ESTIMATION OF POTENTIAL ENERGY EFFICIENCY SAVINGS FOR THE WESTERN REGIONAL AIR PARTNERSHIP BY THE AIR POLLUTION PREVENTION FORUM

Approach, Methods and Summary Results

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1. Introduction

Tellus Institute was asked by the Air Pollution Prevention Forum (the AP2 Forum) to prepare estimates of electric energy efficiency savings in order to determine the potential impact of energy efficiency programs on air pollutant emissions from the electricity generation sector in the West. The Forum asked the Tellus team to estimate the achievable potential for electricity savings through energy efficiency programs in three air pollutant modeling regions: the Interior West (the "WSCR" region including Utah, Colorado, Arizona, New Mexico, Wyoming, Eastern Idaho, and Nevada excluding the Las Vegas area), part of the Pacific Northwest (the "WSCP" region, including Oregon and Western Idaho), and California/Las Vegas (the "CNV" region). Energy efficiency programs for the three areas were modeled over the period from 2002 through 2018, with impacts of measures installed under the programs counted through 2026. Only a limited set of energy efficiency measures were included in the program, so the estimates prepared were not, nor were they intended to be, fully comprehensive assessments of all potential electricity savings. The electricity savings (energy and peak) and the incremental costs of the programs were provided for use in ICF's IPM modeling system, and were used to generate air pollution scenario results as described in the Draft Final Report on Energy Efficiency and Renewable Energy, to which this document is a supplement.

The sections below describe the overall approach used to estimate the potential impacts of energy efficiency programs, present a brief summary of the overall results of the estimation process, and indicate what next steps might be undertaken to elaborate the assessment of energy efficiency opportunities in the West.

2. Overall Approach

The key steps in the estimation of energy efficiency opportunities in the Interior West and Oregon/Western Idaho regions were as follows:

- **Identification of energy efficiency measures**, by Forum group members and the Tellus team

- **Measure evaluation**, to determine the basic cost-effectiveness of individual measure installations.
- **Program evaluation**, including assembly of illustrative energy efficiency programs (application of measures to markets) and estimation of program impacts and costs, by year.

Each of these steps is described briefly below. A different, more aggregate approach was used for the California/Las Vegas region.

2.1 Identification of Measures

The Forum group, based on their knowledge of electricity demand in the West, prepared a preliminary list of energy efficiency measures for the Tellus team to evaluate. The measures spanned all customer categories (including residential, commercial/institutional, industrial, and agricultural consumers), and ranged widely in scope and applicability. Measures designed strictly to reduce or displace load (load response and load management programs), but not save energy, were not included, nor were major uses of renewable energy in end-use settings (such as solar water heating). Likewise distributed generation technologies without heat production, gas energy efficiency measures, and transportation sector measures were also excluded from the study.

The Tellus team performed an initial, qualitative screening of the suggested measures, eliminating (in a relatively few cases) measures from the list, and adding other measures that the team felt merited consideration. The final list of measures considered in the Interior West is presented in Table 1, below. The same list of measures was considered in the Oregon/Western Idaho region, except that two measures for application in the aluminum industry (aluminum production cell retrofit and advanced forming processes) were investigated in the latter region. Summary descriptions of these measures are provided in **Attachment 1** to this document.

Table 1: Energy Efficiency Measures Evaluated, Interior West Region

Residential Sector Measures	Commercial Sector Measures	Industrial Sector Measures
Efficient Central Air Conditioning	Lighting, Advanced Measures	Motor Downsizing
Efficient Room Air Conditioning	Lighting, Efficient Fluorescent	Premium Motors versus Rewinding
Evaporative Cooling	Refrigeration, High-cost Measures	Premium Motors (versus standard new motors)
Indirect-direct Evaporative Cooling	Refrigeration, Low-cost Measures	Air Compressor System Measures
Appliance Recycling (refrigerators)	Air Conditioning Improvement Residential-type Central AC	Fan System Measures
Compact Fluorescent Torchieres	Air Conditioning Improvement Residential-type Room-type AC	Pump System Measures
CFL Fixtures--Indoor	Air Conditioning Improvement, Small Heat Pumps	CHP[1], 10 MW Combustion Turbine (replacing gas boiler)
CFL Fixtures--Outdoor	Air Conditioning Improvement, 20-ton Package Units	CHP, 3000 kW diesel-type (replacing gas boiler)
CFL Bulbs	Air Conditioning Improvement, 350-ton Centrifugal Units	CHP, 40 MW Combustion Turbine (replacing gas boiler)
Duct Test and Seal--Homes with Central AC	Air Conditioning, IDDEC[2], 20, 150, and 350-ton Equivalent Units	Industrial CHP, 800 kW diesel-type (replacing gas boiler)
Duct Test and Seal--Homes with Electric Space Heat	Ground-source Heat Pumps, 1000 to 3000 operating hours/yr	High-efficiency Transformers
Energy Star (Vertical Axis) Clothes Washer	Efficient Clothes Washers	
SEHA (Horizontal Axis) Clothes Washer	LED Exit Signs	
Appliance Standby Loss Reduction, Incentive Approach	LED Traffic Signals	
Appliance Standby Loss Reduction--Standards Approach	Retrocommissioning of Buildings	
Home Weatherization	Space Heat High Efficiency Gas Boiler	
New Home Building Envelope Improvement to IECC 2000 levels	Space Heat, Standard Gas Boiler	
New Home Building Envelope Improvement--Enhanced levels	Space Heat, Gas Unit Heater	
	Water Heat Gas Boiler Fuel Switch	
	Water Heater Fuel Switching	
	Water Heating, Heat Pump Unit	

[1] CHP = Combined Heat and Power (or Cogeneration)

[2] IDDEC = Indirect-direct Evaporative Cooling

Table 1 (Continued): Energy Efficiency Measures Evaluated, Interior West Region

Additional Commercial Sector Measures
Gas Air Conditioning (with heat recovery displacing Electric WH[3])
Gas Air Conditioning (with heat recovery displacing Gas WH)
Gas Air Conditioning (w/o heat recovery)
Building Envelope--Improvements to ASHRAE Standards
Building Envelope--Improvements to Enhanced Level
Cooling Tower VSD[4] (CA Central Valley-type Climate)
Cooling Tower VSD (CA Desert-type Climate)
High-efficiency Transformers
CHP, 100 kW diesel-type replacing Electric WH
CHP, 100 kW diesel-type replacing Gas WH
CHP, 30 kW Micro-turbine replacing Electric WH
CHP, 30 kW Micro-turbine replacing Gas WH
CHP, 800 kW diesel-type replacing Electric WH
CHP, 800 kW diesel-type replacing Gas Boiler

2.2 Measure Evaluation

For each measure listed in Table 1, plus several other measures[5], MS Excel™ workbook tools were used to evaluate the measure cost-effectiveness. For each measure, cost-effectiveness was calculated relative to standard technologies, that is, technologies providing the same energy service but with efficiencies just meeting existing or planned standards, or technologies that correspond to standard practice for the end-use.

Inputs to the measure cost-effectiveness calculation included:

- **Measure cost information**, including incremental or total measure capital cost (of both the energy-efficient and standard measure) per unit, and incremental or total non-fuel annual operating and maintenance (O&M) costs.
- **Energy use impacts**, including annual energy and peak power savings or usage, and annual gas use, if applicable, expressed on the same unit basis as the costs.
- An assumed **discount rate** (4.88 percent per year on a real basis).
- Real levelized **avoided capacity and energy costs**, in this case, estimates based on "proxy" gas-fired combustion turbine or combined-cycle units, using gas prices as defined by the Forum for use in the IPM modeling process. Note that these costs were used for rough

[3] WH = Water Heating

[4] VSD = Variable Speed Drive

[5] Including fuel cell-based and other types/sizes of combined heat and power equipment, as well as several energy-efficiency measures that proved less than cost-effective.

screening purposed only, and are not the same as the costs used in the IPM modeling work to derive the impacts of energy efficiency programs on overall power system costs.

- Estimated **electricity rates**, calculated very roughly as the weighted averages of year 2000 electricity rates in the regions being studied, by sector, escalated at 1 percent annually (on a real basis).
- **Gas avoided costs** based on the costs used in the IPM modeling work.

The data elements above were derived from a wide variety of national and regional publications. Additional inputs were developed through consultation with experts in the energy-efficiency field. In cases where electricity usage in a measure was likely to be weather-sensitive (space cooling, for example), adjustments to national or regional values were made based on conditions in the region (Interior West or Oregon/W. Idaho) modeled. **Attachment 2** to this document provides a tabular summary of key measure cost and savings figures, as well as key program-related inputs to the energy efficiency analysis.

The outputs of the measure cost analyses included life-cycle costs, for those measures where standard units were compared directly with higher-than-standard-efficiency measures, and in all cases benefit-cost ratios for energy-efficiency measures relative to standard practice were calculated. The resulting ratios thus represent "incremental" measure costs and savings, relative to standard equipment. Benefit-cost ratios calculated from a total resource cost perspective were the primary yardstick used to assess whether measures should be included in programs, but in some cases participant cost measures were used to (roughly) inform the level of incentives that might be required.

2.3 Program Evaluation

Increasing the market penetration of energy-efficiency measures in an aggressive manner generally implies the provision of financial incentives to customers. As a consequence, the program evaluation phase of the development of energy-efficiency estimates for use by the AP2 Forum focused on estimating the sponsor costs of reaching a broader market for energy efficiency measures[6]. The estimation of energy-efficiency program costs and benefits involved the following steps:

- **Grouping of measures** into "programs" based, typically, on the end-uses and sectors addressed by the measures.
- Estimating the **program market** by consideration of the electricity demand in the sector and end-use addressed by the program, and of the nature and current market for the measure to be implemented. Sources for information on markets for energy-efficiency measures included national end-use surveys, statistics on electricity use by sector, State, and utility area, and a host of specific studies on particular markets from the national and regional literature.

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[6] The AP2 Forum wished to leave open the question of what types of agencies might organize and offer energy-efficiency programs of the types implied in the work described here. Accordingly, the organizations offering the programs are referred to as "sponsors", which could include government agencies, energy-efficiency program administrators retained to coordinate the use of funds collected through systems benefit charges, or, as in the past, distribution utilities.

- Estimating program penetration rates based on a combination of penetration rates historically achieved by utilities mounting aggressive energy efficiency efforts, and on program targets that were felt to be "aggressive but achievable" in the markets studied.
- Estimating **expenditures for administering** energy-efficiency programs, including both start-up and ongoing costs, based on consideration of the types of activities and interactions with customers that would be required to initiate the energy efficiency programs considered and to carry them out on an ongoing basis.

In a few cases, program impacts were based on the assumption that mandatory standards would be implemented in the future (for example, in 2008), which would raise effective program participation to near 100 percent (and reduce sponsor measure costs to zero).

The ECO2™ DSM analysis software package, developed at Tellus Institute, was used to evaluate the candidate energy-efficiency programs. Key program inputs—such as the number of participants annually per measure, program administrative costs, and shares of measure costs assumed paid by the sponsor and by customers—were developed and documented in the same set of workbooks used to develop measure data. Program results from the ECO2 runs included annual energy savings, peak power savings (summer and winter peak), customer measure costs, sponsor measure costs, administration costs, customer O&M costs, net fuel (gas) and water costs (if any), estimated energy and capacity costs avoided by the program (from the perspectives of customers and society), and end-use pollutant emissions for the years 2002 through 2026. Net present values of program costs (and estimated benefits), as well as costs of saved energy, were calculated in a set of Excel workbooks that compiled ECO2 results for each region. Specific examples, for several of the measures and programs evaluated, of the overall analytical approach used to estimate energy efficiency costs and impacts for the WSCR and WSCP regions, are provided in Attachment 3 to this document.

2.4 Approach Used in the CNV Modeling Region

Savings and costs for energy efficiency in the CNV (California/Las Vegas) region were estimated based on a parameterization of a national (American Council for an Energy Efficient Economy or ACEEE) study. Based on its national analysis, ACEEE provided Tellus with estimated electricity reductions by sector for a number of policies. The Tellus team used results of some of these policies ("Appliance Standards", "Public Benefits Funds", and "Tax Credits") as a base for a rough estimate of potential electricity savings in the CNV modeling region. National electricity reductions through application of energy efficiency measures were allocated to the region based on the base case level of electricity consumption from NEMS (National Energy Modeling System) runs for each sector. From NEMS output, the Tellus team determined the region's electricity sales by sector as a fraction of national sales by sector. This fraction was applied to the national estimate of electricity use reductions from ACEEE to determine CNV reductions. A similar approach was used to estimate program costs[7].

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[7] The ACEEE source document for which the original ACEEE estimates were prepared is Nadel, S. and H. Geller with the Tellus Institute (2001), Smart Energy Policies: Savings Money and Reducing Pollutant Emissions Through Greater Energy Efficiency. American Council for an Energy-Efficient Economy, Report No. E012, September, 2001.

Once estimates based on ACEEE results were obtained, these estimates were "trued-up" for consistency with end-use based energy efficiency costs and savings as estimated by the Tellus team for the Interior West and Oregon/W. Idaho regions. In the process, ACEEE savings estimates were reduced by nearly two-thirds[8]. The results of this "true-up" procedure should be considered only a rough approximation of the probable results if an end-use method were applied for the California/Las Vegas region.

2.5 Selection of Measures and Programs for Use in IPM Emissions Modeling Effort

The AP2 Forum reviewed the results of the energy-efficiency analyses described above in order to decide which results to carry forward for use in the IPM emission modeling effort. In addition to deciding to exclude the results of the combined heat and power analyses (see discussion below), the Forum felt that it would be prudent to remove the costs and savings for those measures with higher costs of saved energy from the packages of energy-efficiency programs modeled in each region. A threshold of 5.4 cents (2001 dollars) per kWh saved (on a levelized basis) was set, based very roughly on current average avoided costs for electricity generation in the West regions, and measures with costs higher than the threshold level were accordingly excluded from the final packages of energy-efficiency programs for which energy/power savings and costs were included in the IPM modeling effort. The cost and savings of the resulting packages of energy-efficiency programs are described below.

3. Summary Results

The summary results provided below present energy and peak power savings, as well as costs, estimated for the energy-efficiency programs and measures included in the final package of programs used in the IPM modeling effort. Results are presented by region, and on an overall basis.

3.1 Energy Savings

Figures 1 through 3 show annual GWh electricity savings for the years 2002 through 2018 in the WSCR (Interior West), WSCP (Oregon/W. Idaho), and CNV (California/Las Vegas) regions, respectively. Results are shown by sector, and indicate that commercial sector savings dominate the package of programs (though the suite of industrial measures examined was relatively limited), followed by residential sector savings. By 2018, annual electricity savings from the package of energy efficiency programs in the Interior West totals about 20,000 GWh, versus about 5,200 GWh in the Oregon/W. Idaho region, and about 28,000 in California/Las Vegas[9].

[8] Note that this "true-up" also implicitly excludes savings due to free-riders, since the WSCR savings used to accomplish the true-up exclude savings from free-riders.

[9] Note that these figures do not include credit for avoided transmission and distribution losses, so the net effect on required generation will be higher than the end-use savings indicated here.

Figure 1:

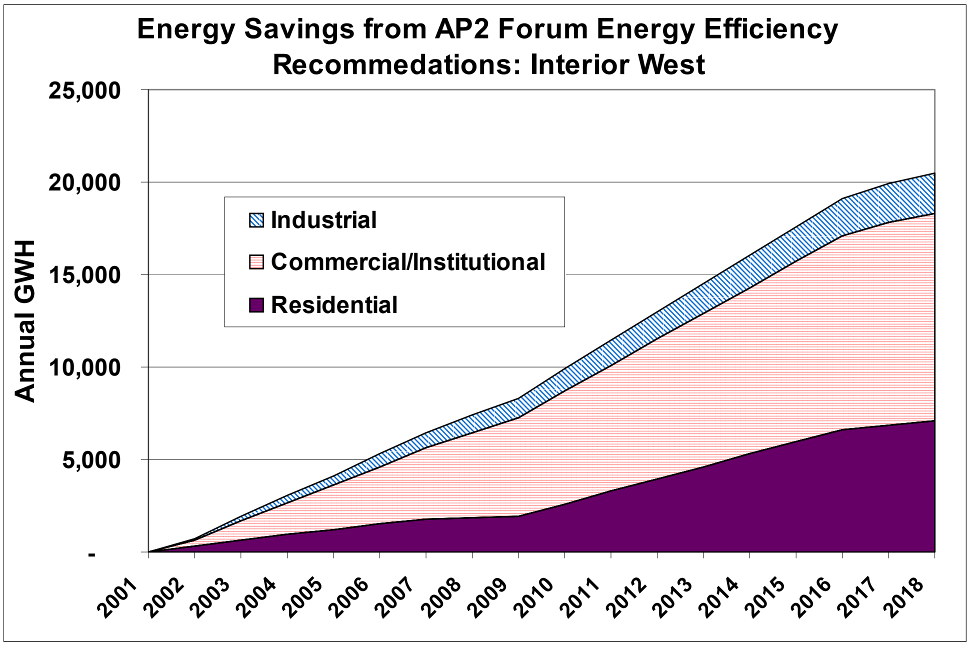


Figure 2:

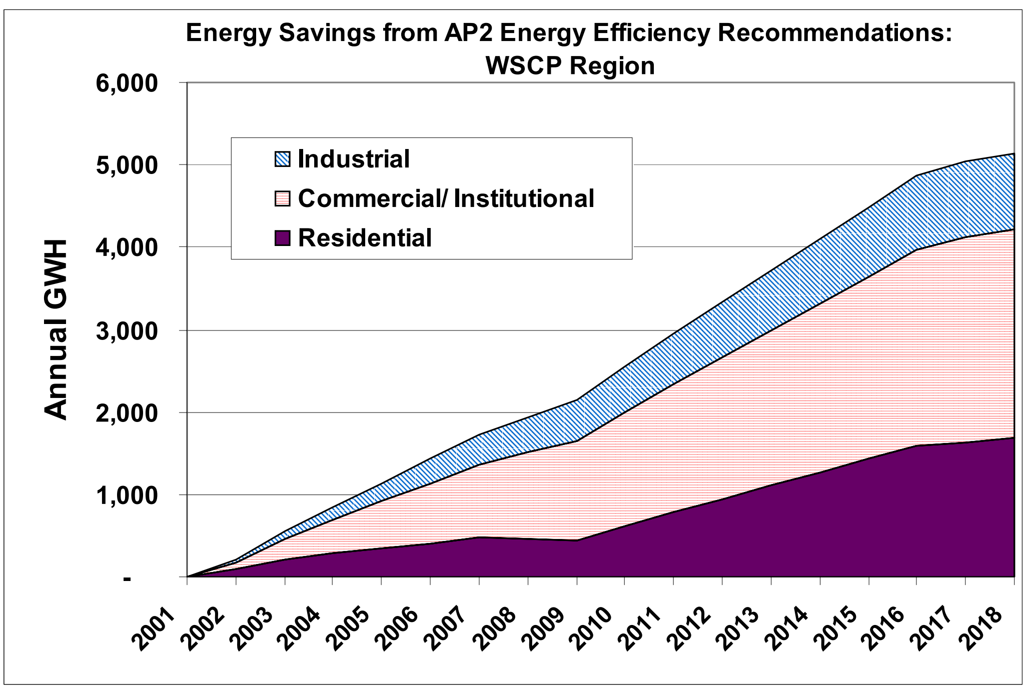


Figure 3:

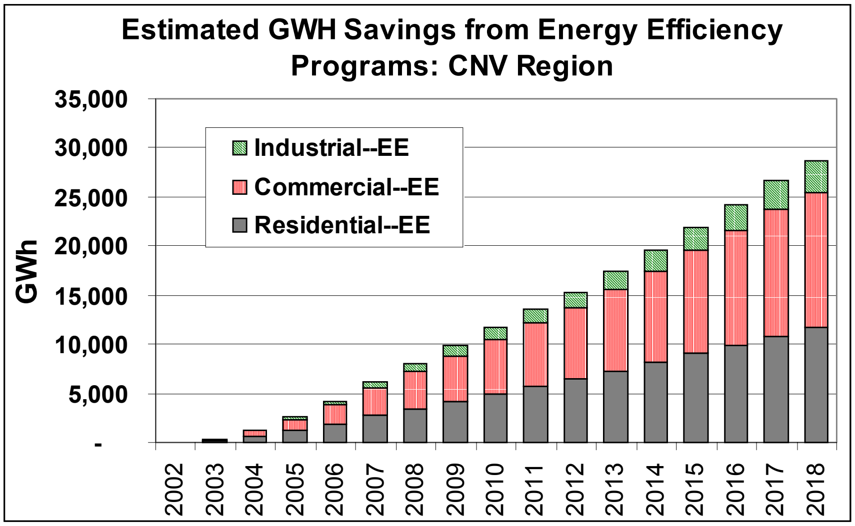
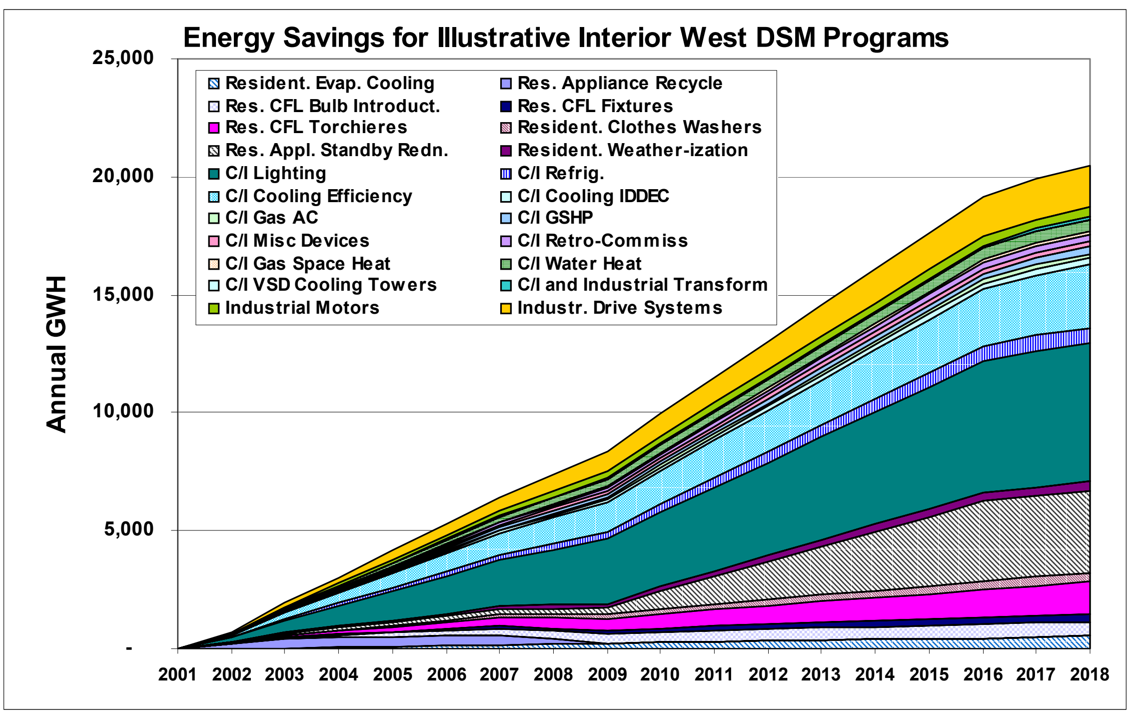


Figure 4 indicates the magnitude of energy savings for each of the programs included in the energy-efficiency package for the Interior West.

Figure 4:



3.2 Peak Power Savings

Figures 5 and 6 present annual summer peak power savings, by region and by sector, for the Interior West and Oregon/W. Idaho regions. By 2018, summer peak savings in the Interior West are over 6,000 MW, and savings in the Oregon/W. Idaho region are over 1,400 MW. Total summer peak power savings for the California/Las Vegas region from the energy-efficiency package were estimated at approximately 780 MW in 2005, 3,500 MW in 2010, 6,600 MW in 2015, and 8,700 MW in 2018. Figure 7 shows summer peak savings by sector for the period 2002 to 2018 in the Interior West.

Figure 5:

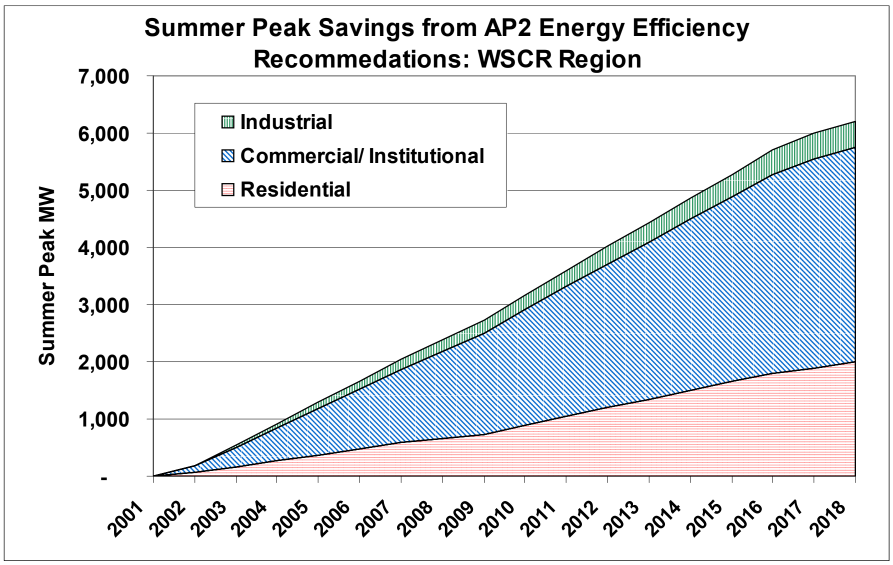


Figure 6:

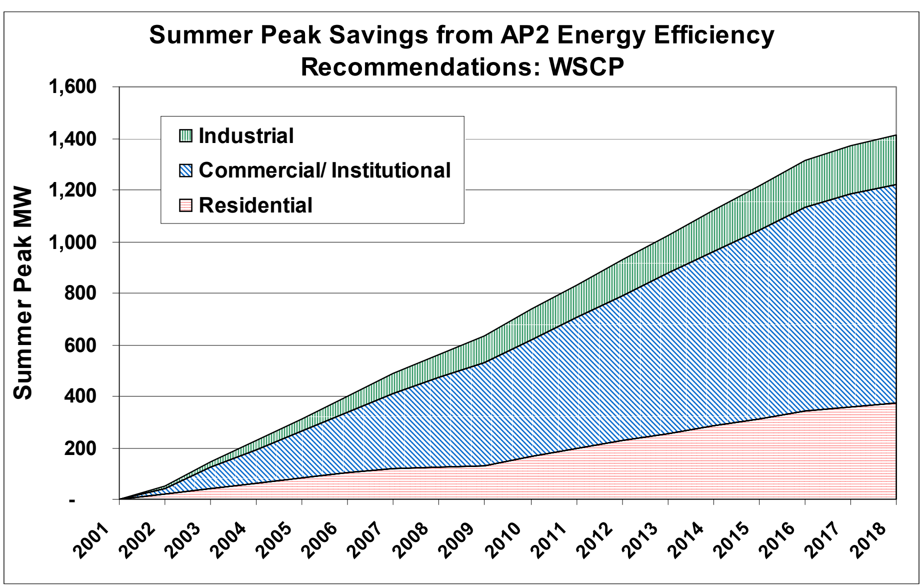
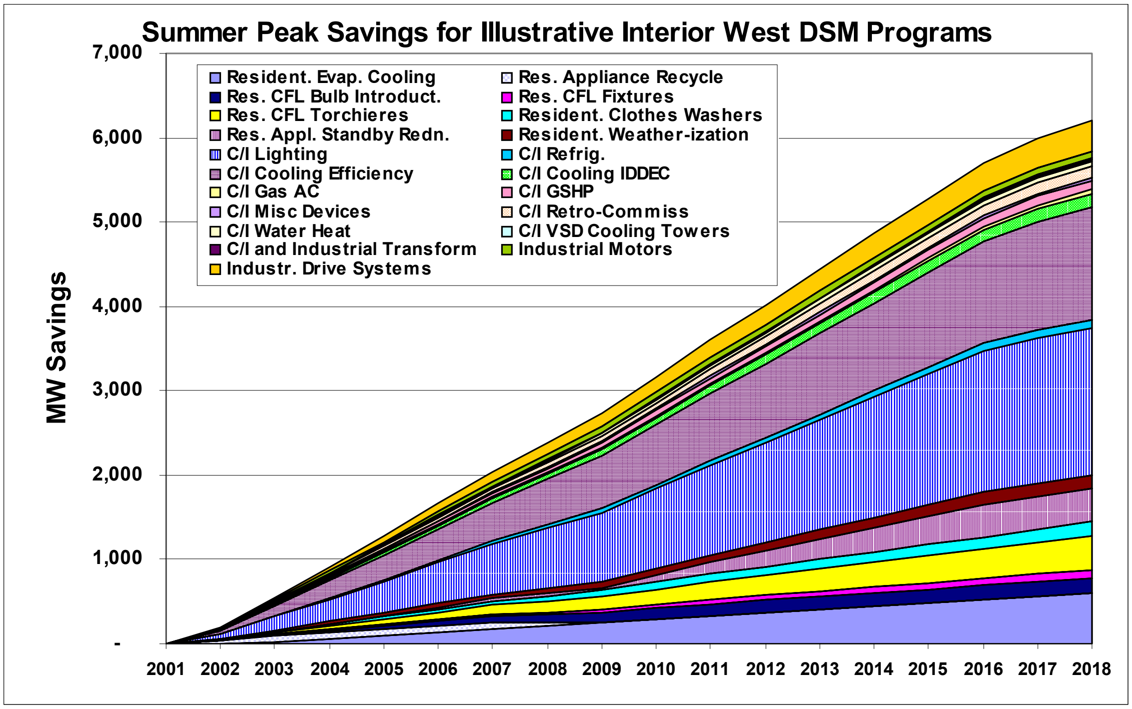


Figure 7:



3.2.1 Program Costs

The total incremental costs of the packages of energy-efficiency programs for each region are presented in Figures 8 through 10 for the three regions modeled. These costs are presented as <u>annualized</u> costs, that is, incremental capital costs for purchase of measures are levelized so that a portion of those costs are ascribed to each year in which a given device installed under the program is in operation. By 2018, total annualized costs in the Interior West region reach about $550 million and costs in the Oregon/W. Idaho region reach $130 million, both in year 2018 dollars (or about $340 and $80 million 2001 dollars, respectively), while total annualized costs in the California/Las Vegas region reach approximately $1,100 million 2001 dollars.

Figure 8:

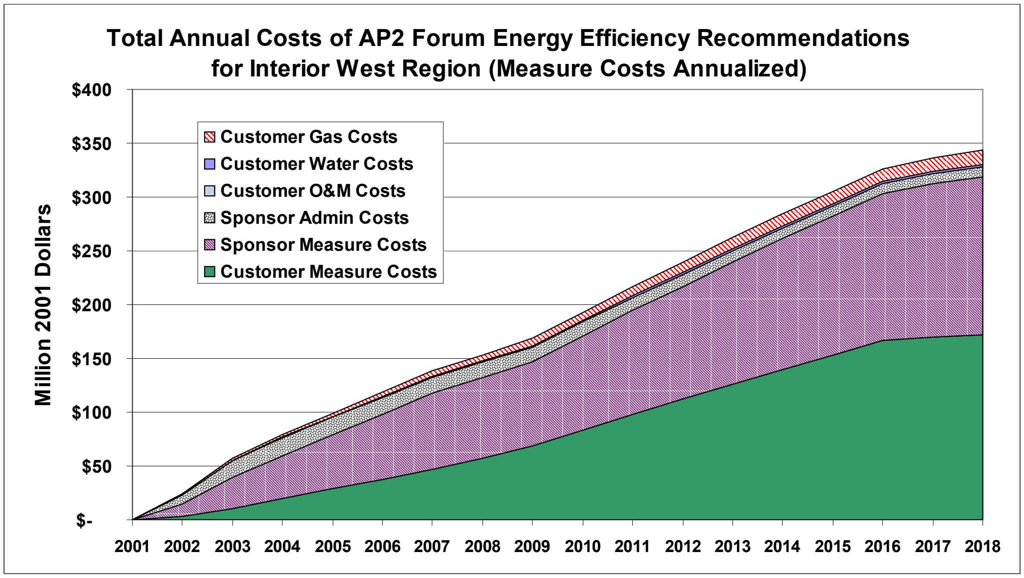


Figure 9:

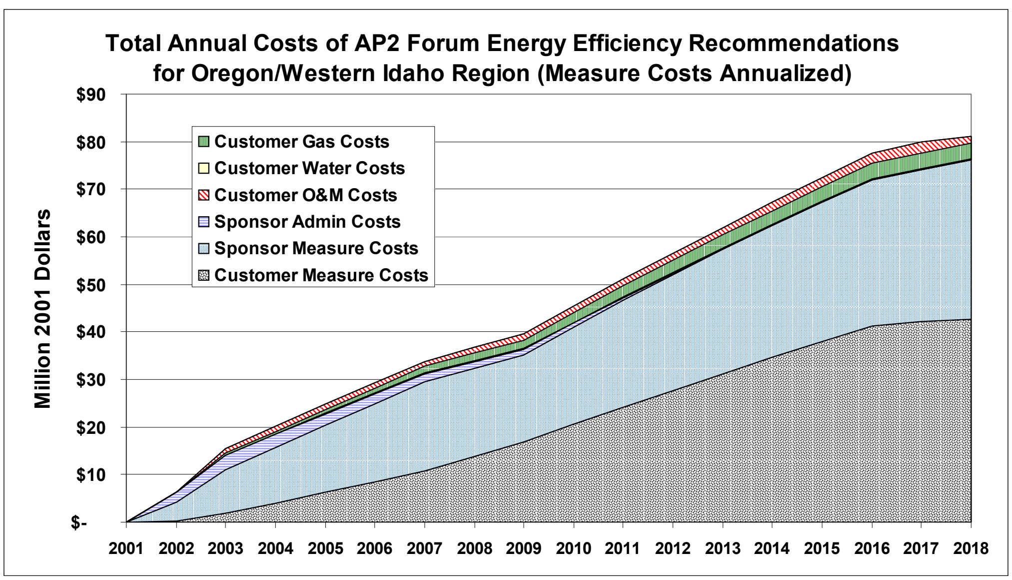
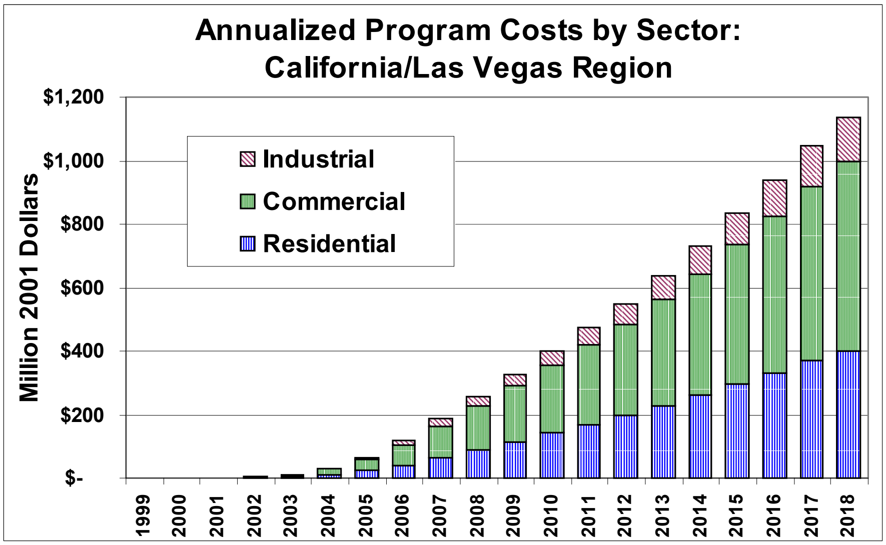


Figure 10:



3.3 Costs of Saved Energy

Figure 11 show the curve of the cost of saved energy for the measures ultimately included in the Interior West energy efficiency package. Table 2 presents the same information in a tabular format that identifies the measures at each cost level. Note that the costs shown in Table 2 are discounted total incremental program costs for the period 2002 to 2026[10]. Cost curve results for the Oregon/W. Idaho region are not shown here, but are similar.

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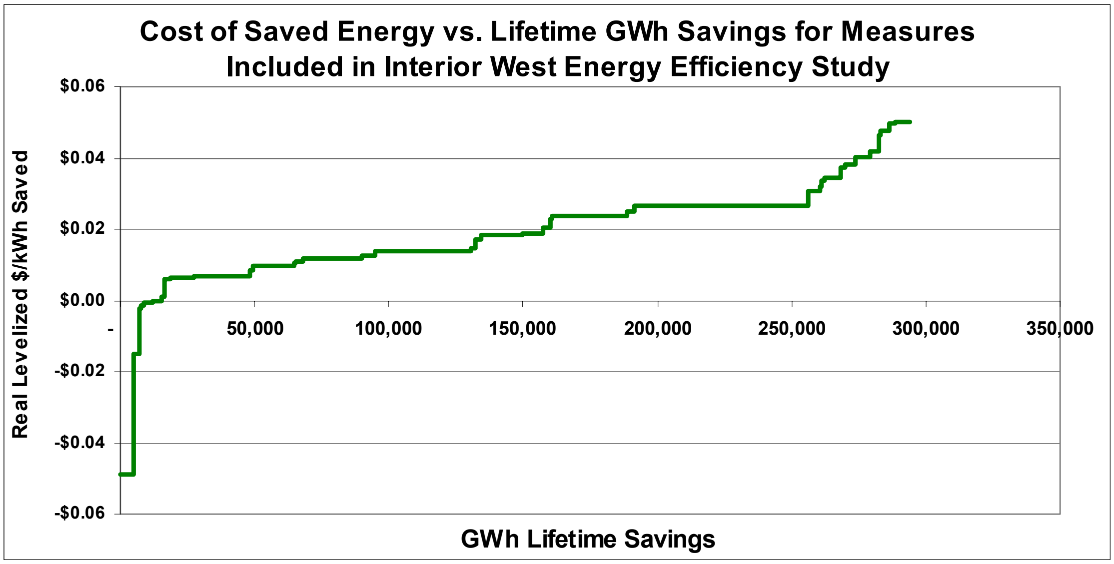
[10] Note that the discounting formulae used to prepare the values in Table 2 incorporate zero cost values for 2001, so the values shown are effectively in year 2001 dollars.

Figure 11:



Cost of Saved Energy vs. Lifetime GWh Savings for Measures Included in Interior West Energy Efficiency Study
Real Levelized $/kWh Saved
$0.06
$0.04
$0.02
$0.00
-$0.02
-$0.04
-$0.06
-
50,000
100,000
150,000
200,000
250,000
300,000
350,000
GWh Lifetime Savings

Table 2: Cost Of Saved Energy Results Sorted By Cost Per kWh:

Measure	Discounted TRC Cost ($1000)	MWh Savings Through 2026	Real Levelized Cost of Saved Energy ($/kWh)	Percent of Total Cummul. Package Savings	Cummulative MWh Savings through 2026	Percent of Total Cummul. Package Costs	Cummulative Discounted TRC Cost
Residential Evaporative Cooling	$ (111,017)	5,007,946	$ (0.0489)	1.7%	5,007,946	-4.4%	$ (111,017)
Residential IDDEC Cooling	$ (15,554)	2,305,001	$ (0.0151)	2.5%	7,312,947	-5.0%	$ (126,571)
Comml/Instit. Space Heat Std. Gas Boiler	$ (458)	465,659	$ (0.0022)	2.6%	7,778,606	-5.0%	$ (127,029)
Comml/Instit. Space Heat High Eff. Gas Boiler	$ (565)	962,327	$ (0.0013)	3.0%	8,740,933	-5.1%	$ (127,594)
Comml/Instit. Water Heat Gas Boiler Fuel Switch	$ (1,145)	3,325,686	$ (0.0008)	4.1%	12,066,619	-5.1%	$ (128,739)
Comml/Instit. Water Heater Fuel Switching	$ (505)	3,484,222	$ (0.0003)	5.3%	15,550,841	-5.1%	$ (129,244)
Comml/Instit. Space Heat Gas Unit Heater	$ 422	803,719	$ 0.0011	5.6%	16,354,560	-5.1%	$ (128,821)
Industrial Fan System Measures	$ 7,041	2,473,382	$ 0.0062	6.4%	18,827,942	-4.8%	$ (121,780)
Industrial Air Compressor System Measures	$ 23,789	8,347,664	$ 0.0062	9.2%	27,175,606	-3.9%	$ (97,991)
Residential CFL Torchiere	$ 62,045	21,232,172	$ 0.0067	16.5%	48,407,778	-1.4%	$ (35,946)
Industrial Motor Downsizing	$ 3,416	865,684	$ 0.0086	16.8%	49,273,462	-1.3%	$ (32,531)
Comml/Instit. Refrigeration, Low-cost Measures	$ 29,224	6,446,877	$ 0.0098	19.0%	55,720,339	-0.1%	$ (3,307)
Residential CFL Bulbs	$ 49,797	8,999,064	$ 0.0099	22.0%	64,719,403	1.8%	$ 46,490
Comml/Instit. Water Heating, Heat Pump Unit	$ 4,169	833,390	$ 0.0106	22.3%	65,552,793	2.0%	$ 50,659
Comml/Instit. LED Exit Signs	$ 10,551	2,212,350	$ 0.0109	23.1%	67,765,143	2.4%	$ 61,210
Comml/Instit. Lighting, Efficient Fluorescent	$ 120,842	22,406,144	$ 0.0117	30.7%	90,171,287	7.2%	$ 182,052
Residential CFL Fixtures--Indoor	$ 24,370	4,477,776	$ 0.0124	32.2%	94,649,063	8.2%	$ 206,422
Industrial Premium Motors	$ 32,469	4,640,110	$ 0.0137	33.8%	99,289,173	9.5%	$ 238,891
Residential Appl. Standby Loss Red.--Mandatory	$ 186,808	31,092,432	$ 0.0138	44.4%	130,381,605	16.9%	$ 425,699
Residential Appl. Standby Loss Red.--Incentive	$ 19,091	2,018,494	$ 0.0148	45.1%	132,400,099	17.7%	$ 444,789
Comml/Instit/Industrial Transformers (C/I)	$ 14,260	1,903,312	$ 0.0172	45.7%	134,303,411	18.2%	$ 459,050
Industrial Pump System Measures	$ 130,051	15,459,078	$ 0.0183	51.0%	149,762,489	23.4%	$ 589,101
Comml/Instit. Retrocommissioning	$ 35,765	4,203,554	$ 0.0186	52.4%	153,966,043	24.8%	$ 624,866
Comml/Instit. Refrigeration, High-cost Measures	$ 30,151	3,487,028	$ 0.0188	53.6%	157,453,071	26.0%	$ 655,018
Residential Appliance Recycling	$ 40,598	2,593,122	$ 0.0204	54.5%	160,046,193	27.6%	$ 695,616
Comml/Instit/Industrial Transformers (Industrial)	$ 2,150	223,428	$ 0.0220	54.6%	160,269,621	27.7%	$ 697,766
Residential CFL Fixtures--Outdoor	$ 5,562	515,112	$ 0.0228	54.7%	160,784,733	27.9%	$ 703,328
Comml/Instit. AC Impr., 20-ton Package Units	$ 296,085	28,046,667	$ 0.0236	64.3%	188,831,400	39.7%	$ 999,414
Comml/Instit. Ground-source HP, 3000 hrs/yr	$ 30,955	2,745,355	$ 0.0249	65.2%	191,576,755	40.9%	$ 1,030,369
Comml/Instit. Lighting, Advanced Measures	$ 795,012	64,744,193	$ 0.0266	87.2%	256,320,948	72.4%	$ 1,825,380
Comml/Instit. AC Impr., Residential-type CAC	$ 57,876	4,042,410	$ 0.0307	88.6%	260,363,358	74.7%	$ 1,883,257
Comml/Instit. LED Traffic Signals	$ 13,697	931,600	$ 0.0322	88.9%	261,294,958	75.3%	$ 1,896,954
Comml/Instit. Efficient Clothes Washers	$ 15,511	914,946	$ 0.0335	89.2%	262,209,904	75.9%	$ 1,912,465
Comml/Instit. AC Impr., Small Heat Pump	$ 93,753	5,867,466	$ 0.0343	91.2%	268,077,370	79.6%	$ 2,006,218
Comml/Instit. Ground-source HP, 2000 hrs/yr	$ 30,955	1,830,237	$ 0.0373	91.9%	269,907,607	80.9%	$ 2,037,173
Comml/Instit. AC Impr., Res. Room-type AC	$ 66,814	3,738,494	$ 0.0383	93.1%	273,646,101	83.5%	$ 2,103,987
Residential Weatherization	$ 109,264	5,824,614	$ 0.0402	95.1%	279,470,715	87.8%	$ 2,213,251
Comml/Instit. Gas AC, w/ heat recov. (EWH)	$ 53,763	2,896,170	$ 0.0420	96.1%	282,366,885	90.0%	$ 2,267,014
Comml/Instit. Cooling Tower VSD--Desert Climate	$ 6,408	336,718	$ 0.0431	96.2%	282,703,603	90.2%	$ 2,273,422
Industrial Prem. Motor vs. Rewind	$ 10,383	436,716	$ 0.0464	96.4%	283,140,319	90.6%	$ 2,283,805
Residential SEHA Clothes Washer	$ 66,392	3,052,546	$ 0.0476	97.4%	286,192,865	93.3%	$ 2,350,197
Residential Energy Star Clothes Washer	$ 57,518	2,527,540	$ 0.0498	98.3%	288,720,405	95.6%	$ 2,407,715
Comml/Instit. AC, IDDEC, 150-ton Equiv. Units	$ 111,958	5,072,414	$ 0.0501	100.0%	293,792,819	100.0%	$ 2,519,673
ALL MEASURES/ALL PROGRAMS	$ 2,519,673	293,792,819	$ 0.0186				

3.4 *Combined Heat and Power*

Based on the results of two national studies, the Tellus team identified a considerable achievable potential for the application of combined heat and power (CHP) in all three of the modeled regions. Implementation of CHP could result in significant cost savings, displacement of capacity (about 7.5 GW at the end-use level), and overall fuel (gas) savings relative to separate production of power and heat, and would also help, in many instances, to ease transmission constraints by providing distributed generation. Gas-fired CHP systems do, however, produce emissions of nitrogen oxides (NO_x) that might, depending on the type of CHP used and the type and extent of emissions control equipment with which it is fitted, result in an increase of NO_x emissions relative to separate heat production and power generation. This result is far from certain, as it depends on the average emission factors for CHP systems meeting current standards in major airsheds in the West. Though any increase in NO_x emissions from the implementation of modern, regulations-compliant CHP system is likely to be modest relative to overall NO_x emissions from power generation in the West, Forum members were sufficiently concerned about the potential impact of CHP systems on local and regional air quality, as well as about the ultimate "marketability" of CHP systems, that a consensus decision was made to leave savings (and costs) of CHP programs out of the total energy-efficiency savings figure passed on to the IPM modeling effort.

3.5 Summary Results, All Regions

Figures 12, 13, and 14 show, respectively the energy savings, summer peak savings, and annualized costs of the sum of all three regional energy efficiency packages modeled for the AP2 Forum. Together, the energy efficiency packages save approximately 54,000 GWh of electricity annually by 2018, with peak savings in that year of about 16,000 MW, at an annualized cost in 2018 of about $1.6 billion (2001 dollars). The savings, both energy and peak power, from the energy efficiency packages in the three regions combined are shown by sector (residential, commercial/institutional, and industrial) in Figures 15 and 16 (peak results are not available by sector for the CNV region).

Figure 12:

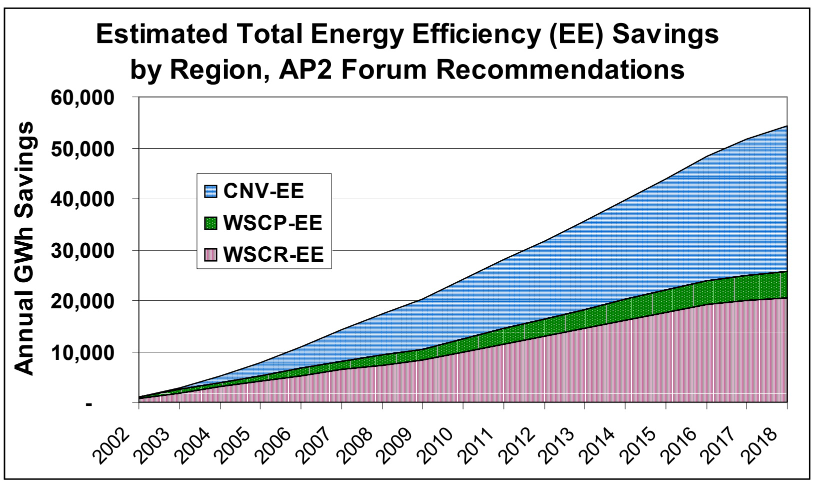


Figure 13:

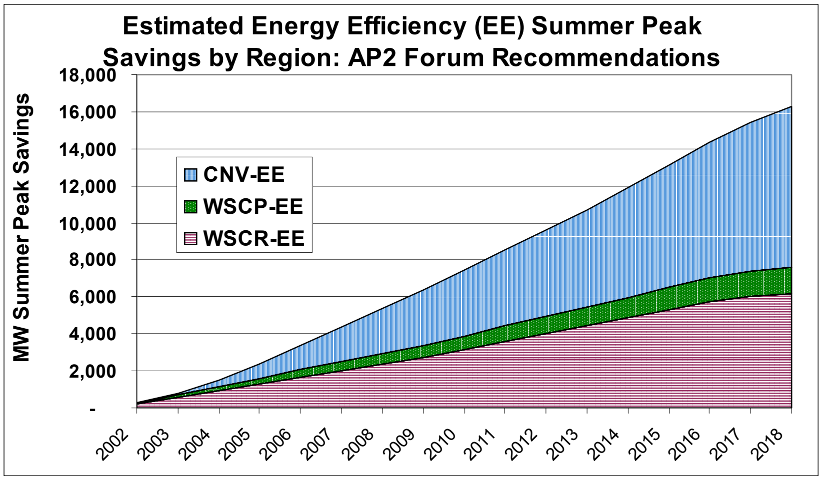


Figure 14:

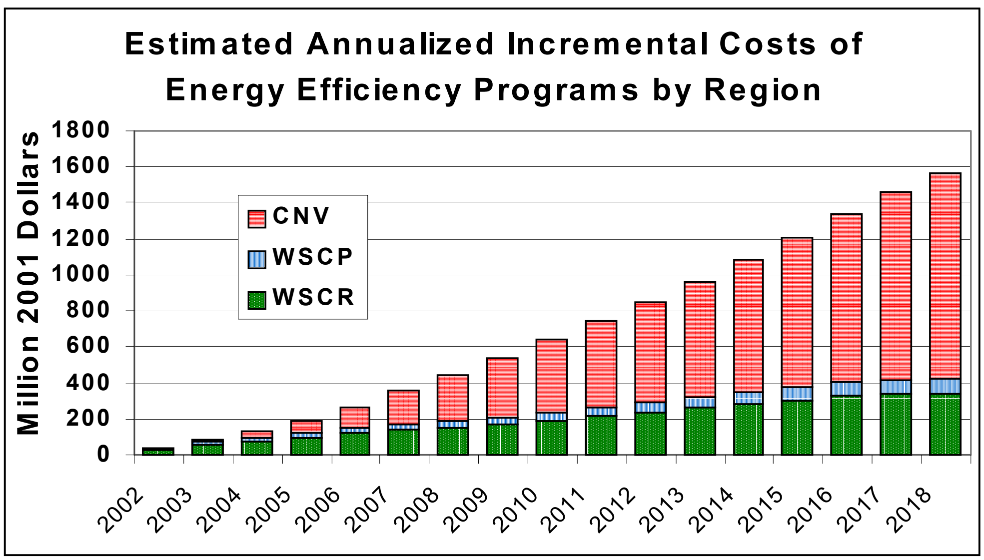


Figure 15:

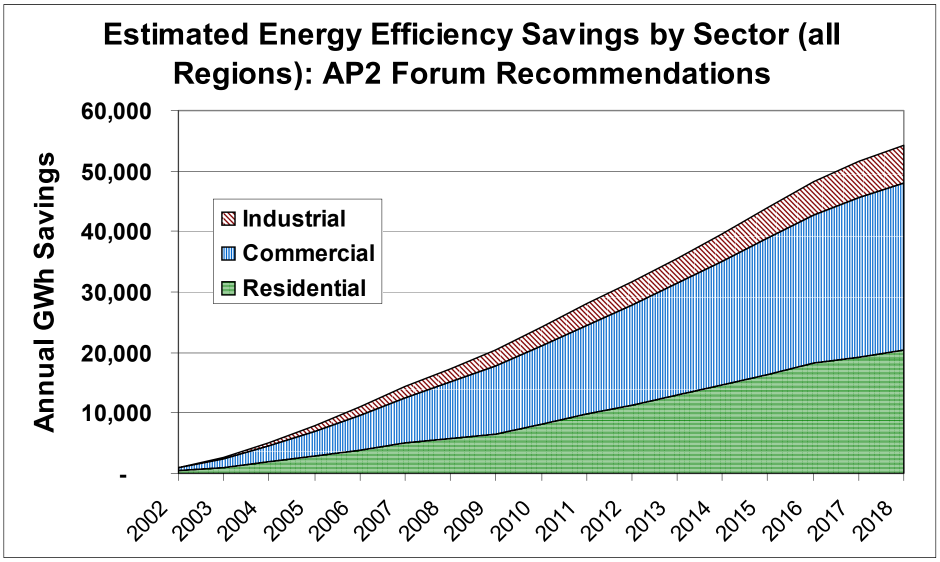
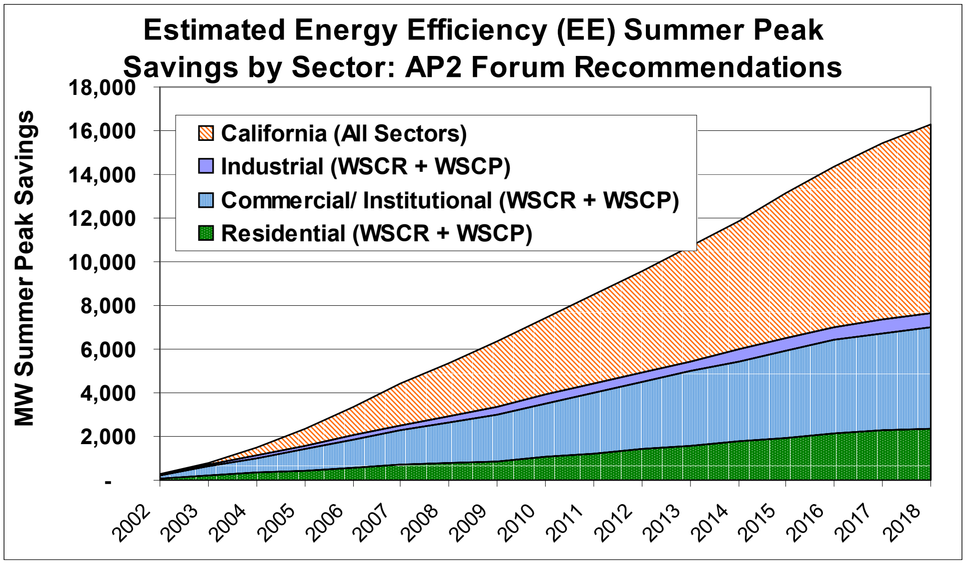


Figure 16:



4. Potential "Next Steps" in Energy Efficiency Analysis for the West

The analysis described above has identified a number of significant energy efficiency opportunities in the West. As with most energy-efficiency analyses of this type, the reliability and accuracy of the work done for the Forum might, given time and resources, be broadened, deepened, and followed-up in a number of ways. Possible "next steps" in identifying, evaluating, and implementing energy-efficiency programs in the West include:

- Obtain additional expert review of the assumptions and other inputs used in the energy-efficiency analysis.
- Preparing a measure-by-measure estimate of energy-efficiency potential, similar to that done for the other two regions, for the California/Las Vegas region.
- Review the air pollutant emissions (especially NO_x) impacts of potential combined heat and power systems, factoring in local regulations on new emissions sources and the types of pollution control used on new CHP systems.
- Deepen the overall analysis by evaluating additional measures, and by incorporating more region-, state-, tribe- and utility-area-specific information into the estimates wherever possible.
- Provide the energy-efficiency analysis on a State-by-State or Tribal level and/or work with state- or tribe-level teams (for example, from State Energy Offices or Tribal groups) to develop individual state- or tribal-level analyses.
- Identify and tailor approaches for implementation of energy-efficiency programs on regional, statewide, or tribal area bases.

ATTACHMENT 1:

BRIEF DESCRIPTIONS OF MEASURES CONSIDERED IN THE WESTERN REGIONAL AIR PARTNERSHIP (WRAP) ENERGY EFFICIENCY ANALYSES

Background

Several members of the Air Pollution Partnership (AP2) Forum have requested, on behalf of their constituents, a listing with brief definitions of the energy efficiency measures considered during the WRAP energy efficiency analyses carried out for the WSCR (Interior West) and WSCP (Northwest—Oregon and Western Idaho) regions. The listing below is divided into residential, commercial/institutional, industrial, and combined heat and power (CHP) measures. This listing is intended to supplement the document Estimation of Potential Energy Efficiency Savings for the Western Regional Air Partnership by the Air Pollution Prevention Forum: Approach, Methods and Summary Results, itself an annex to Final Report on Energy Efficiency and Renewable Energy, which reports on the overall pollution impacts modeling effort overseen by the AP2 Forum.

The descriptions that follow cover all of the energy efficiency measures evaluated, including some measures (higher cost and CHP measures) ultimately not included in the package of energy efficiency measures used in pollutant emissions modeling. For each of the descriptions, names in italics and parentheses (for example "*Residential Efficient CAC*") correspond to the short measure names found in tables of "Cost of Saved Energy Results" presented in Estimation of Potential Energy Efficiency Savings for the Western Regional Air Partnership by the Air Pollution Prevention Forum: Approach, Methods and Summary Results (to which these descriptions are attached) and used by the AP2 Forum to review the energy efficiency analyses.

RESIDENTIAL SECTOR MEASURES

Residential Appliance Recycling: The appliance recycling program approach provides incentives to customers to allow their operable refrigerators or freezers to be disposed of. Appliance recycling has been operated successfully in several regions. A recycling company is contracted to collect the appliances and dispose of them in an environmentally responsible way. The electricity savings result from the fact that the average stock of refrigerators and freezers now in use consumes more than twice the electricity of the new units available on the market today ("*Residential Appliance Recycling*").

Residential Air Conditioning—High-efficiency Units: Compressor, control, fan, heat-exchanger, seal, and other improvements in central and room air conditioners make the most efficient residential units available substantially more efficient than those just meeting standards ("*Residential Efficient CAC*", "*Residential Efficient Room AC*").

Residential Air Conditioning—Evaporative Cooling: In contrast to typical compressor-driven air conditioners, evaporative coolers lower indoor temperatures by evaporating a mist of water, which carries away heat. Evaporative or "swamp" coolers are effective in low-humidity areas, and use only a small fraction of the electricity used by compressor-driven air conditioners ("*Residential Evaporative Cooling*").

Residential Air Conditioning—IDDEC: A variant of residential evaporative cooling called indirect/direct evaporative cooling, or IDDEC, is under development that will provide reliable cooling with significantly less electricity input than typical compressor-driven air conditioning, and is useful in applications where standard evaporative cooling might not be appropriate ("*Residential IDDEC Cooling*").

Residential Heating and Cooling—System and Duct Service and Repair: Many existing heating systems can be made significantly more efficient by applying a package of system and duct repair measures, including tune-ups for heat-pump condenser and evaporator units, cleaning, sealing and insulating duct work, or re-routing duct work to make the flow of heat from the furnace to living areas more efficient (evaluated as two measures: "*Residential Duct Test and Seal--CAC*", and "*Residential Duct Test and Seal--ESH*").

Residential Heating and Cooling—Weatherization Retrofits: The thermal performance of a dwelling—the degree to which a heated house stays warm and a cooled house stays cool, is a function of many factors, including how well insulated the house is, the integrity of its windows and doors, whether it has been well-sealed to control the incursion of outside air, its overall design, its orientation relative to sun and wind, and its proximity to nearby vegetation. Of these factors, the first three are usually addressed by measures installed during a weatherization retrofit of an existing dwelling ("*Residential Weatherization*").

Residential Heating and Cooling—Better-than-Code Building Envelopes for New Homes: Although some parts of the West already have state (and sometime local) residential building codes that mandate quite high residential building performance, there are opportunities to exceed code levels. There are also opportunities to ensure that more buildings are actually built to code, through improved code enforcement, and to strengthen building codes to other states. For the WRAP energy efficiency analysis, incentives were assumed used until 2009 to bring homes to IECC 2000 (International Energy Conservation Code) levels ("*Residential Building Envelope Impr.--IECC 2000*"), and that thereafter code changes mandate enhancements in performance beyond the IECC 2000 level ("*Residential Building Envelope Impr.--Enhanced*").

Residential Lighting—Compact Fluorescent (CFL) Bulbs: Over the last decade or so, compact fluorescent light bulbs (CFLs) designed for use in incandescent fixtures – and lamps and fixtures specifically designed to use CFL technology – have been making inroads in the U.S. market. CFLs use roughly one-quarter of the electricity to produce the same amount of light as incandescent bulbs, and last up to 10 times longer ("*Residential CFL Bulbs*").

Residential Lighting—Indoor CFL Fixtures: CFLs work best when used in fixtures specifically designed for them ("*Residential CFL Fixtures--Indoor*").

Residential Lighting—Outdoor CFL Fixtures: Using CFLs in outdoor fixtures presents an attractive way to save both money and electricity, as long-lived CFL bulbs are used for many hours per day when installed for outdoor security lighting. In addition, as many outdoor incandescent bulbs designed for outdoor use are both expensive and short-lived, there are significant operation and maintenance savings from using outdoor CFL-based fixtures ("*Residential CFL Fixtures--Outdoor*").

Residential Lighting—CFL Torchieres: The "torchiere" style of tall floor lamp gained tremendous popularity in recent years as inexpensive units have become widely available. Most units use bright, but inefficient, halogen bulbs, while some use incandescent bulbs. Their high electricity use and the fire hazards created by high temperature halogen units have prompted the development of the CFL torchiere. The CFL torchiere produces the same light output as the halogen and incandescent units, using 20-30 percent of the electricity and eliminating an important fire risk ("*Residential CFL Torchiere*").

Residential Appliance Standby Loss Reduction: Even when turned off, many household electronic devices consume small amounts of electricity. While insignificant on an individual device basis, the total energy consumed by standby equipment adds up to about 5 percent of current residential electricity use, due to the multitude of devices and their steady power drain. The EPA *Energy Star* program already includes an initiative to encourage the reduction in average standby consumption from 4.4 to 1 watt per device, a drop of over 75 percent. For WRAP, introduction of measures for standby loss reduction were modeled as an incentive program through 2009 ("*Residential Appl. Standby Loss Red.--Incentive*"), and as a mandatory standard thereafter ("*Residential Appl. Standby Loss Red.--Mandatory*").

Residential Clothes Washing: Improvements in clothes washers allow clothes to be cleaned with less hot water use, and often "spin" clothes faster so that less energy is required to dry them. Two types of higher-than-standard-efficiency clothes washers were included in the WRAP analysis: vertical-axis *Energy Star*-qualified machines ("*Residential Energy Star Clothes Washer*"), and horizontal-axis washers ("*Residential SEHA Clothes Washer*", where SEHA is "Super-Efficient Home Appliance").

COMMERCIAL/INSTITUTIONAL SECTOR MEASURES

Commercial/Institutional Cooling—"Package" AC and Chillers: Use of higher-than-standard efficiency "package" air conditioning (AC) units and centrifugal chillers for small-to-meduim-sized and large commercial/institutional buildings produce more cold air (or chilled water) per unit of electricity input than standard models ("*Comml/Instit. AC Impr., 20-ton Package Units*" and "*Comml/Instit. AC Impr., 350-ton Centrif. Units*").

Commercial/Institutional Cooling—Residential-type Units: Many smaller commercial buildings use units that are the same as, or larger but similar to, the AC systems used in homes. For the WRAP study, models of room-type air conditioners, central air conditioners, and heat pumps with energy efficiency ratings significantly higher than standard units were evaluated ("*Comml/Instit. AC Impr., Res. Room-type AC*", "*Comml/Instit. AC Impr., Residential-type CAC*", "*Comml/Instit. AC Impr., Small Heat Pump*").

Commercial/Institutional Cooling—Evaporative Cooling: Evaporative cooling technologies use the latent heat of vaporization of water to cool air. One of the most promising configurations, indirect-direct evaporative cooling (IDDEC) can substantially reduce electricity requirements relative to conventional cooling systems and operate well in the relatively low humidity conditions that prevail during Western summers. For WRAP measures in three size classes were modeled for use in different types of commercial/institutional buildings, based on the size of conventional AC equipment that would otherwise be used ("*Comml/Instit. AC,* *IDDEC, 20-ton Equiv. Units*", "*Comml/Instit. AC, IDDEC, 150-ton Equiv. Units*", and "*Comml/Instit. AC, IDDEC, 350-ton Equiv. Units*").

Commercial/Institutional Cooling—Gas-fired Air Conditioning: Electricity use can be reduced by replacing electric air conditioners with gas-fired air conditioners. Gas-fired air conditioners use either an absorption cooling cycle or a gas-fired internal-combustion engine that turns an air conditioning compressor. Additional energy is saved by using waste heat from the gas-fired engine to heat water. Three gas-fired AC configurations were evaluated: without heat recovery ("*Comml/Instit. Gas AC, w/o heat recovery*"), with heat recovery and with the recovered heat avoiding the use of a gas-fired water heater ("*Comml/Instit. Gas AC, w/ heat recov. (GWH)*"), and with the recovered heat displacing an electric water heater ("*Comml/Instit. Gas AC, w/ heat recov. (EWH)*").

Commercial/Institutional Cooling—Cooling Tower Variable-Speed Drives: Cooling systems for large buildings often have cooling towers, where waste heat is exhausted using fans. Variable-speed drives for the fan motors on cooling tower allow the speed of the fans to be adjusted to cooling needs, and thus save electricity. Efficiency savings were estimated for WRAP using data from different regions of California. For example, for the WSCP (Oregon/Western Idaho) region, "*Comml/Instit. Cooling Tower VSD--Valley Climate*" denotes an installation in a climate similar to that of the Central Valley in California, while "*Comml/Instit. Cooling Tower VSD--N. Coast Clim.*" Uses a California North Coast climate as an analog.

Commercial/Institutional Space Heat: Electricity, and energy overall, can be saved by switching from electric resistance heating to gas-fired heating systems, preferably gas-fired systems of higher than standard efficiency. In some cases, gas-fired heaters and boilers are less expensive to buy (as well as operate) than electric ones of equivalent capacity. Three measures were evaluated for WRAP: High efficiency and standard gas boilers replacing electric resistance boilers ("*Comml/Instit. Space Heat High Eff. Gas Boiler*" and "*Comml/Instit. Space Heat Std. Gas Boiler*"), and gas "unit heaters" (stand-alone or ceiling-mounted, fan-forced heaters often used in spaces such as warehouses or workshops; ("*Comml/Instit. Space Heat Gas Unit Heater*").

Commercial/Institutional Ground-Source Heat Pumps: Ground-source heat pumps (sometimes called "geothermal" heat pumps) are used for both heating and cooling, and differ from typical heat pumps in that they use buried "loops" of piping with water or other fluid running through it to extract heat from (or, in cooling mode, exhaust heat to) the earth below ground level. The relatively constant temperature of the earth allows the heat pump to run more efficiently, under some conditions, than a typical air-source heat pump. As the number of hours a ground-source heat pump will need to run depends on climate, installations with running times (both heating and cooling) of 1000, 2000, and 3000 hours per year were assumed ("*Comml/Instit. Ground-source HP, 1000 hrs/yr*", "*Comml/Instit. Ground-source HP, 2000 hrs/yr*", and "*Comml/Instit. Ground-source HP, 3000 hrs/yr*").

Commercial/Institutional Water Heat: Water heating electricity use can be reduced substantially by switching from standard electric resistance-type water heaters to heat-pump-type water heaters ("*Comml/Instit. Water Heating, Heat Pump Unit*"). Switching from electric water heating to natural gas-fired water heating, using both boilers and tank-type water heaters, can also reduce both electricity use and overall energy requirements after losses in electricity generation are accounted for ("*Comml/Instit. Water Heater Fuel Switching*", "*Comml/Instit. Water Heat Gas Boiler Fuel Switch*").

Commercial/Institutional Building "Retrocommissioning": Retrocommissioning is defined as "a process of thoroughly identifying the current needs for services within a building, assessing the functionality and appropriateness of the equipment now serving the building, devising and implementing a systematic plan for repairing, rejuvenating or replacing the existing systems, and finally creating operations and maintenance practices to assure continued functionality of the systems". It is therefore the process of reviewing all of the energy uses in an existing building, and making changes to maintenance and operation, and in some cases in equipment, to make sure that the building operates as efficiently as possible ("*Comml/Instit. Retrocommissioning*"). Retrocommissioning usually is designed to reduce a building's need for heating, cooling, and/or lighting.

Commercial/Institutional Building Standards: Higher standards for insulation, window performance, thermal seals, and other building components help reduce heating and cooling energy use. Two levels of building standards, one meeting ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) 90.1.99 building guidelines ("*Comml/Instit. Building Envelope--ASHRAE Stds.*"), and one exceeding ASRAE guidelines by about 20 percent ("*Comml/Instit. Building Envelope--Enhanced Level*").

Commercial/Institutional Refrigeration: Commercial sector refrigeration ranges from large refrigerators not much different from residential units to walk-in or building-sized cold storage rooms or freezers. Options for improving the energy efficiency of refrigeration systems in the commercial sector include improving door seals, compressors, insulation, and controls. The WRAP analysis included two sets of measures, one of which includes measures having payback times of less than two years ("lower-cost measures", "*Comml/Instit. Refrigeration, Low-cost Measures*") and the other having offering paybacks of between two and five years ("*Comml/Instit. Refrigeration, High-cost Measures*").

Commercial/Institutional Lighting—Fluorescent Bulbs and Ballasts: Replacing standard bulbs and ballasts in the four-foot fluorescent fixtures that are most common in office and other applications with high-efficiency bulbs and ballasts produces significant savings ("*Comml/Instit. Lighting, Efficient Fluorescent*".

Commercial/Institutional Lighting—Advanced Lighting Measures: This measure includes a "package" of "emerging" lighting measures, ranging from use of daylighting to lighting controls to the use of advanced bulbs and fixtures, offering average energy savings over standard practice of more than 50 percent ("*Comml/Instit. Lighting, Advanced Measures*").

Commercial/Institutional Lighting—LED Exit Signs: LEDs are also increasingly used in commercial and institutional exit signs in place of incandescent or fluorescent bulbs. LED exit signs save a considerable amount of energy, and may not need to be replaced for a decade or more, significantly reducing maintenance ("*Comml/Instit. LED Exit Signs*").

Commercial/Institutional Clothes Washers: Upgrades in commercial clothes washers, as with residential washers, can yield significant energy savings in water heating and clothes drying, as well in the washer itself ("*Comml/Instit. Efficient Clothes Washers*").

LED Traffic Signals ("*Comml/Instit. LED Traffic Signals*"): Light emitting diodes (LEDs) have been widely used in electronics for years, are now starting to find new lighting applications. As with LED exit signs, long-lasting LED traffic signals, though they cost more per bulb than incandescent signals, dramatically reduce energy use (by 90%) as well as O&M costs. Although

LED traffic signals do not produce the same amount of overall light as incandescent signals, the focused points of bright light produced by LEDs make them easy for the eye to pick out, and thus ideal for traffic lights and other signage.

Commercial/Institutional/Industrial Electrical Transformers: In larger commercial buildings and in industrial installations, transformers are used to "step down" high-voltage power from the electrical grid to usable lower voltages. Transformer losses are not substantial, but as each kWh of electricity used in a building typically must pass through a transformer, even a small reduction in losses improves the energy-efficiency of the entire building. The measures "*Comml/Instit/Industrial Transformers (C/I)*" and "*Comml/Instit/Industrial Transformers (Industrial)*" model the purchase of higher-efficiency "TP-1" transformers instead of standard units.

INDUSTRIAL SECTOR MEASURES

Industrial Motors Efficiency Improvements: The efficiency of industrial motors can be improved in several ways: by replacing failed motors with premium (highest efficiency) instead of standard models ("*Industrial Premium Motors*"), by substituting premium motors where motors would otherwise be rewound ("*Industrial Prem. Motor vs. Rewind*"), and by downsizing motors to appropriate capacity for the systems they power ("*Industrial Motor Downsizing*"). These types of improvements typically save only 1-4 percent of motor electricity requirements, but when applied across the large number of industrial motors, the savings can be considerable.

Industrial Motor System Improvements: Even greater savings of motor electricity use can be achieved by modifying the design and operation of systems that motors drive: air compressors, pumps and valves, fans, and other systems (such as conveyors). For the WRAP energy efficiency analysis, the potential savings for improving each of three types of motor systems ("*Industrial Air Compressor System Measures*", "*Industrial Fan System Measures*", and "*Industrial Pump System Measures*") were evaluated. Savings for these measures can range, on average, from 5 percent for fans to nearly 20 percent for pumps and air compressors.

Industrial—Aluminum Production Process Improvements: Primary aluminum production – as opposed to secondary production from recycled aluminum feedstocks -- is a very energy-intensive process. One of the key options for reducing electricity consumption per unit of aluminum produced is to retrofit aluminum production cells for higher electrolytic efficiency and lower heat loss ("*Industrial Aluminum Process Impr.: Cell Retrofit*"). Other technological advances are possible, such as advanced forming and near net-shape casting. These advances are designed to save energy by producing aluminum in shapes that are close to their final form, can provide considerable O&M and thermal energy (typically gas energy) savings, though typically small electricity savings ("*Industrial Aluminum Process Impr.: Adv. Forming*").

Industrial Electrical Transformers: (see listing under Commercial/Institutional sector, above)

COMBINED HEAT AND POWER

From half to two-thirds of the energy used for fuel-based electricity generation is typically lost as waste heat. Combined heat and power (CHP) systems effectively capture this waste heat and supply it to a facility's process or building heat requirements, and can thereby approximately double the overall efficiency of fuel use to 80 percent or so.

We included in our analysis several types of natural gas-fired CHP systems in several size classes:

- **Internal Combustion Engines**: Internal combustion (IC) engines have been used in stationary power generation applications for a century or more, and are a very mature technology. Heat from gas-fired water-cooled IC engines can be captured from the engine's coolant system via a radiator, and used to heat or pre-heat air or water to help provide space or water heat.
- **Combustion Turbines**: Conventional combustion turbines (CT) are a newer, but still quite mature, electric generation option, having been in wide use for decades. Here heat can be captured from the hot exhaust gases of the turbine via a heat exchange unit, and used for space or water heat, or (more likely) for process heat in industrial plants. We incorporated 10 and 40 MW combustion turbines into the industrial sector CHP initiative that we evaluated.
- **"Micro" Turbines**: Micro-turbines (MT) are self-contained CHP devices that are new on the market. These units, the size of a large household refrigerator (in the 30 kW size) produce heat and electricity using a high-speed but very reliable miniature turbine coupled to a generator. These units, recently commercialized, will be available in size classes other than 30 kW soon, but only the 30 kW units are included in our analysis.

The types of CHP systems included in the commercial/institutional and industrial sector WRAP energy efficiency analyses are as follows:

- **Commercial CHP**: CHP measures in the commercial sector included 30 kW MT units, 100 kW IC units, and 800 kW IC units, with some of the units displacing grid electricity and heat from electric resistance boilers or water heaters ("*Comml/Instit. CHP, 30 kW MT repl. Elect. WH*", "*Comml/Instit. CHP, 100 kW IC repl. Elect. WH*", and "*Comml/Instit. CHP, 800 kW IC repl. Elect. WH*"), and other units displacing grid electricity and heat from gas-fired boilers or water heaters ("*Comml/Instit. CHP, 30 kW MT repl. Gas WH*", "*Comml/Instit. CHP, 100 kW IC repl. Gas WH*", and "*Comml/Instit. CHP, 800 kW IC repl. Gas Blr.*")
- **Industrial CHP**: For the industrial sector, our estimate included 800 and 3000 kW IC units, and 10 and 40 MW CT units. All co-generated heat from these units was assumed to displace gas-fired boilers or process heating equipment ("*Industrial CHP, 800 kW IC repl. Gas Blr.*", "*Industrial CHP, 3000 kW IC repl. Gas Blr.*", "*Industrial CHP, 10 MW CT repl. Gas Blr.*", and "*Industrial CHP, 40 MW CT repl. Gas Blr.*")

ATTACHMENT 2:

TABULAR SUMMARY OF DSM MEASURE AND PROGRAM INPUTS AND ASSUMPTIONS

Interior West, Residential Sector

SUMMARY OF DSM MEASURE AND PROGRAM ASSUMPTIONS USED IN EVALUATING AN ENERGY EFFICIENCY PORTFOLIO FOR THE INTERIOR WEST (WSCR) REGION

***PROGRAM*/MEASURE**	Units of Measure Application	Measure Lifetime (years)	Annual kWh Savings per Unit	Summer Peak Savings: kW/Unit	Incremental Installed Cost ($/unit)	Incremental Annual O&M Cost ($/unit)	Program Incentives	Ongoing Admin. Costs	Start-up Admin. Costs
Residential Efficient Cooling Equipment								6.5% of spon. Costs	$1,000,000
High-efficiency Central AC	AC Units	15	863	0.98	$550	$0	70% of incr. cost		
High-efficiency Room AC	AC Units	15	121	0.21	$150	$0	70% of incr. cost		
Residential Evaporative Cooling								10% of spon. Costs	$1,000,000
Direct Evaporative Cooling	AC Units	15	1,870	2.14	$ (1,000)	$ 63	$550		
Indirect/Direct Evaporative Cooling	AC Units	15	1,578	1.80	$ (300)	$ 63	$550		
Residential Lighting--CFL Bulbs								50% of spon. Costs	$500,000
Compact Fluorescent Lamps (CFL)	Bulbs	9	60.2	0.0181	$2.50	$0	$3.75		
Residential Lighting--CFL Fixtures								65% of spon. Costs	$1,000,000
CFL Fixtures--Indoor	Fixtures	19	167	0.050	$14.21	$1.10	100% of incr. cost		
CFL Fixtures--Outdoor	Fixtures	11	143	0.0128	$17.14	($10.60)	100% of incr. cost		
Residential Lighting--Torchieres								20% of spon. Costs	$500,000
CFL Torchieres	Lamps	20	599	0.1797	$40.00	($4.88)	75% of incr. cost		
Residential Appliance Recycling									$500,000
Second Refrigerator Pickup	Appliances	6	1,149	0.196	$125	$0	$75/unit	*(see note)*	
Residential Clothes Washers								15% of spon. Costs	$500,000
EnergyStar Vertical Axis Washers	Appliances	15	674	0.280	$324	$0	50% of incr. cost		
SEHA Horizontal Axis Washers	Appliances	15	814	0.339	$374	$0	50% of incr. cost		
Residential Electronics Standby Loss Reduction									
EnergyStar Devices, Incentive Program	Devices	7	29.8	0.0034	$2.50	$0	50% of incr. cost	15% of spon. Costs	$500,000
EnergyStar Devices, Mandatory Program	Devices	7	29.8	0.0034	$2.50	$0	none	none	$500,000
Residential "Weatherization"								6.6% of spon. Costs	$500,000
Weatherization of Elect. Heated Homes	Homes	15	1,344	1.02	$529	$0	20% of incr. cost		
Residential Duct Testing and Sealing				0.242				16% of spon. Costs	$500,000
Duct Measures, Space Heating Savings	Homes	10	212	0.242	$309	$0	70% of incr. cost		
Duct Measures, Space Cooling Savings	Homes	10	153	0.175	$309	$0	70% of incr. cost		
Residential New Construction Building Shell Improvements								8.6% of spon. Costs	
Improvements to IECC 2000 Level	Homes	50	230	0.096	$1,161	$0	50% of incr. cost		$1,000,000
Enhancements beyong IECC 2000	Homes	50	491	0.205	$2,253	$0	none		$3,000,000

		Annual Program Participation (in measure units)						
***PROGRAM*/MEASURE**	Units of Measure Application	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	**Notes**
Residential Efficient Cooling Equipment								
High-efficiency Central AC	AC Units	10,666	21,412	36,058	37,187	37,064	37,239	SEER 13.5 vs. 10.5
High-efficiency Room AC	AC Units	4,646	9,316	15,639	15,978	15,941	15,993	SEER 10 vs. 8.5
Residential Evaporative Cooling								
Direct Evaporative Cooling	AC Units	3,555	7,137	14,423	14,875	14,826	14,895	Evaporative vs. direct cooling
Indirect/Direct Evaporative Cooling	AC Units	178	1,784	7,212	7,437	7,413	7,448	IDDEC vs. direct cooling
Residential Lighting--CFL Bulbs								
Compact Fluorescent Lamps (CFL)	Bulbs	237,961	729,749	994,749	1,018,306	1,041,666	1,065,305	
Residential Lighting--CFL Fixtures								
CFL Fixtures--Indoor	Fixtures	20,450	62,713	106,859	109,389	111,899	114,438	
CFL Fixtures--Outdoor	Fixtures	3,870	11,869	20,223	20,702	21,177	21,658	
Residential Lighting--Torchieres								
CFL Torchieres	Lamps	26,812	63,952	140,102	143,420	146,710	150,040	Compares CFL torchiere with std halogen or incand. lamp
Residential Appliance Recycling								
Second Refrigerator Pickup	Appliances	186,004	190,138	0	0	0	0	Measure cost includes pickup cost and administrative costs
Residential Clothes Washers								
EnergyStar Vertical Axis Washers	Appliances	5,463	10,954	18,389	18,790	18,744	18,800	
SEHA Horizontal Axis Washers	Appliances	5,463	10,954	18,389	18,790	18,744	18,800	
Residential Electronics Standby Loss Reduction								
EnergyStar Devices, Incentive Program	Devices	518,428	1,038,328	1,737,351	1,758,052	1,755,797	1,758,995	Incentive program ends in 2009
EnergyStar Devices, Mandatory Program	Devices	20,105,881	20,173,792	20,265,715	20,489,221	20,484,333	20,522,500	Mandatory program starts in 2010
Residential "Weatherization"								Includes savings of both
Weatherization of Elect. Heated Homes	Homes	16,739	16,944	17,157	17,400	17,637	17,876	heating and cooling energy.
Residential Duct Testing and Sealing								
Duct Measures, Space Heating Savings	Homes	16,848	17,075	17,292	17,511	17,738	17,997	Winter peak savings
Duct Measures, Space Cooling Savings	Homes	15,996	16,211	16,417	16,625	16,841	17,087	Summer peak savings
Residential New Construction Building Shell Improvements								
Improvements to IECC 2000 Level	Homes	24,458	24,592	24,963	26,093	25,970	26,144	Incentive program ends in 2009
Enhancements beyong IECC 2000	Homes	241,068	243,198	244,371	245,181	246,049	246,352	Mandatory program starts in 2010

Interior West, Commercial Sector

PROGRAM **/MEASURE**	Units of Measure Application	Measure Lifetime (years)	Annual kWh Savings per Unit	Summer Peak Savings: kW/Unit	Incremental Installed Cost ($/unit)	Incremental Annual O&M Cost ($/unit)	Program Incentives	Ongoing Admin. Costs	Start-up Admin. Costs
Commercial/Institutional Cooling								15% of spon. costs	$1,000,000
High-efficiency medium-sized package AC systems	systems	20	12,077	6.29	$3,100	$0	50% of incr. cost		
High-efficiency large centrifugal chillers	systems	24	57,119	29.75	$54,250	$0	50% of incr. cost		
Residential-type Central Air Conditioners	tons of AC	15	529	0.235	$158	$0	50% of incr. cost		
Residential-type Room Air Conditioners	tons of AC	15	346	0.180	$129	$0	50% of incr. cost		
Residential-type Heat Pumps	tons of AC	15	513	0.229	$171	$0	50% of incr. cost		
Indirect/Direct Evaporative Cooling for Commercial/Institutional Air Conditioning								15% of spon. costs	$500,000
Indirect/direct evaporative cooling--medium-sized systems	systems	20	38,841	20.2	$ 35,000	$0	50% of incr. cost		
Indirect/direct evaporative cooling--medium/large-sized systems	systems	24	228,883	119.2	$ 120,000	$0	50% of incr. cost		
Indirect/direct evaporative cooling--large-sized systems	systems	24	291,306	151.7	$ 280,000	$0	50% of incr. cost		
Higher-Efficiency Commercial/Institutional Cooling Towers								10% of spon. costs	$200,000
Cooling tower VSD for centrifugal chiller in Central Valley (CA)-type climate	systems	24	9,688	4.31	$ 7,350	$0	50% of incr. cost		
Cooling tower VSD for centrifugal chiller in Desert (CA)-type climate	systems	24	14,840	4.55	$ 7,350	$0	50% of incr. cost		
Gas-fired Commercial/Institutional Air Conditioning								10% of spon. costs	$500,000
Engine-driven chillers w/o recovery for water heating	systems	24	325,577	170	$ 173,250	$ 4,200	50% of incr. cost		
Engine-driven chillers w/ heat recovery to replace gas water heating	systems	24	325,577	170	$ 161,609	$ 4,200	50% of incr. cost		
Engine-driven chillers w/ heat recovery to replace electric water heating	systems	24	804,894	208	$ 166,571	$ 4,200	50% of incr. cost		
Commercial/Institutional Ground-source Heat Pumps				(winter peak savings)				10% of spon. costs	$200,000
1000 Operating Hours per Year	1000 sq. m. floor space	20	31,150	31.1	$ 25,000	($1,600)	50% of incr. cost		
2000 Operating Hours per Year	1000 sq. m. floor space	20	62,300	31.1	$ 25,000	($1,600)	50% of incr. cost		
3000 Operating Hours per Year	1000 sq. m. floor space	20	93,449	31.1	$ 25,000	($1,600)	50% of incr. cost		
Commercial/Institutional Spare Heating Measures: Fuel Switching				(winter peak savings)				15% of spon. costs	$200,000
Standard Gas boiler replacing electric boiler	1000 kBtu/hr systems	21	299,036	171	($8,364)	$106	$20 per kW displaced		
Higher-efficiency gas boiler replacing electric boiler	1000 kBtu/hr systems	21	299,036	171	($5,193)	$135	$20 per kW displaced		
Gas "Unit" heater/furnace replacing electric heater/furnace	1000 kBtu/hr systems	15	299,036	171	$2,973	$233	$20 per kW displaced		
Commercial/Institutional New Construction - incentives and codes									
New buildings meeting ASHRAE 90.1-99 codes	Square feet floor space	50	1.19	0.000391	$1.32	$0	50% of incr. cost	$0.10 per square ft	$1,000,000
New buildings meeting enhanced codes	Square feet floor space	50	2.54	0.000834	$3.71	$0	none	$0.40 per square ft	$3,000,000
Commercial/Institutional Water Heating Measures: Heat Pump and Fuel Switching								15% of spon. costs	$500,000
Gas boiler replacing electric boiler	1000 kBtu/hr systems	21	1,047,823	144	($8,364)	$106	$20 per kW displaced		
Gas water heater replacing electric WH	1000 kBtu/hr systems	12	1,047,823	144	($2,475)	($58)	$20 per kW displaced		
Heat-pump water heater replacing electric WH	1000 kBtu/hr systems	15	637,076	87	$61,549	$78	50% of incr. cost		
"Retrocommissioning" of Existing Commercial Buildings								10% of spon. costs	$500,000
Commercial Retrocommissioning	Thous. Sq. ft. floor space	15	1,120	0.50	$188	$0	50% of incr. cost		

		Annual Program Participation (in measure units)						
***PROGRAM*/MEASURE**	Units of Measure Application	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	**Notes**
Commercial/Institutional Cooling								
High-efficiency medium-sized package AC systems	systems	4,422	10,832	10,432	10,304	10,337	10,394	20-ton size class
High-efficiency large centrifugal chillers	systems	102	251	242	239	240	241	350-ton size class
Residential-type Central Air Conditioners	tons of AC	16,960	41,544	40,010	39,516	39,646	39,864	CAC, 13 vs. 10 SEER
Residential-type Room Air Conditioners	tons of AC	23,980	58,742	56,573	55,874	56,058	56,365	Room AC ~10 vs. ~8.5 SEER
Residential-type Heat Pumps	tons of AC	25,384	62,181	59,885	59,146	59,340	59,666	Heat Pump (15-30 ton), 8.5 to 10.5 SEER
Indirect/Direct Evaporative Cooling for Commercial/Institutional Air Conditioning								
Indirect/direct evaporative cooling--medium-sized systems	systems	1,327	3,466	3,338	3,297	3,308	3,326	8000 cubic feet/min unit
Indirect/direct evaporative cooling--medium/large-sized systems	systems	36	94	90	89	89	90	60,000 cubic feet/min unit
Indirect/direct evaporative cooling--large-sized systems	systems	15	40	39	38	38	39	140,000 cubic feet/min unit
Higher-Efficiency Commercial/Institutional Cooling Towers								
Cooling tower VSD for centrifugal chiller in Central Valley (CA)-type climate	systems	51	100	97	95	96	96	For 350-ton size class
Cooling tower VSD for centrifugal chiller in Desert (CA)-type climate	systems	51	100	97	95	96	96	For 350-ton size class
Gas-fired Commercial/Institutional Air Conditioning								
Engine-driven chillers w/o recovery for water heating	systems	5	10	10	10	10	10	350-ton size class, annual net gas use, 3344 MMBtu
Engine-driven chillers w/ heat recovery to replace gas water heating	systems	10	25	24	24	24	24	350-ton size class, annual net gas use, 1573 MMBtu
Engine-driven chillers w/ heat recovery to replace electric water heating	systems	8	15	15	14	14	14	350-ton size class, annual net gas use, 3344 MMBtu
Commercial/Institutional Ground-source Heat Pumps								
1000 Operating Hours per Year	1000 sq. m. floor space	38	72	67	65	64	63	Compared with Typical Heat Pump, 1000 hrs/yr operation
2000 Operating Hours per Year	1000 sq. m. floor space	75	143	135	130	128	127	Compared with Typical Heat Pump, 2000 hrs/yr operation
3000 Operating Hours per Year	1000 sq. m. floor space	75	143	135	130	128	127	Compared with Typical Heat Pump, 3000 hrs/yr operation
Commercial/Institutional Spare Heating Measures: Fuel Switching								
Standard Gas boiler replacing electric boiler	1000 kBtu/hr systems	4	8	6	8	8	7	Annual net gas use, 1242 MMBtu
Higher-efficiency gas boiler replacing electric boiler	1000 kBtu/hr systems	16	13	16	15	15	15	Annual net gas use, 1111 MMBtu
Gas "Unit" heater/furnace replacing electric heater/furnace	1000 kBtu/hr systems	13	16	15	15	15	14	Annual net gas use, 1235 MMBtu
Commercial/Institutional New Construction - incentives and codes								
New buildings meeting ASHRAE 90.1-99 codes	Square feet floor space	44,251,731	41,394,375	37,610,446	35,654,056	34,778,859	34,085,519	Incentive program ends in 2009
New buildings meeting enhanced codes	Square feet floor space	141,884,546	137,388,357	132,087,023	125,771,368	121,951,882	118,701,209	Mandatory program starts in 2010
Commercial/Institutional Water Heating Measures: Heat Pump and Fuel Switching								
Gas boiler replacing electric boiler	1000 kBtu/hr systems	8	16	13	16	15	15	Annual net gas use, 4353 MMBtu
Gas water heater replacing electric WH	1000 kBtu/hr systems	11	24	20	23	23	22	Annual net gas use, 4380 MMBtu
Heat-pump water heater replacing electric WH	1000 kBtu/hr systems	7	8	8	7	7	7	Compared with resistance water heater or boiler
"Retrocommissioning" of Existing Commercial Buildings								
Commercial Retrocommissioning	Thous. Sq. ft. floor space	6,166	15,967	16,443	16,879	17,298	17,703	

PROGRAM/MEASURE	Units of Measure Application	Measure Lifetime (years)	Annual kWh Savings per Unit	Summer Peak Savings: kW/Unit	Incremental Installed Cost ($/unit)	Incremental Annual O&M Cost ($/unit)	Program Incentives	Ongoing Admin. Costs	Start-up Admin. Costs
Commercial/Institutional Lighting								10% of spon. costs	$2,000,000
Advanced Measures	MWh lighting energy	15	656	0.197	$175	$0	40% of incr. cost		
T8 lamps, electronic ballast, & similar	MWh lighting energy	15	227	0.068	$27	$0	40% of incr. cost		
Commercial/Institutional Refrigeration								10% of spon. costs	$2,000,000
Higher-cost Technologies	MWh refrig. energy	15	366	0.055	$65	$0	40% of incr. cost		
Lower-cost Technologies	MWh refrig. energy	15	290	0.043	$27	$0	40% of incr. cost		
Miscellaneous Measures, Commercial Sector								15% of spon. costs	$1,000,000
Exit Lighting	Units	25	223	0.0255	$30	($12.72)	40% of incr. cost		
Traffic Lights	Units	15	431	0.0492	$125	($40.00)	40% of incr. cost		
Commercial Clothes Washers	Units	8	1,009	0.2731	$200	$0	40% of incr. cost		
*Commercial/Institutional Combined Heat and Power^*								5% of spon. costs	$1,000,000
30 kW Micro-turbines replacing electric water heater or boiler	CHP units	20	3,080	60.72	$37,295	$2,610	30% of incr. cost		
Lower-cost 30 kW Micro-turbines replacing gas water heater or boiler	CHP units	20	2,199	26.48	$14,911	$2,610	30% of incr. cost		
100 kW Internal Combustion replacing electric boiler	CHP units	20	9,714	243.39	$121,062	$13,120	30% of incr. cost		
Lower-cost 100 kW Internal Combustion replacing gas boiler	CHP units	20	8,920	91.32	$82,751	$13,120	30% of incr. cost		
800 kW Internal Combustion replacing electric boiler	CHP units	20	64,226	1,502.35	$743,295	$68,480	30% of incr. cost		
Lower-cost 800 kW Internal Combustion replacing gas boiler	CHP units	20	59,991	730.59	$518,423	$68,480	30% of incr. cost		

PROGRAM/MEASURE	Units of Measure Application	Annual Program Participation (in measure units)					
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Commercial/Institutional Lighting							
Advanced Measures	MWh lighting energy	231,041	438,341	438,806	449,311	458,787	467,527
T8 lamps, electronic ballast, & similar	MWh lighting energy	231,041	438,341	438,806	449,311	458,787	467,527
Commercial/Institutional Refrigeration							
Higher-cost Technologies	MWh refrig. energy	21,760	41,353	42,060	43,079	44,079	45,025
Lower-cost Technologies	MWh refrig. energy	50,773	96,489	98,141	100,518	102,851	105,059
Miscellaneous Measures, Commercial Sector							
Exit Lighting	Units	12,814	35,043	35,081	35,920	36,678	37,377
Traffic Lights	Units	3,854	10,483	10,692	10,906	11,124	11,347
Commercial Clothes Washers	Units	2,561	7,086	7,244	7,504	7,753	7,994
*Commercial/Institutional Combined Heat and Power^*							
30 kW Micro-turbines replacing electric water heater or boiler	CHP units	0	0	45	80	125	125
Lower-cost 30 kW Micro-turbines replacing gas water heater or boiler	CHP units	0	0	0	10	15	25
100 kW Internal Combustion replacing electric boiler	CHP units	100	240	210	142	71	74
Lower-cost 100 kW Internal Combustion replacing gas boiler	CHP units	30	100	150	225	284	296
800 kW Internal Combustion replacing electric boiler	CHP units	20	38	26	20	11	11
Lower-cost 800 kW Internal Combustion replacing gas boiler	CHP units	10	15	25	32	44	45

Interior West, Industrial Sector

PROGRAM /MEASURE	Units of Measure Application	Measure Lifetime (years)	Annual kWh Savings per Unit	Summer Peak Savings: kW/Unit	Incremental Installed Cost ($/unit)	Incremental Annual O&M Cost ($/unit)	Program Incentives	Ongoing Admin. Costs	Start-up Admin. Costs
Higher-Efficiency Commercial/Institutional and Industrial Transformers								15% of spon. costs	$500,000
Commercial "TP-1" Units	kVA capacity	30	23.34	0.0036406	$4.42	$0	50% of incr. cost		
Industrial "TP-1" Units	kVA capacity	30	7.43	0.0011589	$1.81	$0	50% of incr. cost		
Industrial Efficient Motors								10% of utility costs	$1,000,000
Motor Downsizing	MWh motors energy	8	14	0.0031708	$1.20	$0	40% of incr. cost		
Premium Motors in lieu of Rewinding	MWh motors energy	8	48	0.0111193	$14.58	$0	40% of incr. cost		
Premium Replacement Motors	MWh motors energy	8	34	0.0080143	$3.04	$0	40% of incr. cost		
Industrial Motor Drive Improvements								10% of utility costs	$1,000,000
Compressed air system measures	MWh motors energy	15	171	0.0342	$10.58	$0	40% of incr. cost		
Fan system measures	MWh motors energy	15	55	0.011	$3.40	$0	40% of incr. cost		
Pump system measures	MWh motors energy	15	201	0.0402	$36.71	$0	40% of incr. cost		
*Industrial Combined Heat and Power^^*								3% of utility costs	$1,000,000
800 kW Internal Combustion Engine	CHP units	20	6,400,000	731	$518,423	$68,480	30% of incr. cost		
3 MW Internal Combustion Engine	CHP units	20	24,000,000	2,740	$2,442,353	$247,200	30% of incr. cost		
10 MW Combustion Turbine	CHP units	20	80,000,000	9,132	$9,205,263	$440,000	30% of incr. cost		
40 MW Combustion Turbine	CHP units	20	320,000,000	36,530	$26,880,864	$1,760,000	30% of incr. cost		

^ Annual gas use for Commercial/Institutional CHP systems are 3080 (30 kW repl. EWH), 1421 (30 kW repl. GWH), 9714 (100 kW repl. EWH), 3546 (100 kW repl. GWH), 64226 (800 kW repl. EWH), and 31751 (800 kW repl. GWH) MMBtu, respectively.
^^ Annual net gas use for Industrial CHP systems are 31751 (800 kW),134432 (3 MW), 424706 (10 MW), and 1475459 (40 MW) MMBtu.

	Annual Program Participation (in measure units)						
***PROGRAM*/MEASURE**	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	**Notes**
Higher-Efficiency Commercial/Institutional and Industrial Transformers							
Commercial "TP-1" Units	141,720	294,140	300,706	311,505	321,826	331,828	Evaluated relative to standard transformers
Industrial "TP-1" Units	57,459	116,468	117,601	119,625	122,126	124,330	Evaluated relative to standard transformers
Industrial Efficient Motors							
Motor Downsizing	152,876	286,635	289,424	294,406	300,560	305,984	Evaluated relative to standard replacement
Premium Motors in lieu of Rewinding	38,219	71,659	72,356	73,602	75,140	76,496	Evaluated relative to standard replacement
Premium Replacement Motors	573,284	1,074,881	1,085,342	1,104,023	1,127,100	1,147,438	Evaluated relative to standard replacement
Industrial Motor Drive Improvements							
Compressed air system measures	120,691	226,291	228,493	232,426	237,284	241,566	Evaluated relative to standard practice
Fan system measures	111,182	208,462	210,490	214,114	218,589	222,534	Evaluated relative to standard practice
Pump system measures	190,144	356,511	359,981	366,177	373,831	380,577	Evaluated relative to standard practice
*Industrial Combined Heat and Power^^*							
800 kW Internal Combustion Engine	10	21	21	22	23	23	"Lower-cost" systems with heat displacing gas boiler
3 MW Internal Combustion Engine	1	2	1	2	2	2	CHP heat displacing gas boiler
10 MW Combustion Turbine	0	1	2	2	2	2	CHP heat displacing gas boiler
40 MW Combustion Turbine	0	0	1	0	1	0	CHP heat displacing gas boiler

ATTACHMENT 3:

EXAMPLES OF ENERGY EFFICIENCY MEASURE AND PROGRAM EVALUATIONS PERFORMED FOR THE WESTERN REGIONAL AIR PARTNERSHIP (WRAP)

The "text box" that follows provides an example of the procedures used in the evaluation of energy efficiency measures for the Air Pollution Partnership Forum of WRAP. The example shown—for Commercial/Institutional/Industrial Transformers—illustrates the process used in the "bottom-up" (end-use based) energy efficiency analysis carried out for the Interior West and Oregon/Western Idaho regions, and provide examples of some of the data sources and assumptions used. Each example documents three analytical "steps" for the measures and programs considered. The first two steps, compilation of measure costs and performance data and measure benefit/cost analysis, and estimation of program markets and participation, are carried out and documented in MS Excel™ workbooks. The third step, estimation of program costs and savings, was accomplished using the ECO energy-efficiency program analysis software tool, developed by Tellus Institute.

Commercial/Institutional/Industrial Transformers

Step 1: Compilation of Measure Cost and Performance Data, and Measures Benefit/Cost Analysis:

Incremental costs for commercial-sized units were taken to be $4.42 per kVA, and for industrial-sized transformers, $1.81 per kVA (where "kVA" is thousand volt-amps, a measure of transformer capacity). These high-efficiency "TP-1" transformers save, for commercial and industrial applications, respectively, an average of 23.3 and 7.4 kWh per kVA of transformer capacity, relative to standard new transformers[11]. In order to estimate peak savings, a "peak factor" of 0.156 kW per MWh of energy savings was used, along with a transformer lifetime of 30 years[12].

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[11] Data on incremental costs and savings for high-efficiency transformers were derived based on Tables 5.4, 5.7, and 5.8 of Supplement to the "Determination Analysis" (ORNL-6847) and Analysis of the NEMA Efficiency Standard for Distribution Transformers, by P. R. Barnes, S. Das, B. W. McConnell, and J. W. Van Dyke. This Oak Ridge National Laboratory Report No. ORNL-6925, dated September 1997, was received as ORNL6925.pdf from Jan Berry of ORNL, 10/24/01. The designation "TP-1" refers to a USEPA EnergyStar program standard for transformers. An ORNL expert on transformer technology (Mr. Lance McCord) was consulted regarding estimates for other parameters needed to estimate average transformer costs and savings.

[12] The peak factor used, 0.000156 kW per kWh saved, is taken from the "National" worksheet of the workbook "neep1017.xls", prepared by various researchers for the NEEP (Northeast Energy Efficiency Partnerships, Inc.) energy efficiency analyses, and summarizing national energy savings potential for a variety of energy efficiency improvements, most related to appliance or equipment standards. The average lifetime of transformers is also from this source.

The measure cost and savings data described above were used, along with rough estimates of avoided energy and capacity costs for electricity generation, to estimate benefit/cost ratios for the two transformer measures. Both proved very cost-effective (with benefit/cost ratios of about 3.3 for commercial transformers and 2.6 for industrial units), and were thus included in the WRAP energy efficiency package.

Step 2: Program Market and Participation Estimation, and Estimation of Administration Costs

The markets for commercial and industrial transformers in the Interior West (WSCR) region were estimated starting with an estimate that of nationwide annual sales of "dry-type" transformers in 2000 totaled 22 million kVA[13]. In order to estimate the fraction of these transformers that were sold in each sector, average commercial-sector and industrial-sector load factors of 20 and 40 percent, respectively, were applied[14]. Using these load factors, the implied distribution of transformer sales nationally was calculated as 14.7 million kVA in the commercial sector, and 7.3 million kVA in the industrial sector. Based on WSCR region commercial and industrial electricity sales in 2000 (61,615 and 54,858 GWh, respectively) and analogous figures for the U.S. as a whole, estimated year-2000 sales of transformers in the WSCR were calculated as 870,654 kVA in the commercial sector, and 375,684 kVA in the industrial sector[15]. These year-2000 sales by sector were then extrapolated through 2018 using the rates of growth in commercial and industrial electricity sales included in National Energy Modeling System (NEMS) projections for the Mountain Census Region, yielding estimates of the markets for transformer sales during the 2002 to 2018 program period.

Program participation was assumed to be 15 percent of transformer sales in the first program year, and 30 percent in subsequent years. This participation rate was based on experience as to what well-advertised, aggressive programs have accomplished in the past, and included the assumption of a budget of $500,000 to start up the program (the equivalent of perhaps 5 full-time staff, plus funds for developing program marketing materials), and a sponsor incentive equal to 50 percent of the incremental cost of the transformers. Administrative costs equal to 15 percent of sponsor measure costs were estimated, based on consideration of the effort likely to be required to process incentive payments and for ongoing program marketing, and the "free- rider" fraction was taken to be 15 percent[16].

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[13] From the 1997 ORNL report cited earlier.

[14] See, for example, The Cadmus Group, Inc (1999), Metered Load Factors for Low-Voltage, Dry-Type Transformers in Commercial, Industrial, and Public Buildings. File 120799_cadmus.pdf, downloaded 10/23/01 from www.neep.org.

[15] National and state-level electricity sales data from the Energy Information Administration (EIA) of the US Department of Energy (USDOE).

[16] "Free-riders" are program participants that would have adopted the measure even in the absence of the sponsor's incentive program. In practice, "free-ridership" is sometimes measured by post-program evaluation surveys or by market studies, but in many instances, for planning of DSM programs, values in the range of 10 to 20 percent are assumed.

Step 3: Program Costs and Savings Estimates

Measure cost, savings, and lifetime estimates prepared as described in Step 1, above, together with estimates of annual program participation for each measure, administrative cost factors, sponsor cost fractions, and free-ridership estimates estimated as described in Step 2, were entered into the ECO software tool, together with estimates of parameters such as discount rates (4.88 percent annually, on a real basis) capital recovery factors (based on device lifetimes and the assumed discount rate), and the future inflation rate (2.8 percent annually)[17]. ECO was then used to calculate streams of annual costs (on both "expensed" and annualized bases) and savings (electrical energy and peak power) for each of the two measures (commercial and industrial transformers) in the program, as well as for the program as a whole. Cost data from ECO (presented as customer and sponsor measure costs, and sponsor administrative costs) and savings data were aggregated with costs from other programs, and savings data were likewise aggregated, and the "package" of annual costs and savings results was summarized for consideration by the Air Pollution Prevention Forum and for inclusion in air pollution and economic impacts modeling using ICF, Inc.'s IPM software tool.

[17] The discount rate used here is similar to real discount rates used by large utilities operating in the West.