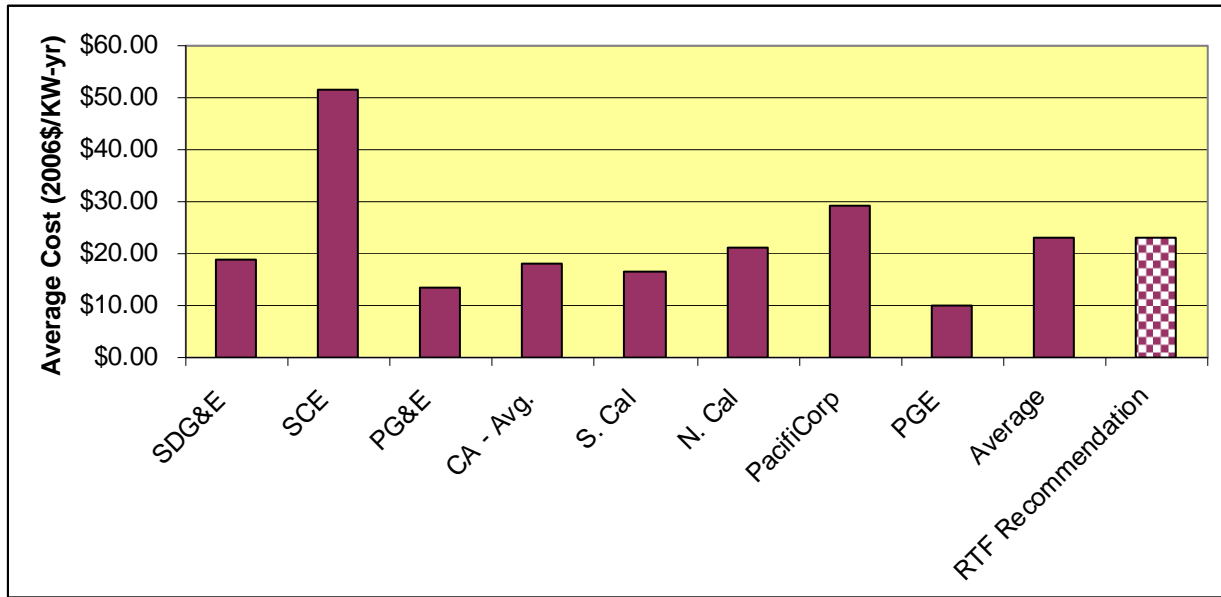
In order to capture this differential in benefits, the Council computes the weighted average time-differentiated value of the savings of each conservation measure based on its unique conservation load shape. Each month’s savings are valued at the avoided cost for that time period based on the daily and monthly load shape of the savings. The weighted value of the all time period’s avoided costs establishes the cost-effectiveness limit for a particular end use.

Forecast of future wholesale power market prices are subject to considerable uncertainty. Therefore, in order to determine a more “robust” estimate of a measure’s cost-effectiveness it should be tested against a range of future market prices. The Council currently uses its “base case” AURORA model forecast of future wholesale market prices to determine conservation cost-effectiveness. However, in order to reflect the uncertainty of future market prices rather than a single market price forecast the Council adjusts the AURORA market price forecast to incorporate the value that conservation provides as a hedge against future market price volatility. The derivation of this value is described fully in Chapter 9 of the Sixth Plan.

Value of Deferred Transmission and Distribution Capacity

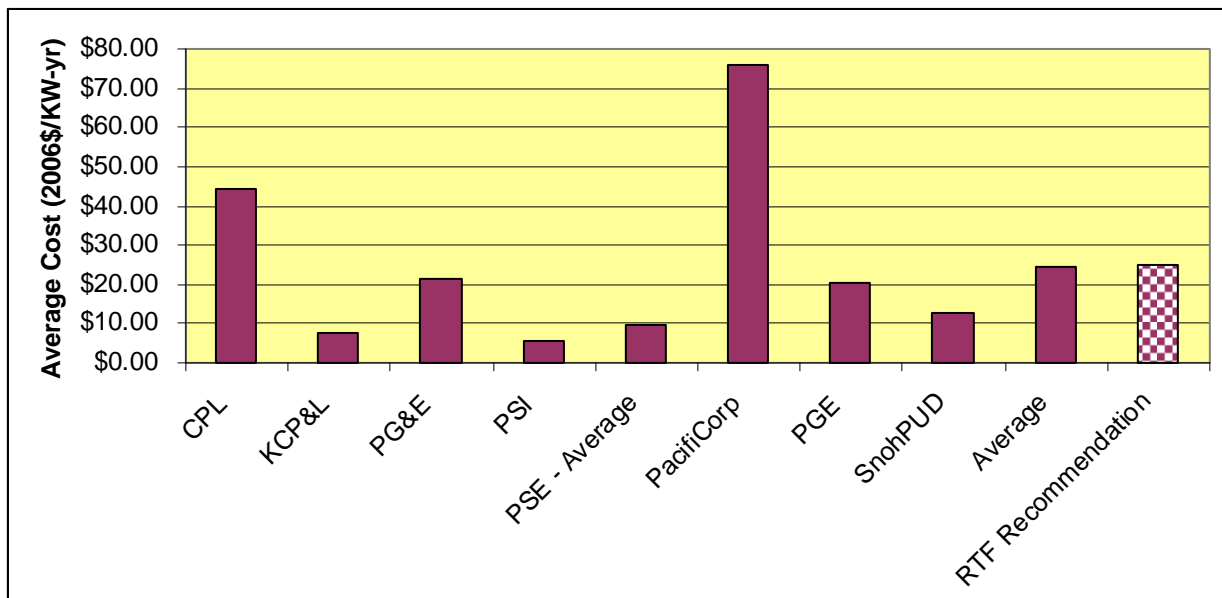
In addition to its value in offsetting the need for generation, conservation also reduces the need to expand local power distribution system capacity. The next step used to determine conservation’s cost effectiveness is to determine whether the installation of a particular measure will defer the installation or expansion of local distribution and/or transmission system equipment. The Council recognizes that potential transmission and distribution systems cost savings are highly dependent upon local conditions. However, the Council relied on data obtained by its Regional Technical Forum (RTF) to develop a representative estimate of avoided transmission and distribution costs. Figure E-3 presents data for the avoided cost of transmission system expansion and Figure E-4 presents data for the avoided cost of distribution system expansion.

Figure E-3: Average Avoided Cost of Deferred Transmission System Expansion



After reviewing this data the RTF recommended a value of \$23/kW-yr for “representative” of avoided transmission system expansion cost and \$25/kW-yr as “representative” of avoided cost of distribution system expansion. The Council adopted the RTF recommended value for distribution system avoided cost. However, because the value of avoiding the transmission system investments is already included in the wholesale market prices produced by the AURORA model the Council did not use the RTF estimate of the benefits of deferring transmission system expansion so as to avoid double counting.

Figure E-4: Average Avoided Cost of Deferred Distribution System Expansion



As discussed above, due to the interconnected nature of the West coast wholesale power market, conservation measures that reduce consumption during the on peak hours are the most valuable, even though the region has significant peaking resources from the hydro-system. In contrast,

throughout most of the Northwest region measures conservation measures that reduce peak demand during the winter heating season are of more value to the region's local distribution systems and to its wholesale transmission system.⁴ This is because these systems must be designed and built to accommodate "peak demand" which occurs in winter. If a conservation measure reduces demand during these periods of high demand it reduces the need to expand distribution and transmission system capacity.

In order to determine the benefits a conservation measure might provide to the region's transmission and distribution system it is necessary to estimate how much that measure will reduce demand on the power system when regional loads are at their highest. The same conservation load shape information that was used to estimate the value of avoided market purchases was also used to determine the "on-peak" savings for each conservation measure.

Value of Non-Power System Benefits

In addition to calculating the regional wholesale power system and local distribution system benefits of conservation the Council analysis of cost-effectiveness takes into account a measure's other non-power system benefits. For example, more energy efficient clothes washers and dishwashers save significant amounts of water as well as electricity. Similarly, some industrial efficiency improvements also enhance productivity or improve process control while others may reduce operation and maintenance costs. Therefore, when a conservation measure or activity provides non-power system benefits, such benefits should be quantified (e.g., gallons of water savings per year and where possible an estimate of the economic value of these non-power system benefits should be computed. These benefits are added to the Council's estimate of the value of energy savings to the wholesale power system and the local electric distribution systems when computing total system/societal benefits.

Regional Act Credit

The Northwest Power Act directs the Council and Bonneville to give conservation a 10 percent cost advantage over sources of electric generation. The Council does this by adding 10 percent to the AURORA model forecast of wholesale market power prices and to its estimates of capital costs savings from deferring electric transmission and distribution system expansion. Since the Council's Resource Portfolio Model (RPM) does not address the Act's credit for conservation, the levelized cost of conservation in the supply curves are adjusted downward so that this credit is reflected in its comparison of conservation with other resources.

Financial Input Assumptions

The present value cost of conservation is determined by who pays for it. The RTF was asked to provide recommendations on the anticipated "cost-sharing" between utilities and consumers. Staff also developed estimates of the cost of capital and equity used to pay for conservation based on the mix of consumers in each of the major sectors. Tables E-1 through E-4 show the financial assumptions used in the economic analysis of conservation opportunities in each of the four major economic sectors.

⁴ Some areas of the region now experience both summer and winter peaks of almost equal magnitude due to increased use of air conditioning.

Table E-1: Residential Sector Financial Input Assumptions

| Sponsor Parameters | Customer | Wholesale Electric | Retail Electric | Natural Gas |
|--|-----------------|---------------------------|------------------------|--------------------|
| Real After-Tax Cost of Capital | 3.90% | 4.40% | 4.90% | 5.00% |
| Financial Life (years) | 15 | 1 | 1 | 1 |
| Sponsor Share of Initial Capital Cost | 35% | 20% | 45% | 0% |
| Sponsor Share of Annual O&M | 100% | 0% | 0% | 0% |
| Sponsor Share of Periodic Replacement Cost | 100% | 0% | 0% | 0% |
| Sponsor Share of Administrative Cost | 0% | 50% | 50% | 0% |
| Last Year of Non-Customer O&M & Period Replacement | | 20 | | |

Table E-2: Commercial Sector Financial Input Assumptions

| Sponsor Parameters | Customer | Wholesale Electric | Retail Electric | Natural Gas |
|--|-----------------|---------------------------|------------------------|--------------------|
| Real After-Tax Cost of Capital | 6.70% | 4.40% | 4.90% | 5.00% |
| Financial Life (years) | 20 | 1 | 1 | 1 |
| Sponsor Share of Initial Capital Cost | 35% | 10% | 55% | 0% |
| Sponsor Share of Annual O&M | 100% | 0% | 0% | 0% |
| Sponsor Share of Periodic Replacement Cost | 100% | 0% | 0% | 0% |
| Sponsor Share of Admin Cost | 0% | 50% | 50% | 0% |
| Last Year of Non-Customer O&M & Period Replacement | | 20 | | |

Table E-3: Industrial Sector Financial Input Assumptions

| Sponsor Parameters | Customer | Wholesale Electric | Retail Electric | Natural Gas |
|--|-----------------|---------------------------|------------------------|--------------------|
| Real After-Tax Cost of Capital | 7.60% | 4.40% | 4.90% | 5.00% |
| Financial Life (years) | 20 | 1 | 1 | 1 |
| Sponsor Share of Initial Capital Cost | 35% | 10% | 55% | 0% |
| Sponsor Share of Annual O&M | 100% | 0% | 0% | 0% |
| Sponsor Share of Periodic Replacement Cost | 100% | 0% | 0% | 0% |
| Sponsor Share of Admin Cost | 0% | 50% | 50% | 0% |
| Last Year of Non-Customer O&M & Period Replacement | | 20 | | |

Table E-4: Agriculture Sector Financial Input Assumptions

| Sponsor Parameters | Customer | Wholesale Electric | Retail Electric | Natural Gas |
|--|-----------------|---------------------------|------------------------|--------------------|
| Real After-Tax Cost of Capital | 7.60% | 4.40% | 4.90% | 5.00% |
| Financial Life (years) | 5 | 1 | 1 | 1 |
| Sponsor Share of Initial Capital Cost | 35% | 10% | 55% | 0% |
| Sponsor Share of Annual O&M | 100% | 0% | 0% | 0% |
| Sponsor Share of Periodic Replacement Cost | 100% | 0% | 0% | 0% |
| Sponsor Share of Admin Cost | 0% | 50% | 50% | 0% |
| Last Year of Non-Customer O&M & Period Replacement | | 20 | | |

RESIDENTIAL SECTOR

Residential Sector Definition and Coverage

For the Council's conservation analysis the residential sector includes single family, multifamily and manufactured homes buildings. Single family buildings are defined as all structures with four or fewer separate dwelling units, including both attached and detached homes. Multifamily

structures include all housing with five or more dwelling units, up to four stories in height.⁵ Manufactured homes are dwellings regulated by the US Department of Housing and Urban Development (HUD) construction and safety standards (USC Title 42, Chapter 70). Modular homes, which are regulated by state codes, are considered single family dwellings.

One of primary inputs into the residential sector conservation assessment is the number of units that each conservation measure or measure bundle could be applied to in the region. Space conditioning savings are a function of both the characteristics of the structure and the climatic conditions where the home is located. Therefore, the Council's assessment includes estimates of the number of new and existing dwelling units of each type (i.e., single family, multifamily, manufactured homes) in nine different climate zones. The Council defines climate zones by specific combinations of heating and cooling degree days. Table E-5 shows the nine climate zones in the region.

Measure Bundles

Nearly 60 individual residential-sector measures are analyzed in the Sixth Power Plan. In the case of heat pumps and central air conditioning three measures were consolidated into a single bundle of related measures. Two levels of efficiency above the current federal minimum standards were tested, HSPF 8.5/SEER 14 and HSPF 9.0/SEER 14. For purposes of analytical expediency it was assumed that when a high efficiency heat pump was installed it would also undergo commissioning to ensure it functions properly and that it would have controls installed to optimize its operation. In addition, it was also assumed that in the case of existing homes the duct system would be sealed and in the case of new homes the duct system would be located inside the conditioned space or be sealed. As a result “duct sealing” and “heat pump commissioning and controls” are not identified separated in the supply curve, but are bundled with “heat pump efficiency upgrades” and “heat pump conversions.” These measure bundles do not and should not dictate the way measures are bundled for programmatic implementation.

Table E-5: Regional Heating and Cooling Climate Zones

| Climate Zone | Heating Degree Days | Cooling Degree Days |
|-------------------------------------|----------------------------|----------------------------|
| Climate Zone: Heating 1 - Cooling 1 | < 6000 | <300 |
| Climate Zone: Heating 1 - Cooling 2 | < 6000 | > 300 - 899 |
| Climate Zone: Heating 1 - Cooling 3 | < 6000 | > 900 |
| Climate Zone: Heating 2 - Cooling 1 | 6000 - 7499 | <300 |
| Climate Zone: Heating 2 - Cooling 2 | 6000 - 7499 | > 300 - 899 |
| Climate Zone: Heating 2 - Cooling 3 | 6000 - 7499 | > 900 |
| Climate Zone: Heating 3 - Cooling 1 | > 7500 | <300 |
| Climate Zone: Heating 3 - Cooling 2 | > 7500 | > 300 - 899 |
| Climate Zone: Heating 3 - Cooling 3 | > 7500 | > 900 |

Measures are also consolidated into three types of application modes. These modes are new, natural replacement and retrofit. The new mode applies primarily to new buildings or new equipment. The natural replacement mode applies to subsystems and equipment within buildings that are replaced on burnout, at the end of their useful life, or at the time of remodel of

⁵ The conservation potential for water heating, lighting, appliances and consumer electronics in high rise multifamily dwellings (i.e., those covered by non-residential codes) are included in the residential sector. However, the savings from building shell and HVAC improvements in high rise multifamily buildings is not included in the Council's assessment of regional conservation potential due to lack of data.

the building or system within a building. Examples of this mode include appliance and water heater replacements and conversions of electric forced air furnaces to air source heat pumps are assumed to take place when the existing furnace needs to be replaced. Retrofit mode is used where a measure or a building subsystem upgraded, replaced or retired before the end of its useful life. The installation of insulation, window replacements and installation of ductless heat pumps to provide higher efficiency supplemental space conditioning are all examples of retrofit measures.

There are three reasons to distinguish the new, natural replacement and retrofit application modes. First, costs and savings can be different by application mode. Second, in the case of new and natural replacement, the available stock for the measure depends on the forecast of new additions and replacement rate for equipment. These opportunities are tracked separately over course of the forecast period and limit the annual availability of conservation opportunities. Third, the Council's portfolio model treats new and natural replacement applications as lost-opportunity measures that can only be captured at the time of construction or natural replacement.

Measure costs, savings, applicability, and achievability estimates are identified separately for each of the new, natural replacement and retrofit application modes. The Council analyzes measure costs and savings on an incremental basis. Measure cost is the incremental cost over what would be done absent the measure or program. The same is true for savings. Incremental measure costs and savings can be different depending on the application mode. For example, incremental costs of high performance windows in a new application only include the additional cost of the windows required by code. In a retrofit application, the labor cost of removing and replacing the existing window are added to the measure cost.

Overview of Methods

Measure costs and savings are developed at a level of detail compatible with data availability, expected variance in measure costs and savings, the diversity of measure applications and practical limitations on the number of measures that can be analyzed. Costs and savings are based both on engineering estimates as well as estimates based on results from the operation of existing programs. Savings potential is the product of savings per unit and the forecast of number of units that the measure is applicable to. For the residential sector measures the unit of measure is a function of the measure type. Most measures apply to a fraction of the building stock in a particular building type. For example, insulation measures are a function of the number of households with electric heat, refrigerator efficiency improvements are a function of the number of refrigerators that are replaced or purchase new each year and the potential savings from ductless heat pumps are function of the number of single family homes with zonal electric heating systems.

For every measure or practice analyzed, there are four major methodological steps to go through. These steps establish baseline conditions, measure applicability, and measure achievability. For the residential-sector conservation measures, each of these is treated explicitly for each measure bundle.

Baseline Characteristics

Baseline conditions are estimated from current conditions for existing buildings and systems. Estimates of current conditions and characteristics of the building stock come from several sources. Key among these are the market research projects of the Northwest Energy Efficiency Alliance (NEEA), selected studies from utilities, Energy Trust of Oregon, and other sources.

For new buildings, new and replacement equipment, baseline conditions are estimated from a combination of surveys of new buildings, state and local building energy codes and federal and state appliance efficiency standards. The most recent survey data used is from the NEEA New Single Family and New Multifamily Buildings Characteristics studies completed in 2007 which looked at buildings built in the 2003-2004. Codes and standards are continually being upgraded. The baseline assumptions used in the Sixth Power Plan are those that were adopted at the end of 2008, with a few exceptions. Some of these include standards that are adopted now but with effective dates that occur in the future. For such codes or standards, both savings estimates and the demand forecast reflect the effective dates of adopted standards. Baseline characteristics for major appliances (washers, dishwashers, refrigerators and freezers) are the national sales weighted average efficiency levels. This data was obtained from the American Home Appliance Manufacturer's Association (AHAM). Cost data for appliances was obtained from an analysis of the Oregon Residential Energy Tax Credit data and Internet searches. Heating, cooling, insulation and window cost were obtained from an analysis of program data from Puget Sound Energy and the Energy Trust of Oregon.

Measure Applicability

Measure applicability reflects several major components. First is the technical applicability of a measure. Technical applicability includes what fraction of the stock the measure applies to. Technical applicability can be composed of several factors. These include the fraction of stock that the measure applies to, overlap with mutually exclusive measures and the existing saturation of the measure. Existing measure saturation reflects the fraction of the applicable stock that has already adopted the measure and for which savings estimates do not apply. There are hundreds of applicability assumptions in the residential-sector conservation assessment. Applicability assumptions by measure appear in the three supply curve summary workbooks. Table E-6 shows the measures covered by each of these three workbooks.

Measure Achievability

The Council assumes that only a portion of the technically available conservation can be achieved. Ultimate achievability factors are limited to 85 percent of the technically available conservation over the twenty-year forecast period. In addition to a limit of 85 percent, the Council considers near-term achievable penetration rates for bundles of conservation measures. Several factors are used to estimate near-term achievability rates. Recent experience with region wide conservation program accomplishments is one key factor. But in addition to historic experience, the Council also considers a bottom-up approach to estimate near-term achievability.

In the bottom-up approach, the Council estimates near-term achievability rates of each bundle of conservation measures based on the characteristics of the measures in the bundle being described. In the bottom-up approach, the Council estimates near-term achievability rates of each bundle of conservation measures based on the characteristics of the measures in the bundle being described and consideration of likely delivery mechanisms. This detailed bottom-up approach is a new

element in the Sixth Power Plan. In the Sixth Plan, the Council uses a suite of typical ramp rates to reflect near-term penetration rates. For example, measures involving emerging technology might start out at low penetration rates and gradually increase to 85 percent penetration. Measures suitable for implementation by a building code or a federal equipment standard might increase rapidly to 85 percent penetration in new buildings and major remodels. Measures requiring new delivery mechanisms might ramp up slowly. Simple measures with well-established delivery channels, like efficient shower heads, might take only half a dozen years to fully implement. Whereas retrofit measures in complex markets might take 20 years to reach full penetration. Assumptions for the bottom-up approach are detailed in the conservation supply curve workbooks shown in Table E-6 below.

Table E-6: Measures Covered in Residential Supply Curve Summary Worksheets

| Measures | Worksheet Name |
|--|---|
| New and existing lighting Clothes washers and dryers Dishwashers Refrigerators and Freezers Microwaves and ovens High efficiency water heaters, including heat pump water heaters Showerheads Waste water heat recovery Solar water heating Solar photovoltaic | PNWResDHWLight&ApplianceCurve_6thPlanv1_3.xls |
| Thermal Envelop Improvements (insulation, windows, air sealing) High Efficiency heat pumps (upgrades and system conversions) High Efficiency air conditioners (Room AC and Central AC) Duct Efficiency (sealing and interior ductwork) Heat pump commissioning and controls Ductless heat pumps | PNWResSpaceConditioningCurve_6thPlanv1_5.xls |
| Televisions Set Top Boxes Desktop computers Desktop computer monitors | PNWConsumerElectronicsSupplyCurve_6thPlanv1_3.xls |

Physical Units

The conservation supply curves are developed primarily by identifying savings and cost per unit and estimating the number of applicable and achievable units that the measure can be deployed on. In the residential sector analysis, the applicable unit estimates for space conditioning, water heating, lighting and appliances are based on the number of existing housing units and forecast of future housing growth from the Council’s Demand Forecasting Model. The housing units from the forecasting model were allocated to climate zones based on the population weighted average heating and cooling degrees for each county in the region. The housing unit data and zone allocations are all contained in the spreadsheet entitled “PNWResSectorSupplyCurveUnits_6thPlan.xls.” The estimates of physical units available include the number of units available annually. For example, for new buildings, the estimate of available new building stock is taken from the Council’s baseline forecast for annual additions by building type. Similarly for equipment replacement measures the annual stock available is

taken from estimates of the turnover rate of the equipment in question. For retrofit measures, the annual stock availability is a fraction of the estimated stock remaining at the end of the forecast period.

The number of applicable and achievable units for consumer electronics were derived from national and regional sales data and forecast for televisions, set top boxes and desktop computers and monitors. The estimates of physical units for these products are embedded in the consumer electronics supply curve workbooks cited in Table E-6.

Guide to the Residential Conservation Workbooks

Table E-7 provides a cross-walk between the measures included in the Council's assessment of regional conservation potential in the residential sector and the name of the individual workbooks. The most recent version of these workbooks are posted on the Council's website and are available for downloading.

Table E-7: Residential Sector Supply Curve Input Workbooks

| File Scope | File Name |
|---|---|
| Lighting - Existing | EStarLighting_ExistingFY09v1_1.xls |
| Lighting - New | EStarLighting_NewFY09v1_0.xls |
| Refrigerator | EStarRefrigeratorFY09v1_0.xls |
| Dishwasher | EStarResDishwasherFY09v1_0.xls |
| Freezer | EStarResFreezersFY09v1_0.xls |
| Window AC Upgrades | EStarRoomACFY09v1_0.xls |
| Clothes Washers and Dryers - Single Family | EStarWasher_DryerSingleFamily_FY09v1_1.xls |
| Clothes Washers and Dryers - Multifamily | EStarWasher_DryerMultifamily_FY09v1_0.xls |
| Marginal Cost and Load Shape Data File (needed to run Procost models to update cost-effectiveness) | MC_and_LoadShape_6P.xls |
| Residential Appliance, Lighting and Domestic Water Heating Supply Curve for Draft 6th Plan | PNWResDHWLight&ApplianceCurve_6thPlanv1_5.xls |
| Residential Supply Curve Housing and Appliance Units | PNWResSectorSupplyCurveUnits_6thPlan.xls |
| Residential Space Conditioning Supply Curve | PNWResSpaceConditioningCurve_6thPlanv1_5.xls |
| New and Existing Single Family & Manufactured Home HVAC Conversions and Upgrades to High Efficiency Heat Pumps | ResDHP&HPConversions_UpgradesFY09v1_4.xls |
| Showerhead | ResDHW_2_0gpmShowerheads_FY09v1_0.xls |
| Efficient Water Heater Tanks and Heat Pump Water Heaters | ResDHWFY09v1_1.xls |
| Waste Water Heat Recovery | ResDHWHeatRecoveryFY09v1_1.xls |
| New Multifamily Thermal Shell | ResNewMF_wAdvancedLightingsqftFY09v1_2.xls |
| New Manufactured Home Thermal Shell | ResNewMH_wAdvancedLightingsqftFY09v1_2.xls |
| New Single Family Thermal Shell | ResNewSF_wAdvancedLightingsqftFY09v1_2.xls |
| Microwaves and Ovens | ResOven_MicrowaveFY09v1_0.xls |
| Residential Sector Supply Curve Summary | ResSectorConAsmnt_070109Summary.xls |
| Multifamily Weatherization | ResWxMF_w/AdvancedLightingsqftFY09v1_2.xls |
| Manufactured Home Weatherization | ResWxMH_w/AdvancedLightingsqftFY09v1_2.xls |
| Single Family Weatherization | ResWxSF_w/AdvancedLightingsqftFY09v1_2.xls |
| Solar Domestic Water Heating | SolarDHW_FY09v1_0.xls |
| Solar Photovoltaic | SolarPV_FY09v1_0.xls |
| Consumer Electronics (Televisions, Set-top-Boxes, Computers & Monitors) | PNWConsumerElectronicsSupplyCurve_6thPlanv1_3.xls |
| Climate Zone Assignments by State and County | PNWClimateZones_6thPlan.xls |
| Housing Foundation Types | PNWFoundTypes-_6thPlan.xls |

COMMERCIAL SECTOR

Commercial Sector Definition and Coverage

For the Council's conservation analysis the commercial sector includes non-residential buildings except for industrial, as well as non-building economic activities such as street and highway lighting, outdoor area lighting, municipal sewage treatment, and water supply systems.

Commercial building floor area is one of the key drivers of the commercial conservation assessment. Floor area estimates are driven by economic forecasts of business activity, employment, demographics, and other factors such as floor area per employee. The development of the commercial floor area and load forecasts is described in Appendix C. The commercial building sector is categorized into 11 economic activity types and 18 separate building types. These building types are listed in Table E-8.

Table E-8: Building Types Covered in Commercial Supply Curve Summary Worksheets

| Primary Activity | Council Building Type | Gross Floor Area in Square Feet | Number of Stories | Note, Comment, or Example |
|------------------|-----------------------|---------------------------------|-------------------|---|
| Office | Large Office | > 100,000 | Any | |
| Office | Medium Office | 20,000 to 100,000 | Any | |
| Office | Small Office | < 20,000 | Any | |
| Retail | Big Box | > 50,000 | 1 | Includes some Grocery |
| Retail | Small Box | <50,000 | 1 | |
| Retail | High End | < 20,000 | 1 | High lighting density |
| Retail | Anchor | > 50,000 | >1 | |
| Education | K-12 | Any | Any | |
| School | University | Any | Any | University, community college |
| Warehouse | Warehouse | Any | Any | Excludes refrigerated warehouse |
| Retail Food | Supermarket | > 5000 | Any | |
| Retail Food | MiniMart | < 5000 | Any | |
| Restaurant | Restaurant | Any | Any | Fast food, sit-down, café & bar |
| Lodging | Lodging | Any | Any | Hotel, motel & residential care |
| Health Care | Hospital | Any | Any | Medical, surgical, psychiatric |
| Health Care | Other Health | Any | Any | Outpatient health, labs, ambulance |
| Assembly | Assembly | Any | Any | Churches, museums, airports, stadiums, etc. |
| Other | Other | Any | Any | Parking lots, fire protection, car wash, gasoline , cemetery, air traffic control |

Estimates of existing stock by building type and vintage cohort are based on data from the Commercial Building Stock Assessments from 2001 and 2004, construction data from F.W. Dodge, and other sources. Figure E-5 identifies floor area estimates for the 18 building types for 2010. Figure E-6 shows total historic and base case forecast commercial floor area for the period 1987 through 2029. Figure E-7 shows annual additions to commercial floor space for the same period. The year-by-year forecast of floor area by building type, employment and population used to estimate future stock is in the workbook Commercial Forecast 6P.xls identified in table E-11. The file also contains a detailed mapping of economic activity types to building types. Economic activity definitions are base on the North American Industry Classification System (NAICS) codes.

Figure E-5: Commercial Floor Area by Building Type for 2010

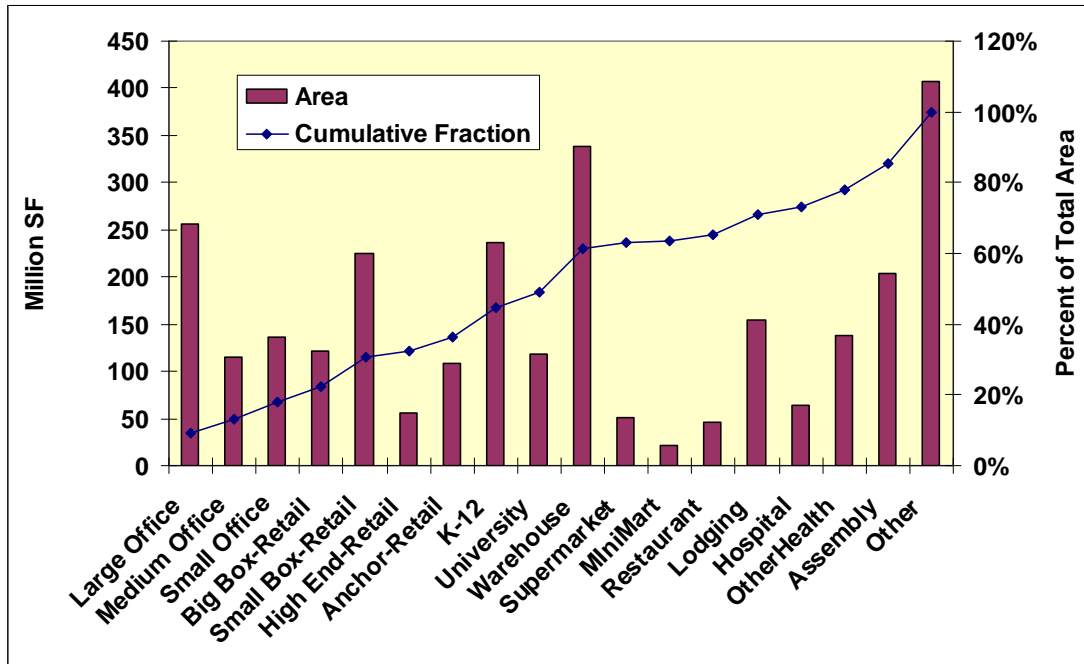


Figure E-6: Total Commercial Floor Area 1987-2029

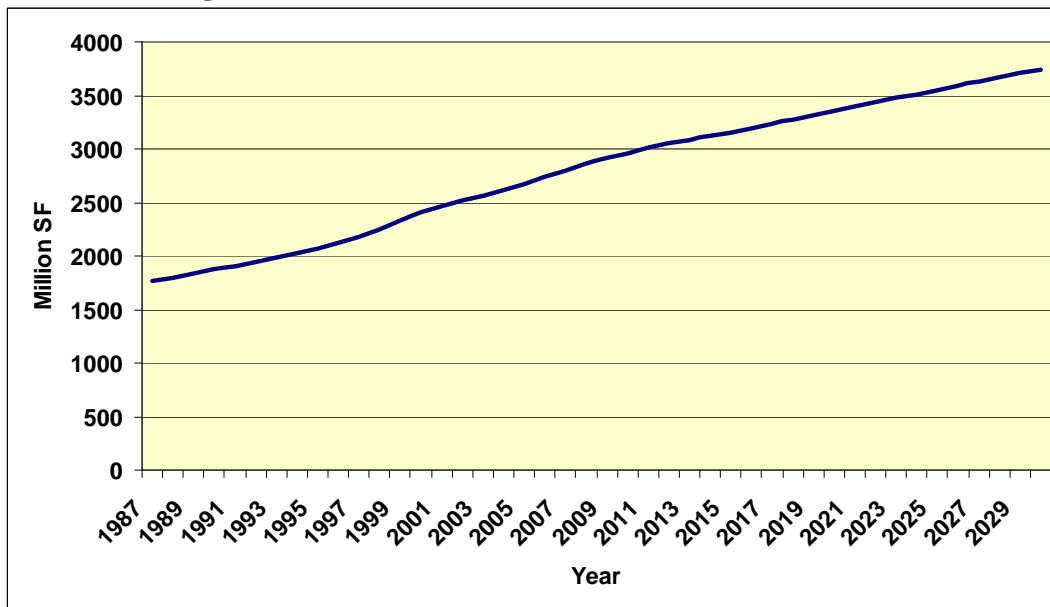
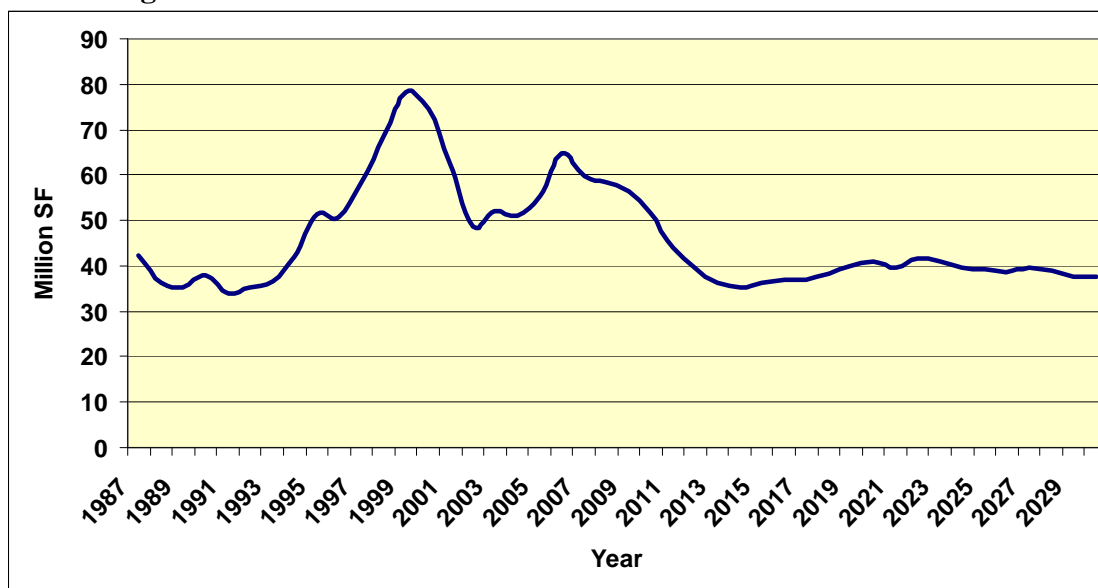


Figure E-7: Annual Commercial Floor Area Additions 1987-2029

Measure Bundles

Over 250 individual commercial-sector measures are analyzed in the Sixth Power Plan. These measures are consolidated into 45 bundles of related measures. The measure bundles are chosen primarily for analytical expediency. For example, measures that reduce interior lighting power density (LPD) are bundled together. Measures that reduce lighting hours through occupancy sensors are bundled separately. Measures that reduce interior lighting through daylighting are also bundled separately. Measure bundles do not always correspond to the way measures are bundled for programmatic implementation.

Measures are also consolidated into three types of application modes. These modes are new, natural replacement and retrofit. The new mode applies primarily to new buildings or new equipment. The natural replacement mode applies to subsystems and equipment within buildings that are replaced on burnout, at the end of their useful life, or at the time of remodel of the building or system within a building. Retrofit mode is used where a measure or a building subsystem is replaced or retired before the end of its useful life.

There are three reasons to distinguish the new, natural replacement and retrofit application modes. First, costs and savings can be different by application mode. Second, in the case of new and natural replacement, the available stock for the measure depends on the forecast of new additions and replacement rate for equipment. These opportunities are tracked separately over course of the forecast period and limit the annual availability of conservation opportunities. Third, the Council's portfolio model treats new and natural replacement applications as lost-opportunity measures that can only be captured at the time of construction or natural replacement.

Measure costs, savings, applicability, and achievability estimates are identified separately for each of the new, natural replacement and retrofit application modes. The Council analyzes measure costs and savings on an incremental basis. Measure cost is the incremental cost over what would be done absent the measure or program. The same is true for savings. Incremental

measure costs and savings can be different depending on the application mode. For example, incremental costs for high performance T8 fluorescent lamps and ballasts in a new application only include the additional cost above standard T8 lamps and ballast. But in a retrofit application, the cost of removing and disposing of existing tubes and ballast are added to the measure cost.

Table E-10 lists the commercial sector measure bundles, a short description of the measures, the number of measures in each bundle and the technical energy savings potential by 2029 in each bundle by application mode.

Table E-10: Commercial Sector Measure Bundles

| | | | | Technical Potential in MWa by Year 2029 | | | |
|--|--------------|------------------------------|---|---|-------------|------------|-------------|
| Measure Bundle | End Use | Number of Measures in Bundle | Measure Description | New | Natural | | Total |
| | | | | | Replacement | Retrofit | |
| Lighting Power Density | Lighting | 54 | Lamp, ballast and fixture improvements to lighting power density | 51 | 354 | 38 | 443 |
| Daylighting with Skylights | Lighting | 6 | Skylights with lighting controls | 16 | 0 | 0 | 16 |
| Daylighting with Windows | Lighting | 6 | Perimeter daylighting controls | 3 | 12 | 0 | 15 |
| Lighting Controls Interior | Lighting | 6 | Occupancy controls for areas not required by code such as open office, warehouse aisle, classrooms | 6 | 65 | 8 | 79 |
| Exit Signs | Lighting | 2 | LED and electroluminescent "Exit" signs | 0 | 0 | 0 | 0 |
| Premium HVAC Equipment | HVAC | 4 | HVAC equipment more efficient than applicable code or standard practice | 8 | 31 | 0 | 39 |
| Variable Speed Chiller | HVAC | 2 | Variable speed chillers | 1 | 14 | 0 | 15 |
| Controls Commission Complex HVAC | HVAC | 20 | Commissioning on HVAC systems in buildings with complex HVAC systems | 10 | 0 | 124 | 134 |
| Package Roof Top Optimization and Repair | HVAC | 8 | Suite of measures and control strategies for buildings served by package roof top HVAC units | 4 | 8 | 16 | 29 |
| Low Pressure Distribution Complex HVAC | HVAC | 2 | Dedicated Outside Air or Underfloor Air distribution systems in buildings with complex HVAC systems | 6 | 0 | 0 | 6 |
| Demand Control Ventilation | HVAC | 5 | Fan control strategies, DCV and Fleet Strategy DOAS with heat recovery in simple HVAC systems | 4 | 4 | 14 | 22 |
| ECM Motors on Variable Air Volume Boxes | HVAC | 2 | Electrically Commutated Motors on Variable Air Volume Boxes | 3 | 9 | 0 | 12 |
| Evaporative Assist Cooling | HVAC | 0 | Evaporative Assist Cooling | 0 | 0 | 0 | 0 |
| Windows | HVAC | 39 | Windows and glazing more efficient than code or standard practice | 3 | 8 | 22 | 33 |
| Roof Insulation | HVAC | 2 | Add insulation during re-roofing | 0 | 3 | 0 | 3 |
| Duct Sealing and Repair | HVAC | 0 | Sealing and repair of ductwork in unconditioned spaces | 0 | 0 | 0 | 0 |
| Efficient fans, pumps and drives | HVAC | 0 | Variable speed fans, pumps and drives, pump and fan system efficiencies and demand control | 0 | 0 | 0 | 0 |
| Exterior Building Lighting | Ext Lighting | 4 | Efficient façade, walkway, area and decorative exterior lighting, such as LED | 0 | 67 | 0 | 67 |
| Integrated Building Design | Multi | 13 | Multiple measures applied in integrated design practice | 61 | 0 | 0 | 61 |
| Street and Roadway Lighting | Ext Lighting | 2 | Efficient street and roadway lighting, LED and induction | 8 | 42 | 0 | 51 |
| Parking Lighting | Ext Lighting | 2 | Efficient parking lot and garage lighting and controls | 1 | 38 | 0 | 38 |
| LED Traffic Lights | Ext Lighting | 1 | LED traffic signals | 0 | 0 | 0 | 0 |
| Signage | Ext Lighting | 1 | LED advertising signs | 0 | 5 | 0 | 5 |
| Municipal Sewage Treatment | Process | 10 | Suite of measures for sewage treatment | 0 | 0 | 27 | 27 |
| Municipal Water Supply | Process | 5 | Suite of measures for water supply systems | 0 | 0 | 13 | 13 |
| Network PC Power Management | Process | 1 | Control of a networked computer's advanced energy management systems | 0 | 0 | 40 | 40 |
| Packaged Refrigeration Equipment | Process | 20 | Efficient refrigerators and freezers, beverage merchandizers, ice makers and vending machines | 52 | 0 | 0 | 52 |
| Commercial Clothes Washers | Process | 0 | Clotheswashers more efficient than federal standard | 0 | 0 | 0 | 0 |
| Cooking Equipment | Process | 0 | Efficient cooking equipment such as hot food holders, grills, fryers and steam tables | 0 | 0 | 0 | 0 |
| Office Equipment | Process | 2 | Efficient Desktop PC and Efficient Monitor | 0 | 0 | 0 | 0 |
| Computer Servers and IT | Process | 2 | Consolidation & virtualization & upgrade of servers in embedded server rooms in buildings | 0 | 0 | 88 | 88 |
| DCV Restaurant Hood | Process | 1 | Demand control ventilation systems for large restaurant hoods | 0 | 0 | 4 | 4 |
| DCV Parking Garage | Process | 1 | Demand control ventilation systems for parking garages | 0 | 0 | 0 | 0 |
| Grocery Refrigeration Bundle | Process | 12 | Grocery store refrigeration measures | 0 | 0 | 68 | 68 |
| Plug Load Sensor | Process | 1 | Occupancy controls for task lighting and other ancillary loads in offices | 0 | 0 | 0 | 0 |
| Premium Fume Hood | Process | 1 | Efficient fume hoods in labs | 21 | 0 | 0 | 21 |
| Pre-Rinse Spray Wash | Process | 1 | Low-flow pre-rinse spray valves for restaurant kitchens, cafeterias, and food-serving | 0 | 0 | 2 | 2 |
| Total | | 238 | | 258 | 662 | 462 | 1382 |

Overview of Methods

Measure costs and savings are developed at a level of detail compatible with data availability, expected variance in measure costs and savings, the diversity of measure applications and practical limitations on the number of measures that can be analyzed. Costs and savings are based both on engineering estimates as well as estimates based on results from the operation of existing programs. Savings potential is the product of savings per unit and the forecast of number of units that the measure is applicable to. For most of the commercial sector measures, building floor area, by building type, is the primary unit of measure. Most measures apply to a fraction of the building stock in a particular building type. In addition to building floor area, several of the measure potential estimates are based on forecast of equipment stock, equipment turnover rates, equipment sales data, population, and process capacity.

For every measure or practice analyzed, there are four major methodological steps to go through. These steps establish baseline conditions, measure applicability, and measure achievability. For the commercial-sector conservation measures, each of these is treated explicitly for each measure bundle.

Baseline Characteristics

Baseline conditions are estimated from current conditions for existing buildings and systems. Estimates of current conditions and characteristics of the building stock come from several sources. Key among these are the Pacific Northwest Commercial Building Stock Assessment (CBSA), the national Commercial Building Energy Consumption Survey (CBECS), market research projects of the Northwest Energy Efficiency Alliance (NEEA), selected studies from utilities, Energy Trust of Oregon, and other sources.

For new buildings, new and replacement equipment, baseline conditions are estimated from a combination of surveys of new buildings, state and local building energy codes and federal and state appliance efficiency standards. The most recent survey data used is from the NEEA New Buildings Characteristics study completed in 2008 which looked at buildings built in the 2002-2004. Codes and standards are continually being upgraded. The baseline assumptions used in the Sixth Power Plan are those that were adopted at the end of 2008, with a few exceptions. Some of these include standards that are adopted now but with effective dates that occur in the future. For such codes or standards, both savings estimates and the demand forecast reflect the effective dates of adopted standards.

Measure Applicability

Measure applicability reflects several major components. First is the technical applicability of a measure. Technical applicability includes what fraction of the stock the measure applies to. Technical applicability can be composed of several factors. These include the fraction of stock that the measure applies to, overlap with mutually exclusive measures and the existing saturation of the measure. Existing measure saturation reflects the fraction of the applicable stock that has already adopted the measure and for which savings estimates do not apply. There are hundreds of applicability assumptions in the conservation assessment. Applicability assumptions and source references are detailed in the workbooks for each measure bundle.

Measure Achievability

The Council assumes that only a portion of the technically available conservation can be achieved. Ultimate achievability factors are limited to 85 percent of the technically available

conservation over the twenty-year forecast period. In addition to a limit of 85 percent, the Council considers near-term achievable penetration rates for bundles of conservation measures. Several factors are used to estimate near-term achievability rates. Recent experience with region wide conservation program accomplishments is one key factor. But in addition to historic experience, the Council also considers a bottom-up approach to estimate near-term achievability.

In the bottom-up approach, the Council estimates near-term achievability rates of each bundle of conservation measures based on the characteristics of the measures in the bundle being described and consideration of likely delivery mechanisms. This detailed bottom-up approach is a new element in the Sixth Power Plan. In the Sixth Plan, the Council uses a suite of typical ramp rates to reflect near-term penetration rates. For example, measures involving emerging technology might start out at low penetration rates and gradually increase to 85 percent penetration. Measures suitable for implementation by a building code or a federal equipment standard might increase rapidly to 85 percent penetration in new buildings and major remodels. Measures requiring new delivery mechanisms might ramp up slowly. Simple measures with well-established delivery channels, like efficient shower heads, might take only half a dozen years to fully implement. Whereas retrofit measures in complex markets might take 20 years to reach full penetration.

Assumptions for the bottom-up approach are detailed in the conservation supply curve workbooks. The worksheet “ACHIEV” in the workbook ComMaster contains all the achievability assumptions by measure bundle.

Physical Units

The conservation supply curves are developed primarily by identifying savings and cost per unit and estimating the number of applicable and achievable units that the measure can be deployed on. In the commercial sector analysis, the applicable units estimates come from several sources. For measures in buildings, the units are primarily floor area with applicable characteristics. These data come primarily from the Commercial Building Stock Assessment (CBSA). For some of the equipment measures, additional unit data from utility surveys of characteristics, national data from Commercial Building Energy Consumption Survey (CBECS), equipment sales data, census data, and many others.

The estimates of physical units available include the number of units available annually. For example, for new buildings, the estimate of available new building stock is taken from the Council’s baseline forecast for annual additions by building type. Similarly for equipment replacement measures the annual stock available is taken from estimates of the turnover rate of the equipment in question. For retrofit measures, the annual stock availability is a fraction of the estimated stock remaining at the end of the forecast period. The estimates of physical units available are called stock models and are embedded in the measure bundle workbooks. The worksheets that contain the stock models are identified by the prefix “SC”.

Guide to the Commercial Conservation Workbooks

There are about 50 Excel workbooks used to develop the commercial-sector conservation assessment. In addition there are dozens of outside sources of data which are referenced. The Council workbooks are available from the Council website.⁶ Supporting data sources are identified in the workbooks and the key supporting data from these sources is summarized in the

⁶ <http://www.nwcouncil.org/energy/powerplan/6/supplycurves/default.htm>

Council workbooks. All outside source data is cited in the workbooks or otherwise made available to the extent it is not proprietary.

Figure E-8 describes the main components and structure of the commercial conservation assessment workbooks. The workbooks and brief descriptions of their purpose are listed in Table E-11.

Figure E-8: Main Components and Structure of the Commercial Conservation Assessment Workbooks

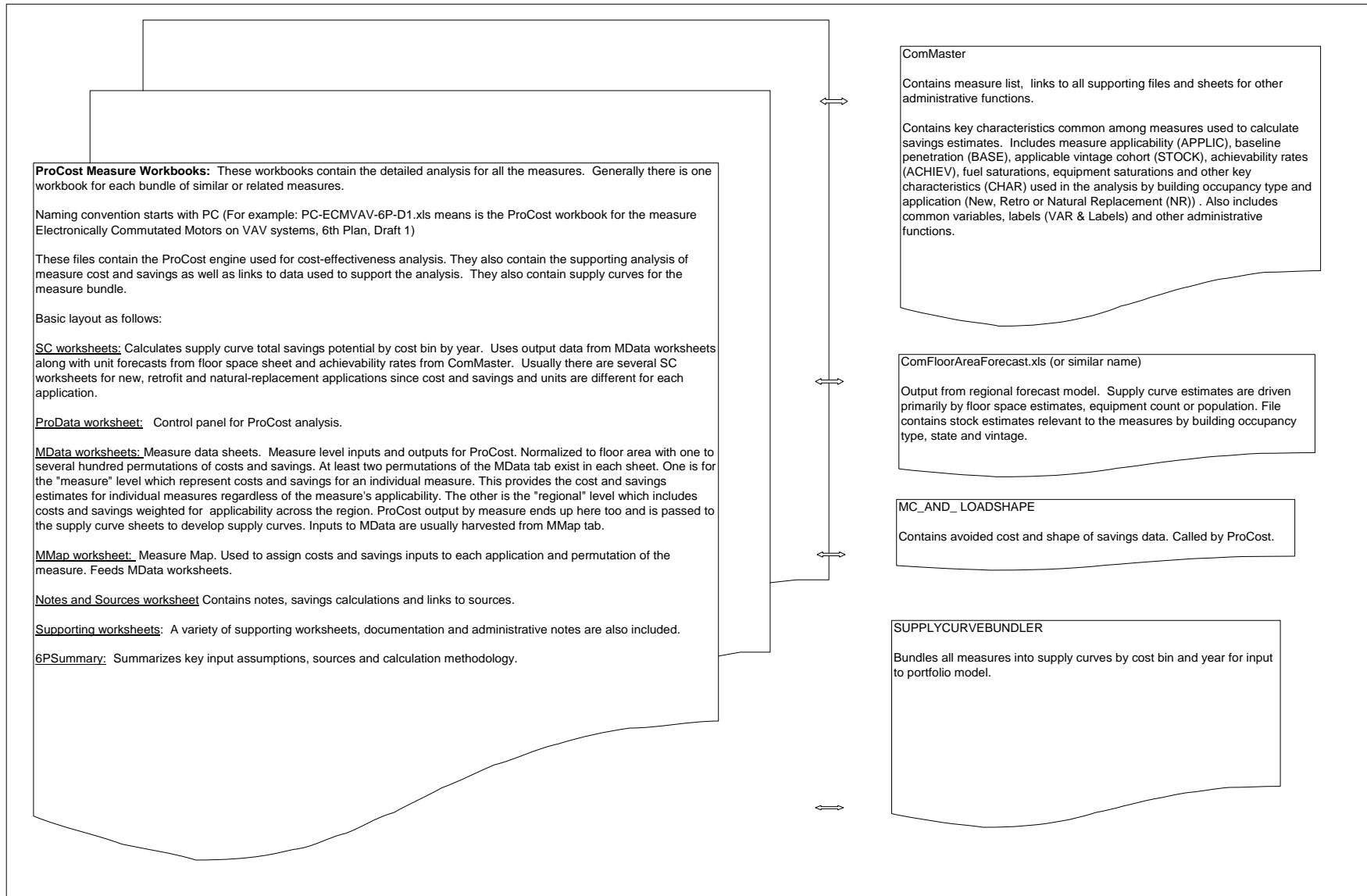


Table E-11: List of Commercial-Sector Workbooks

| File Name | File Description |
|--|---|
| Com_Master | Master Workbook for Commercial Sector Conservation |
| ComLighting_v2008-D2 | Support file for lighting power density measure workbook |
| Commercial Forecast 6P | Floor area and population forecast |
| InteractionsBldgType01082004- | Space Heat and Cooling Interaction Factors for Lighting Savings |
| MC_AND_LOADSHAPE_6P | Marginal Cost and Load Shape Data File |
| PC-Cooking-6P-D1 | Measure workbook: Cooking |
| PC-DCVGarage-6P-D1 | Measure workbook: Demand Control Ventilation Parking Garage |
| PC-DCVHood-6P-D1 | Measure workbook: Demand Control Ventilation Restaurant |
| PC-DemandControlVent-6P-D4 | Measure workbook: Demand Control Ventilation for HVAC |
| PC-DuctSeal-6P-D1 | Measure workbook: Duct Sealing |
| PC-ECMVAV-6P-D4 | Measure workbook: ECM Motors in Variable Air Volume HVAC |
| PC-EvapAssist-6P-D1 | Measure workbook: Evaporative Assist Cooling |
| PC-Exit Sign-6P-D2 | Measure workbook: Exit Signs |
| PC-ExtLight-6P-D1 | Measure workbook: Exterior Building Lighting |
| PC-FanPumpDrive-6P-D1 | Measure workbook: Adjustable Drives for Fans & Pumps |
| PC-FumeHood-6P-D1 | Measure workbook: Efficient Lab Fume Hood |
| PC-Grocery-6P-D3 | Measure workbook: Grocery Store Measures |
| PC-HVACControls-6P-D4 | Measure workbook: Controls Commission Complex HVAC |
| PC-HVACEQUIP-6P-D7 | Measure workbook: Premium HVAC Equipment |
| PC-IntDesign-6P-D1 | Measure workbook: Integrated Building Design |
| PC-Lighting Controls Interior-6p- | Measure workbook: Lighting Controls Interior |
| PC-Lodging-6P-D1 | Measure workbook: Lodging-Specific Measures |
| PC-LowPressureDist-6P-D1 | Measure workbook: Low Pressure Distribution Complex HVAC |
| PC-LPDPackage-6P-D16 | Measure workbook: Lighting Power Density Interior |
| PC-NetworkPC Power | Measure workbook: Network PC Power Management |
| PC-OfficeEquip-6P-D1 | Measure workbook: Office Equipment |
| PC-Pack Refrig Equip-6P-D3 | Measure workbook: Refrigerators, freezers, ice makers, |
| PC-PackRTOptimize-6P-D6 | Measure workbook: Package Roof Top Optimization and Repair |
| PC-Parking Lighting-6P-D1 | Measure workbook: Parking Lighting |
| PC-PlugLoadSensor-6P-D1 | Measure workbook: Plug Load Sensor |
| PC-ReRoof-6P-D1 | Measure workbook: Roof Insulation |
| PC-ServerRooms and IT-6P-D1 | Measure workbook: Computer Server Room Efficiency |
| PC-SideDaylight-6P-D1 | Measure workbook: Day Lightng Control - Windows |
| PC-Singage-6P-D1 | Measure workbook: LED Signage |
| PC-Spray Head-6P-D1 | Measure workbook: Pre-Rinse Spray Valve |
| PC-StreetRoadway-6P-D2 | Measure workbook: Street and Roadway Lighting |
| PC-TopDaylightNew-6P-D5 | Measure workbook: Day Lighting Control - Skylights |
| PC-Traffic Signals-6P-D1 | Measure workbook: LED Traffic Signals |
| PC-VSDChiller-6P-D3 | Measure workbook: Variable Speed Chillers |
| PC-Wastewater-6P-D1 | Measure workbook: Municipal Wastewater |
| PC-WaterSupply-6P-D3 | Measure workbook: Municipal Water Supply |
| PC-Windows-6P-D10 | Measure workbook: Windows |
| ProCostFinAssumptions_Sector | Financial Assumptions |
| SupplyCurveBundlerLO | Bundles all Lost-Opportunity Measures into Supply Curves |
| SupplyCurveBundlerRetro | Bundles all Retrofit Measures into Supply Curves |

The main workbook is named ComMaster. ComMaster contains the master measure list, the measure bundles, common assumptions used throughout the analysis and links to the ProCost

Appendix E: Conservation Supply Curve Development

measure files where detailed measure-specific analysis resides. The reference data in ComMaster are primarily in matrices by measure bundle and building type. The reference data in the ComMaster file are listed and described in Table E-12.

Table E-12: Reference Data in ComMaster Workbook

| Sheet Name | Contents |
|------------|--|
| Overview | Overview of model structure |
| MLIST | Master List of measure bundles |
| FILES | List and links to measure-level files. Plus housekeeping. |
| APPLIC | Applicability factor for the measure. Fraction of stock the measure applies to. |
| BASE | Baseline penetration of measure. Estimated fraction of stock where the measure is already in place. |
| STOCK | Vintage cohort that the measure applies to. |
| TURN | Turnover rate for stock to which measure applies. |
| ACHIEVE | Achievable rate of acquisition for measure bundles by year |
| CODE | Tables developed to estimate regional baseline penetration for various elements of energy codes by jurisdiction |
| CHAR | Key characteristics for stock by vintage cohort and building subtype. Used to develop regional application of meas |
| FLOOR | Floor area forecast summary used to develop data in CHAR |
| VARS | List of variables used in the CHAR tab and elsewhere in the files. |
| Labels | Map of building types labels from different sources. |
| Lookup | Lookup table for vintage cohort |
| EUI | Reference EUI from various sources including CBECS & CBSA. |

INDUSTRIAL SECTOR

Overview

The Sixth Plan Industrial Supply Curve (ISC) conservation assessment was prepared by a contractor, Strategic Energy Group (SEG) with guidance from Council staff and an advisory group. The assessment includes an Excel workbook, referred to as the Measure Analysis Tool, which contains industrial load data, measure data, conservation supply curves and documentation. There is another Excel workbook, referred to as the NPCC Supply Curve Generator, which converts measure costs and savings data to conservation supply curves for input to the Council's Resource Portfolio Model. The contractor also prepared documentation of the development of the analysis, the Measure Analysis Tool, and a detailed description of the modeling of a subset of the measures referred to as System Optimization Measures.

In addition to these major components, the assessment includes a rich dataset of sources referred to as the Industrial Data Catalogue and a guide to that catalogue. Finally, the project also developed a detailed database on motor loads at industrial facilities in the Northwest. This is called the Northwest Industrial Motor Database.

Industrial Sector Overview and Coverage

The Council's industrial sector analysis covers most of the region's non-DSI industries plus refrigerated warehouse storage. The assessment does not include savings estimates for the direct-service industries. Nor does it cover savings potential in the information technology sector (IT). These two subsectors were beyond the scope of the industrial assessment.

Structure of the Analysis

The conservation assessment model is structured differently than the Council's assessments in other sectors. The ISC model uses estimates of energy savings as a fraction of load by end use by industry.

Appendix E: Conservation Supply Curve Development

First, data were collected on electricity use by industry by state. These data came from a variety of sources primarily utility-provided reports. But other sources were considered too including data supplied by individual plants, proprietary datasets and publicly-available data. These data were calibrated to industrial load data reported by state to EIA. Then the consumption estimates were split into estimates of electricity use by major process end use. Then energy conservation measures (ECMs) are applied to the use by end use estimates as a percent savings with associated costs. Finally, factors for measure applicability, measure interaction, and achievability rates over time are applied. A detailed summary of the structure of the assessment is available in the document entitled “ISC Model Review R4”.

Guide to the Industrial Sector Workbooks and Data

Table E-13 identifies the key workbooks and files that comprise the industrial conservation assessment.

Table E-13: List of Industrial Sector Workbooks

| Item | Description |
|--|--|
| Measure Analysis Tool | Excel workbook containing the major elements of the industrial sector characterization, the estimates of end use splits and the details on the energy conservation measures |
| Description of Measure Analysis Tool | Description of the structure and development of the Measure Analysis Tool |
| NPCC Supply Curve Generator | Excel workbook which translates the costs and savings from the Measure Analysis Tool into supply curve data for the Regional Portfolio Model. Uses ProCost to develop TRC Net levelized costs consistent with estimates in other sectors |
| Documentation on System Optimization Measures | Excel workbook containing detailed derivation of costs, savings and measure applicability for a suite of measures related to system optimization of key industrial processes |
| Systems Whole Plant Optimization Overview | Description of the system optimization and whole plant measure bundles, the input assumptions, and supporting sources |
| Industrial Data Catalogue and Guide | Large database of industrial data sources. A compilation of published and unpublished resource assessments, market and technology reports, datasets, case studies and guidebooks focused on industrial energy efficiency and energy management. The files include N electronic collection of these resources |
| Northwest Industrial Motor Database | Information on motors that collected over 20 years by the Industrial Assessment Center (IAC) at Oregon State University (OSU). The Northwest Industrial Motor Database includes a database of a total of 22,514 records, each with detailed motor application data. |

AGRICULTURAL SECTOR

Overview

The Sixth Power Plan’s assessment of conservation potential in the agriculture sector covers irrigation hardware system efficiency improvements, irrigation water management (scientific irrigation scheduling) and dairy farm milk processing. Consistent with the conservation assessments in prior plan’s the largest potential savings in the agriculture sector are available through irrigation hardware system efficiency improvements, including reducing system

operating pressures, reducing system leaks and improving pump efficiency. The next largest savings in this sector come from improved water management practices followed by dairy milk processing savings. This is the first Council plan to estimate savings from irrigation water management and dairy milk production.

Measure Bundles

Seven generic irrigation hardware system efficiency improvements and three “operation and maintenance” (e.g., gasket and nozzle replacement) measures are analyzed in the Sixth Power Plan. Irrigation water management practices were considered as a bundled measure consisting of moisture monitoring hardware and software. Four individual, non-interactive measures were considered for improving the energy efficiency of dairy milking barns and milk processing.

Overview of Methods

The irrigation hardware efficiency measures were evaluated using savings derived from an engineering spreadsheet model that simulates the energy use of a center pivot system using alternative pump efficiencies, static and dynamic head, annual water throughput and system leakage rates. Each hardware efficiency measure’s savings were estimated based on water supplied by a well of average depth and water supplied by a deep well for each of the Northwest states. Data on well depth, amount of water applied, average pump size and irrigated acreage served by each type of irrigation system were drawn from the most recent USDA Farm and Ranch Survey. All data used from this survey are shown in the “IrrgAgHardwareSupplyCurve_6Pv1_1.xls.”

Irrigation water management savings were estimated using a spreadsheet developed by the Columbia Basin Ground Water Management Association (GAMA). This spreadsheet was modified to reflect the average water savings achieved in Bonneville’s evaluation of irrigation water management. This evaluation documented the average water savings from scientific irrigation water management as well as the cost of carrying out improved practices. Dairy efficiency improvements were based on detailed audits and retrofits of 30 dairies in New York carried out by the New York State Energy Research and Development Administration (NYSERDA).

Baseline Characteristics

Baseline conditions for irrigation hardware system efficiency improvements were estimated from the USDA Farm and Ranch survey and discussions with Bonneville and utility staff with in-depth experience working with farmers on these systems. Baseline characteristics (i.e., the average amount of water applied by crop type and acreage) for irrigation water management in the Columbia Basin Project was provided by GAMA. Dairy efficiency in the region was assumed to parallel that found by NYSERDA.

Measure Applicability and Measure Achievability

No quantitative study has been conducted in the region to determine the current saturation and remaining opportunities for improvement in either irrigation system hardware or on dairies. Therefore, judgment, based on discussions with Bonneville and utility program staff served as the basis estimating the remaining number of systems and dairies in the region that could carry out cost-effective energy efficiency improvements. Where quantitative data was available (e.g.

Appendix E: Conservation Supply Curve Development

the acreage irrigated with high pressure systems) this data was used to size the remaining opportunities for savings.

Physical Units

The conservation supply curves are developed primarily by identifying savings and cost per unit and estimating the number of applicable and achievable units that the measure can be deployed on. In the irrigation sector analysis, the applicable unit estimates for irrigated acreage, system types and annual water application were drawn from the USDA Farm and Ranch Survey. GAMA provided data on the acreage and crop types present in Columbia Basin Project. The estimate of current dairy production in the region also comes from the USDA and the US Department of Commerce. Staff developed a forecast of future milk production growth in the region using historical trends.

The three workbooks containing the Agriculture Sector conservation resource assessment are downloadable from the web. These are:

- Irrigation Hardware System Efficiency Improvements - IrrgAgHardwareSupplyCurve_6Pv1_1.xls
- Irrigation Water Management - SIS_SupplyCurve_6thPlanv1_1.xls
- Dairy Efficiency Improvement - DairySupplyCurve_6thPlanv1_1.xls

DISTRIBUTION SYSTEM

Overview

The Sixth Power Plan includes a conservation potential assessment on the region's electric distribution system. The assessment is based on a study completed in 2007 by R.W. Beck for the Northwest Energy Efficiency Alliance (NEEA).

Structure of the Analysis

The distribution system conservation assessment uses savings estimates from measured data on 33 utility feeders, and analytical methods developed by RW Beck in the NEEA study. Costs and savings for four major measures were identified and applied to a descriptive data set of the region's distribution system. The dataset contains system loads by customer class, substation counts, feeders counts, customer counts and climate zones for 137 regional utilities used to generate the units estimates. Table E-14 below identifies the key workbooks and data used in the analysis.

Table E-14 identifies the key workbooks and files that comprise the distribution system conservation assessment.

Table E-14: List of Agriculture Sector Workbooks

| Item | Description |
|---|---|
| NPPC Supply Curve | Excel workbook used to generate the supply curves with documentation |
| Supporting Data | Excel workbook containing the data on distributions systems and the key factors for the savings estimates |
| Distribution Efficiency Initiative | 2007 RW Beck Study for NEEA. Findings from this study were used to develop the conservation supply curves |