Conservation Cost-Effectiveness Determination Methodology

CONSERVATION COST-EFFECTIVENESS

As with all other resources, the Council uses its portfolio model to determine how much conservation is cost-effective to develop.[1] The portfolio model is designed to compare resources, including conservation on a "generic" level. That is, it does not model a specific combined cycle gas or coal plant 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. In order to capture the impact of variations in wholesale market prices during the day and through the year have on conservation's value, the savings in these two supply curves are allocated to "on-peak" and "off-peak" periods for each quarter of the year. This allocation is done based on the collective savings-weighted load shape of the individual measures in each of these supply curves.

However, it is not possible to determine individual measure or program cost-effective using the Council's portfolio model. Run time constraints limit the number of conservation programs the portfolio model can consider. The portfolio model 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. In addition, conservation provides other benefits that are not accurately captured by the portfolio model.

First, unlike generating resources, conservation savings can defer the need to expand distribution and transmission networks. While the Council attempts to capture these benefits by adjusting the levelized cost of the aggregate supply curves, the portfolio model does not evaluate each measure's specific load shape and therefore does not accurately reflect that measure's impact on the need to expand transmission and distribution systems. Second, some conservation measures, for example high efficiency clothes washers that save both water and electricity, provide "non-energy system" benefits to consumers. Because of programming constraints, the levelized costs of conservation used in the portfolio model are not adjusted for non-energy benefits that accrue to the customers. Therefore, to determine whether a specific conservation measure or package of measures is regionally cost-effective requires the Council to compare the present value of each measure's benefits to the present value of its life cycle costs based on its specific benefits and costs. Benefits

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[1] 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.

include energy and capacity cost savings, local distribution cost savings and the 10 percent credit given conservation in the Northwest Power Act and any quantifiable non-energy benefits.[2]

Benefit-to-Cost Ratio

The costs included in the Council's analyses are the sum of the total installed cost of the measure, program administrative costs and any operation and maintenance costs (or savings) associated with ensuring the measure's proper functioning over its expected life. The benefit-to-cost ratio of a measure is the sum of the present value benefits divided by the sum of the present value costs. Any measure that has a benefit-to-cost ratio of 1.0 or greater is deemed to be regionally cost effective. Those measures that pass this screening step are then grouped into "programs. The cost of this package of measures is then increased to account for program administrative expenses to estimate whether the overall package is regionally cost-effective.[3] If the "program" package has a benefit-to-cost ratio of less than 1.0 then the most expensive measures are removed from the package until the program's benefits equal or exceed its costs.

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. Each measure's annual savings are evaluated for their effects on the power system over the 8,760 hours in a year and over the twenty years in the planning period.

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.

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

[2] To ensure that conservation and generating resources are compared fairly, the costs and savings of both types of resources must be evaluated at the same point of distribution in the electrical grid. Conservation savings and costs are evaluated at the point of use, such as in the house. In contrast, the costs and generation from a power plant are evaluated at the generator itself (busbar). Thus, to make conservation and the traditional forms of generation comparable, the costs of the generation plant must be adjusted to include transmission system losses and transmission costs.

[3] In addition to the direct capital and replacement costs of the conservation measures, administrative costs to run the program must be included in the overall cost. Administrative costs can vary significantly among programs and are usually ongoing annual costs. In prior power plans, the Council used 20 percent of the capital costs of a conservation program to represent administrative costs. The Council's estimate of 20 percent falls within the range of costs experienced in the region to date. Therefore, the average cost of all conservation programs is increased 20 percent before being compared to generating resources.

Southwest. Consequently, wholesale power prices are significantly higher during the peak air conditioning season in July and August than they are during the remainder of the year. As a result, 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.

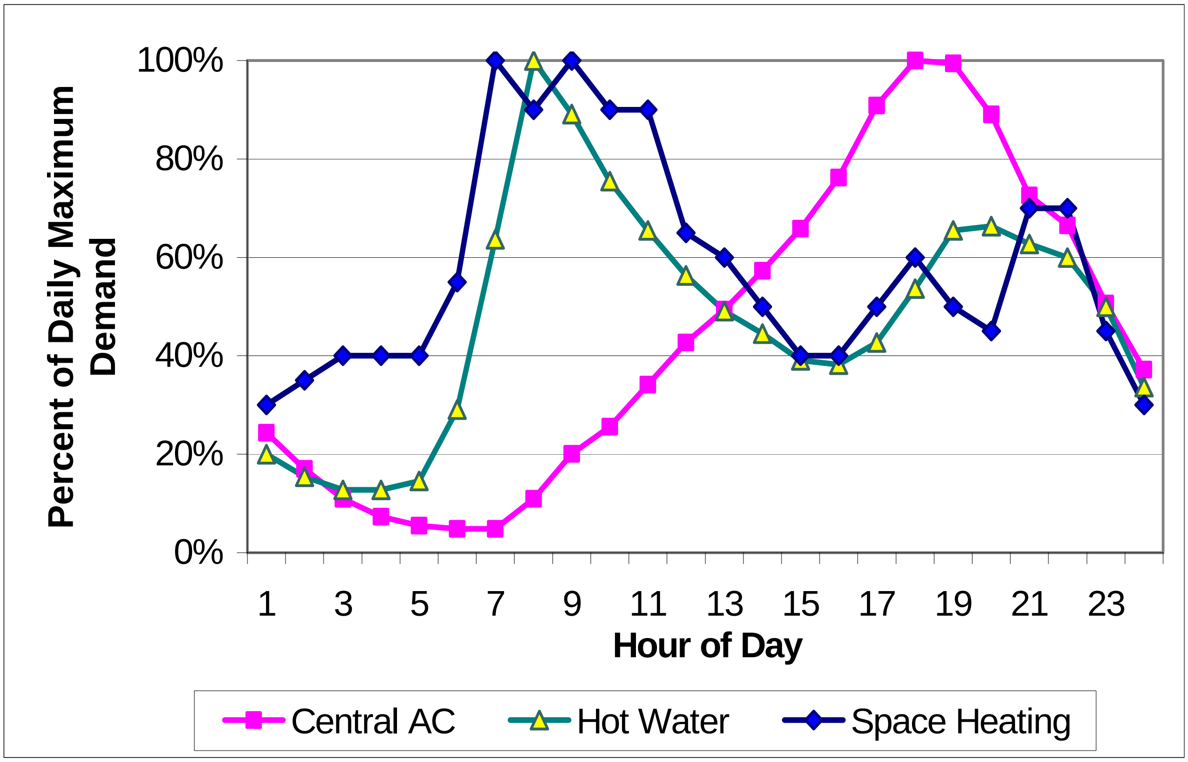

Figure E-1: Hour Load Profile for Residential Central Air Conditioning Water Heating and Space Heating Conservation Savings

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 over the course of a typical day. The horizontal axis shows the hour of the day, with hour "0" representing midnight.

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 significantly over the course of a typical summer day and less significantly over the course of a winter day. Figure E-2 shows the average levelized "on peak" and "off peak" wholesale market prices at the Mid-Columbia trading hub for January and August. As can be seen from Figure E-2, summer “on-peak” savings are far more valuable than those that occur either “off-peak” during the summer or either “on” or “off-peak” during the winter.

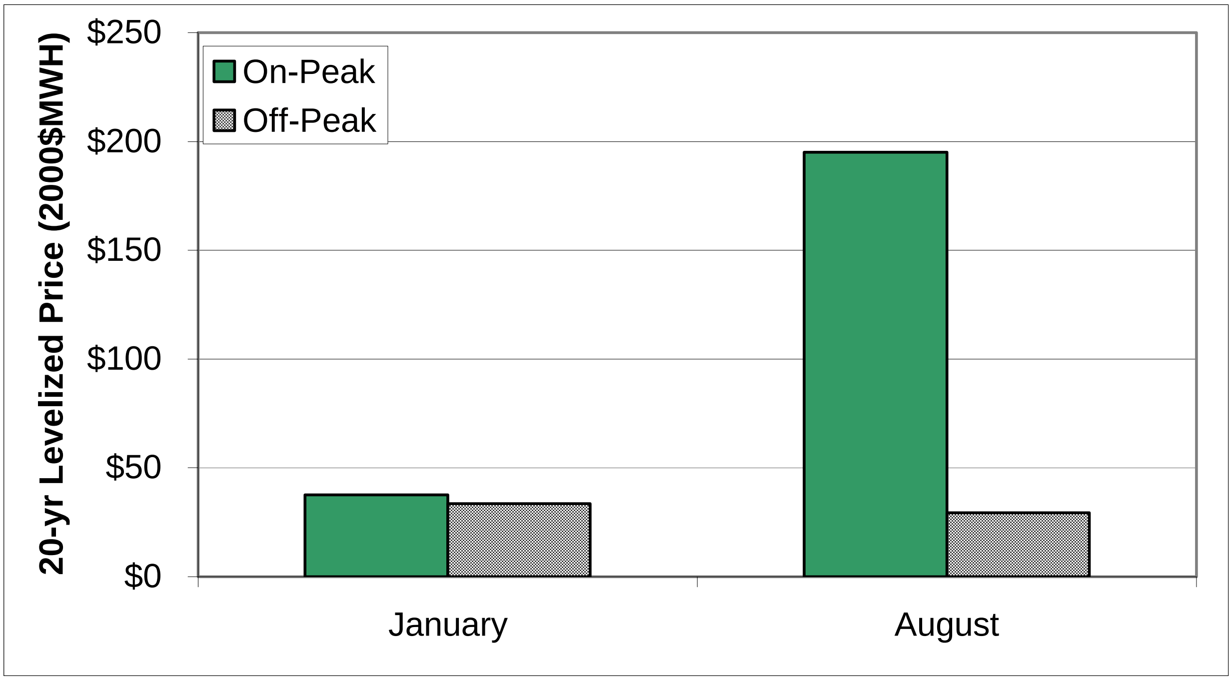

Figure E-2: Forecast Levelized “On” and “Off-Peak” Wholesale Power Market Prices for January and August at Mid Columbia Trading HUB

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. Figure E- 3 shows an illustrative example of the levelized avoided cost by month compared to the monthly distribution of central air conditioning and space heating savings. 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 all time periods’ avoided costs establishes the value of the kilowatt-hour portion of the energy savings.

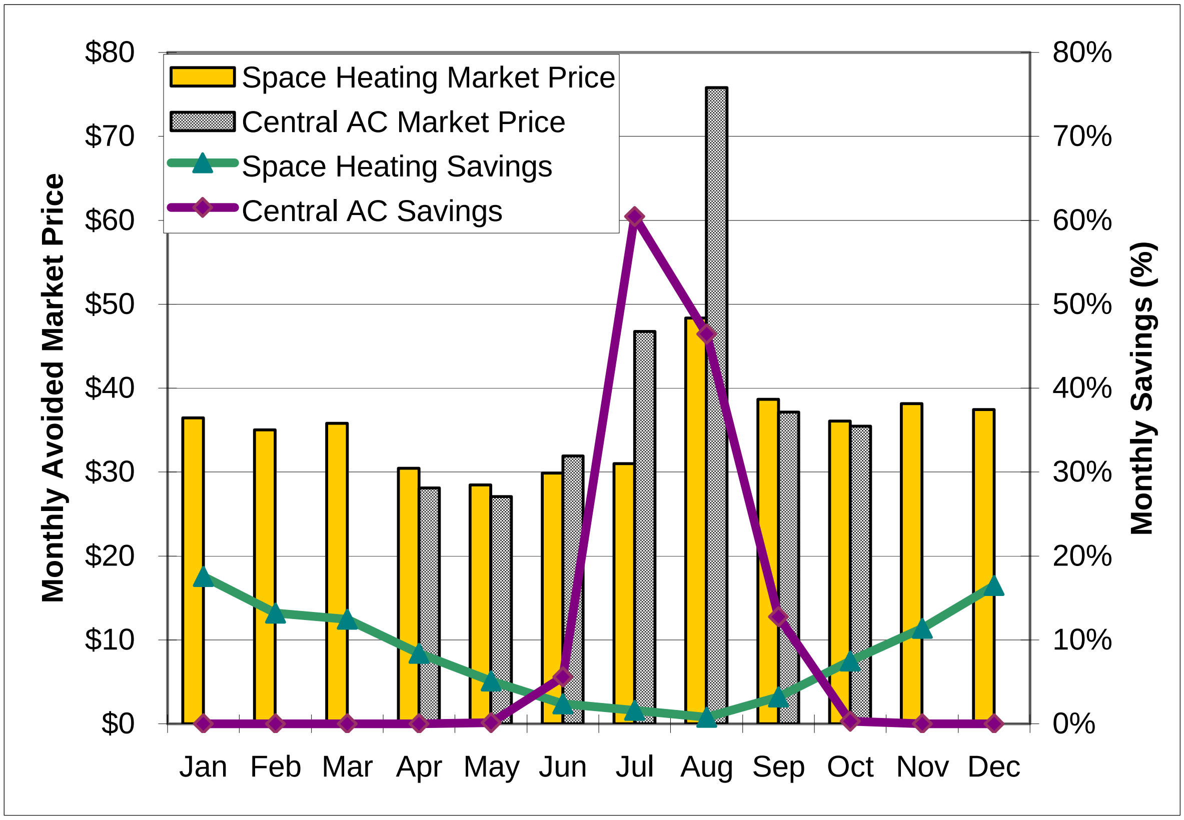

Figure E-3: Illustrative Levelized Wholesale Market Price by Month Compared to Monthly Energy Savings for Space Heating and Central Air Conditioning

An inspection of Figure E-3 reveals that the cost-effectiveness limit for air conditioning will be higher than for space heating because wholesale market prices for electricity are higher at the times when air conditioning energy is saved. In this example, the "cost-effectiveness limit" for a conservation measure that produced savings shaped like those for residential central air condition would be 8.8 cents per kilowatt-hour compared to just 3.7 cents per kilowatt-hour if its savings were shaped like residential space heating.

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. Although the Council currently uses its "base case" AURORA® model forecast of future wholesale market prices to determine conservation cost-effectiveness, the Council is reviewing its analytical system to determine whether it is feasible to use the portfolio model's distribution of future market prices rather than a single market price forecast. In the interim, the value of conservation savings determined using the "base case" AURORA® market price forecast should be viewed as conservative since this value does not incorporate any hedge against future market price volatility.

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) from the Oregon Public Utilities Commission to develop a "default" estimate of avoided transmission and distribution costs. Table 6 presents data collected from PacifiCorp and Portland General Electric (PGE) based on their filings in Oregon. Information from Snohomish County Public Utility District (Snohomish PUD) on distribution system costs only is also included in this table.

Table E-1: Utility Specific Avoided Costs for Transmission and Distribution

COMPANY	TRANSMISSION	DISTRIBUTION	TOTAL
PacifiCorp	$21.40/kW-yr	$57.59/kW-yr	$78.99/kW-yr
PGE	$7.18/kW-yr	$15.40/kW-yr	$22.58/kW-yr
Snohomish PUD	(N/A)	$9.50/kW-yr	(N/A)

From the information collected, the RTF chose as its "default" assumption a value of $20 per kilowatt year as the avoided cost of local utility transmission and distribution avoided cost. The RTF also chose a “default” value of $3 per kilowatt year for avoided transmission system expansion cost. The present value of avoiding these investments is included as part of the wholesale transmission and local distribution system benefits of conservation and distributed renewable resources.

As discussed above, due to the interconnected nature of the West coast wholesale power market, conservation measures that reduce consumption during the summer air conditioning season are the most valuable. 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. 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 is also used to determine the “on-peak” savings for each conservation measure. This varied from zero value for central air conditioning to 1.8 cents per kilowatt-hour for residential space heating.

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 when estimating benefit-to-cost ratios.[4]

Comparative Examples of Cost-Effectiveness Limits

Table E-2 shows the levelized cost for a sample of conservation measures that would produce a Total Resource Cost benefit-to-cost ratio of 1.0 based on avoided wholesale market purchases and deferred capital investments for transmission and distribution. As can be seen from a review of Table E-2 the "cost-effectiveness" limit ranges from 3.7 cents per kilowatt-hour for more efficient street and area lighting to 8.8 cents per kilowatt-hour for savings from efficiency improvements in window air conditioners when transmission and distribution benefits are considered. When these benefits are not considered the range extends from 3.3 cents per kilowatt-hour up to 7.0 cents per kilowatt-hour. These ranges are completely attributable to the load shape of each measures savings. In Table E-2 measure life is assumed to be 20 years for all measures for purposes of comparison. Actual measure lives used by the Council differ.

While the Act's 10 percent credit for conservation is included in the values shown in Table E-2 all measures shown in the table are assumed to have no non-energy benefits. As mentioned previously, some measures such as residential clothes washers provide the region with substantial non-energy benefits. One of the reasons high efficiency clothes washers save electricity is that they use less hot water. Consequently, they also use less detergent as well as reduce the amount of wastewater that needs to be treated. The Council includes these additional non-energy benefits in its calculation of the Total Resource Cost effectiveness. In the case of residential clothes washers, this increases the "cost-effectiveness limit" from 5.3 cents per kilowatt-hour to 12.1 cents per kilowatt-hour.

Cost-Effectiveness Limits and Power System Acquisition Costs

The Council uses Total Resource Cost as its measure of regional cost-effectiveness. It selected this metric because it attempts to account for all of a measure's costs and benefits, regardless of who pays or receives them. Ignoring a consumer's share of the cost of installing a conservation measure would understate its true cost to the region. Alternatively, ignoring a consumer's savings in operation and maintenance cost or reduced water consumption would understate a conservation measures actual benefits. Unfortunately, the distribution of conservation's costs and benefits among the region's consumers is rarely perfectly aligned. For example, the non-energy benefits accrue to the consumer purchasing the clothes washer and not to the region's power system. Therefore, while electricity savings from high efficiency clothes washers (and other similar measures) should be

[4] The Council's Portfolio analysis model uses levelized cost, rather than benefit-to-cost ratio to as its measure of cost-effectiveness when testing conservation development strategies. In its portfolio analysis process the Council eliminates from consideration any resource plans that do not develop at least the level of conservation that is consistent with the Act's requirement to provide conservation with a 10 percent premium over other resources.

viewed as regionally cost-effective, the power system's maximum contribution to the acquisition of these savings should be limited by the benefits provided by electricity savings.

Table E-2: Cost-Effectiveness Limits for Illustrative Conservation Resources[5]

Conservation Resource Category	Cost-Effectiveness Limit w/ Transmission and Distribution Benefits (Cents/kWh)	Cost-Effectiveness Limit w/o Transmission and Distribution Benefits (Cents/kWh)
Street & Area Lighting	3.7	3.3
Commercial - Existing Small Office and Retail Building Envelope Measures	4.1	3.5
Flat Load Profile	4.2	3.9
Commercial Lighting - New Small Office, Gas Heating	4.3	3.8
Agricultural - Dairy Milking Barn, Electric Hot Water	4.3	3.8
Residential Refrigerators	4.4	4.0
Agricultural - Dairy Milking Barn, Milking Machine Pumps (VFD)	4.4	4.0
Industrial - Primary Aluminum Smelting	4.4	3.9
Industrial - Pulp & Paper (SIC 26)	4.5	4.0
Industrial - Lumber & Wood Products (SIC 24)	4.5	4.1
Residential Lighting	4.5	3.9
Commercial Lighting - New Small Office, Air Source Heat Pump Heating and Cooling	4.6	4.0
Residential Freezers	4.6	4.1
PNW System Load Shape	4.6	4.1
Industrial - Food Processing (SIC 20)	4.6	4.1
Commercial Lighting - New Warehouse - Top Daylight, Unspecified Heating Fuel	4.6	4.0
Residential Space Heating - New Homes	4.8	3.3
Residential Domestic Water Heating	4.9	4.0
Commercial Lighting - New Large Retail, Electric Resistance Heating	4.9	4.4
Industrial - Generic Plant with One Shift	5.2	4.6
Commercial Lighting - New Large Office, Air Source Heat Pump Heating and Cooling	5.3	4.7
Residential Clothes Dryers	5.3	4.2
Residential Clothes Washers	5.3	4.2
Agricultural - Irrigation	5.5	4.7
Commercial Lighting - New Hotel, Electric Resistance Heating	5.5	5.1
Commercial Lighting - Existing School, Electric Resistance Heating	5.9	5.5
Commercial Lighting - New School - Top daylight, Unspecified Fuel	6.0	5.4

[5] The values in this table assume a 20 year measure life, the Council's medium market price forecast and that the measures are financed at 4% real interest over 15 years using a 4% real discount rate. Dollars are year 2000. In computing the regional benefit-to-cost ratios the Act's 10% conservation credit has been included. However none of these measures are assumed to produce any non-energy benefits.

Solar Domestic Water Heating - Summer Peaking Solar Zone 3	6.1	6.0
Commercial Lighting - New Large Office, Electric Resistance Heating	6.2	5.7
Residential Cooking	6.2	4.1
Customer Side Photovoltaic - Summer Peaking Solar Zone 1	6.3	5.5
Commercial Lighting - Existing Health Care Facility, Electric Resistance Heating	6.9	6.5
Commercial - Existing Small Office and Retail Building Central Air Conditioning Efficiency Improvements	7.3	5.9
Commercial Lighting - New Health Care Facility, Electric Resistance Heating	7.4	7.0
Residential Central Air Conditioning Regional Average	7.7	6.3
Residential Window Air Conditioning - Cooling Zone 2	8.8	7.4