DRAFT REPORT

Economic Assessment of Implementing the 10/20 Goals and Energy Efficiency Recommendations

Prepared for

Western Regional Air Partnership
Air Pollution Prevention Forum

Prepared by

ICF CONSULTING

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Executive Summary

With a view towards improving visibility and air quality in the national parks and wilderness areas of the Colorado plateau, the Grand Canyon Visibility Transport Commission (GCVTC) issued several recommendations in 1996 on strategies for air pollution prevention. In its recommendations, the GCVTC emphasized the need to integrate air pollution prevention with cost-effective pollution control strategies in order to prevent degradation of natural resources in the West.[1]

Two key recommendations from the GCVTC focused on the development of renewable energy sources and the promotion of energy conservation. Labeled the "10/20 goals", the recommendation on development of renewable energy sources encouraged states and tribes in the Transport Region to undertake steps that would increase the use of renewable energy to 10 percent of the regional power needs by 2005 and 20 percent of the regional power needs by 2015. For energy conservation, the commission supported the continued development of energy efficiency standards and suggested that the emphasis on energy conservation be maintained within the changing electric power markets. In addition to the 10/20 goals and energy conservation recommendations, the GCVTC suggested that future modeling work be conducted to analyze the potential emission reductions, cost savings and secondary benefits associated with the use of renewable energy, energy efficiency and pollution prevention.

The Regional Haze Rule issued by the US Environmental Protection Agency in April 1999 included the air pollution prevention recommendations of the GCTVC. Under the rule, the states of the Transport Region must include in their State Implementation Plans (SIP) an outline of the programs and policies that each state will rely on to work towards meeting the air pollution prevention recommendations. Tribal governments may seek approval from EPA to incorporate the requirements of the regional haze regulations, including the GCVTC recommendations, in their Tribal Implementation Plans (TIP) under the provisions of the Tribal Authority Rule (TAR).

The Air Pollution Prevention (AP2) forum of WRAP has been charged with implementing the air pollution prevention recommendations of the GCVTC. The AP2 forum commissioned ICF Consulting to analyze the potential emissions reductions, costs and secondary regional economic impacts of meeting the 10/20 goals and energy efficiency recommendations.

This study documents the analytic and technical support to the AP2 forum's report detailing its recommendations regarding renewable energy and energy efficiency to the WRAP Board. The AP2 forum's report provides a discussion of the policy imperatives and broader implications of the GCVTC air pollution prevention recommendations, while this report describes the emissions reductions, costs and secondary economic impacts of meeting the 10/20 goals and implementing the energy efficiency recommendations, given the assumptions and scenarios developed by the AP2 forum. The analysis examines the impacts for the nine states and tribal lands of the Transport region and was focused around stationary sources engaged in the production of electricity and

[1] "Recommendations for Improving Western Vistas," The Grand Canyon Visibility Transport Commission, June 1996, page 28.

industrial steam along with and process-related SO_2 sources such as refineries and smelters.

Analytical Framework

The AP2 forum developed a three-phase analytical framework to assess the potential emissions reduction, costs and secondary regional economic impacts of implementing the 10/20 goals and energy efficiency recommendations. These included: (1) assumptions and scenario development, (2) modeling of the electric, steam and process source sectors, and (3) modeling of the secondary regional economic impacts.

The AP2 forum developed two types of scenarios in order to examine the emissions, costs and secondary regional economic impacts of meeting the 10/20 goals and implementing the energy efficiency recommendations. The first was the Business-As-Usual (BAU) scenario that characterized how the future might unfold with the proposed regional backstop SO_2 trading program but without any policy measures designed to accomplish the 10/20 goals and energy efficiency recommendations. The second set of scenarios reflected a future with the regional backstop SO_2 trading program and policy drivers designed to meet the 10/20 goals or energy efficiency recommendations, or both. Assessments of emissions, costs and secondary regional economic impacts were estimated by analyzing the changes in the policy scenarios relative to the BAU scenario.

The AP2 forum selected as the business-as-usual scenario the Annex cap-and-trade scenario developed by the WRAP/Market Trading Forum (MTF)[2] for its economic analysis, with minor modifications to account for the planned additions to renewable energy capacity. The policy scenarios developed by the AP2 forum were focused around objectives of implementing the 10/20 goals and energy efficiency recommendations with some additional scenarios designed to analyze the sensitivity of the results to higher gas prices and improvements in renewable energy technology cost and performance.

In designing the policy scenarios and in developing the data for those scenarios, the AP2 forum modified some of the assumptions on the cost and performance of renewable energy technologies from those used in the MTF Annex scenario. The AP2 recognized that the 10/20 goals had the potential to not only affect the level of renewable energy generation in the West, but would also had to potential to influence the underlying market conditions for those technologies. Under a climate where policies are in place designed to achieve the 10/20 renewable energy goals and energy efficiency recommendations, the AP2 forum believes that the wind resource development costs could improve over time because of the cost benefits of “learning by doing”, because of better alignment of incentives for improving technologies’ cost and performance and because of reduced barriers to entry.

The adjustments in the assumptions for the policy scenarios were focused only around wind technologies because wind was likely to be the largest renewable energy and it was resource also where the forum anticipated most improvements in cost and performance would occur. However, recognizing the uncertainty inherent in such

[2] “Economic Impacts of Implementing a Regional SO2 Emissions Program in the Grand Canyon Visibility Transport Region,” Western Regional Air Partnership/ Market Trading Forum, September 2000. (MTF 2000).

assumptions about technology improvements, the AP2 forum developed a sensitivity scenario to test the cost implications of implementing the 10/20 goals without the assumed improvements in renewable technology cost and performance.

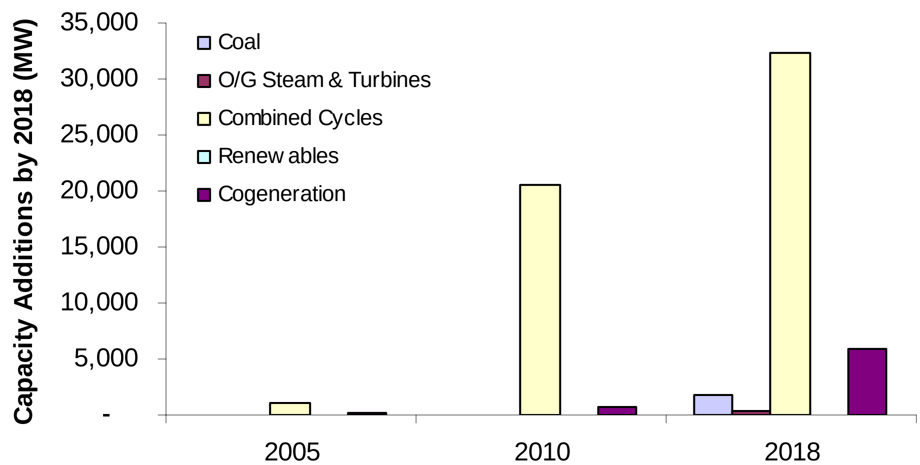
In Phase II of the analysis, ICF Consulting's Integrated Planning Model (IPM®) was used as the analytical tool for modeling the costs and emissions impacts of the policy scenarios. IPM simulates productions activity in the electricity generation and industrial steam production markets using an integrated view of fuel, emissions, capacity and generation markets. Results from IPM served as inputs to modeling of the secondary regional economic impacts in Phase III of the analysis. The Policy Insights model produced by Regional Economic Models Inc. (hereafter referred to as REMI) was used as the analytical tool for estimating the secondary regional economic impacts.

Emissions Reductions and Cost Impacts

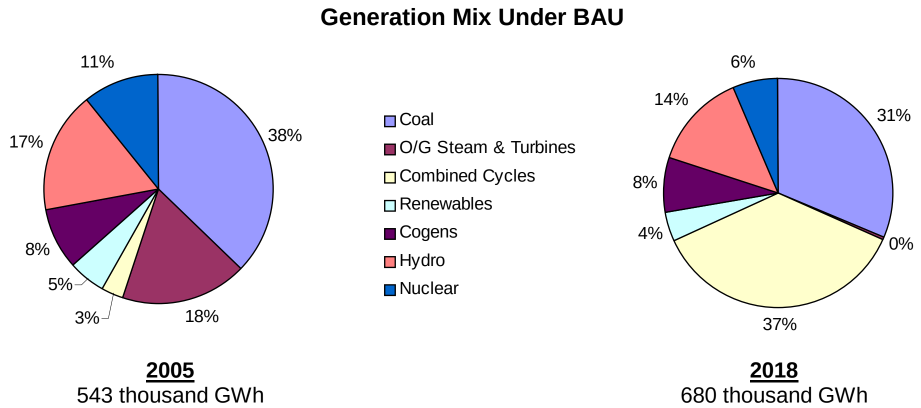
The 10/20 goals require renewable energy to satisfy 10 percent of the regional energy needs by 2005 and 20 percent of the regional energy needs by 2015. The energy efficiency recommendations developed by the AP2 forum calls for electricity demand reductions in the Transport Region to grow to 8 percent of the electricity generation demand by 2018. The analysis indicates that both these policy objectives could serve as cost-effective air pollution prevention strategies because they provide opportunities for emissions reductions at modest costs or with some savings.

Because the assessment of impacts are based on analysis of the differences between the policy scenarios and the BAU scenario, some notable elements of the BAU scenario are described below to provide a helpful context for understanding the results. One of the most important components of the BAU scenario driving the results is the growth of gas-fired generation capacity. Under the BAU scenario, the growth in electricity demand is met by additions of new gas-fired combined cycle capacity. As illustrated in Figure ES-1 below, almost 30 GW of new combined cycle capacity is projected under the BAU scenario by 2018. This represents 80 percent of the growth in capacity additions and accounts for 37 percent of all generation in the Transport Region in that year.

Figure ES-1: Capacity Additions Under the BAU Scenario[3]



[3] O/G steam & Turbines refers to Oil/Gas Steam and Gas Turbines; combined cycles refer to gas-fired combined cycles and cogeneration refers to combined heat and power.



The mix of generation and capacity additions under the BAU scenario has important implications both for the growth in emissions under the BAU scenario and the potential for emissions reductions from the 10/20 goals and energy efficiency recommendations. Because generation from new gas capacity is assumed to be relatively clean, NO_x emissions under the BAU scenario remains relatively changed between 2005 and 2018, growing by 1 percent to 606 thousand tons in 2018. During that same period, the NO_x emissions rate for oil/gas units declines from 0.2 lbs/MWh in 2005 to 0.05 lbs/MWh, reflecting the projected turnover to newer efficient combined cycle generation.

As a result of increased fossil fuel generation, CO_2 emissions under the BAU scenario increases by 19 percent between 2005 and 2018 to 401 million metric tones. SO_2 emissions under the BAU scenario is held to the regional targets specified in the Annex because the scenario includes the assumptions that the regional SO_2 trading program proposed under the Annex will be in place. Because of the SO_2 cap-and-trade program, none of the policy scenarios will result in any changes in SO_2 emissions.

Implementation of the 10/20 goals and energy efficiency recommendations will lead to significant growth in renewable energy capacity, totaling 20 GW by 2018. The growth reflects the requirements of the 10/20 goals and the assumption that the policy climate of the 10/20 goals may better align incentives to spur the improvements in renewable technology cost and performance through accelerated learning by doing and by easing some of the barriers to entry for renewable energy. Figure ES-2 below summarizes the growth in renewable energy capacity under the 10/20 goals and Figure ES-3 below contrasts the generation mix in 2018 between the BAU and 10/20 goals policy scenario.

Figure ES-2: Renewable Energy Capacity Additions Under the 10/20 Goals

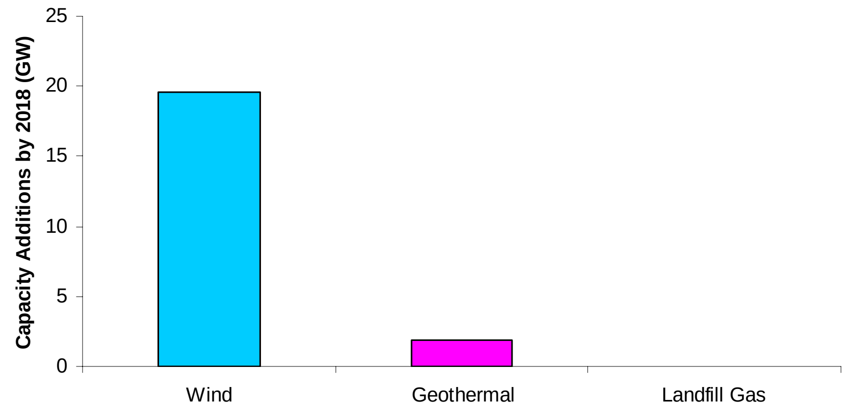
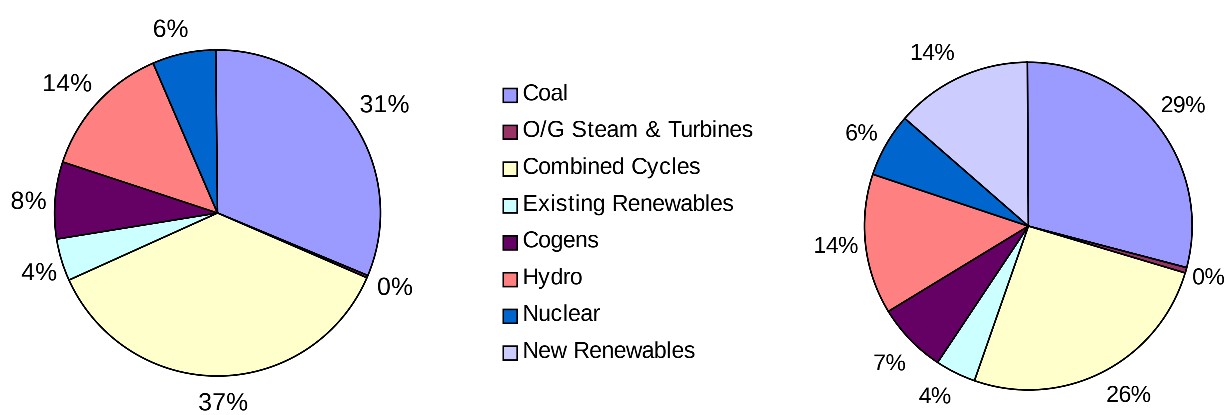


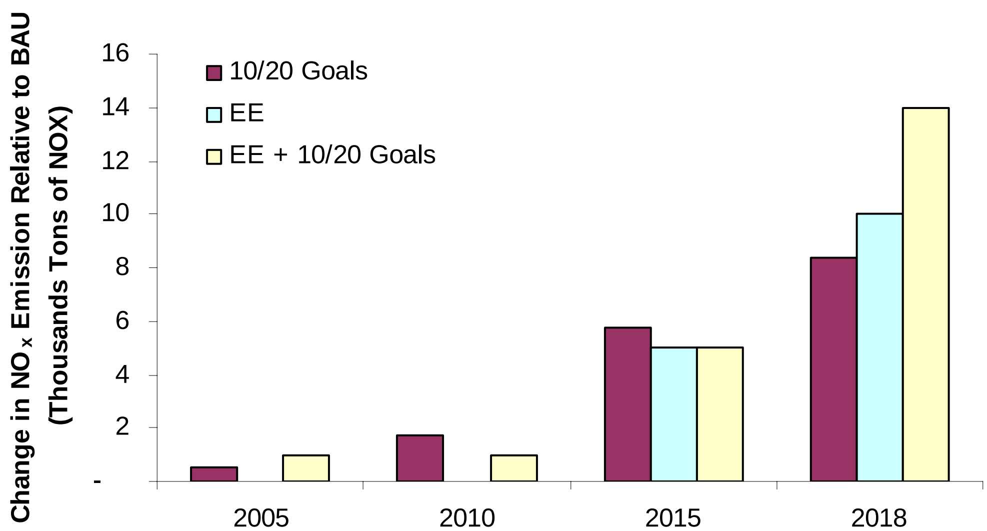
Figure ES-3: Generation Mix in 2018 Under the BAU and 10/20 Goals



As illustrated in Figures ES-2 and ES-3, wind power dominates most of the growth in new renewable capacity and the increased use of renewable energy displaces new gas-fired generation. While these results illustrate only the impact for the 10/20 goals, similar impacts occurs with increased use of energy efficiency. The important results in capacity changes of the 10/20 goals and energy efficiency is that new renewable energy capacity and energy conservation compete against new conventional capacity while leaving the existing electricity generation stock relatively undisturbed.

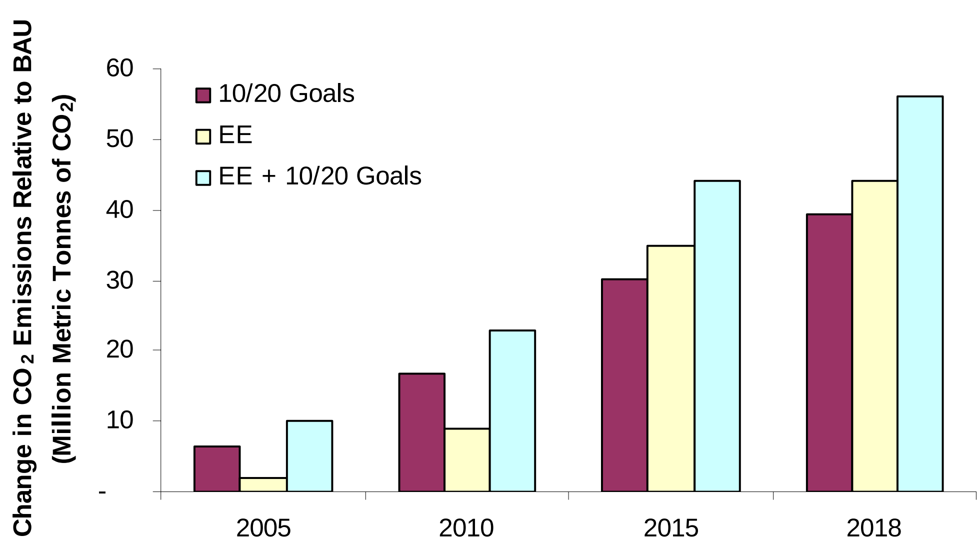
The fact that the renewable energy and energy efficiency are likely to compete against generation from new gas-fired capacity affects the emissions reductions projected under the 10/20 goals and energy efficiency recommendations. As illustrated in Figure ES-4 below, the analysis indicates that under the 10/20 goals and energy efficiency, the potential savings in NO_x emissions are likely to range between 8,000 tons and 14,000 tons (or 1 percent to 2 percent relative to the BAU). In Figure ES-4 below, the bars labeled "10/20 goals" represents the policy scenario with the 10/20 goals, "EE" represents the policy scenarios with the energy efficiency recommendations and "EE + 10/20 goals" represents the policy scenario with both the 10/20 goals and the energy efficiency recommendations.

Figure ES-4: Potential NO_x Emissions Reductions Under the 10/20 Goals and Energy Efficiency Recommendations



Implementation of the 10/20 goals and energy efficiency recommendations also lead to reductions in CO_2 emissions through displaced fossil fuel generation. As illustrated in Figure ES-5, CO_2 emissions savings in 2018 from meeting the 10/20 goals and implementing the energy efficiency recommendations is projected to range between 40 million metric tones and 55 million metric tones (or 10 percent to 14 percent relative to the BAU).

Figure ES-5: Potential CO_2 Emissions Reductions Under the 10/20 Goals and Energy Efficiency Recommendations

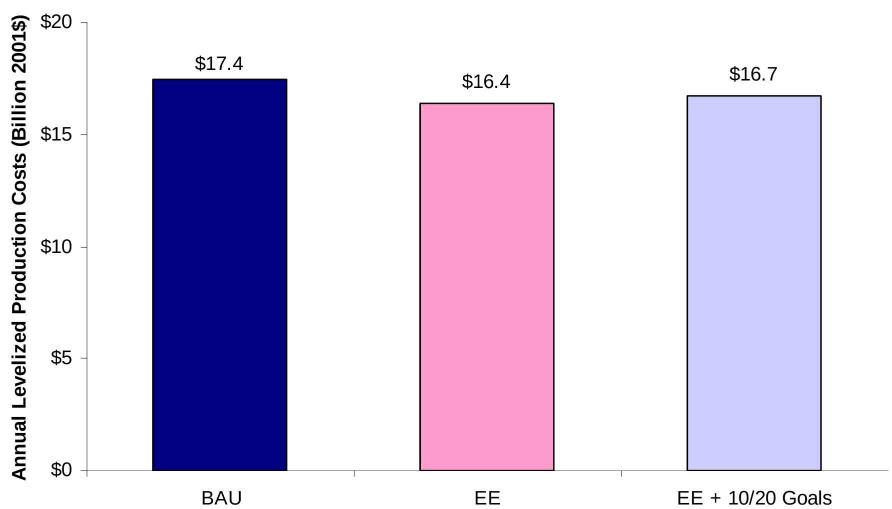


Though the emissions reduction potential for NO_x and CO_2 appears to be modest, it is important to recognize the source of those reductions and the implications for air pollution prevention. Because these emissions reductions come from new generating sources, the 10/20 goals and energy efficiency recommendations provide opportunities to hedge against future emissions growth.

Implementation of the 10/20 goals and energy efficiency scenarios does not reduce SO_2 emissions because of the regional SO_2 trading program proposed under the Annex. However, because the trading program creates a monetary value for emissions reductions, any potential for emissions reductions is fully offset by increases in SO_2 emissions from sources affected by the trading program. In other words, with the 10/20 goals and energy efficiency, the level of SO_2 emissions in 2013 and 2018 will remain unchanged from the emissions caps specified by the Annex. The 10/20 goals and energy efficiency could, however, decrease the compliance cost of the SO_2 trading program by as much as $ 7 million (or 10 percent of projected compliance cost[4]) in 2018 and could displace 1,200 MW to 1,700 MW of new scrubber capacity by 2018.

In addition to the potential emissions savings, implementation of the10/20 goals and energy efficiency recommendations could be achieved through modest production cost or with some savings. In particular, implementation of the energy efficiency recommendations leads to net annual levelized production costs[5] savings of $750 million to $1 billion (or 4 percent to 7 percent relative to the BAU scenario). These net savings reflect the cost of implementing the recommendations, the avoided investment costs of transmissions and distribution, and the reductions in electricity and steam production costs resulting from lower electricity demand. Figure ES-6 compares the production cost across the BAU and energy efficiency policy scenarios.

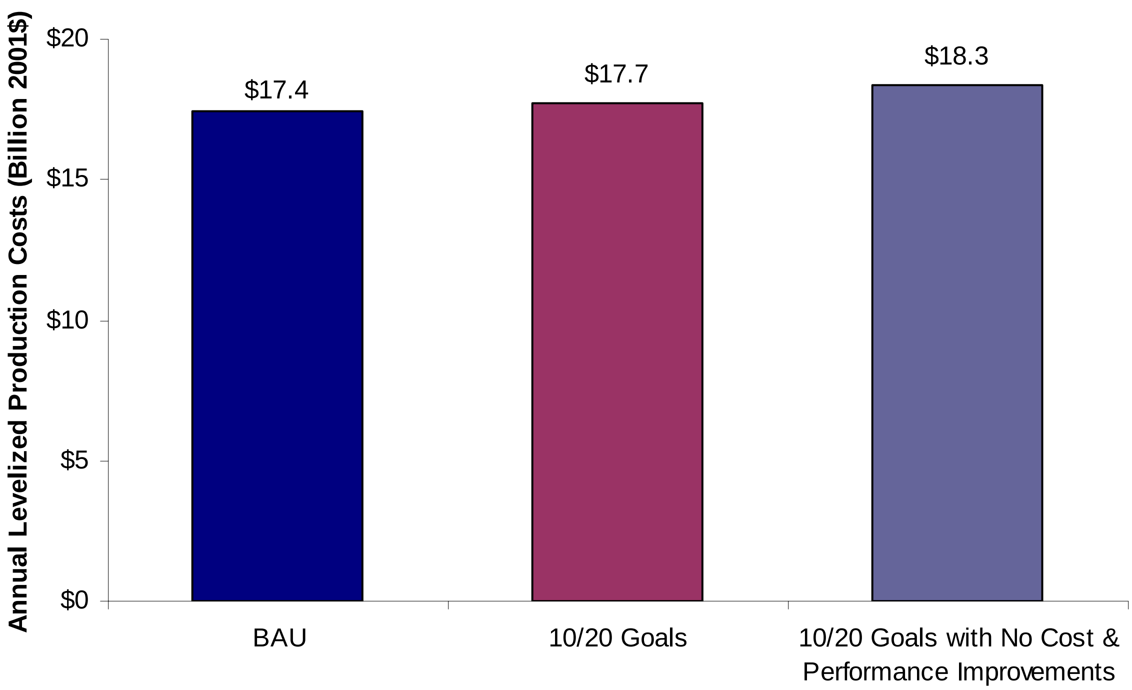
Figure ES-6: Annual Levelized Production Cost Under the BAU and Energy Efficiency Policy Scenarios



[4] MTF 2000.
[5] Annual levelized production costs reflect the capital, fuel and operation and maintenance expenditures associated with the production of electricity and industrial steam levelized over the years 2005 – 2022. These modeled production costs do not include the sunk costs (capital cost or carrying charges) of existing units.

Implementation of the10/20 goals by themselves will lead to modest increases in annual levelized production costs. The impact on production costs could range between $300 million and $900 million (or 2 percent to 5 percent relative to the BAU scenario). The range reflects the impacts under alternative assumptions about renewable technology cost and performance: the former includes the assumption that renewable technology cost and performance will improve over time, while the latter cost impacts do not allow for those improvements. The increase in production costs under the 10/20 goals is largely driven by the capital investments in new renewable energy generation capacity and is offset by the production cost savings from the displaced fossil fuel generation. Figure ES-7 compares the annual levelized production costs across the BAU and 10/20 goals policy scenarios.

Figure ES-7: Annual Levelized Production Costs Under the BAU and 10/20 Goals Policy Scenarios



Secondary Regional Economic Impacts

The objective of the secondary regional economic analysis was to assess the impacts of the 10/20 goals and energy efficiency recommendations on the regional economy of the Transport Region. For this analysis, the results from the IPM modeling served as inputs to the REMI model. This assessment of regional economic impacts is focused around changes in employment, gross regional product and personal disposable income.

Implementation of the 10/20 goals and energy efficiency recommendations has little or no impact on the regional economy. Most of the regional impacts are less than one half of one percent. Table ES-1 summarizes the annual average secondary region economic impacts under the policy scenarios for the years 2005 - 2020.

Table ES-1: Annual Average (2005 – 2020) Changes In Key Economic Indicators for the Transport Region Under the Policy Scenarios

	Employment		Gross Regional Product		Personal Disposable Income	
	(Persons)	(% Change)	(Million 2001$)	(% Change)	(Million 2001$)	(% Change)
10/20 Goals	627	0.00%	-312	-0.01%	73	0.00%
Energy Efficiency (EE)	8,415	0.02%	450	0.02%	776	0.04%
10/20 Goals + EE	4,097	0.01%	-58	0.00%	547	0.03%

The results of the regional economic analysis indicate that the 10/20 goals and energy efficiency may, on average, lead to an increase in economic activity. Over time, the policies lead to small increases in economic activity in the early years a small decline in later years. The impacts in the 2005 to 2015 time period are largely the result of investment in new renewable energy facilities that increase labor demand and have secondary impacts on output and income. Following the investment and construction boom, the region will see some decline in employment, gross regional product and personal disposable income.

On average, the 10/20 goals will lead to small increases in employment and personal income along with a small decline in gross regional product. Implementation of the energy efficiency recommendations results in small increases in employment, personal disposable income and gross regional product. The economic impacts under the 10/20 goals and energy efficiency are largely the result of increased capital investments in new renewable energy generating capacity. The boom in construction sparked by the investments appears to be the key reason for growth.

Caveats and Uncertainties

This analysis was conducted to help the AP2 forum understand the potential emissions reductions, costs and secondary regional economic impacts of the implementing the 10/20 goals and the energy efficiency recommendations. The assumptions developed by the AP2 for this study are based on a variety of different sources including research of existing literature, data developed by the Energy Information Administration, and the National Renewable Energy Laboratory. Key drivers affecting the results on projections of renewable energy capacity, emissions savings and costs include the assumptions on renewable energy technology cost and performance.

Though the modeling and analytical results provide detailed estimates of potential impacts, it is important to recognize that the magnitude of the results are quite small, particularly in estimates of the regional economic impacts. As with any analytical results, small perturbations are difficult to interpret precisely. In instances where the changes appear to be very small, analysis of broader trends, rather than specific numbers, will often provide a more robust and meaningful description of the impacts.

Conclusions

The analysis indicates that the 10/20 goals and energy efficiency recommendations could both serve as cost-effective air pollution prevention strategies. The 10/20 goals will lead to increases renewable energy capacity, while the energy efficiency recommendations will result in lower energy demand through conservation. Because both the 10/20 goals and energy efficiency displace new additions of fossil fuel capacity and generation, they are likely to provide a hedge against future emissions growth in

NO_x and CO_2. The 10/20 goals can be achieved under modest cost impacts, while energy efficiency will result some cost savings and both the objectives have little or no regional economic impacts.

I. Introduction

This analysis was commissioned by the Air Pollution Prevention (AP2) forum of the Western Regional Air Partnership (WRAP) to help WRAP participants, western states and Indian tribes understand the potential emissions reductions, costs and secondary economic impacts from meeting the 10/20 renewable energy goals and implementing the energy efficiency recommendations. This study builds upon the framework, data and assumptions previously developed by the Market Trading Forum[1] (MTF) of WRAP and examines the impacts on electricity, industrial and process sources located within the nine states and tribal lands of Transport Region.

This report includes seven sections discussing the analytical framework, data, assumptions and results. Specifically:

- Section II provides background to the study, describes the key objectives of the analysis and summarizes the main findings.
- Section III details the scenarios, data, assumptions and analytical framework. Details on renewable energy technology costs and performance assumptions developed by the AP2 forum are also described. The section also provides an overview of the modeling tools used -- ICF's Integrated Planning Model® (IPM) and REMI's Policy Insights® model-- and a discussion of the approach used to integrate the two models.
- Section IV discusses the emissions and production costs impacts of implementing the 10/20 goals and energy efficiency recommendations based on the IPM modeling results.
- Section V discusses the secondary regional economic impacts based on the results of the REMI model. The analysis focuses on impacts on employment, gross regional product and disposable income.
- Section VI contains a discussion of the caveats and uncertainties underlying the results.
- Section VII describes the conclusions of the study.

[1] "Economic Impacts of Implementing a Regional SO2 Emissions Program in the Grand Canyon Visibility Transport Region," Western Regional Air Partnership/ Market Trading Forum, September 2000. (MTF 2000).

II. Overview

II.1 Background

With a view towards improving visibility and air quality in the national parks and wilderness areas of the Colorado plateau, the Grand Canyon Visibility Transport Commission (GCVTC) issued several recommendations in 1996 on strategies for air pollution prevention in the West. In its recommendations, the GCVTC emphasized the need to integrate air pollution prevention with cost-effective pollution control strategies in order to prevent degradation of natural resources in the West.[2]

Two key GCVTC recommendations focused on the development of renewable energy sources and the promotion of energy conservation. The recommendation on development of renewable energy sources encouraged states and tribes in the Transport Region to undertake steps that would increase the use of renewable energy to 10 percent of the regional power needs by 2005 and 20 percent of the regional power needs by 2015 (hereinafter the "10/20 goals"). For energy conservation, the commission supported the continued development of energy efficiency standards and suggested that the emphasis on energy conservation be maintained within the changing electric power markets. In addition to the renewable resource and energy conservation recommendations, the GCVTC suggested that future analysis examine the potential emission reductions, cost savings and secondary benefits associated with the use of renewable energy and energy efficiency.

The Regional Haze Rule issued by U.S. Environmental Protection Agency in April 1999 included the air pollution prevention recommendations of the GCTVC. Under the rule, the states of the Transport Region must include in their State Implementation Plans (SIP) an outline of the programs and policies that each state will rely on to work towards meeting the air pollution prevention recommendations. Tribal governments may seek approval from EPA to incorporate the requirements of the regional haze regulations, including the GCVTC recommendations, in their Tribal Implementation Plans (TIP) under the provisions of the Tribal Authority Rule (TAR)[3].

The AP2 forum of WRAP has been charged with implementing the air pollution prevention recommendations of the GCVTC and commissioned ICF Consulting to examine the potential emissions reductions, costs and secondary economic impacts of meeting the 10/20 goals and energy efficiency recommendations.

II.2 Objective

This study serves as the documentation of the analytic and technical support to the AP2 forum's report detailing its recommendations regarding renewable energy and energy efficiency to the WRAP Board. While the AP2 forum's report provides a discussion of the policy imperatives and broader implications of the GCVTC air pollution prevention

[2] "Recommendations for Improving Western Vistas," The Grand Canyon Visibility Transport Commission, June 1996, page 28.
[3] 63 Fed. Reg. 7254-7274, codified at 40 CFR Part 49.

recommendations, this report describes the potential emissions reductions, costs and secondary economic impacts of meeting the 10/20 goals and implementing the energy efficiency recommendations, given the assumptions and scenarios developed by the AP2 forum. The analysis examined the impacts for the nine states and tribal lands of the Transport region and was focused around stationary sources engaged in the production of electricity and industrial steam along with process sources (e.g., copper smelters and refineries).

II.3 Summary of Key Findings

The analysis indicates that the 10/20 goals and energy efficiency could both serve as cost-effective air pollution prevention strategies.

- The objective of the 10/20 goals is to have renewable energy providing 10 percent of the regional energy demand by 2005 and 20 percent by 2015. The AP2 forum's recommendations for energy efficiency seeks to reduce electricity demand in the Transport region by 8 percent by 2018 from the Business-As-Usual (BAU) conditions through energy conservation in the residential, commercial, industrial and manufacturing sectors.

- Wind power is expected to provide the largest source of renewable energy generation in meeting the 10/20 goals, accounting for much as 80 percent of the growth in renewable energy capacity. By 2018, the expansion in wind capacity under the 10/20 goals is expected to reach 18 GW. The 10/20 goals will also lead to some expansion of renewable energy generation from geothermal and landfill gas.

- Penetration of energy efficiency and renewable energy will primarily compete against new conventional capacity additions. In the absence of energy efficiency and the 10/20 goals, most of the expansion in conventional capacity will likely consist of gas-fired combined cycles. New additions to renewable energy capacity and demand reductions motivated by the 10/20 goals and the energy efficiency recommendations are projected to displace new gas-fired combined cycle capacity while leaving the existing stock relatively unaffected.

- Under the scenarios analyzed, energy efficiency and 10/20 goals provide 1 to 2 percent reductions in NO_x emissions and 10 to 14 percent reductions in CO_2 emissions. The reduction potential appears to be modest partly because the displaced generation consists almost entirely of relatively clean gas-fired combined cycle. Since the 10/20 goals and energy efficiency primarily displace generation from new fossil fired capacity additions, the 10/20 goals and energy efficiency can provide a hedge against future emissions growth.

- The 10/20 goals and energy efficiency do not provide any SO_2 reductions in the presence of a regional SO_2 emissions cap and trading program proposed in the Annex. However, the 10/20 goals and energy efficiency may lower the compliance cost of the trading program by as much as $ 10 million in 2018 (or 7 percent) and displace the need for 1,200 MW to 1,700 MW of new scrubber capacity.

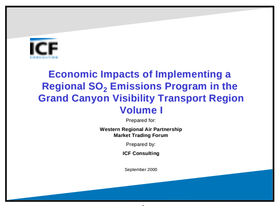
- The increase in annual levelized production costs under the 10/20 goals will range between $ 300 million and $ 900 million (or 2 percent to 5 percent relative to the business-as-usual scenario). Under an energy efficiency scenario, the savings in annual levelized production cost may range between $ 700 million to $ 1 billion (or 5 percent to 7 percent relative to the business-as-usual scenario).

- Implementation of the 10/20 goals and energy efficiency recommendations will have small or no impacts on the regional economy. Under the 10/20 goals scenario, employment and personal income is projected to increase on average by less than one half of one percent per year. Gross regional product is likely to decline by approximately the same percentage impact. Similarly, implementation of the energy efficiency recommendations is projected to lead to small increases in employment, gross regional product and personal income of less than one half of one percent each.

III. Analytical Approach

This section describes the analytical approach, data, assumptions, methodology and modeling tools used in the analysis. There were three distinct phases to the analysis: (1) assumptions and scenario development, (2) modeling of the electric and steam sectors, and (3) modeling of the secondary regional economic impacts. Figure I presented below illustrates the three phases of the analysis and the overall analytical approach. Details on each of the phases of the analysis are described below.

Figure I: Overview of Analytical Approach



WRAP/MTF Economic Analysis

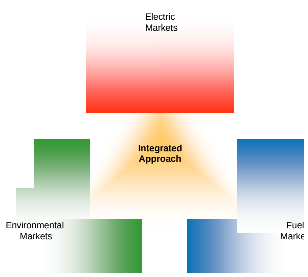
- Served as starting point for analysis
- AP2 selected Annex Scenario as Business-As-Usual scenario

Phase I:
Assumptions and Scenario Development

AP2 Forum

- Reviewed and revised assumptions for renewable energy technology
- Developed energy efficiency cost and performance assumptions
- Developed scenarios for analysis of 10/20 goals and energy efficiency (EE)

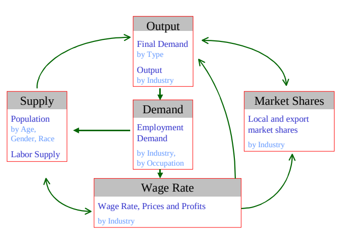
Phase II:
Modeling of Electric and Steam Sector



IPM® Modeling

- Modeled 10/20 and EE Scenarios developed under Phase I
  - ➢ Electric/Steam Sector System Impacts
  - ➢ Emission Impacts
  - ➢ Production Cost Impacts

Phase III:
Modeling of Secondary Economic Impact



REMI™ Modeling

- Secondary regional economic impacts
  - ➢ Employment Impacts
  - ➢ Gross Regional Product Impacts
  - ➢ Income Impacts

III.1 Scenarios Analyzed

The AP2 forum developed two types of scenarios in order to examine the emissions, costs and secondary regional economic impacts of meeting the 10/20 goals and implementing the energy efficiency recommendations. The first was the Business-As-Usual (BAU) scenario that characterized how the future might unfold without any policy measures designed to accomplish the 10/20 goals and energy efficiency recommendations. The second set of scenarios reflected a future with policy drivers designed to meet the 10/20 goals or energy efficiency recommendations, or both. Assessments of emissions, costs and secondary regional economic impacts were estimated by analyzing the changes in the policy scenarios relative to the BAU scenario.

This analysis examined the 10/20 goals and energy efficiency recommendations in the context of the regional backstop SO_2 trading program proposed in the Annex. In September 2000 the WRAP/MTF conducted extensive analysis of the economic impacts of the Annex proposal.[4] The AP2 forum selected the WRAP/MTF scenario with the Annex as the basis for the BAU scenario. However, the existing stock of renewable energy plants under the WRAP/MTF Annex scenario was modified to account for firm projected renewable energy plants.

The policy scenarios developed by the AP2 forum were focused around the policy objectives of the 10/20 goals and energy efficiency recommendations. Policy scenarios also included cases designed to test the sensitivity of the impacts to changes in technology improvements and higher gas prices. The results of the sensitivity scenarios are mentioned briefly in the report since they do not appear to add substantively to the insights gained from the core policy scenarios.

In designing the policy scenarios and in developing the data for those scenarios, the AP2 forum modified some of the assumptions on the cost and performance of renewable energy technologies from those used in the BAU scenario. There were two reasons for this. First, the AP2 forum felt that the BAU scenario, which was adopted from the WRAP/MTF Annex scenario, did not contain enough details on renewable energy technologies since that had not been the focus of the WRAP/MTF.

Second, and more importantly, the AP2 recognized that the 10/20 goals would not only affect the level of renewable energy generation in the west, but also had the potential to influence the underlying market conditions for those technologies. Under a climate where policies are in place designed to achieve the 10/20 renewable energy goals and energy efficiency recommendations, the AP2 forum believes that the wind resource development costs could improve over time because of the cost benefits of "learning by doing", from better alignment of incentives for improving technologies' cost and performance and from reduced barriers to entry. The adjustments in the assumptions for the policy scenarios were focused only around wind technologies since wind was likely to be the largest sources of renewable energy and it was also where the forum anticipated most improvements in cost and performance would occur.

Recognizing the inherent uncertainty in assumption on technological improvements over time, the AP2 forum developed a sensitivity scenario that did not include the assumed

[4] MTF 2000.

improvements in renewable technology cost and performance. The objective of this sensitivity scenario was to capture the higher end of the potential cost impacts of the 10/20 goals. Table 1 presented below provides a summary of the scenarios developed by the AP2 forum.

Table 1: Scenarios

Scenario		Assumptions Used
Business-As- Usual Scenario		• Used WRAP/MTF Annex scenario • Includes firm new renewable projects in existing generation stock
Policy Scenarios	10/20 Goals	• Updated renewable technology cost and performance assumptions • Includes 10/20 goals as requirements that electric system has to meet • Retained all other assumptions from WRAP/MTF Annex scenario
	10/20 Goals and Energy Efficiency	• Updated renewable technology cost and performance assumptions • Includes energy efficiency recommendations • Includes 10/20 goals as requirements that electric system has to meet • Retained all other assumptions from WRAP/MTF Annex scenario
	Energy Efficiency Only	• Updated renewable technology cost and performance assumptions • Includes energy efficiency recommendations • Retained all other assumptions from WRAP/MTF Annex scenario
	Sensitivity Scenarios	• Impact of 10/20 goals assuming no improvements in renewable technology cost and performance over time • Impact of higher gas prices on 10/20 goals

All the scenarios summarized in Table 1 above were modeled under Phase II of the analysis that examined the electric and steam sectors. In Phase III where the regional economic impacts were modeled, only selected policy scenarios were analyzed. These included the 10/20 goals policy scenario, the 10/20 goals and energy efficiency policy scenario and the energy efficiency policy scenarios.

III.2 Analytical Tool

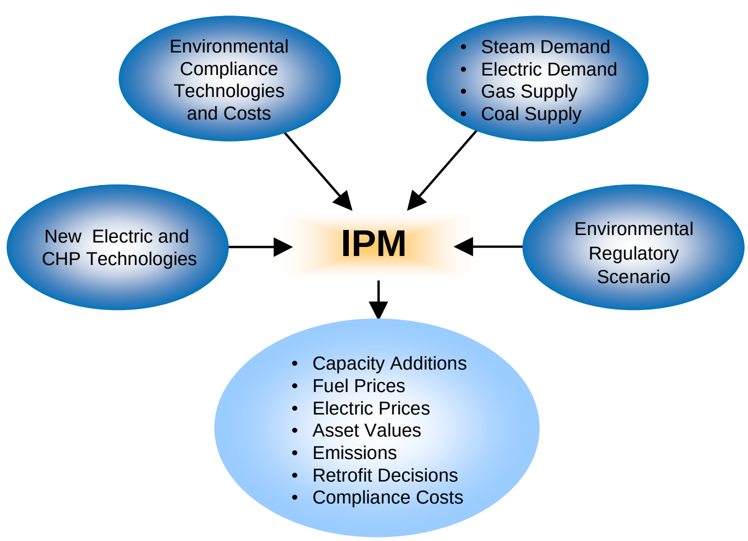
Integrated Planning Model (IPM®)

ICF's Integrated Planning Model (IPM) was used as the analytical tool for modeling the costs and emissions impacts of the policy scenarios under Phase II of the analysis. IPM is a well-established electric and industrial boiler sectors model. For the WRAP/MTF analysis of the SO_2 program, it was enhanced to capture emissions from process sources. The model has been used in a wide range of analyses by government and industry. Within WRAP, the model was used by WRAP/MTF for the economic analyses and for the analysis of market issues related to the SO_2 emissions trading program. The model is also currently being used by the National Tribal Environmental Council (NTEC) to analyze issues related to the tribal set-asides under the regional backstop SO_2 trading program.

IPM is a detailed engineering-economic capacity expansion and production-costing model of the power and industrial sectors supported by an extensive database of every boiler and generator in the nation. It is a multi-region model that provides least-cost capacity expansion plans, credible plant dispatch, and electric prices forecasts. IPM explicitly considers gas, oil, and coal markets, power plant costs and performance characteristics, environmental constraints and emissions markets, and other power market fundamentals.

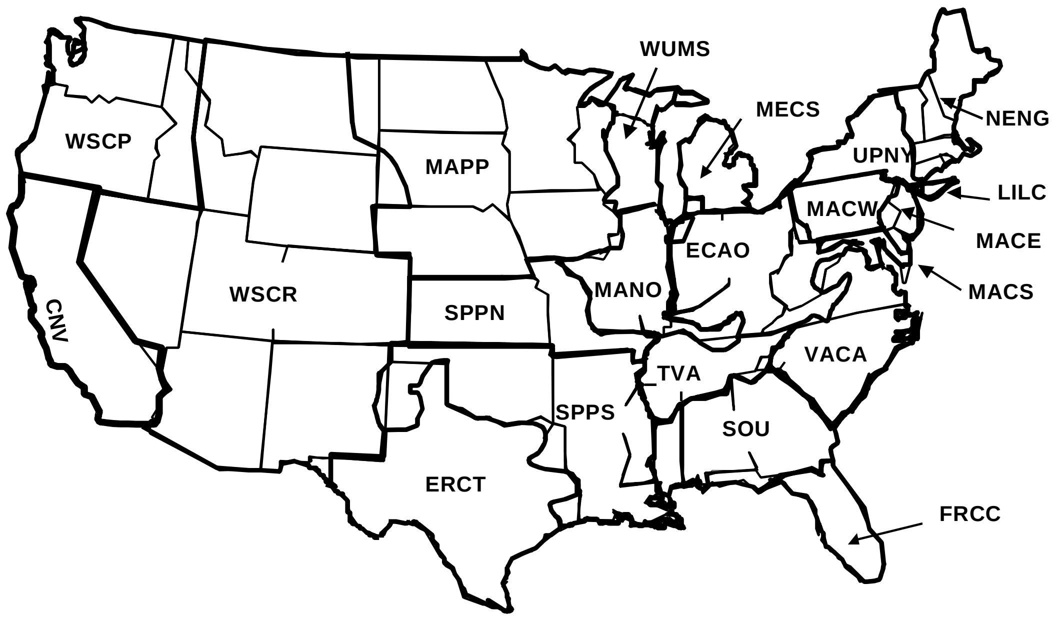
As illustrated in Figure 2 below, IPM provides an integrated analysis of electricity and steam markets. The model captures the interactions of real world constraints and simulates electric and steam markets based on economic fundamentals using a linear programming structure. Figure 2 illustrates the key components of IPM.

Figure 2: The Integrated Planning Model



IPM models the contiguous U.S. using distinct power markets represented as "model regions." These regions correspond in most cases to the regions and sub-regions of the North American Electric Reliability Council (NERC). For this analysis, the nine western states and tribes of the GCVTC region are contained within the model regions of California and Southwest Nevada (CNV), Pacific Northwest (WSCP) and interior West (WSCR). The models regions used in this study are illustrated in Figure 3 below.

Figure 3: Regional Structure of IPM for AP2 Forum Analysis



The modeling for this analysis covered the electricity, industrial steam and other industrial process sources of SO_2 emissions (e.g., copper smelters and refineries). The electricity sector includes all existing boilers and generators. IPM forecasts new capacity builds to meet the growth in electricity demand. The industrial steam sector includes sources that sell steam to industrial, commercial and institutional facilities. Expansion in steam demand is met through new boilers and/or combined heat and power (CHP) cogeneration facilities. Process sources of SO_2 such as refineries and smelters are also included in the modeling to capture their potential interactions in the regional SO_2 allowance markets. The analysis does not model production activity of these industrial process sources.

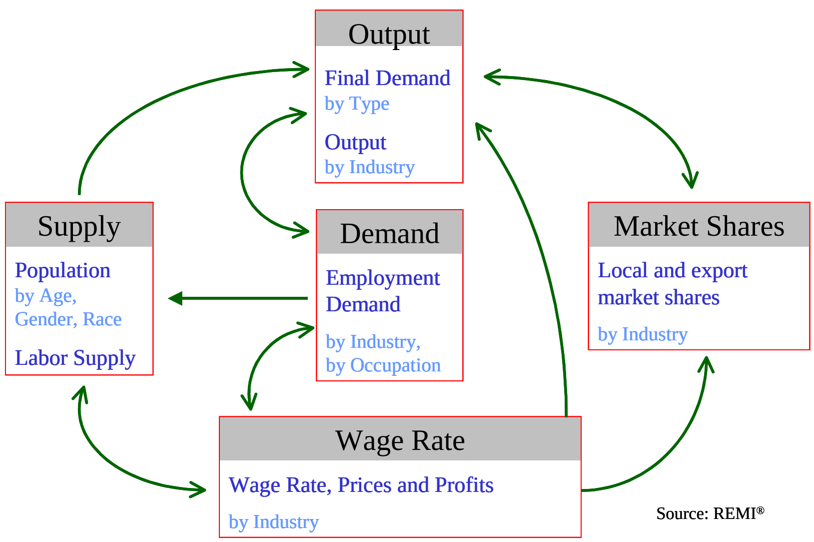
In IPM the 10/20 goals are modeled as electricity generation constraint on the power system that requires that the system must produce at a minimum the renewable generate targets specified by the 10/20 goals. The IPM model determines the optimal mix of renewable energy taking into account the target levels and their timing and geographic scope. In determining the optimal plan, the model also takes into account all existing and future air regulations included in the scenario, fuel prices and availability, and emission markets. The energy efficiency recommendations are modeled as reductions in energy requirements and peak demand levels. Reductions in demand are specified exogenously; the model responds to the new demand and determines the least cost method for satisfying that demand.

Regional Economic Assessment: REMI's Policy Insights® Model (REMI)

The Policy Insights® model produced by Regional Economic Models Inc. (hereinafter "REMI") was used to estimate the secondary regional economic impacts of the implementing the 10/20 goals and the energy efficiency recommendations. REMI is a widely accepted tool for analyzing regional economic impacts and was previously used by WRAP/MTF for economic analysis of alternative emissions milestones (or caps) on the regional SO_2 trading program.

The REMI model is composed of five basic blocks – output, supply, demand, market shares and wage rate - that broadly characterize the regional economy. These blocks are inter-linked and the model uses a single set of simultaneous equations to estimate how a change from a policy might filter through the economy. Figure 4 illustrates the analytical framework of the REMI model.

Figure 4: Analytical Framework in the REMI Model



The REMI model used in this analysis consists of 10 regions, which include Arizona, Colorado, California, New Mexico, Nevada, Utah, Wyoming, Oregon, Idaho and the rest of the country. Because of the analytical difficulty in modeling tribal areas as a separate model region, tribal areas have been integrated in with the state in which they are located.

The AP2 Forum selected three scenarios for analysis of the regional economic impacts. These include:

1. 10/20 Goals;
2. Energy Efficiency Recommendations; and
3. 10/20 Goals and Energy Efficiency Recommendations.

For all the three scenarios, the inputs to REMI are derived from the IPM modeling results. Most of the inputs to REMI require changes relative to a reference point and the Business-As-Usual (BAU) scenario was used as the reference case in developing the inputs to REMI. All REMI inputs are specified by year, state and sector.

There are three IPM outputs that form the basis for the inputs to REMI. These include

1. Incremental Production Cost Impacts;
2. Changes in Wholesale Electricity Price; and
3. Revenue Changes from Allowance Allocations.

The approach and methodology used in adapting the IPM outputs for use in REMI are discussed in detail below.

Incremental Production Cost Impacts

Incremental production costs in IPM are composed of the capital, fixed operating, variable operating and fuel costs associated with the 10/20 goals and energy efficiency recommendations. Under the 10/20 goals, for instance, the incremental annual levelized production cost was $ 300 million annually and reflects the total change in production costs in meeting the 10/20 targets.

Impacts on production costs of sectors aside from power generators as a result of the policies are captured through REMI variables that reflect the factors of production in these sectors. Within REMI, these changes in production costs affect both market shares and final demand for each sector's products through changes in the relative price of the products. Industries within these sectors that compete in regional markets (and thus are price setters for their product) are able to pass through cost via regional price increases, while sectors that compete nationally (and thus are "price takers") experience a change in competitiveness relative to other regions and rest of the U.S.

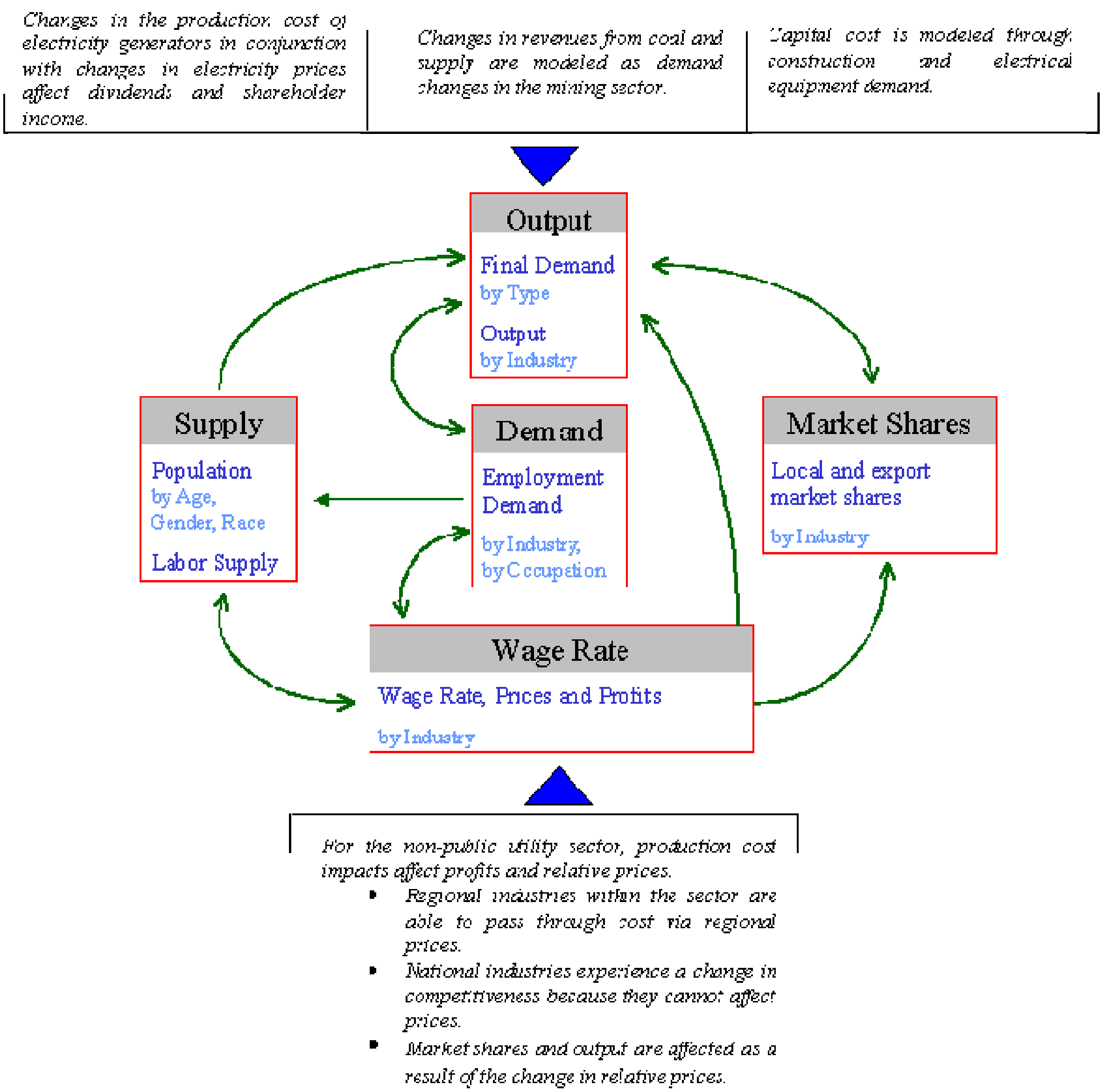
For electric generators, the production cost impacts are not modeled directly in REMI because the electricity price impact is already known through IPM modeling. Instead, the production cost impacts are combined with the electricity price change and the net revenue impacts are input into REMI as changes in dividends or shareholder income. Changes in dividends and shareholder income directly affect changes in personal income, which in turn affects output and employment demand. For purposes of REMI modeling, avoided transmission and distribution avoided costs under the EE recommendations are treated as changes in production cost.

The capital investments for new electric generation capacity projected in IPM were modeled as construction and electric equipment demand in REMI. An increase in construction demand has a pronounced effect on the regional economy because it leads to an increase in employment, which in turn affects output, income, wages, population and labor supply. The increase in electrical equipment demand also affects output but the regional impacts are less pronounced than construction demand impacts because some of the expenditures flow out of the region for capital purchases made elsewhere. The regional purchase coefficients in REMI determines how much of the expenditures are spent locally versus outside of the region.

Changes in fuel expenditures, which are a component of total production costs, have been modeled in REMI as mining demand impacts. The change in mining demand affects employment and also flows through to changes in income and output.

Figure 5 below illustrates how production cost impacts from IPM have been modeled in REMI and also describes how those impacts relate to changes in the regional economy.

Figure 5: Production Cost Impacts in REMI



Changes in Wholesale Electricity Prices

Wholesale electricity prices are outputs of IPM and have been used in REMI to describe how retail rates might change as a result of the policies. Wholesale electricity price impacts have been converted to retail rates based on the assumption that distribution and retailing cost do not change under the policies and that the changes in wholesale electricity price changes are fully realized by end use customers.

Under the 10/20 goals, the wholesale electricity price impacts modeled in REMI also include the premium necessary for implementing the renewable energy targets. In this analysis, the premium is based on a System Benefits Charge (SBC) type approach where every end user pays the levelized renewable energy credit price. Under the scenarios involving the EE recommendations, the EE implementations cost were also included in the electricity price impacts. EE implementation costs were provided by state and sector and were converted to a kWh basis using the share of electricity demand for that state and sector. In effect, the EE implementation costs are recovered through changes in electricity prices. In sum, the electricity price changes modeled in REMI include the following components:

1. Wholesale electricity prices;
2. Premium for 10/20 goals; and
3. EE implementation costs.

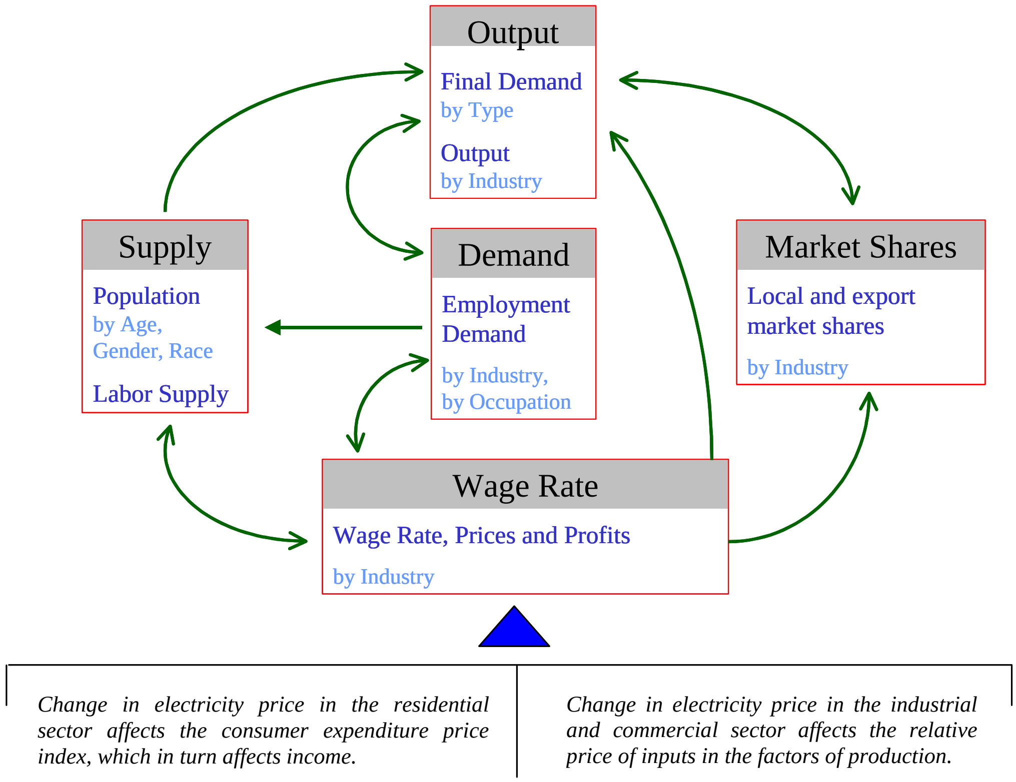
The changes in electricity prices are modeled separately for the residential, commercial and industrial sectors.

For the industrial and commercial sectors the changes in electricity prices affect their raw material cost. The change in the price of electricity affects the relative price of their factors of production and affects the type of resources (labor, capital) that the sectors might employ in production. With lower electricity prices, these sectors might substitute capital for labor thereby leading to an increase in investments, which in turn affects demand and output.

For the residential sector, the change in electricity price is modeled through the consumer price index. In this case, a reduction in electricity price implies an increase in income because consumers have more to spend on other goods and services, which in turn increases consumption, demand and output.

Figure 6 below illustrates how the electricity price impacts have been modeled in REMI and its linkages in the regional economy.

Figure 6: Electricity Price Impacts in REMI

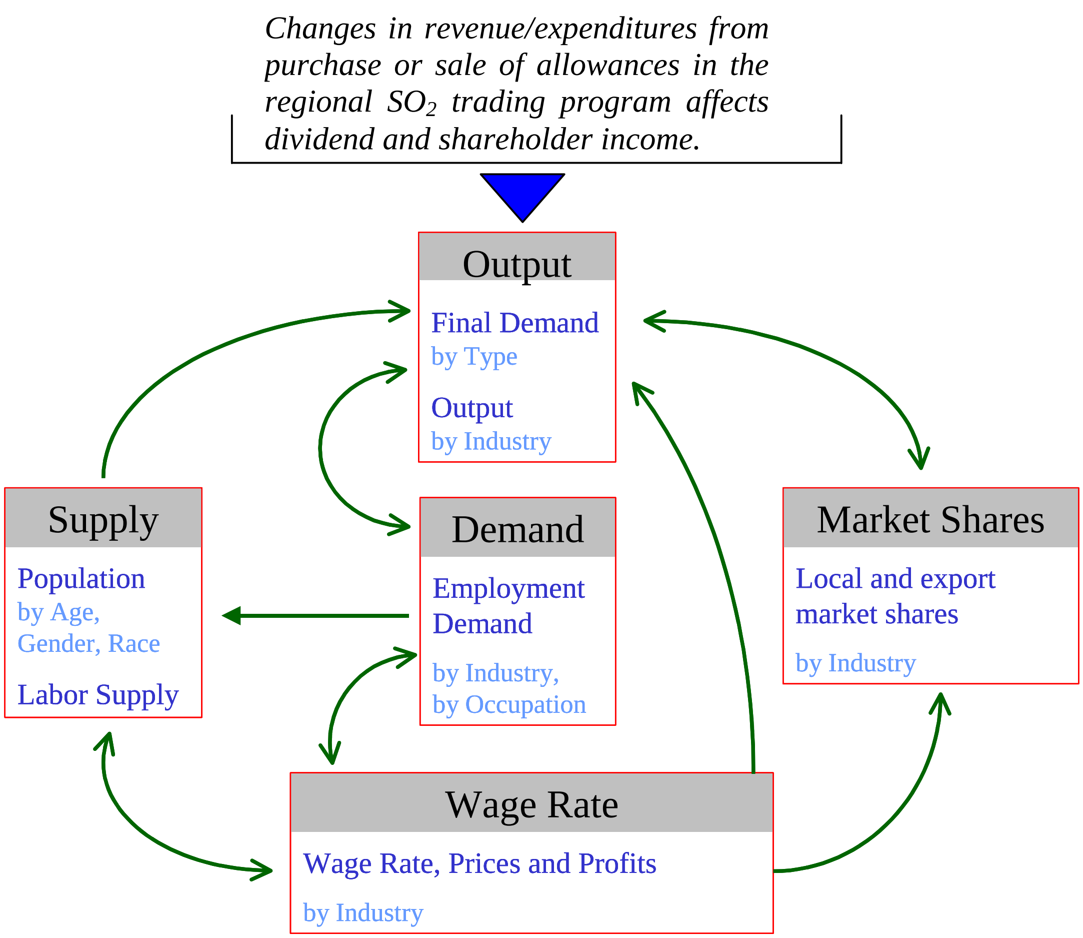


Revenue Changes from Allowance Allocation

The revenue changes from allowance allocation account for changes in the allowance position under the SO_2 trading program of the Annex. Although the cap in the trading program does not change under the 10/20 goals and the energy efficiency recommendations, the compliance strategy changes, which in turn affects the number of allowances that sources in a state will have to buy or sell.

The expenditures/revenues from the sale/purchase of allowances is based on the allowance price of the regional SO_2 trading program and the net allowance position of the state. A state that has allowances to sell will realize an increase in revenues, while a state that needs to purchase allowances will see an increase in expenditures. Because these revenues/expenditures accrue to the sources affected by the trading program, the changes in expenditures/revenues from allowance allocations have been modeled in REMI as dividend and shareholder income. The impact of the allowance allocation does not change the overall cost to the region (because expenditures and revenues cancel out) but merely redistributes the impacts across the region. Some of the dividend and shareholder incomes are assumed to flow out of the region based on the income distribution. Figure 7 illustrates how revenue changes from allowance allocations have been modeled in REMI and the related impacts on the regional economy.

Figure 7: Revenue Impacts from Allowance Allocations



III.3 Data and Assumptions

As noted before, for this analysis the AP2 forum used much of the data and assumptions developed by the WRAP/MTF. These assumptions are fully documents in the economic analysis report produced by the WRAP/MTF in September 2000[5] and have not been replicated in this report. The section describes only the data and assumptions that changed relative to the WRAP/MTF economic analysis. In addition, as noted before, the AP2 forum updated the renewable energy technology cost and performance assumptions for the policy scenarios. Because the BAU scenario did not include any projected additions to renewable energy capacity (outside of firm new capacity), for renewable energy technologies, this section describes only the assumptions used in the policy scenarios.

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[5] MTF 2000.

Environmental Regulations

Regional and national existing environmental regulations affecting stationary sources that produce electricity and/or industrial steam are represented identically in both the BAU and policy scenarios. The regulations modeled include:

- 1990 Clean Air Act Amendments Title IV NO_x and SO_2,
- Title IV SO_2 national trading program,
- Northeast NO_x SIPCALL, and
- Regional backstop SO_2 trading program proposed under the Annex for the states and tribes of the Transport Region with the assumption that all states/tribes will participate in the trading program. The specific milestones used in modeling the Annex are summarized in Table 2 below.

Table 2: Milestones Used for the Regional Backstop SO_2 Trading Program Proposed In the Annex

	2013	2018
Thousands Tons of SO_2	630	507

Natural Gas Prices

The AP2 forum retained the natural gas price assumptions developed by the WRAP/MTF for this analysis. In addition, the AP2 forum developed the high natural gas prices for the sensitivity scenario based on the approach used in the WGA Transmission Report.[6] Table 3 below provides a summary of the natural gas prices assumed in the study. The BAU and policy scenarios both include the base price while the high prices were used only in the high gas price sensitivity policy scenario.

Table 3: Assumptions on Delivered Natural Gas Price

National Average Delivered Natural Gas Price (2001 $/mmbtu)		
Year	**Base**	**High Gas Price**
2005	$3.16	$4.44
2010	$3.31	$4.99
2020	$3.49	$5.93

Cost and Performance for Grid Connected Utility Scale Solar Technologies

The AP2 forum assumed that two types of grid-connected utility scale solar technologies -- solar photovoltaic and solar thermal -- would be available under the policy scenarios. Recognizing that some cost improvements in these technologies would occur over time, the forum allowed for some cost decline in both technologies after 2010. Table 4 presented below provides the cost and performance assumptions for solar photovoltaic and solar thermal.

[6] "Conceptual Plans for Electricity Transmission in the West," Report to the Western Governors' Association, August 2001. High gas prices were based on gas prices in Annual Energy Outlook 2001 plus 50%.

Table 4: Cost and Performance Assumptions for Solar Technologies[7]

Available Years	Technology	Annual Average Capacity Factor	Overnight Capital Cost (2001$/kW)	Fixed O&M Cost (2001$/kW-Yr)
2000-2009	Solar PV Solar Thermal	28% 42%	4,576 3,170	11 50
2010-2030	Solar PV Solar Thermal	28% 42%	2,737 2,853	11 50

The analysis reflects the fact that solar plants are not dispatchable by basing the generation estimates on generation profiles that describe the hourly generation for a typical day in the winter and summer. Furthermore, in order to account for the intermittency in generation from solar technologies, solar photovoltaic and solar thermal plants do not receive capacity credit on their entire nameplate capacity. Instead, the capacity credit is limited to their capacity factor in the peak 30 percent of hours.

Cost and Performance for Biomass Technologies

The AP2 forum assumed that both direct combustion and biomass gasification combined cycles (BGCC) would be available for commercial application to electricity generation. However, recognizing that BGCC is not yet a mature technology, the forum assumed that BGCC would be available only after 2010. Table 5 presented below summarizes the cost and performance assumptions for biomass technologies.

Table 5: Cost and Performance Assumptions for Biomass Technologies[8]

Available Year	Technology	Heat Rate (Btu/kWh)	Overnight Capital Cost (2001$/kW)	Fixed O&M (2001$/kW-Yr)	Variable O&M (2001mills/kWh)
2000	Direct Combustion	8,219	1,420	48	5.75
2010	Biomass Gasification Combined Cycle	13,000	1,489	66	7.74

Biomass fuel supply is reflected in a composite supply curve containing energy crops, agricultural residue, forestry residue, and urban wood waste and mill residue available for electricity generation. For each model region and year, the supply curve denotes the price-quantity relationship of biomass.[9]

[7] Annual Energy Outlook (AEO) 2001.
[8] Data for Direct Combustion Biomass from Technology Characterization report by DOE-NREL 1997. Data for Biomass Gasification Combined Cycle from Annual Energy Outlook 2001.
[9] Biomass supply curve based on data from Annual Energy Outlook 2001.

Cost and Performance for Geothermal Technologies

For geothermal generating technologies, the AP2 forum wanted to ensure that the effects of resource depletion were included in the cost and performance. Consequently, rather than a single option, the policy scenarios include a geothermal supply curve that characterize the relationship between available capacity and development-production cost. The supply curve is specified for each of the three model regions that circumscribe the Transport Region and is presented in Table 6 below.

Table 6: Cost and Performance Assumptions for Geothermal Technologies[10]

Region	Potential Capacity (MW)	Overnight Capital Cost (2001$/kW)	Fixed O&M (2001$/kW-Yr)	Capacity Factor (%)
CNV [California and Southern Nevada)	653	2,137	75	90
	6,782	2,312	98	90
	3,806	3,311	122	90
	12,836	5,979	258	90
WSCP [Pacific Northwest]	3,500	2,332	72	90
	2,200	3,563	130	90
	3,075	5,156	195	90
WSCR [Interior West]	920	2,113	70	90
	250	2,735	96	90
	5,713	3,515	122	90
	5,606	6,877	238	90

Cost and Performance for Landfill Gas Technologies

A limited amount of potential landfill gas capacity was expected to be available in the Transport Region in the future and this resource was included by the AP2 in its policy scenarios. The potential capacity reflects landfill gas with a gas collection system already in place; capital costs reflect addition of generating equipment. Table 7 presented below summarizes the cost and performance assumptions for landfill gas generation.

[10] Annual Energy Outlook 2001.

Table 7: Cost and Performance Assumptions for Landfill Gas Generation[11]

Region	Potential Capacity (MW)	Overnight Capital Cost (2001$/kW)	Fixed O&M (2001$/kW-Yr)	Variable O&M (2001 mills/kWh)	Capacity Factor (%)
CNV [California and Southern Nevada]	528	1,291	85	11	87
WSCP [Pacific Northwest]	128	1,291	85	11	87
WSCR [Interior West]	336	1,291	85	11	87

Cost and Performance for Wind Technologies

Because wind generation is the renewable energy resource most likely to penetrate in the future, the AP2 forum spent considerable time characterizing wind resources for the policy scenarios. In developing the assumptions, the forum sought to capture the issues of intermittency, resource availability, reliability and transmission access that are often associated with wind generation.

The AP2 forum assumed that grid-connected central station wind plants could be located in wind classes 6 or greater, 5 and 4[12]; lower wind classes were unlikely to support commercial electricity generation. Within each wind class, the total resource is divided into four cost categories to account for resource degradation and impact on electric system reliability stemming from the intermittency in wind generation.

Cost multipliers are applied to each of the four wind classes to reflect these factors. The four cost categories reflect multipliers of 1, 1.2, 1.4 and 1.6 applied to base cost. The result is a wind resource supply curve that limits how much wind capacity is available at each cost point. The AP2 forum assumed that the highest cost category could not exceed 1.6 since at the very most (or at high levels of wind generation) a combustion turbine could be used to provide backup for the intermittency in wind generation to guard against any system reliability concerns. The available wind capacity resources were distributed among the four cost categories as outlined below with the best wind resource being assigned to the lowest cost scalar first.[13]

- Cost Scalar 1.0: Wind capacity equal to 10 percent of the region's generation or 10 percent of available capacity whichever is lower;

[11] "Energy Project Landfill Gas Utilization Software Manual," Appendix A, US EPA 1997 and "Turning a Liability into An Asset: A Landfill Gas-to-Energy Project Development Handbook," US EPA September 1996.
[12] Wind classes are based on average wind speed in the area. Class 6 or greater have the highest average wind speeds, while class 4 has the least average wind speed.
[13] Data provided by Walter Short, National Renewable Energy Laboratory. A similar methodology was also used in "Scenarios for Clean Energy Future," Union of Concerned Scientists.

- Cost Scalar 1.2: Wind capacity meeting 10 percent – 15 percent of region's generation;
- Cost Scalar 1.4: Wind capacity meeting 15% - 20% of region's generation; and
- Cost Scalar 1.6: Remaining wind capacity.

Table 8 presented below summarizes the potential capacity by wind class and cost category for each model region.

Table 8: Potential Wind Capacity by Model Region, Wind Class and Cost Class

(in MW)		Cost Scalars			
Model Region	**Wind Class**	**1**	**1.2**	**1.4**	**1.6**
CNV	Class 6	1,574	4,543		
(California and South-	Class 5		2,775		
West Nevada)	Class 4		4,699	2,145	
CNV Total		1,574	12,017	2,145	-
WSCP	Class 6	678			
(Pacific Northwest)	Class 5		6,088		
	Class 4		962	3,316	17,935
WSCP Total		678	7,050	3,316	17,935
WSCR	Class 6	6,593	3,297	3,297	55,156
(Interior West)	Class 5				32,384
	Class 4				292,468
WSCR Total		6,593	3,297	3,297	380,008

To characterize the cost and performance of wind technologies, the AP2 forum developed four technology vintages that become available for commercial application at different times in the planning horizon. The four vintages reflect expectations of declining costs and technological improvements. Table 9 provides a summary of the cost and performance assumptions for wind technologies.

Table 9: Cost and Performance Assumptions for Wind Technologies[14]

Available Years	Overnight Capital Costs (2001$/kW)	Fixed O&M (2001$/kW-Yr)	Variable O&M (2001 cents/kWh)	Annual Average Capacity Factor
Wind Class 6				
2000-2004	1000	4.00	0.5	40.4
2005-2009	915	4.00	0.2	45.3
2010-2014	800	4.00	0.18	46.4
2015-onward	770	4.00	0.17	47.9
Wind Class 5				
2000-2004	1000	4.00	0.5	35.3
2005-2009	915	4.00	0.2	40.2
2010-2014	855	4.00	0.18	41.3
2015-onward	825	4.00	0.17	42.75
Wind Class 4				
2000-2004	1000	4.00	0.5	30.2
2005-2009	915	4.00	0.2	35.1
2010-2014	910	4.00	0.18	36.2
2015-onward	880	4.00	0.17	37.6
Notes: Does not include Production Tax Credit.				

For this analysis, the generation output from wind plants is based on generation profiles that describe the hourly generation for a typical day in summer and winter. The annual average capacity factor presented in Table 9 above is therefore a summary characteristic of that generation profile. Furthermore, because wind plants are not dispatchable, the capacity credit for wind is restricted to the average generation in the peak 30% of the hours represented by the profile.

Recognizing that wind technologies may encounter problems with transmission bottlenecks, particularly in the interior West where significant resources are located, the AP2 forum decided to include a transmission cost adder of $208 ($2001/kW)[15] for wind resources located in the interior west. While the cost of interconnection to the grid is reflected in the capital costs reported in Table 9 above, the transmission cost adder for the interior West reflects the fact that these resources may also require some upgrades to the existing transmission system in order to deliver the power to the load centers. Connection to the grid alone does not guarantee delivery because there may not be sufficient capacity on the transmission lines to carry the additional power. The forum felt that this cost was particularly warranted for the interior west because much of the wind resource there is located in Wyoming. The forum felt that developing the resources in the interior west would, at a minimum, require some upgrades to the local transmission system to get the power to the demand centers.

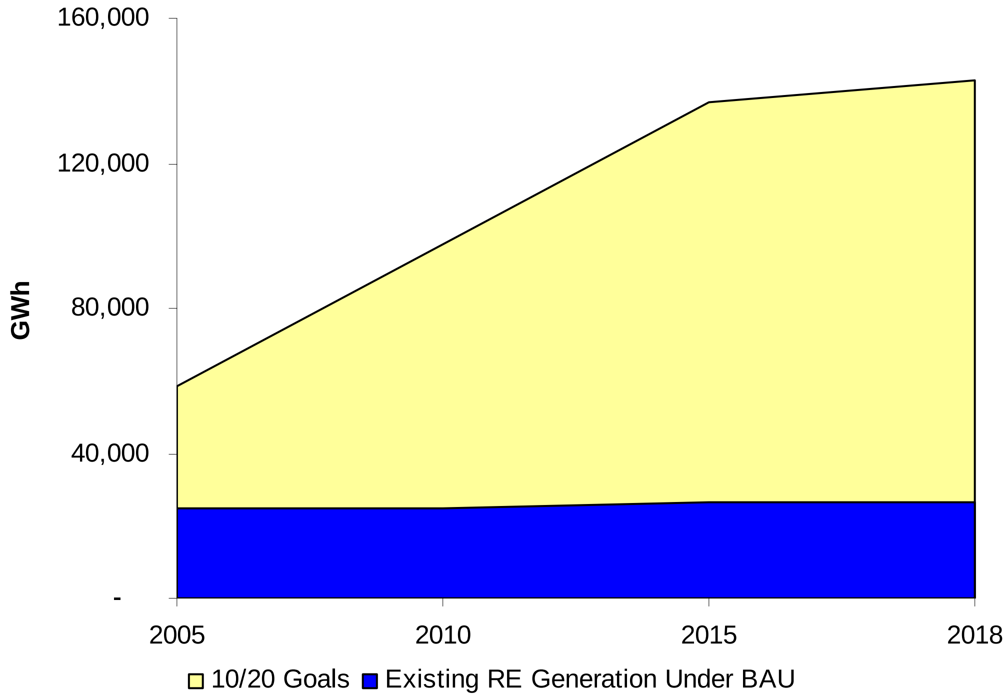
[14] Data provided by Walter Short, National Renewable Energy Laboratory.
[15] Based on "Conceptual Plans for Electricity Transmission in the West," Report to the Western Governors' Association, August 2001. Estimated using the incremental cost between the Gas transmission scenario and the Alternative Fuel Scenarios. Consistent with this report, the transmission cost adder is also applied to new coal capacity in the interior west.

The assumptions presented in Table 9 reflect declining technology costs and improved capacity factors over time. In the sensitivity policy scenario that do not allow for those improvements, the 2000-2004 costs and performance are held constant over all time periods.

Assumptions on the 10/20 Renewable Energy Goals

The 10/20 goals were an explicit requirement in many of the policy scenarios and the characterization of that policy goal is based on the recommendations of the GCVTC. The AP2 forum assumed that the minimum renewable energy generation targets for the 10/20 goals would be based on the electricity demand in the nine states and tribal land of the Transport Region. The 10/20 goals, as modeled in this analysis, requires that by 2005 10 percent of the regional electricity demand be met by generation from renewable energy and by 2015 20 percent of the regional electricity demand be met by generation from renewable resources. Existing generation from renewable energy also counts towards that target. Figure 8 presented below provides a summary of the targets and the existing generation from renewable energy under the BAU.

Figure 8: 10/20 Renewable Energy Generation Targets



This analysis assumes that the 10/20 renewable energy targets can be met by generation from wind, solar photovoltaic, solar thermal, biomass gasification combined cycle, biomass direct combustion, landfill gas and geothermal. The analysis did not include options for small hydro (due to data limitations), though small hydro is a potential renewable energy supply option. In addition, the renewable energy targets can be met by generation from renewable technologies located anywhere within the nine states and tribal lands of the Transport Region and also within the state of Washington and Montana[16].

Assumptions on Energy/Capacity Savings and Implementation Costs for Energy Efficiency Recommendations

The AP2 forum commissioned the Tellus Institute to develop the energy savings and implementation cost assumptions for the energy efficiency recommendations. A description of the approach and method used for the energy efficiency analysis along with the detailed results are presented in Appendix II.

The assumptions on the energy savings and implementation costs for the energy efficiency measures were developed outside of IPM, the power-industrial-process sources sectors modeling framework. The energy and peak capacity savings associated with energy efficiency were introduced into IPM to estimate the emissions reductions and cost savings resulting from lower energy demand. The potential emissions reductions were estimated using the change in emissions between the energy efficiency policy scenarios and the BAU scenario. The net production costs impacts were determined based on the following:

(1) The energy efficiency implementation costs estimated outside of IPM;
(2) The avoided investment cost savings in transmission and distribution estimated outside of IPM;
(3) The cost saving from reduced generation estimated using IPM.

The assumptions for the energy efficiency recommendations were specified by model region (CNV – California and Southwest Nevada; WSCP – Pacific Northwest; and WSCR – Interior West) to fit in with the modeling specification for IPM. Though the three model regions encompass more than the nine states and tribal lands of the Transport Region, the saving and cost estimates were based only the states and tribal lands of the Transport Region. Savings were characterized as electricity demand savings, the annual reduction in electricity demand inclusive of loss, and peak savings, the avoided generation capacity associated with the electricity demand savings. Figures 9 and 10 presented below describe the total regional energy and capacity savings. The total savings reflects the sum of savings across the industrial, residential and commercial sectors and represents 1 percent of electricity demand in 2005 and growing to 8 percent by 2018 under BAU conditions.

[16] Renewable generation located in Washington and Montana were allowed to count towards the 10/20 targets because, in the modeling, these states share common electricity markets with many of the states/tribes of the Transport Region.

Figure 9: Annual Electricity Demand Savings Under the Energy Efficiency Recommendations

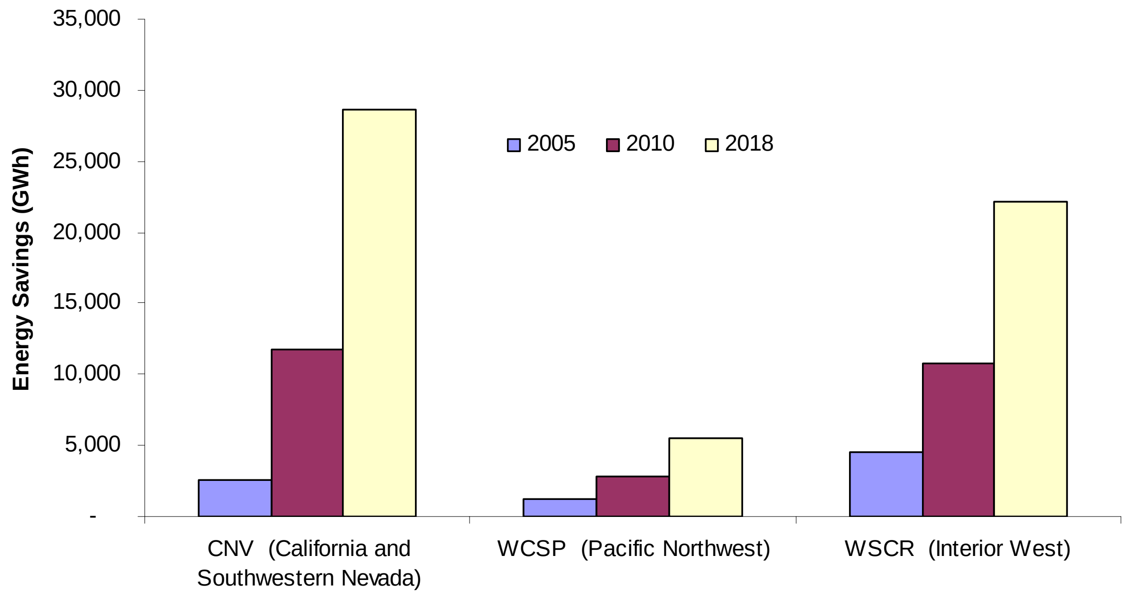
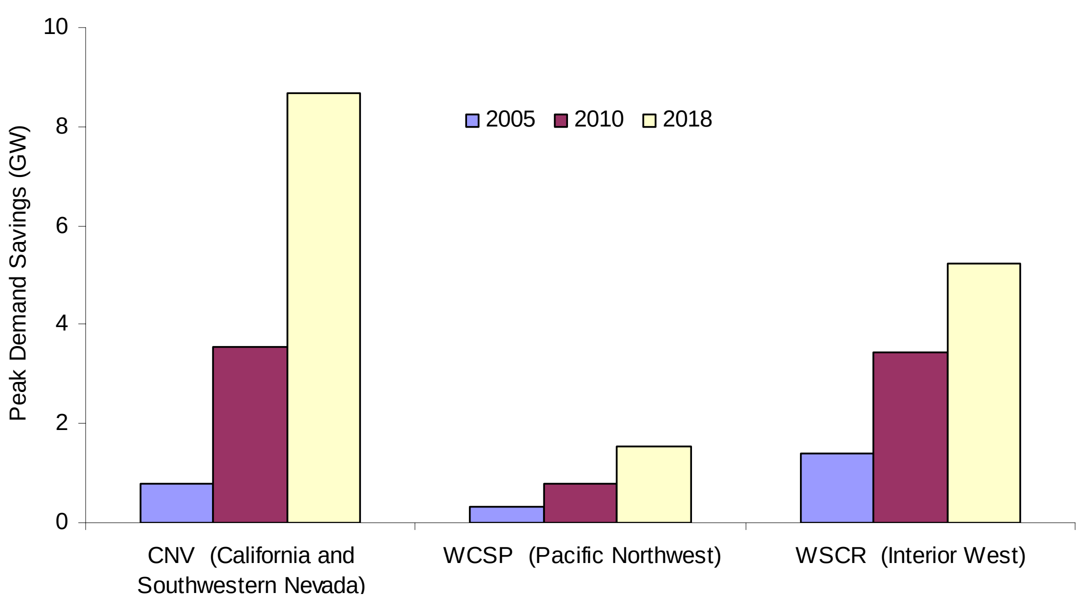
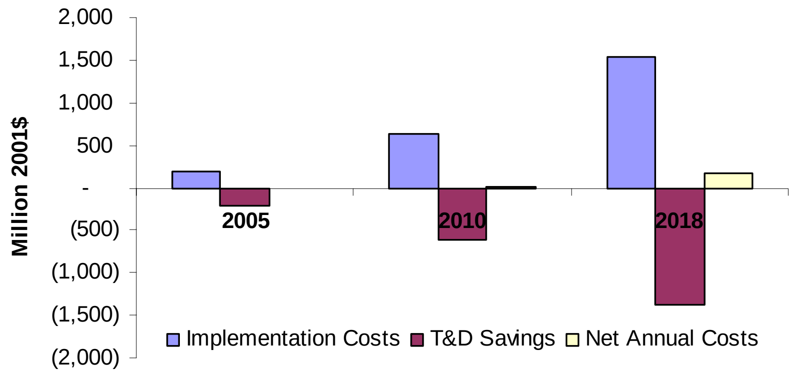


Figure 10: Generation Capacity Savings Under the Energy Efficiency Recommendations



The costs for implementing the energy efficiency recommendations include the costs borne by both the customer and the sponsor and reflect the equipment purchase, fuel, operations, administration and marketing costs. In addition to the implementation costs, the AP2 forum assumed that the energy efficiency measures would lead to avoid investments in the transmission and distribution system at an annual average cost savings of 2.4 cents/kWh (2001 $). Because IPM is a wholesale electricity model that captures cost savings only at the wholesale generation levels, it was necessary to account for these avoided transmission and distribution (T&D) costs outside the model. Figure 11 provides a summary of the assumptions on total implementation costs and avoided T&D investments costs savings for the energy efficiency recommendations. In IPM modeling of the energy efficiency scenarios, the projected production cost savings from IPM are compared against the assumed implementation and avoided T&D costs to estimate net savings.

Figure 11: Annual Implementation Costs and Avoided T&D Cost Savings Under the Energy Efficiency Recommendations



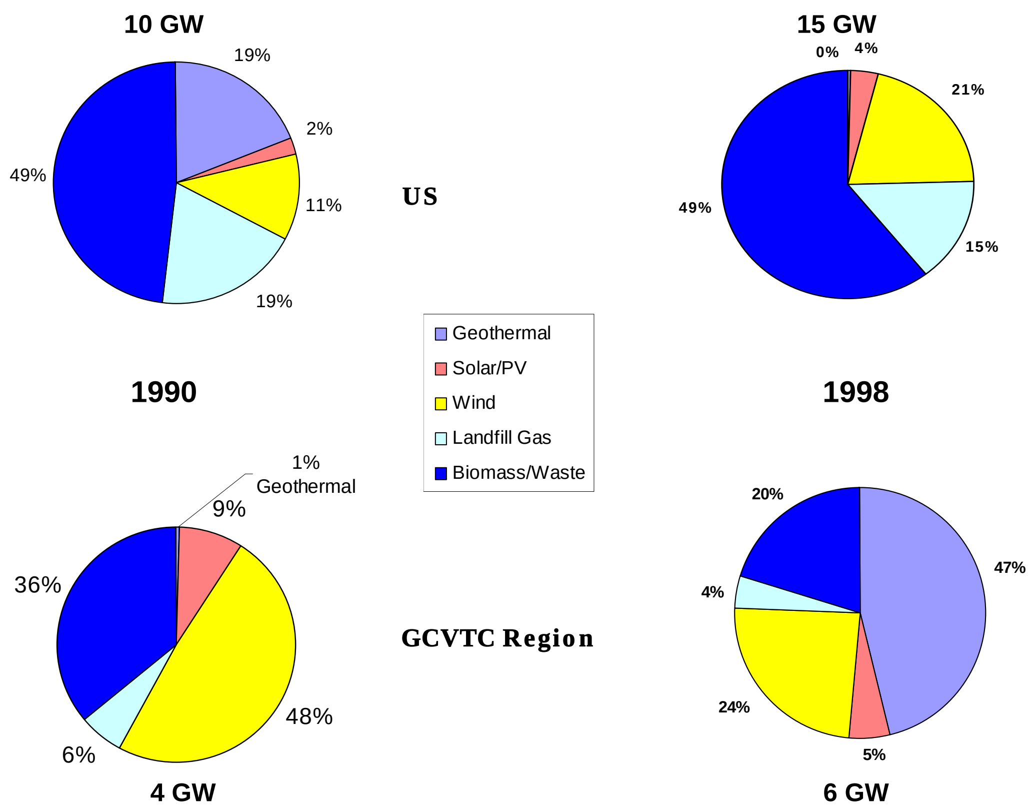
IV. Emissions and Production Costs Impacts

This section describes the emissions and costs impacts on the electricity, industrial and process source sectors under the policy scenarios. The impacts are described in terms of the changes relative to the BAU scenario, thus the first section outlines the notable elements under the BAU scenario.

IV.1 Key Elements Under the Business-As-Usual (BAU) Scenario

The BAU scenario represents a projection of the future without additional efforts to promote renewable energy and energy efficiency in the West. It provides a good reference point for analyzing the impacts of meeting the 10/20 goals and implementing the energy efficiency recommendations. The BAU scenario includes about 1 GW of additional renewable resources that are currently under construction or near the construction phase. However, no additional renewable resources beyond these planned additions are projected in the BAU. As a point of reference, over the last decade about 2 GW of new renewable resources have been brought on line.

Figure 12: Existing Renewable Energy Capacity[17]

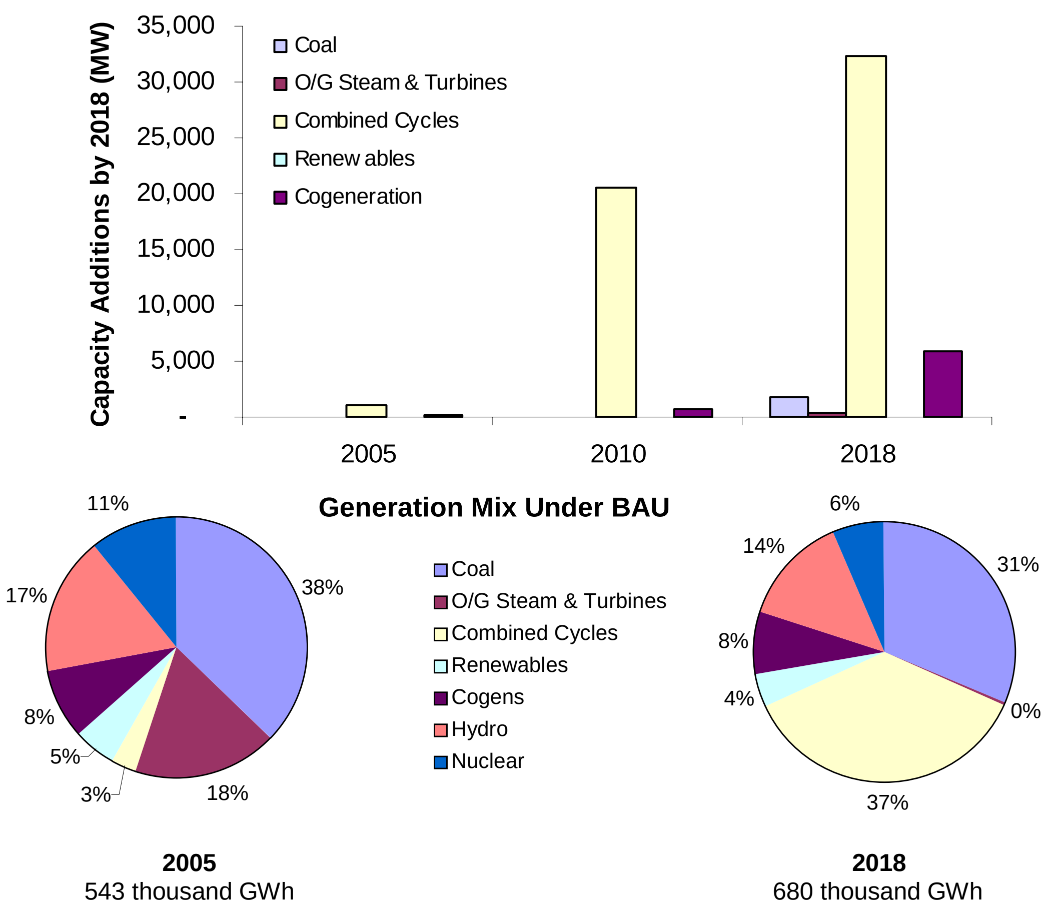


[17] 1990 Data: Energy Information Administration (EIA) Form 860 and EIA Form 867. Some 1990 capacity has been withheld for confidentiality. 1998 Data: EIA Form 860A and EIA Form 860B.

The BAU does not assume any major policy efforts to increase renewable energy or energy efficiency, aside from the indirect benefits afforded clean energy sources by existing air regulations including the Title IV SO_2 program under the Clean Air Act Amendments and the regional SO_2 backstop trading program proposed under the Annex. The growth in renewable capacity under the BAU is limited to the firm capacity additions planned and/or under construction.

Under the BAU scenario, the growth in electricity demand is likely to be met by additions of new gas-fired capacity. By 2018, almost 30 GW of new combined cycle capacity, representing 80 percent of the total growth in new capacity is projected under the BAU. The new combined cycle capacity will likely consist of new combined-cycle and repowering of the older stock of oil/gas steam units to more efficient combined cycle units. As illustrated in Figure 13, by 2018 gas-fired generation from combined cycles represents 37 percent of all generation in the Transport Region up from 21 percent in 2005 (oil/gas steam and combined cycle). The generation from nuclear, hydro and renewable energy remains unchanged between 2005 and 2018, but accounts for a smaller share of the total generation in 2018.

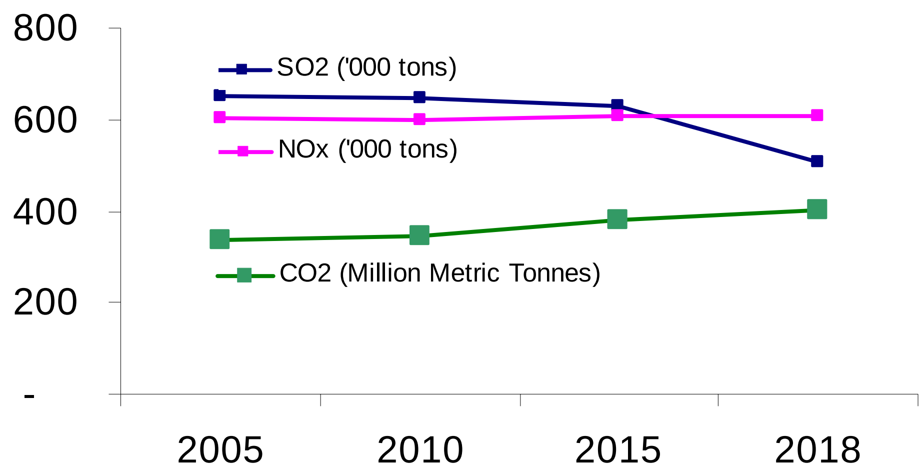
Figure 13: Capacity Growth and Generation Mix Under the BAU



The changes in emissions over time under the BAU scenario reflect the changing mix in capacity and generation. SO_2 emissions under the BAU scenario remain relatively unchanged till 2013, after which the emissions decline as a result of the assumed SO_2

cap and regional trading program. Though NO_x emissions remain relatively unchanged under the BAU scenario between 2005 and 2018, the NO_x emissions *rate* declines significantly as a result of the repowering of existing oil/gas steam units. For CO_2, the change in emissions between 2005 and 2018 mirrors the increase in fossil fuel usage and rises by 19 percent between the two years. Figure 14 presented below provides a summary of projected emissions under the BAU scenario.

Figure 14: Emissions Under the BAU Scenario



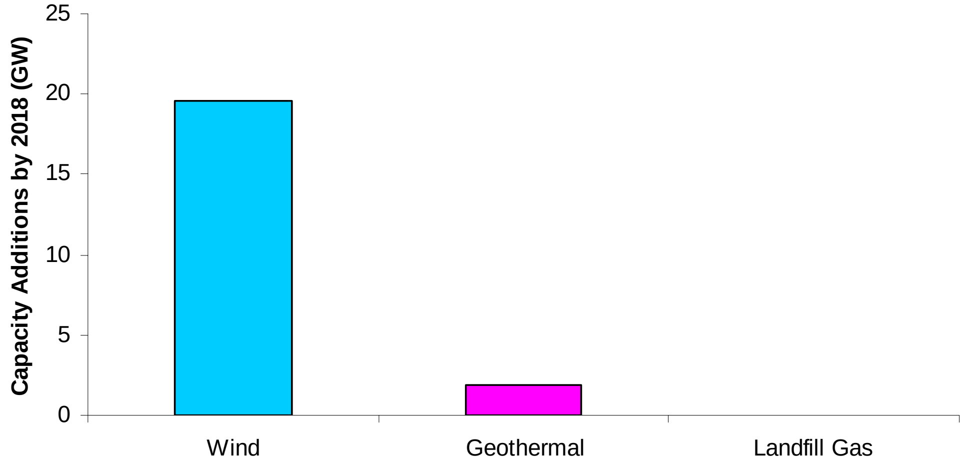
IV.2 Electric System Capacity and Generation Impacts

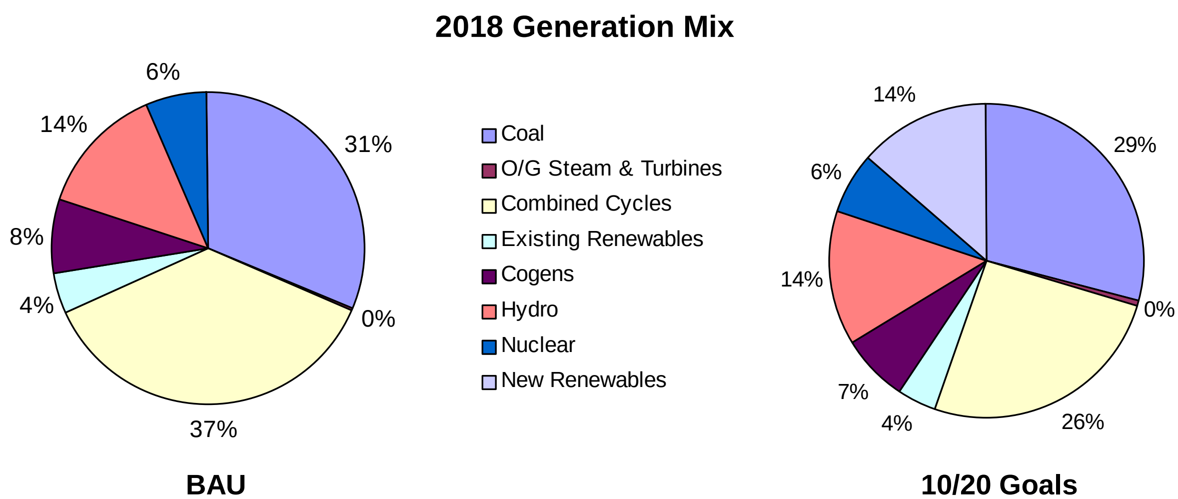
Implementation of the10/20 goals and energy efficiency recommendations lead to significant increases in renewable energy capacity, totaling nearly 20 GW by 2018. The increase in renewable energy capacity is driven by the combination of two key factors. First, under the policy scenarios that include the 10/20 goals there is an explicit requirement that by 2005 10 percent of the regional electricity demand must be met by renewable resources. By 2015, the requirement increases to 20 percent. Second, the growth in renewable energy capacity is spurred by declining renewable technology cost and performance improvements that the AP2 forum assumed would occur in the policy scenarios.

Under the 10/20 goals policy scenario, as illustrated in Figure 15 below, renewable energy generation in the states and tribal lands of the Transport region expands to 18 percent, up from 4 percent under the BAU scenario[18]. Most of this expansion comes from new wind capacity, which accounts for 65 percent of the renewable energy generation.

[18] Two percent of the renewable energy generation for the 10/20 goals comes from states and tribal regions outside the Transport Region but that share common electric market with the states/tribes in the Transport Region. The scenario assumes that renewable energy generation from such sources can be used towards the 10/20.

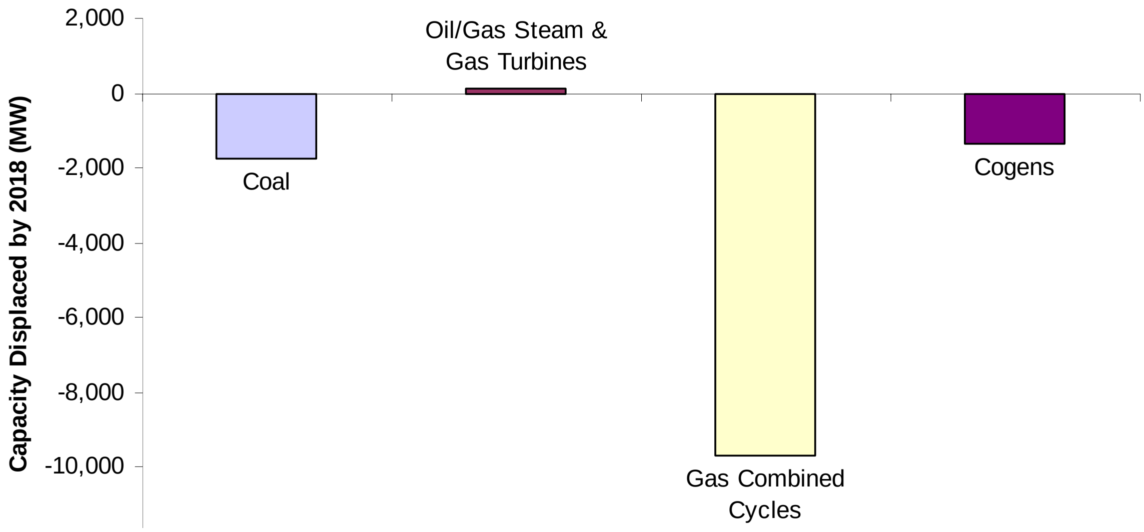
Figure 15: Renewable Energy Capacity and Generation Under the 10/20 Goals





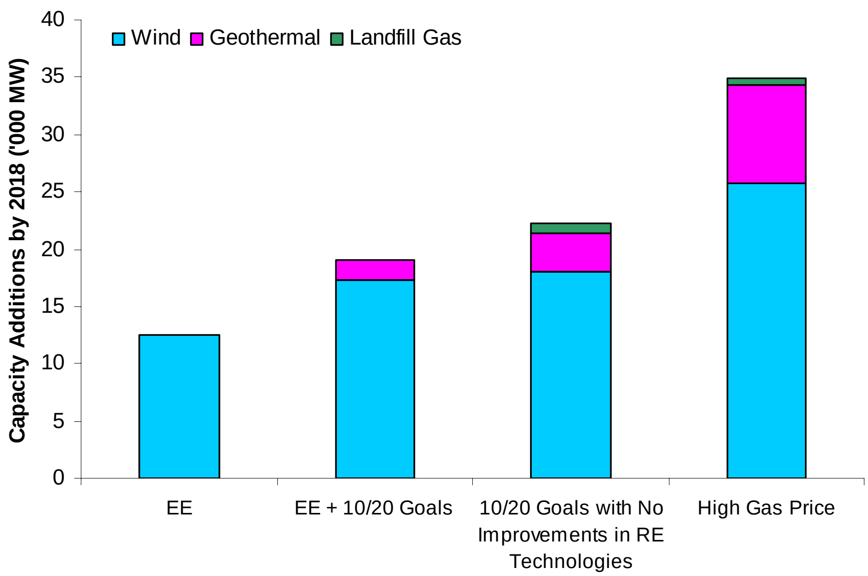
The expansion of renewable energy capacity under the 10/20 goals predominantly displaces new gas-fired capacity. As illustrated in Figure 16 below, by 2018 displaced gas fired combined cycles accounts for almost 80 percent of the 13 GW of the total displaced capacity. The type of displaced capacity (i.e., gas fired combined cycle) reflects the fact that renewable energy capacity will compete against new fossil capacity additions rather than affect the stock of existing units.

Figure 16: Capacity Displaced Under the 10/20 Goals



Results of the analysis indicate that wind will remain the dominant renewable energy technology across a range of different sensitivities and assumptions, particularly when renewable energy generation accounts for 10 percent to 20 percent of regional electricity generation. As illustrated in Figure 16 below, across the other policy scenarios analyzed by the AP2 forum, new wind capacity accounts for at least 75 percent of the additions to renewable energy capacity. In Figure 17 presented below, "EE" refers to the energy efficiency policy scenario, "EE + 10/20" refers to the policy scenario that includes energy efficiency along with the 10/20 goals, "10/20 Goals with No Improvements in RE Technologies" refers to the policy scenario that includes the 10/20 goals but does not allow for improvements in renewable technology cost and performance and "High Gas Prices" refers to the policy scenario with 50% higher gas prices.

Figure 17: Renewable Energy Capacity Additions Under Alternative Policy Scenarios



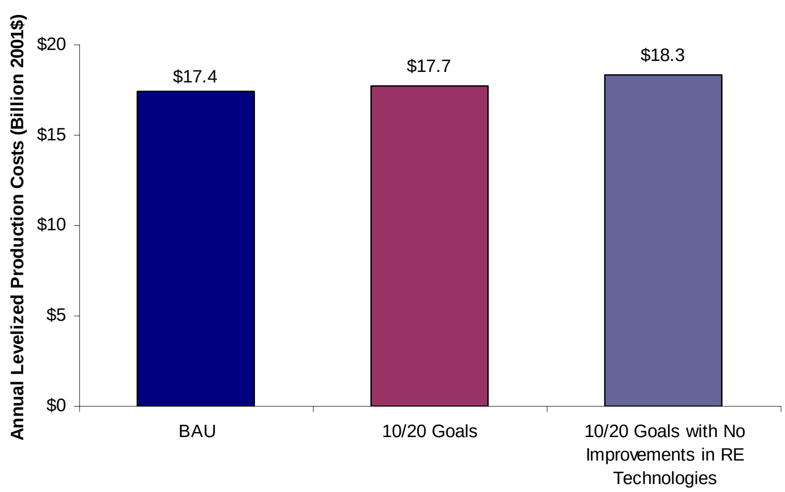
In summary, the changes in electric capacity and generation under the policy scenarios provide some interesting insights. First, the results of the analysis suggest that wind is likely to be the primary choice for renewable energy technology in the West. Even with renewable energy generation providing over 20 percent of the region's electricity generation demand, as in the high gas price scenario, wind appears to be the dominant technology of choice. Second, the penetration of the renewable energy capacity and energy efficiency appears to displace mostly new additions to capacity rather than affecting the existing generation stock. Because most of the new capacity additions under the BAU are gas-fired combined cycle, the results indicate that new gas-fired capacity will be primarily displaced under the policy scenarios. The more important, broader implication is also that renewable energy and energy efficiency compete against new capacity in the supplying electricity.

IV.3 Production Costs Impacts

Implementing the 10/20 renewable energy goals will lead to increased production costs, while the energy efficiency recommendations will result in production costs savings. Production costs, in this case, reflects the incremental or going forward costs [19] associated with producing electricity and industrial steam and includes incremental capital costs, fuel costs and operation and maintenance costs.

As mentioned previously, the AP2 forum considered the production cost impacts of meeting the 10/20 goals under two alternative policy scenarios. In the first policy scenario, the AP2 forum assumed that the cost of developing renewable energy, particularly wind, would improve in the future as a result of the growth in renewable energy capacity. In the second scenario, the AP2 forum wanted to examine the production costs impacts without allowing for any improvements in renewable technology cost and performance. As illustrated in Figure 18 below, the annual levelized production cost impacts under the two policy scenarios could range between $300 million (2001 $) and $900 million (2001 $) or 2 percent to 5 percent of the production costs under the BAU respectively.

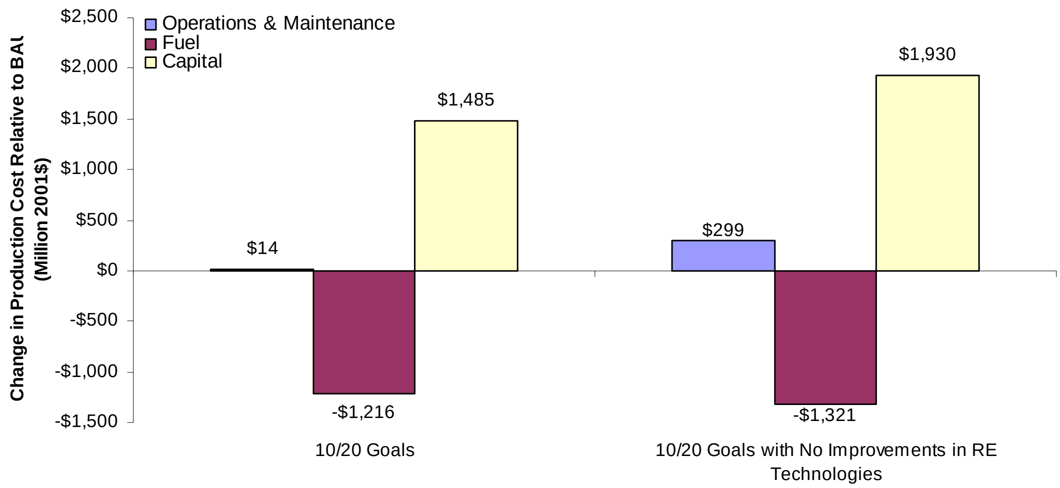
Figure 18: Production Cost Impacts in Meeting the 10/20 Renewable Energy Goals



[19] Embedded cost associated with the capital cost of existing units are not included in modeled production costs.

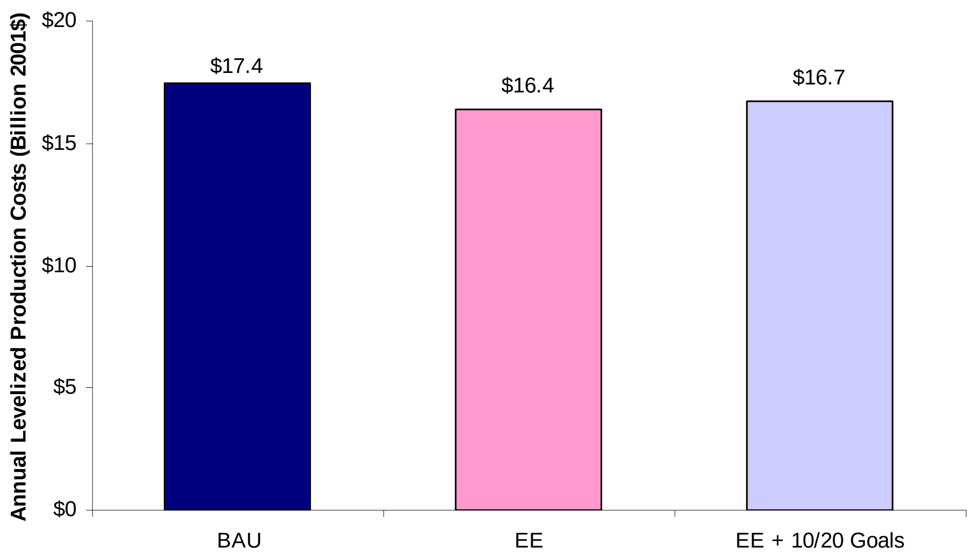
The increase in production costs in meeting the 10/20 goals is largely driven by the capital expenditures required for new renewable energy projects. While the penetration of renewable energy leads to reductions in costs from displaced fossil fuel generation, it is not sufficient to fully offset the increased capital expenditures. Nonetheless, there is a shift in production costs away from fuel and towards capital. Under the 10/20 goals, operation-and-maintenance costs remain relatively unchanged. Figure 19 presented below highlights the composition of the change in annual levelized production costs for 2018.

Figure 19: Composition of Annual Levelized Production Cost Impacts in Meeting the 10/20 Goals



Unlike the 10/20 goals, implementation of the energy efficiency recommendation with and without the 10/20 goals leads to annual levelized production costs *savings* of $730 million to $1 billion (2001 $) respectively. These net savings reflect the cost of implementing the recommendations, the avoided investment costs for transmission and distribution infrastructure and the reduction in electricity production costs from decreased electricity demand. Though the requirements of the 10/20 goals somewhat lowers the savings from energy efficiency, the 10/20 goals and energy efficiency recommendations still result in annual levelized production costs savings of over $700 million. These savings represent 4 percent to 7 percent of the annual levelized production costs of the BAU scenario. Figure 20 presented below contrasts the annual levelized production costs under the BAU and policy scenarios with the energy efficiency recommendations.

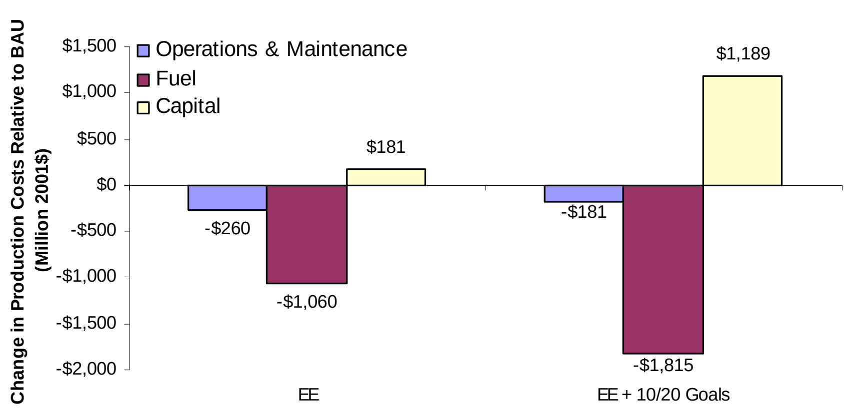
Figure 20: Annual Levelized Production Costs Under the BAU and Policy Scenarios with the Energy Efficiency Recommendations



The projected production costs savings presented in Figure 19 reflects the assumed improvements in renewable energy technology cost and performance. The AP2 forum assumed that the energy efficiency recommendations would occur under a policy regime that would actively promote renewable energy, though without explicit targets, thus leading to enhancements in technology cost and performance.

Much like the policy scenarios with the 10/20 goals, the production cost savings under the policy scenarios with are driven by reductions in fuel expenditures because energy efficiency displaces gas generation. Figure 21 presented below illustrates that by 2018, energy efficiency and energy efficiency with the 10/20 goals leads to almost $ 2 billion in fuel expenditure savings, offset only by increased capital investments in renewable energy capacity.

Figure 21: Composition of Production Cost Impacts Under the Energy Efficiency Policy Scenarios



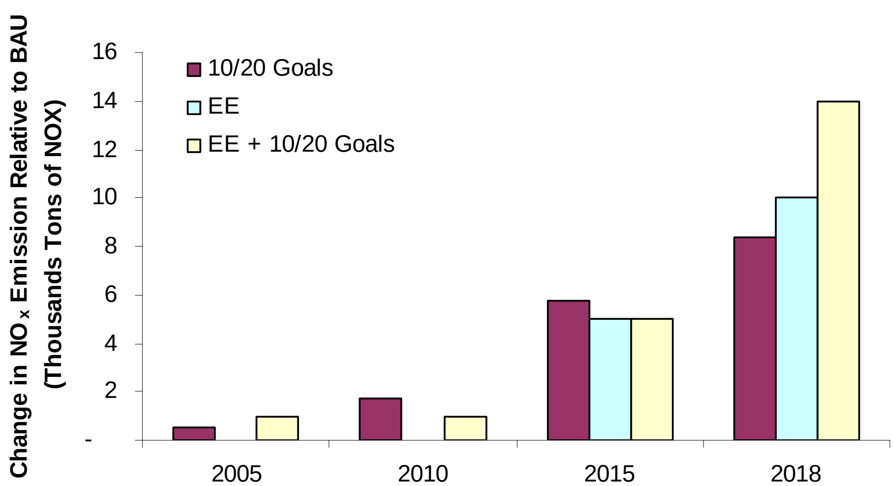
In summary, the production cost impacts of the policy scenarios yield some interesting insights for the 10/20 goals and energy efficiency recommendations. First, the 10/20 goal will results in modest production cost impacts of 2 percent to 5%, while energy efficiency recommendations will achieve production cost *savings* of 5 percent to 7 percent. Second, and perhaps the most notable feature of these policies is that because both the 10/20 goals and energy efficiency recommendations shift production expenditures away from fuel and towards capital, these policy objectives can offer some security against fuel price volatility and fuel supply shocks.

IV.4 Emissions Impacts

Under the 10/20 goals, the emissions reductions occur because conventional fossil fuel generation is replaced with clean or low emissions generation from renewable energy. With energy efficiency, demand savings displaces electricity generation, which in turn creates the opportunities for emissions reductions. The level of associated emissions reductions depends on the pollutant being examined. Fuel based emissions (CO_2) generally follow fuel consumption, while technology/fuel dependent emissions such as NO_x depends on the relative emission rate of displaced technologies.

Under the policy scenarios of the 10/20 and energy efficiency, the change in NO_x emissions relative to the BAU scenario range between 1 percent and 2 percent. As illustrated in Figure 22 below, by 2018 the emissions reduction in NO_x from implementing the 10/20 goals and the energy efficiency will be between 8,000 tons and 14,000 tons annually. Most of the emissions reductions are likely to occur after 2010, when the penetration of renewable energy and energy efficiency is most significant.

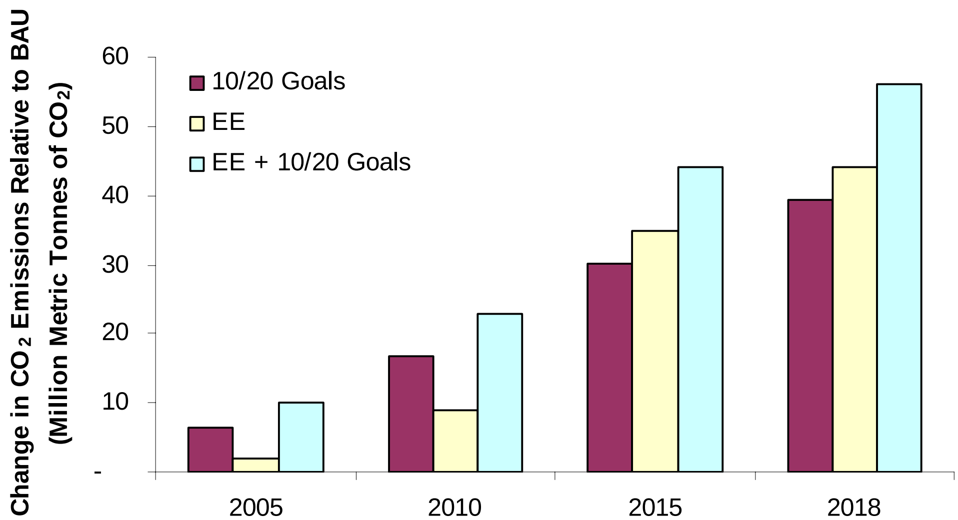
Figure 22: Reductions In NO_x Emissions Under the Policy Scenarios



The modes emissions reductions in NO_x under the 10/20 goals and energy efficiency recommendations reflect that the fact that they largely displaced new gas-fired combined cycles, which are expected to have relatively low NO_x emission rates. However, it is important to recognize that because these reductions come from new generation capacity, renewable energy and energy efficiency will provide a hedge against future NO_x emissions growth.

Estimated emissions reductions in CO_2, on the other hand, are driven largely by reductions in fossil fuel use. As highlighted in Figure 23 below, the reductions in CO_2 emissions range between 10 percent and 14 percent under the various policy scenarios. By 2018, when the penetration of renewable energy and energy efficiency are most significant, the reductions are projected to between 40 million metric tonnes and 55 million metric tones.

Figure 23: Reductions In CO_2 Emissions Under the Policy Scenarios



As was true for NO_x emissions, because CO_2 emissions reductions derive from reductions in fossil fuel use in new capacity additions, the 10/20 goals and energy efficiency will likely provide a hedge against future CO_2 emissions growth.

Unlike NO_x and CO_2 emissions, the analysis projects no reductions in SO_2 emissions reflecting the regional emissions cap and SO_2 trading program as proposed in the Annex and modeled in all scenarios. However, because the SO_2 trading program creates a monetary value for SO_2 emissions, affected sources under the cap and trade program take advantage of reduced fuel use and associated lower emissions to reduce their overall cost of compliance with the cap. Thus, there is an economic benefit to fully offsetting any SO_2 emissions reductions provided by the 10/20 goals and energy efficiency recommendations. This result is not unique to this particular situation but is rather a general outcome under an emissions cap and trading program. Analysis of the extent to which the 10/20 goals might lower the costs of compliance in the regional backstop SO_2 trading program in the Transport Region is discussed below.

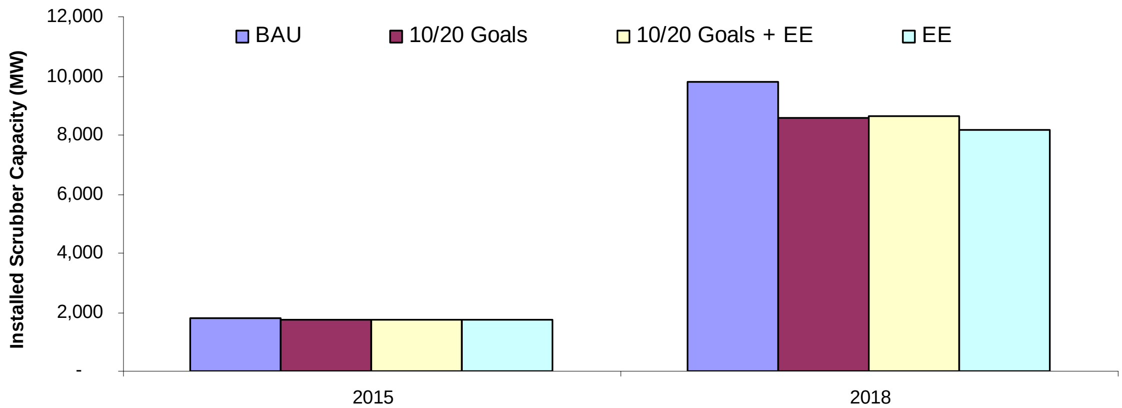
IV.5 Impact on the Regional Backstop SO_2 Trading Program

The compliance cost of the regional trading program such as the Annex depends on the level of reductions required. The 10/20 goals and energy efficiency programs help to lower the compliance cost of the regional backstop SO_2 trading program by lowering the amount of reductions needed to meet the milestone. The penetration of renewable energy under the 10/20 goals displaces fossil fuel generation, which in turn provides the remaining plants in the trading program with more headroom under the emissions cap. The implementation of the energy efficiency recommendations would have the same effect because it also displaces fossil fuel generation.

The results of the analysis indicate that by implementing the 10/20 goals, the compliance cost of meeting the SO_2 reduction requirements through a trading program as proposed in the Annex could decline by approximately $10 million (or 7 percent of the compliance cost without the 10/20 goals[20]) in 2018. This estimate is based on a comparison between two scenarios, one including the 10/20 goals without the regional trading program and the other including the 10/20 goals and the regional trading program (i.e., the 10/20 goals policy scenario).

The fact that the 10/20 goals may make it cheaper to comply with the SO_2 cap and trade program can be illustrated by examining projected amount of SO_2 scrubbers constructed under the scenarios. Scrubber installations (or enhancements to existing scrubbers) are likely to be a key compliance strategy in meeting the SO_2 reduction requirements under the Annex trading program. As illustrated in Figure 24 below, 1,200 MW to 1,700 MW, representing 13 percent to 17 percent, of fewer scrubber installations are projected under the policy scenarios relative to the BAU scenario.

Figure 24: Projected Scrubber Installations Under the Annex SO_2 Trading Program



In summary, the results of the analysis suggest that implementation of the10/20 goals and energy efficiency recommendations will help to reduce the compliance cost of the regional backstop SO_2 trading program by as much as $ 10 million (or 7 percent) in 2018 and displaces 1,200 MW to 1,700 MW of new scrubber installations.

IV.6 Wholesale Electricity Price Impacts

This section discusses the wholesale electricity price impacts and the renewable energy credit price under the policy scenarios of the 10/20 goals and the energy efficiency recommendations. The distinction between the wholesale electricity price and the renewable energy credit price has been maintained for this discussion because the policy design of the 10/20 goals, particularly on how the compliance cost of the 10/20

[20] Ibid., MTF 2000.

goals might be recovered, has not been determined.

In the IPM framework, wholesale electricity prices represent the price at which electricity would be sold by a generator to a retail distributor, assuming competitive generation markets. The model is a wholesale power market model and thus does not model retail markets or project electricity retail prices.[21] In IPM, wholesale electricity prices are based on two separate components, energy price and capacity price, which together reflect the price of simultaneously satisfying electricity and reliability demand.

- Energy prices reflect the variable cost of operation and include fuel cost, variable operating costs and emissions-related costs. Emissions-related costs only exist if an emissions trading program is in place and the allowance price in the trading program is greater than zero.

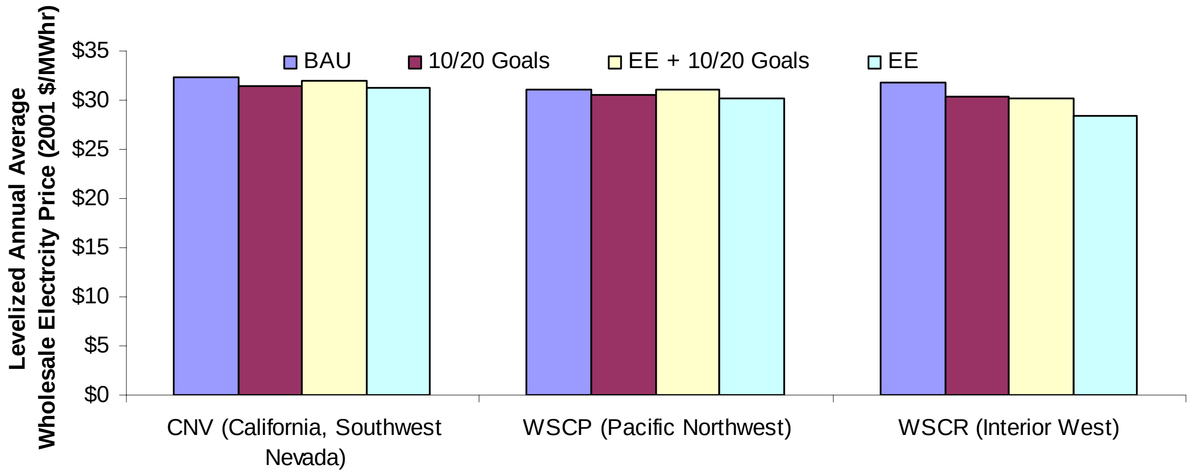
- Capacity prices relate to fixed costs and include the capital and fixed operating costs. Some generating units, such as peaking combustion turbines, often come on-line to serve reliability and only operate a very small fraction of the hours in a year. Such plants often recover their costs through capacity payments. The capacity price can be zero if an electricity market has excess capacity.

The wholesale electricity price is the sum of the energy price and capacity price and both prices reflect the cost of the marginal unit. For energy, the marginal unit is the generating unit that provides the last kWh to satisfy demand and the energy price is based on the variable cost of that marginal unit. All generators, independent of their own cost of generation, receive the same price for the energy sold. Marginal energy prices vary hourly in energy markets. In IPM, marginal energy prices vary by season and load segment (i.e., base, peak, etc). Similarly, the marginal unit in capacity markets is the last unit that has to come on-line to satisfy the peak plus reliability demand and the resulting capacity price is based on the capital and fixed operating costs of that marginal unit.

As illustrated in Figure 24 below, the 10/20 goals and energy efficiency leads to a decline in wholesale electricity prices, of as much as 10 percent under the policy scenario with the 10/20 goals and energy efficiency. The electricity price impacts are differentiated by model region because each of the three regions has separate electricity markets. Though electricity prices often vary within a year and across years, for clarity Figure 25 contrasts the levelized annual average wholesale electricity price between the BAU and policy scenarios.

[21] For purposes of regional economic modeling, where changes in prices (rather than the actual price) serve as modeling inputs, we have included the assumption that end-use electricity customers realize the full benefit (or cost) of the change in wholesale electricity price. In other words, the distribution and/or retailing costs between the Business-As-Usual scenario and the 10/20 goals scenario are assumed to remain constant and the changes in wholesale electricity prices fully flows through to retail rates.

Figure 25: Levelized Annual Average Wholesale Electricity Price



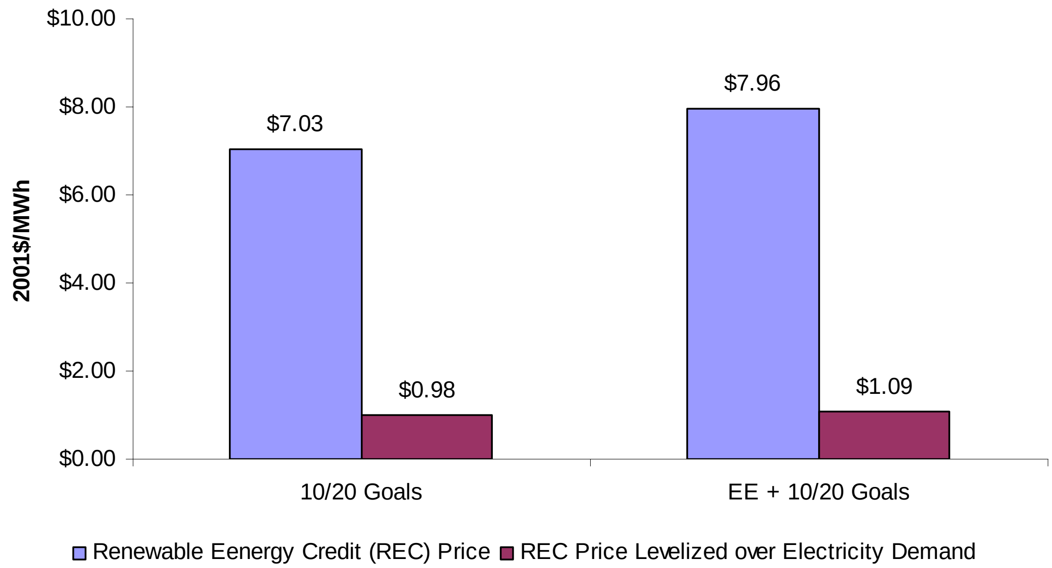
Under the 10/20 goals, the wholesale electricity price declines for two reasons: (1) generation from renewable energy have little or no variable cost of operation and (2) because the 10/20 goals essentially requires the power system to produce the level of generation associated with the targets, in generation markets, wholesale electricity price is determined by the marginal cost in meeting the incremental demand (i.e., the demand left after the generation required by the 10/20 goals have been accounted for). Under energy efficiency, the change in wholesale electricity price results from reduced demand, which eliminates the need for the higher cost units and thus leads to lower prices.

Figure 25 presented above, however, does not account for the "compliance cost" of the 10/20 goals or the implementation costs associated with energy efficiency. The issue of how those costs are recovered is more an issue of policy design but for purposes of this analysis the AP2 forum assumed that the costs of meeting the 10/20 goals and implementing the energy efficiency recommendations would be recovered uniformly through all end-users, as in a Systems Benefit Charge (SBC) type framework.

To achieve the 10/20 goals, developers of renewable energy must earn sufficient revenue to cover their investment costs and earn a reasonable return. These required earnings are reflected in the marginal costs of satisfying the goal – or in the language of renewable portfolio approaches – the renewable energy credit (REC) price. The value of the REC represents the incremental costs over the wholesale energy price that the marginal renewable energy producer must earn – over the commodity energy price – to give him sufficient returns and incentives to construct the renewable capacity. RECs reflect the market price implications of achieving the 10/20 goals while production costs impacts only describe the total production cost implications of meeting the 10/20 targets without describing the price implications (opportunity cost) of the target.

Figure 25 presented below summarizes the annual levelized REC for the policy scenarios with the 10/20 goals. In addition, Figure 26 also describes the value of the REC levelized over the electricity demand of the Transport Region.

Figure 26: Renewable Energy Credit Price for the 10/20 Goals

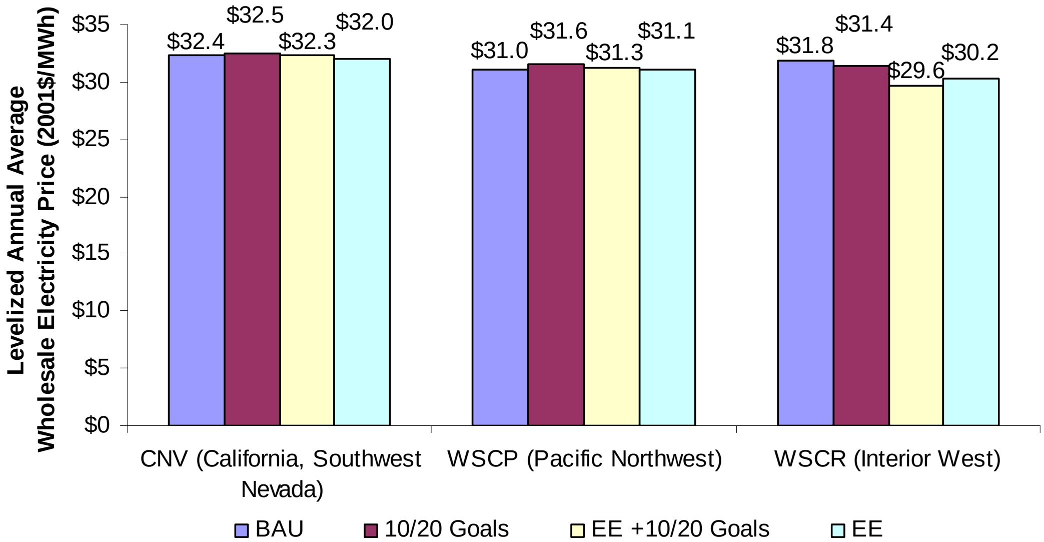


Similarly implementation costs of the energy efficiency recommendations have been translated into price impacts by assuming that the annual levelized implementation costs of $ 45 million[22] will be distributed evenly through all end-users, resulting in an annual levelized cost of $ 0.07/MWh.

The wholesale electricity price along with the renewable energy credit price and the energy efficiency implementation costs provide a better description of electricity price impacts because it explicitly accounts for the compliance cost of the policy objectives. As presented in Figure 27 below, the wholesale electricity price in the Transport Region will increase by 1 percent to 2 percent under the 10/20 goals, decrease by as much as 5 percent with energy efficiency and decrease by as much as 8 percent with energy efficiency and the 10/20 goals. This projected electricity price impact is measured at the wholesale level (the price at which generators will sell to utilities or distribution companies for end-use sales) because it does not account for the distribution and retailing costs. Retail price impacts would be lower in proportion to the share of retail prices that are wholesale price component.

[22] Includes implementation costs and avoided investments costs in transmission & distribution, see Section III.2 above for details.

Figure 27: Wholesale Electricity Price Impacts Under the Policy Scenarios



In summary, the analysis indicates that the 10/20 goals can be achieved with modest price impacts of 1 percent to 2 percent, while energy efficiency could help to reduce the wholesale price by as much as 8 percent in some regions. The largest gains appear to be concentrated in regions that achieve the highest levels of renewable energy and energy efficiency penetration.

V. Secondary Regional Economic Impacts

This section describes the secondary regional economic impacts resulting from the implementation of the 10/20 goals and the energy efficiency recommendations. The AP2 forum selected three policy scenarios for analysis of the regional economic impacts: (1) 10/20 goals; (2) energy efficiency; and (3) 10/20 goals and energy efficiency. Details of the modeling framework and assumptions on regional economic impacts are contained in Section III.2.

Although the REMI model provides estimates on a variety of different impacts, the analysis has been focused around gross regional product (GRP), employment and real disposable personal income. These selected parameters provide a reasonably clear picture of the overall economic impacts of the 10/20 goals and energy efficiency. Gross regional product is analogous to national gross domestic product and describes the final demand or output of the regional economy. It consists of consumption, investment, government expenditures and net exports, while real personal disposable income describes personal income after taxes.

The most informative aspects of the economic impacts are contained in the estimates of the overall regional impacts rather than the state-by-state impacts. While the state-by-state impacts provide a description of how the broader regional impacts may be distributed by state, the state level results may be sensitive to assumption on the distribution of the initial impacts. In particular, the state level results may be sensitive to assumption on how renewable energy investments are allocated across states. IPM projects renewable energy capacity only by model regions and the state level allocations were based on how the renewable energy resources were distribution by state.

On average over the analysis horizon, the 10/20 goals and the EE recommendations have a small impact on GRP, employment and personal income, often less one half of one percent. Most of the impacts are closely aligned with the construction boom that results from capital investment in renewable energy. In addition, the decline in electricity prices from the 10/20 goals and energy efficiency lowers the cost of production in the commercial, industrial and manufacturing sector, which in turns leads to higher income and output. The reduction in electricity prices for the residential sector also leads to higher real income, increased consumption and investments. Table 10 presented below summarizes the change in employment, gross regional product and personal disposable income across the three policy scenarios. State/level details are presented in Appendix I.

Table 10: Annual Average (2005 – 2020) Changes In Key Economic Indicators for the Transport Region Under the Policy Scenarios

	Employment		Gross Regional Product		Personal Disposable Income	
	(Persons)	(% Change)	(Million 2001$)	(% Change)	(Million 2001$)	(% Change)
10/20 Goals	627	0.00%	-312	-0.01%	73	0.00%
Energy Efficiency (EE)	8,415	0.02%	450	0.02%	776	0.04%
10/20 Goals + EE	4,097	0.01%	-58	0.00%	547	0.03%

Under the 10/20 goals, the employment impacts occur mostly in the 2005 to 2015 time period because most of the investment in renewable energy capacity occurs at that time.

Under the scenario that includes only the EE recommendations, the increase in capital investments occur a little later, in the 2011-2015 time period, resulting in an increase in employment over that time period.

The increase in employment also affects gross regional product (or output) through changes in investment and consumption. The increase in employment demand briefly causes wage rates to increase, as labor markets adjust, and this along with the increase in output leads to the increase in personal income. In short, the increase in employment caused by increased investments in renewable energy has the most dominant impact in the regional economy and also leads to related increase in gross regional product and personal income.

The change in employment, though, is temporary and begins to ebb after the 2015 time period as investments in renewable energy decline. The decline in income, which have a less pronounced effect during times of high investments but continue to occur even after the investments have tapered off, add to the regional economic impacts after 2015. The decline in income reflects the drop in profits as a result of the changes in electricity prices and mining revenues from reduced fossil fuel consumption. These income effects are somewhat mitigated by the lower electricity cost faced by the residential, commercial and industrial sector but are not sufficient to offset the decline in income from profits. In addition, wages begins to decline slightly after 2010 as the construction demand begins to taper off and labor markets readjust.

On average over the analysis horizon, the 10/20 goals lead to small increases in employment and personal income and to a minor decline in gross regional product. Energy efficiency leads to increases in employment, personal disposable income and gross regional product over the entire analysis horizon.

In summary, the results of the regional economic analysis indicate that the 10/20 goals and the energy efficiency recommendations will have small or no impacts on the regional economy. The policies may lead to small increases in economic activity in the early years and a small decline in the later years. The impacts in the 2005 to 2015 time period are largely the result of investment in new renewable energy facilities that increase labor demand and have secondary impacts on output and income. Following the investment and construction boom, the region sees some decline in employment, gross regional product and personal disposable income because of the income impacts from lower profits in the electric and mining sector.

VI. Caveats and Uncertainties

The objective of this analysis was to assist the AP2 forum in understanding the potential emissions reductions, costs and secondary regional economic impacts of implementing the 10/20 goals and energy efficiency recommendations. The AP2 forum intends for this report to serve as a technical appendix, providing the analytical support for its recommendation to WRAP. As with any analytical assessment, the findings presented in this report should be understood and applied in the context of which it was developed and recognizing the assumptions, analytical framework, caveats and uncertainties underlying the analysis.

One of the key factors driving the results of the analysis is the assumption on renewable energy technology cost and performance. Existing literature on this subject provide a wide range of estimates, particularly in how the cost and performance might change in future years. The assumptions developed by the AP2 forum for the policy scenarios was based on a variety of different sources, including research of existing literature, data developed by the Energy Information Administration, data developed by the National Renewable Energy Laboratory and stakeholder input. The assumptions represent the forum's best view of renewable energy technologies given the policy climate likely under the 10/20 goals and energy efficiency recommendations.

Outside of the cost and performance assumptions for renewable energy technologies, this analysis was conducted using the data, assumptions and analytical framework developed by the WRAP/MTF in 2000 for the economic analysis of regional trading program in support of the Annex. Those assumptions describe the electric system operation, technology cost and performance including pollution control equipment, fuel prices and economic conditions.[23] In addition, the AP2 forum adopted the WRAP/Annex scenario as the BAU scenario for this analysis with minor modifications to account for the planned additions to renewable energy capacity.

The state level description of the secondary regional economic impacts presented in Appendix I should be used with some caution because the results may be sensitive to the assumptions on how the impacts were allocated by state. A key driver of the regional economic impacts was the capital investments for renewable energy projects. In IPM, which provided inputs for the REMI modeling, the growth in renewable energy capacity is described only by model region and the investments for new capacity were allocated by state based on distribution of renewable resource availability.

Though the modeling and analytical results provide detailed estimates of emissions reductions, cost and secondary regional economic impacts, it is important to recognize that the magnitude of the projected changes are quite small. This is particularly important for analysis of secondary regional economic impacts projected through the REMI model because most of the impacts are less than one half of one percent. Similarly, many of the costs projected from the IPM model are small relative to the total production costs of the sectors modeled. As with any analytical results, small perturbations are difficult to interpret precisely. In instances where the changes appear

[23] MTF 2000.

to be very small, analysis of broader trends, rather than specific numbers, will often be a more robust and meaningful description of the impacts.

VII. Conclusions

The objective of the analysis was to assist the AP2 forum in assessing the potential emissions reduction, costs and secondary regional economic impacts of meeting the 10/20 goals and implementing the energy efficiency recommendations in the states and tribal lands of the Transport Region. The analysis suggests that the 10/20 goals and energy efficiency could both serve as cost-effective air pollution prevention strategies because they provide opportunities for emissions reductions with modest cost or with some cost savings.

The 10/20 goals require that renewable energy resource satisfy 10 percent of the regional energy needs by 2005 and 20 percent of the regional energy needs by 2015. Most of the expansion in renewable energy is likely to come from wind power, where the greatest improvements in technology cost and performance are expected. Additional penetration of geothermal and landfill gas capacity are also projected under the 10/20 goals. The investments required for this expansion is likely to increase annual levelized production costs by $300 million to $900 million, representing a production cost increase of 2 percent to 5 percent relative to the BAU scenario. The increase in wholesale electricity prices from meeting the 10/20 goals are likely to be less than 2 percent.

The energy efficiency recommendations developed by the AP2 forum calls for electricity demand reductions in the Transport Region growing to 8 percent of the electricity demand by 2018. Implementation of the energy efficiency recommendations will lead to annual levelized production cost savings between $700 million and $1 billion in addition to some reductions in wholesale electricity prices. The savings under the energy efficiency policy scenarios accrue from reduced electricity and steam production cost and from avoided investment costs in transmissions and distribution, but are offset by the energy efficiency implementation costs.

Future expansion of renewable energy capacity and increased penetration of energy efficiency is likely to compete against new conventional generation technologies. Analysis of the BAU scenario indicates that in the absence of 10/20 goals or energy efficiency, the growth of conventional capacity will consist mostly of gas-fired combined cycles. The penetration of renewable energy and energy efficiency under the policy scenario is likely to displace new gas-fired combined cycles, which are relatively low emissions technologies.

For 2018, the analysis indicates that annual emissions savings from implementing the 10/20 goals and energy efficiency recommendations will be between 1 percent and 2 percent in NO_x and 10 percent to 14 percent in CO_2. Though the potential for emissions reductions may appear to be modest because renewable energy and energy efficiency compete against new gas fired generation sources, the 10/20 goals and energy efficiency will provide a hedge against future emissions growth.

Though the 10/20 goals and energy efficiency are unlikely to reduce SO_2 emissions in the presence of regional backstop SO_2 trading program proposed in the Annex, they could help reduce the compliance cost of trading program. By meeting the 10/20 goals, the compliance cost of the trading program could decrease the compliance cost by as much as $ 10 million (or 7%) and may displace 1,200 MW to 1,700 MW of new scrubber installations.

The 10/20 goals and energy efficiency are likely to have very small impacts on the regional economy. On average over the analysis horizon, energy efficiency will lead to small gains of less than one half of one percent in employment, gross regional product and personal disposable income. Similarly, on average over the analysis horizon, the 10/20 goals will lead to small increases of less than one half of one percent in employment and personal income along with an equally small decline the gross regional product. The economic impacts under the 10/20 goals and energy efficiency are the result of increased capital investment in renewable technologies and lower electricity prices. In implementing the 10/20 goals and the energy efficiency recommendations, the boom in construction job sparked by the investments along with the lower production costs from lower electricity prices appear to be key reasons for the changes in the regional economy.

Appendix I: Regional Economic Impacts

Economic Impacts by State
10/20 Goals Scenario
Annual Average Change in Employment

	2005-2010		2011-2015		2016-2020		
	Persons	Percent	Persons	Percent	Persons	Percent	Annual Average
AZ	278	0.01%	-768	-0.02%	-1,530	-0.04%	-614
CA	-612	0.00%	-4,123	-0.02%	-6,724	-0.03%	-3,619
CO	651	0.02%	450	0.01%	1,160	0.03%	747
ID	854	0.10%	1,274	0.15%	264	0.03%	801
NM	177	0.02%	-522	-0.04%	-1,372	-0.11%	-525
NV	285	0.02%	451	0.03%	791	0.05%	495
OR	-2,541	-0.11%	-1,351	-0.06%	-1,549	-0.06%	-1,859
UT	720	0.05%	172	0.01%	-391	-0.02%	201
WY	6,271	1.70%	10,380	2.71%	-1,897	-0.48%	5,003
9 States	6,080	0.02%	5,961	0.02%	-11,250	-0.03%	627

Economic Impacts by State
EE Only Scenario
Annual Average Change in Employment

	2005-2010		2011-2015		2016-2020		Annual Average
	Persons	Percent	Persons	Percent	Persons	Percent	
AZ	902	0.03%	3,434	0.10%	1,837	0.05%	1,986
CA	-3,269	-0.01%	5,131	0.02%	-11,315	-0.05%	-3,158
CO	849	0.03%	4,060	0.12%	6,603	0.19%	3,651
ID	925	0.11%	680	0.08%	-193	-0.02%	499
NM	270	0.02%	762	0.06%	-406	-0.03%	212
NV	-81	-0.01%	724	0.05%	252	0.02%	275
OR	1,084	0.05%	1,871	0.08%	997	0.04%	1,303
UT	321	0.02%	1,347	0.08%	-98	-0.01%	511
WY	-27	-0.01%	11,148	2.91%	-1,071	-0.27%	3,139
9 States	975	0.00%	29,156	0.08%	-3,397	-0.01%	8,415

Economic Impacts by State
EE + 10/20 Goals Scenario
Annual Average Change in Employment

	2005-2010		2011-2015		2016-2020		
	Persons	Percent	Persons	Percent	Persons	Percent	Annual Average
AZ	859	0.03%	2,811	0.08%	3,297	0.10%	2,231
CA	-4,828	-0.02%	-6,640	-0.03%	-10,943	-0.05%	-7,305
CO	1,218	0.04%	2,930	0.09%	8,049	0.23%	3,888
ID	986	0.12%	2,573	0.29%	-297	-0.03%	1,081
NM	307	0.03%	230	0.02%	-274	-0.02%	101
NV	302	0.02%	481	0.03%	543	0.03%	433
OR	-923	-0.04%	167	0.01%	-1,131	-0.05%	-647
UT	959	0.06%	1,048	0.06%	422	0.03%	819
WY	6,169	1.67%	4,843	1.27%	-1,055	-0.27%	3,497
9 States	5,050	0.01%	8,441	0.02%	-1,389	0.00%	4,097

Economic Impacts by State
10/20 Goals Scenario
Annual Average Changes in Gross Regional Product

	2005-2010		2011-2015		2016-2020		
	Million $ (F	Percent	Million $ (F	Percent	Million $ (F	Percent	Annual Levelized (million 2001$)
AZ	26	0.01%	-46	-0.02%	-129	-0.05%	-29
CA	-135	-0.01%	-554	-0.03%	-958	-0.04%	-423
CO	42	0.02%	36	0.01%	90	0.03%	49
ID	31	0.06%	49	0.08%	-14	-0.02%	27
NM	4	0.01%	-35	-0.04%	-98	-0.11%	-30
NV	15	0.02%	25	0.02%	56	0.05%	27
OR	-148	-0.10%	-95	-0.06%	-138	-0.07%	-129
UT	36	0.04%	7	0.01%	-35	-0.03%	12
WY	242	0.95%	392	1.39%	-172	-0.54%	185
9 States	112	0.00%	-221	-0.01%	-1399	-0.04%	-312

Economic Impacts by State
EE Only Scenario
Annual Average Changes in Gross Regional Product

	2005-2010		2011-2015		2016-2020		
	Million $ (F	Percent	Million $ (F	Percent	Million $ (F	Percent	Annual Levelized (million 2001$)
AZ	57	0.02%	249	0.10%	141	0.05%	129
CA	-200	-0.01%	293	0.01%	-1108	-0.05%	-233
CO	63	0.03%	318	0.13%	613	0.22%	251
ID	41	0.07%	42	0.07%	-17	-0.02%	27
NM	12	0.02%	40	0.05%	-21	-0.02%	13
NV	-4	0.00%	53	0.05%	26	0.02%	18
OR	67	0.04%	146	0.08%	77	0.04%	91
UT	22	0.02%	100	0.09%	31	0.03%	46
WY	-5	-0.02%	451	1.60%	-100	-0.32%	109
9 States	52	0.00%	1,692	0.05%	-359	-0.01%	450

Economic Impacts by State
EE + 10/20 Goals Scenario
Annual Average Changes in Gross Regional Product

	2005-2010		2011-2015		2016-2020		
	Million $ (F	Percent	Million $ (F	Percent	Million $ (F	Percent	Annual Levelized (million 2001$)
AZ	61	0.03%	194	0.08%	230	0.08%	133
CA	-409	-0.02%	-720	-0.03%	-1232	-0.05%	-650
CO	85	0.04%	236	0.09%	712	0.25%	258
ID	38	0.07%	113	0.18%	-36	-0.05%	43
NM	8	0.01%	1	0.00%	-33	-0.04%	-3
NV	16	0.02%	30	0.03%	40	0.03%	24
OR	-57	-0.04%	16	0.01%	-91	-0.05%	-44
UT	52	0.05%	74	0.07%	51	0.04%	57
WY	235	0.92%	156	0.56%	-115	-0.36%	125
9 States	30	0.00%	100	0.00%	-475	-0.01%	-58

Economic Impacts by State
10/20 Goals Scenario
Annual Average Changes in Real Disposable Income

	2005-2010		2011-2015		2016-2020		
	Million $ (F	Percent	Million $ (F	Percent	Million $ (F	Percent	Annual Levelized (million 2001$)
AZ	31	0.02%	13	0.01%	-35	-0.02%	11
CA	-77	-0.01%	-221	-0.02%	-373	-0.03%	-175
CO	42	0.03%	97	0.06%	125	0.07%	75
ID	18	0.05%	36	0.08%	6	0.01%	21
NM	11	0.02%	-8	-0.01%	-46	-0.07%	-7
NV	16	0.02%	45	0.05%	52	0.05%	33
OR	-110	-0.10%	-85	-0.07%	-80	-0.06%	-95
UT	29	0.05%	19	0.03%	-8	-0.01%	18
WY	183	1.06%	379	2.01%	3	0.02%	193
9 States	143	0.01%	277	0.01%	-357	-0.02%	73

Economic Impacts by State
EE Only Scenario
Annual Average Changes in Real Disposable Income

	2005-2010		2011-2015		2016-2020		
	Million $ (F	Percent	Million $ (F	Percent	Million $ (F	Percent	Annual Levelized (million 2001$)
AZ	72	0.05%	331	0.19%	245	0.13%	182
CA	-55	0.00%	217	0.02%	-401	-0.03%	-40
CO	67	0.04%	382	0.22%	612	0.32%	272
ID	33	0.08%	45	0.10%	-3	-0.01%	28
NM	22	0.04%	88	0.14%	32	0.05%	42
NV	9	0.01%	96	0.11%	83	0.09%	50
OR	54	0.05%	110	0.09%	92	0.07%	78
UT	21	0.03%	99	0.14%	48	0.06%	49
WY	2	0.01%	371	1.97%	23	0.11%	115
9 States	224	0.01%	1,741	0.09%	731	0.03%	776

Economic Impacts by State
EE + 10/20 Goals Scenario
Annual Average Changes in Real Disposable Income

	2005-2010		2011-2015		2016-2020		
	Million $ (F	Percent	Million $ (F	Percent	Million $ (F	Percent	Annual Levelized (million 2001$)
AZ	69	0.04%	285	0.16%	414	0.22%	204
CA	-140	-0.01%	-352	-0.03%	-599	-0.04%	-285
CO	76	0.05%	325	0.19%	747	0.39%	288
ID	31	0.08%	90	0.20%	4	0.01%	42
NM	21	0.04%	62	0.10%	70	0.10%	43
NV	24	0.03%	80	0.09%	109	0.11%	58
OR	-27	-0.03%	6	0.00%	1	0.00%	-12
UT	42	0.07%	83	0.11%	87	0.11%	63
WY	180	1.05%	209	1.11%	21	0.10%	146
9 States	278	0.02%	788	0.04%	854	0.04%	547

Appendix II: Energy Efficiency Analysis and Methodology

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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(Revised draft, June 26, 2002)

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.

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.

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[24], 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[25], 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	

[24] CHP = Combined Heat and Power (or Cogeneration)
[25] 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[26])
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[27] (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

Measure Evaluation

For each measure listed in Table 1, plus several other measures[28], 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 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

[26] WH = Water Heating
[27] VSD = Variable Speed Drive
[28] 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.

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.

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[29]. 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.
- 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

[29] 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.

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.

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[30].

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[31]. 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.

[30] 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.

[31] 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.

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.

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.

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[32].

[32] 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:

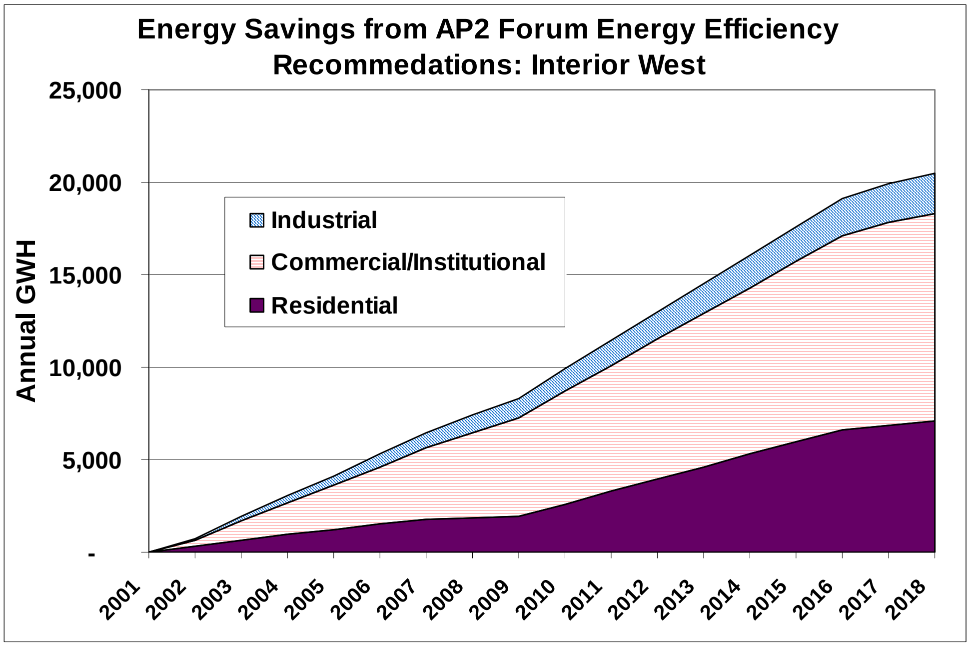


Figure 2:

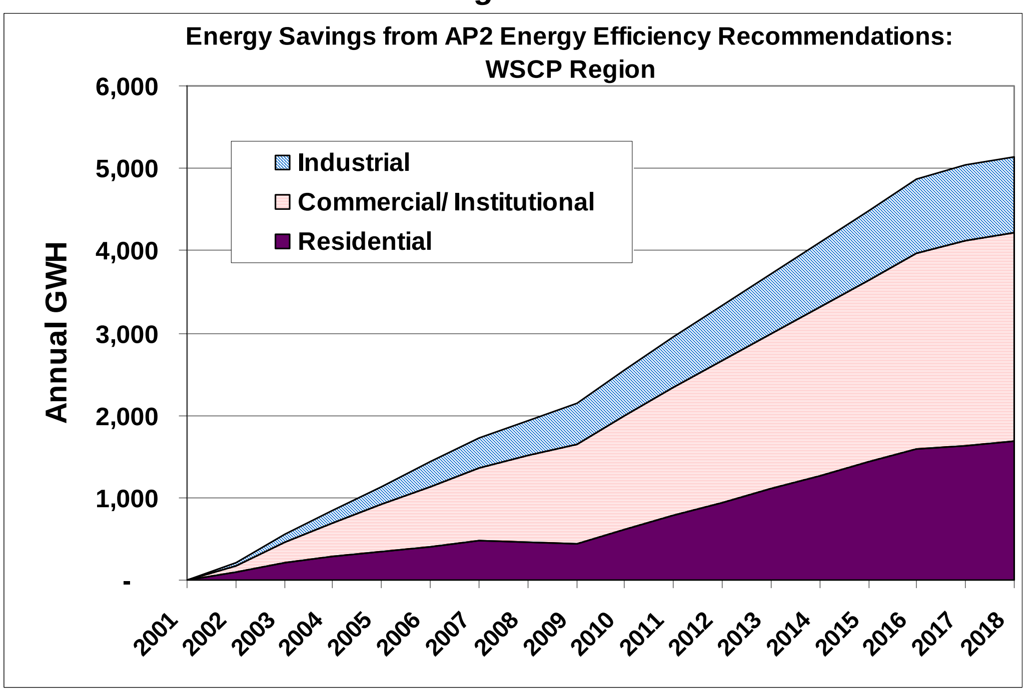


Figure 3:

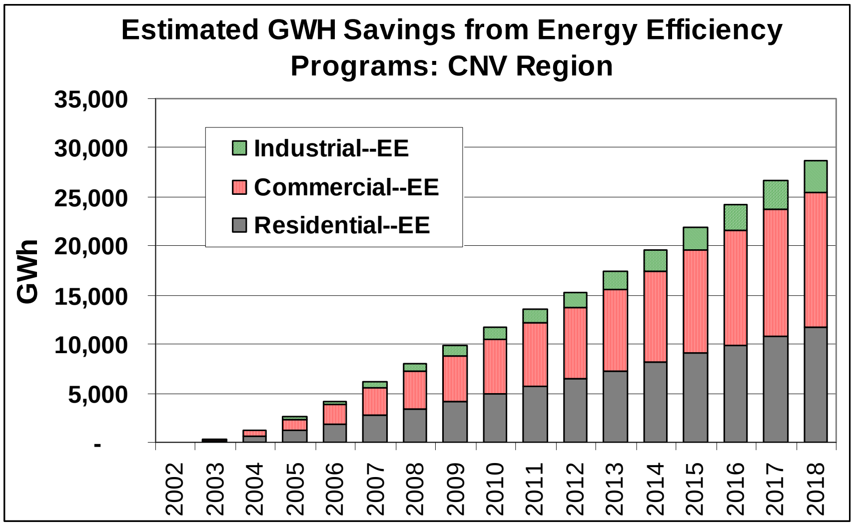
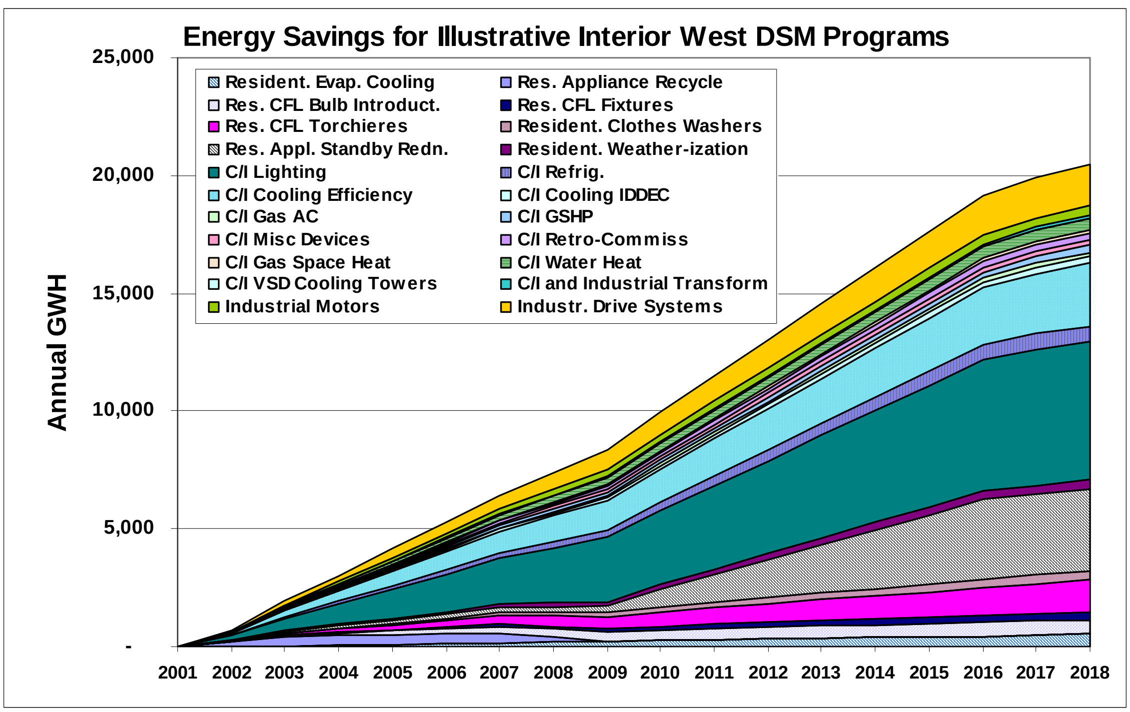


Figure 4 indicates the magnitude of energy savings for each of the programs included in the energy-efficiency package for the Interior West.

Figure 4:



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:

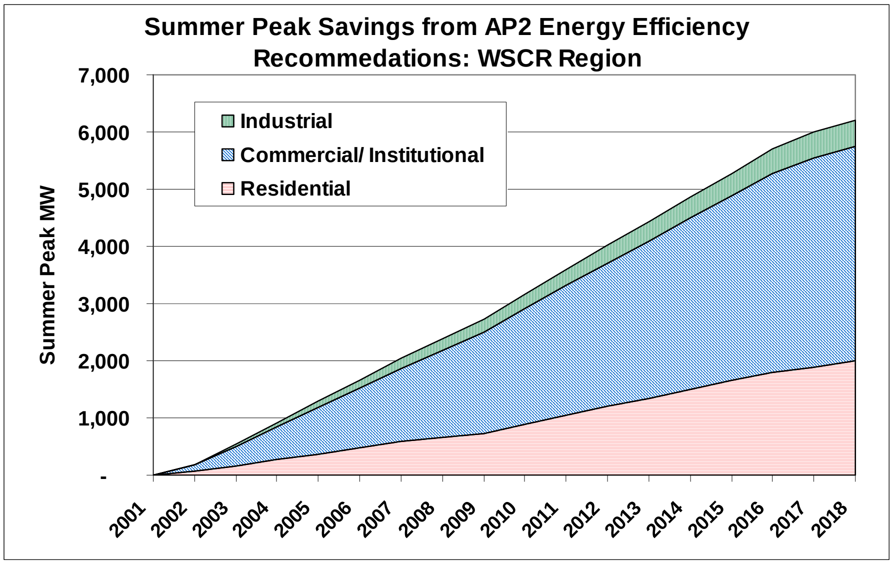


Figure 6:

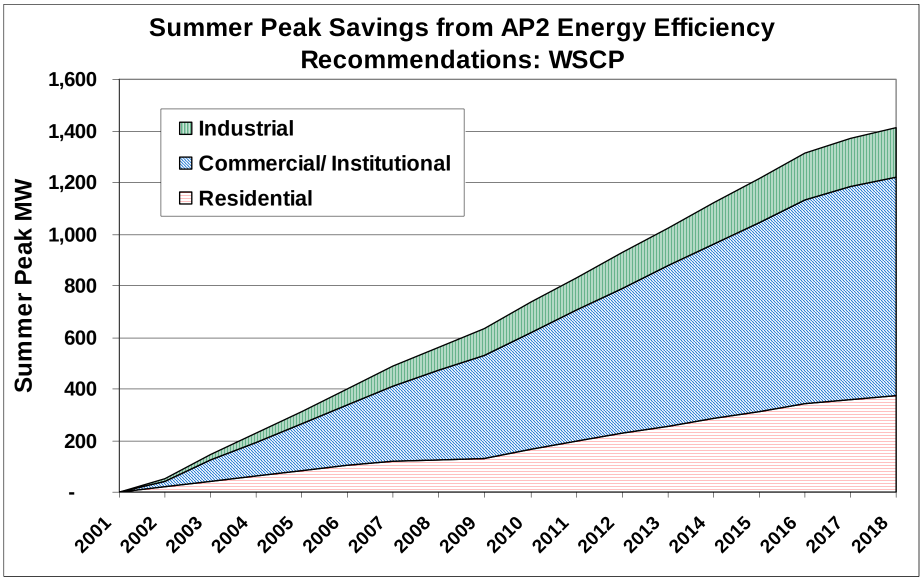
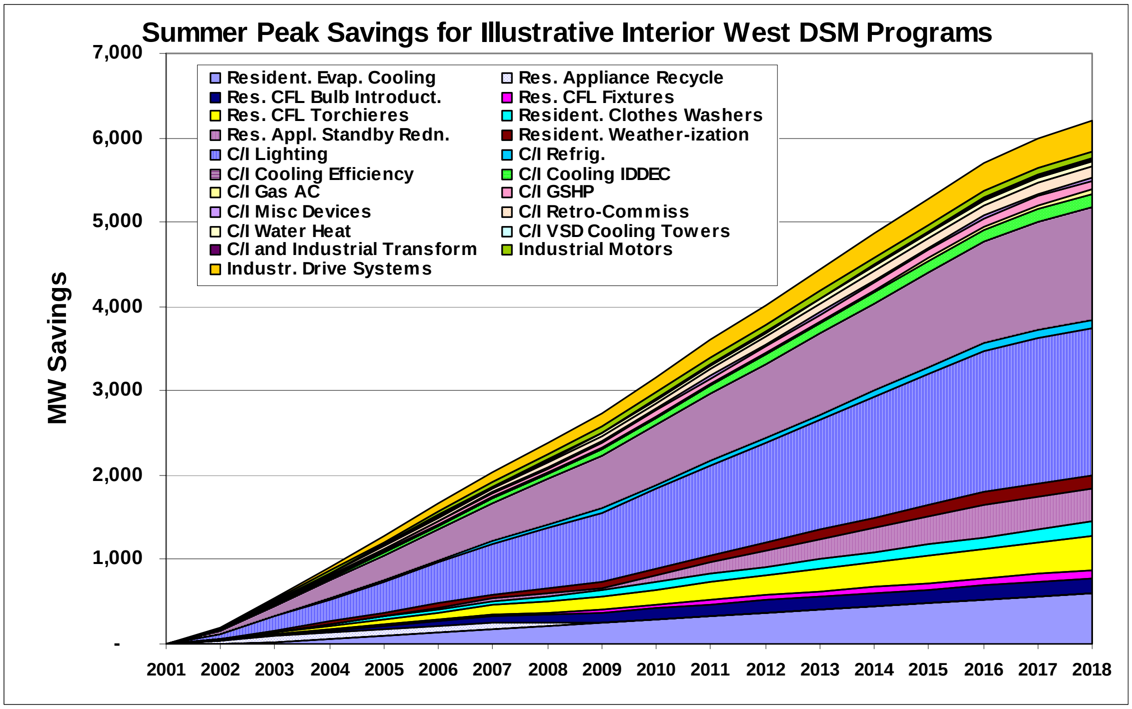


Figure 7:



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 annualized 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:

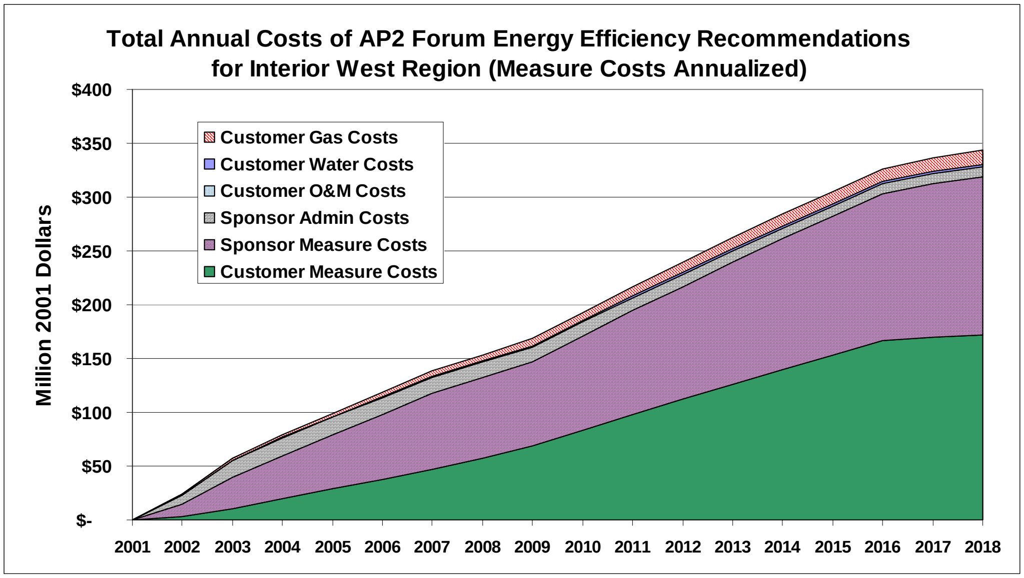


Figure 9:

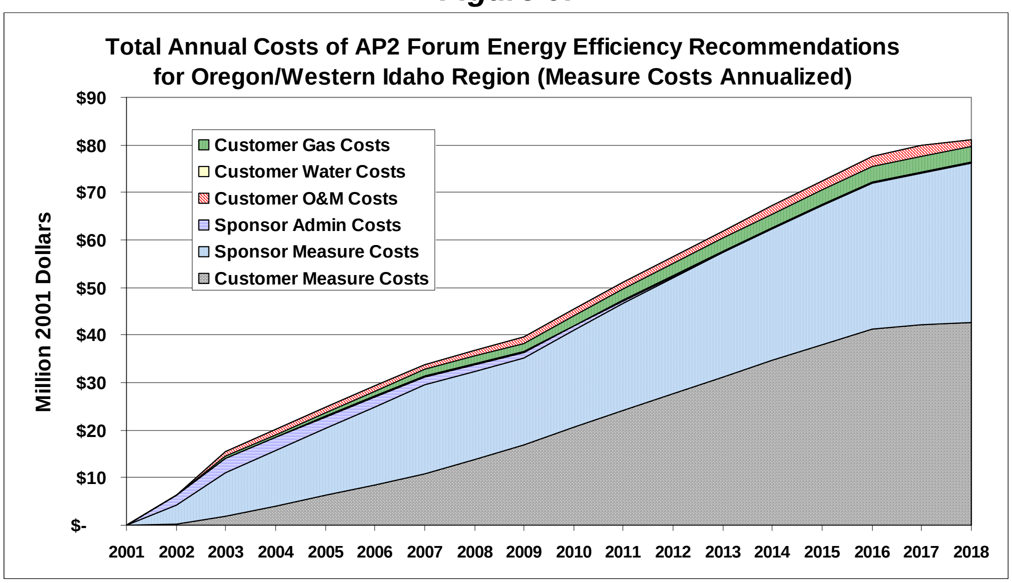
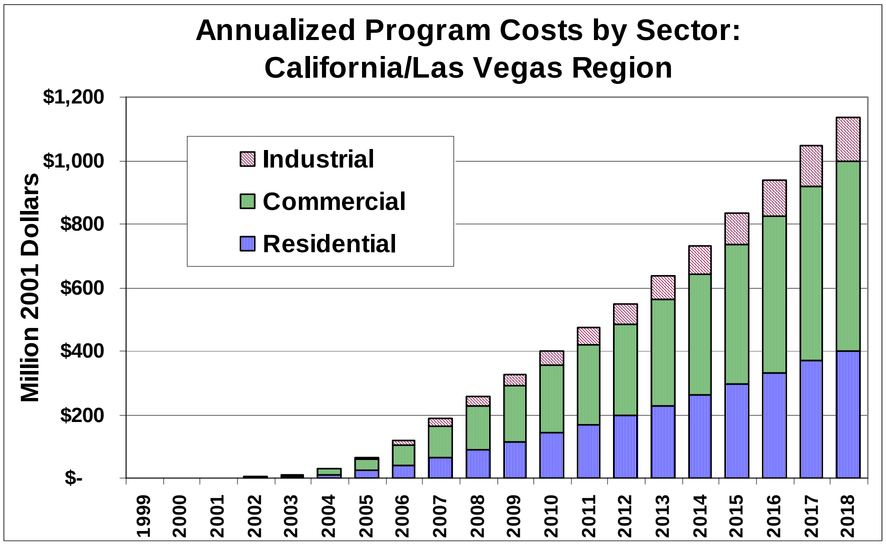


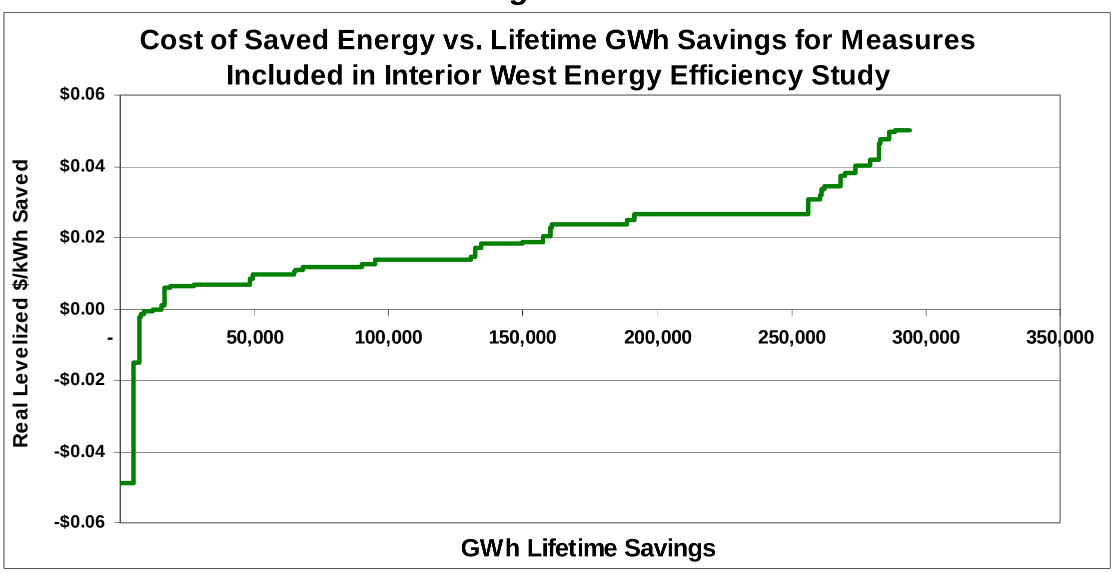
Figure 10:



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[33]. Cost curve results for the Oregon/W. Idaho region are not shown here, but are similar.

Figure 11:



[33] 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.

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				

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 air sheds 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.

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:

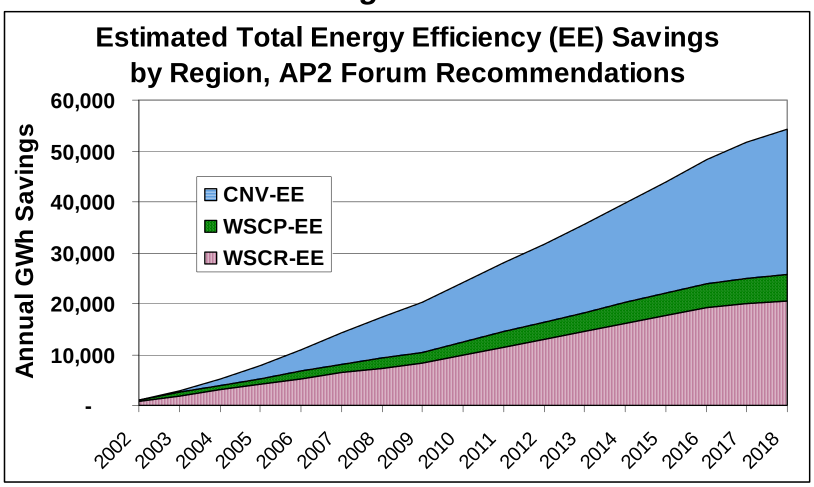


Figure 13:

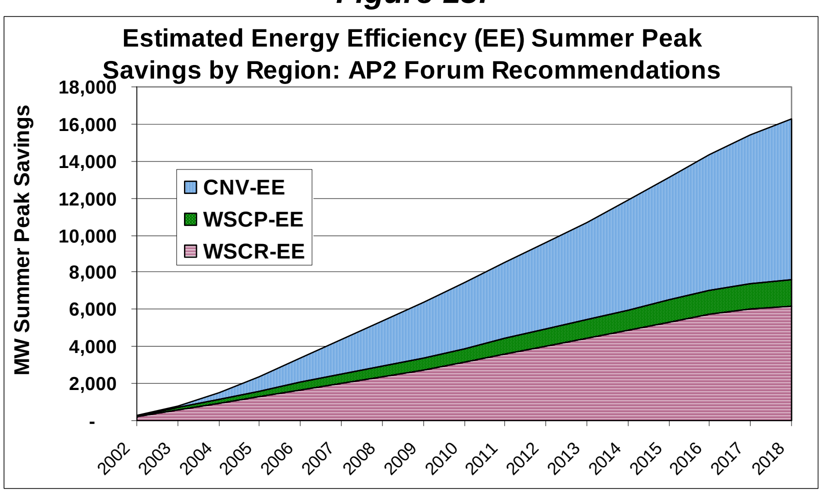


Figure 14:

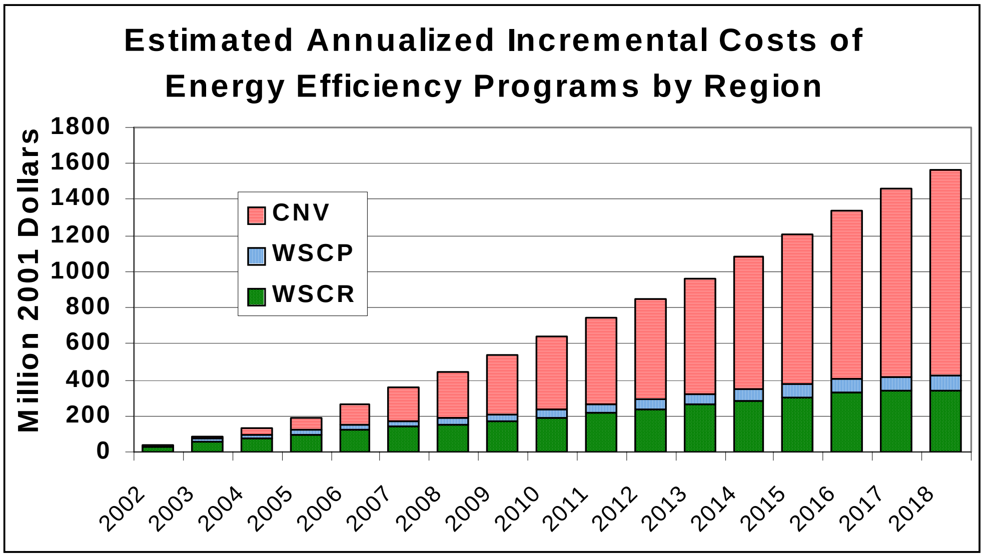


Figure 15:

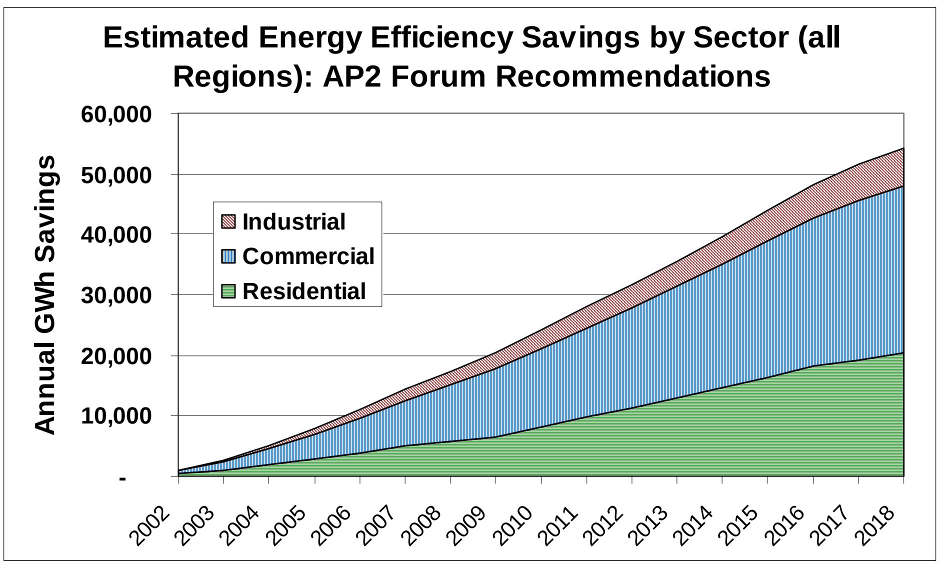
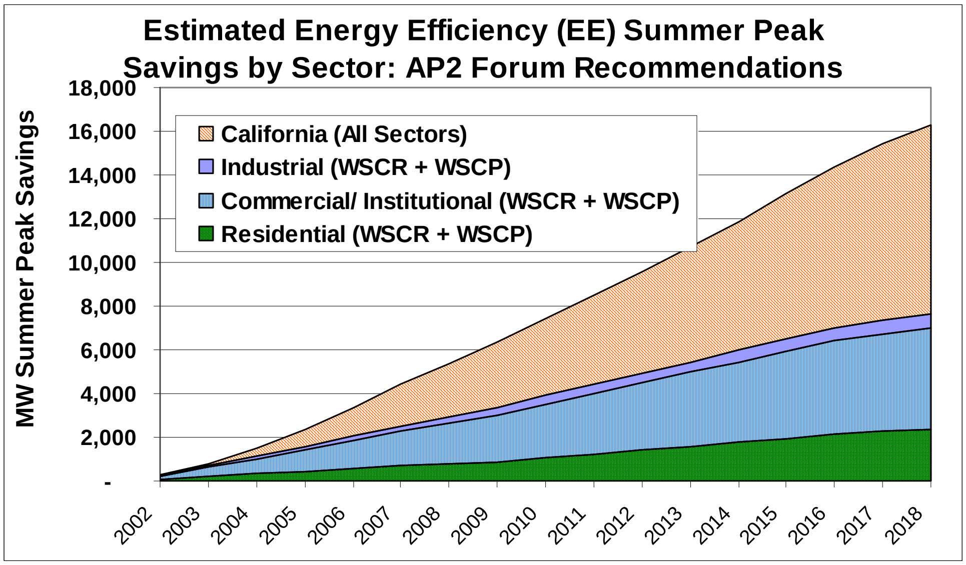


Figure 16:



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-medium-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

WSCR, 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

PROGRAM/MEASURE	Units of Measure Application	Annual Program Participation (in measure units) 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

ATTACHMENT 3:
EXAMPLES OF ENERGY EFFICIENCY MEASURE AND PROGRAM EVALUATIONS PERFORMED FOR THE WESTERN REGIONAL AIR PARTNERSHIP (WRAP)

The three "text boxes" that follow provide example of the procedures used in the evaluation of energy efficiency measures for the Air Pollution Partnership Forum of WRAP. The examples shown—for Commercial/Institutional/Industrial Transformers, Residential Air Conditioning, and Commercial Refrigeration—illustrate 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[34]. 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[35].

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.

[34] 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.

[35] 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.

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[36]. 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[37]. 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[38]. 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 judgment as to what a well-advertised, aggressive program might accomplish, 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 assumed, 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[39].

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)[40]. ECO was then used to calculate streams of annual costs (on

[36] From the 1997 ORNL report cited earlier.
[37] 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.
[38] National and state-level electricity sales data from the Energy Information Administration (EIA) of the US Department of Energy (USDOE).
[39] "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.
[40] The discount rate used here is similar to real discount rates used by large utilities operating in the West.

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.