THE NEW MOTHER LODE

The Potential for More Efficient Electricity Use in the Southwest

A report in the Hewlett Foundation Energy Series

November 2002

SWEEP

Southwest Energy Efficiency Project

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This study is available on the SWEEP (www.swenergy.org) and Energy Foundation (www.ef.org) websites.

PREFACE

This study was prepared by a team of researchers commissioned by the Southwest Energy Efficiency Project (SWEEP). Howard Geller, director of SWEEP, conceived the study and supervised the project. He also wrote the Executive Summary, Chapters 1 and 5, and edited the entire study. Chapter 2 along with Appendices A, B, and C were prepared by Neal Elliott, Toru Kubo, Steve Nadel, and Anna Shipley of the American Council for an Energy-Efficient Economy, along with Robert Mowris of Robert Mowris and Associates, Patti Case of the Etc Group, Inc., and Steve Bernow and Rachel Cleetus of the Tellus Institute. Chapter 3 and Appendix D were prepared by Alison Bailie, Steve Bernow, Bill Dougherty, and Ben Runkle of the Tellus Institute. Chapter 4 was prepared by Marshall Goldberg of MRG & Associates. Larry Kinney and Mark Ruzzin of SWEEP assisted with portions of Chapter 5, the appendices, editing, and formatting.

A number of individuals provided valuable information and/or reviewed a draft of the study. We thank Jeff Bumgarner, Jeff Burks, Mark Case, Ed Lewis, Arnold Lopez, John Nielsen, Jeff Schlegel, Chris Schroeder, Harold Trujillo, and Heidi VanGenderen for their assistance in this regard.

The Energy Foundation and the Hewlett Foundation provided primary funding for this study. In addition, the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy and the U.S. Environmental Protection Agency, Office of Air and Radiation provided supplemental funding. All views and opinions expressed herein are those of SWEEP and do not necessarily reflect the views of the funders, contributors, or reviewers.

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HIGHLIGHTS

The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest examines the potential for and benefits from increasing the efficiency of electricity use in the southwest states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming. The study models two scenarios, a "business as usual" Base Scenario and a High Efficiency Scenario that gradually increases the efficiency of electricity use in homes and workplaces during 2003-2020.

Major regional benefits of pursuing the High Efficiency Scenario include:

- Reducing average electricity demand growth from 2.6 percent per year in the Base Scenario to 0.7 percent per year in the High Efficiency Scenario;
- Reducing total electricity consumption 18 percent (41,400 GWh/yr) by 2010 and 33 percent (99,000 GWh/yr) by 2020;
- Eliminating the need to construct thirty-four 500 megawatt power plants or their equivalent by 2020;
- Saving consumers and businesses $28 billion net between 2003-2020, or about $4,800 per current household in the region;
- Increasing regional employment by 58,400 jobs (about 0.45 percent) and regional personal income by $1.34 billion per year by 2020;
- Saving 25 billion gallons of water per year by 2010 and nearly 62 billion gallons per year by 2020; and
- Reducing carbon dioxide emissions, the main gas contributing to human-induced global warming, by 13 percent in 2010 and 26 percent in 2020, relative to the emissions of the Base Scenario.

These significant benefits can be achieved with a total investment of nearly $9 billion in efficiency measures during 2003-2020 (2000 $). The total economic benefit during this period is estimated to be about $37 billion, meaning the benefit-cost ratio is about 4.2. The efficiency measures on average would have a cost of $0.02 per kWh saved.

The High Efficiency Scenario is based on the accelerated adoption of cost-effective energy efficiency measures, including more efficient appliances and air conditioning systems, more efficient lamps and other lighting devices, more efficient design and construction of new homes and commercial buildings, efficiency improvements in motor systems, and greater efficiency in other devices and processes used by industry. These measures are all commercially available but underutilized today. Accelerated adoption of these measures cannot eliminate all the electricity demand growth anticipated by 2020 in the Base Scenario, but it can eliminate most of it.

The High Efficiency Scenario indicates slightly different savings levels among the six states. The savings potential in 2010 equals 17 percent in Colorado and Utah, 18 percent in Arizona and Nevada, and 19 percent in New Mexico and Wyoming. The savings potential in 2020 equals 31 percent in Colorado, Nevada, and Utah, 34 percent in Arizona, and 36 percent in New Mexico and Wyoming.

The study acknowledges that the High Efficiency future will not happen on its own. While some utility, state, and local energy efficiency programs are advancing energy efficiency in the region, these programs are relatively limited in scope and budget. The study recommends new and expanded initiatives to achieve the High Efficiency future and its benefits, including:

- Adopting Systems Benefit Charges or Energy Efficiency Performance Standards to expand utility-based energy efficiency programs;
- Providing utilities with financial incentives to implement effective energy efficiency programs;
- Reforming utility rates to encourage greater energy efficiency;
- Upgrading to state-of-the-art building codes and promoting the construction of highly efficient new buildings that exceed these codes;
- Adopting minimum efficiency standards on products not yet covered by national standards;
- Providing sales tax waivers or income tax credits for innovative energy-efficient technologies;
- Expanding participation in industrial voluntary commitment programs;
- Adopting “best practices” in public sector energy management;
- Expanding energy efficiency training and technical assistance programs; and
- Incorporating energy efficiency initiatives in pollution control strategies.

Implementing a combination of these policies could result in achieving the full savings potential identified in this study, 18 percent savings by 2010 and 33 percent saving by 2020 for the region as a whole. The time has come for the southwest to “mine” this most attractive energy resource—greater energy efficiency.

EXECUTIVE SUMMARY

INTRODUCTION

The southwest region, consisting of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming, is the fastest growing region of the country in terms of both population and electricity demand. Electricity demand in this region rose 3.7 percent per year on average during 1990-2000, compared to 2.5 percent per year for the nation as a whole. The region is also heavily dependent on coal-fired power plants. These plants provided 72.5 percent of the 269,000 GWh of electricity generated in the six-state region in 1999.

Both coal and natural gas are produced in large quantities in the region. With plentiful and inexpensive fuels, electricity is relatively low cost. The consumption-weighted average electricity price in the region was about 6.2 cents per kWh as of 2000, about 10 percent less than the national average of 6.8 cents per kWh. Within the region, prices are above average in Arizona and New Mexico mainly because of the expensive nuclear power capacity co-owned by utilities in these states.

The region as a whole spent $11.6 billion on electricity purchases as of 2000. This is equivalent to about $2,100 per household (i.e., the sum includes the money spent by businesses and households on electricity, not just direct household purchases). For comparison, this is slightly more than property taxes paid in these states and about half what state and local governments spend on education in these states. Electricity expenditures are increasing due to both rising electricity prices and growing electricity consumption.

Due to high growth in electricity use, many new power plants and associated transmission and distribution (T&D) facilities are under construction or proposed in the region. Today utilities are mainly constructing gas-fired power plants, but some new coal-fired power plants have been proposed and are undergoing regulatory review. High growth in electricity use causes a number of problems including:

- placing upward pressure on electricity and natural gas prices,
- causing power plant and transmission line siting controversies,
- increasing the risk of power outages and diminished electrical reliability,
- increasing air pollution and other adverse environmental impacts,
- increasing the social and monetary costs associated with pollution-related illnesses,
- increasing water consumption, and
- increasing the “greenhouse gas” emissions that are contributing to global warming.

This study analyzes the technical and economic potential for improving the efficiency of electricity use in the southwest region. It develops a High Efficiency Scenario assuming aggressive but achievable implementation of cost-effective efficiency measures, as well as a

Base Scenario assuming a continuation of current policies and trends. The two scenarios are compared in terms of their impacts on construction of new power plants, total energy supply costs, regional employment and income, water consumption, and pollutant emissions. In addition, this study reviews the policies and programs that are promoting more efficient electricity use in the region, and recommends new or expanded policies that would accelerate the implementation of cost-effective efficiency measures.

ENERGY EFFICIENCY POTENTIAL (Chapter 2)

Specific Savings Opportunities

Many cost-effective energy savings measures are available in the marketplace today. For commercial buildings, large energy savings can be achieved through: 1) installing more efficient lighting systems, 2) replacing HVAC equipment with more efficient units and improving the efficiency of existing HVAC systems, 3) testing and sealing air distribution ducts, and 4) replacing inefficient office equipment with more energy-efficient products. Replacing lighting systems in commercial buildings with more efficient fixtures, lamps, ballasts, and improved controls can save more than 50 percent of lighting energy use. We estimate that the payback period for lighting efficiency improvements in commercial buildings is only 1.3 years on average. Installing more efficient fans, chillers, and packaged air conditioning equipment in commercial buildings can reduce overall electricity consumption by 14-18 percent with a payback of 1.3-2.0 years on the incremental first cost. Testing and sealing air distribution ducts can save 9-15 percent of a building’s total electricity consumption with a payback period of 2.8-3.4 years on average. And energy-efficient office equipment can reduce total electricity consumption by 15-20 percent in office buildings at minimal incremental cost.

In the residential sector, the major electricity savings opportunities are in the areas of lighting, water heating, and air conditioning. Use of more energy efficient lamps can save approximately 630 kWh per year per home, over two-thirds of the energy used for lighting in a typical home. We estimate that the payback period for these efficiency measures is around 2.4 years on average. Electricity use for water heating can be cut by 50 percent or more through measures that lower hot water use as well as increase the efficiency of water heating. Substantial electricity savings also will occur when older refrigerators and freezers are replaced with new models. But these savings are occurring due to national appliance efficiency standards that have already been adopted, so we do not include these savings in the High Efficiency Scenario.

There are many techniques for reducing electricity use for air conditioning through lowering cooling load (e.g., installing energy-efficient windows, programmable thermostats, reflective roofs, and more efficient lighting) and increasing cooling system efficiency (e.g., high efficiency air conditioners, air conditioner tune-ups, duct testing and sealing, and conversion to evaporative cooling). The overall savings potential from a combination of these measures can be 70 percent or greater, with an estimated payback period of 3.2 years on average in the southwest region.

In the industrial sector, motors consume about two-thirds of electricity used in general. Furthermore, motors consume about 90 percent of the electricity used in the mining industry, the most important industrial sub-sector in the southwest. Energy savings opportunities exist in both the motor, the motor-driven device (e.g., fan, compressor, or pump), and in overall motor system design. These measures include replacing oversized motors, cutting unnecessary flows and friction losses in fluid systems, improving gear ratios, changing fan pulleys or trimming pump impellers, and replacing throttling valves with adjustable speed drives or other speed control devices. Electricity use can drop by 5-50 percent depending on the characteristics of the initial system.

Compressed air systems often present a significant opportunity for cost-effective energy savings through cutting leaks and inappropriate uses, reducing operating pressure, improving maintenance, and installing better controls. The overall savings range from 25 to over 60 percent.

Increasing energy efficiency can provide a variety of non-energy benefits in addition to saving energy. For example, sealing and properly sizing air distribution ducts as well as properly sizing air conditioning systems can greatly improve thermal comfort within homes. Use of daylighting can increase worker productivity or retail sales in the commercial sector, as well as student performance in schools. And industrial process efficiency improvements can improve productivity, reduce materials use and waste, and save energy. These non-energy benefits were not considered or included in this study, suggesting that our results are conservative.

Analytical Methodology

In the Base Scenario, we estimate that residential electricity demand will increase 2.4 percent per annum, commercial sector electricity demand 3.5 percent per annum, and industrial electricity demand by 1.6 percent per annum during 2003-2020. The overall growth rate for electricity demand is 2.6 percent per annum in the Base Scenario.

The High Efficiency Scenario assumes widespread adoption of cost-effective, commercially available energy efficiency measures during 2003-2020. For the buildings sectors, the analysis was conducted using a “bottom up” approach that considers a wide range of efficiency measures for different end uses and building types. The analysis examined six different building types: single family homes, multifamily homes, office buildings, retail stores, schools, and food service/sales buildings. For each building type, separate analyses were carried out for typical new and existing buildings. Furthermore, in-depth analyses were carried out for two cities in the region: Denver (representative of the northern tier states) and Las Vegas (representative of the southern tier states). The cost-effective savings potential identified for these building types and cities was then extrapolated to other building types and locales in the region.

Aggregate energy savings potential was estimated by first determining the proportion of the building stock for which each efficiency measure is appropriate (i.e., had not been installed yet, is technically feasible, and is cost-effective to consumers on a life-cycle cost basis). Efficiency measures were considered cost effective if they exhibited a cost of saved energy below the retail electricity price, with a 5 percent real discount rate used to compute cost of saved energy. For measures such as high efficiency appliances or air conditioners, the "cost" of the measure is the incremental cost for greater energy efficiency at the time of equipment replacement or purchase for a new building. In addition, we added 10 percent to the installed cost of all efficiency measures to account for policy and program implementation costs.

Regarding implementation rates, we assumed aggressive but potentially achievable implementation of cost-effective efficiency measures. For existing buildings, we assumed that cost-effective measures would be gradually installed during 2003-2020, specifically that 4.4 percent of cost-effective measures would be implemented each year. This means that 80 percent of the identified cost-effective savings potential would be realized in existing buildings by 2020. For new buildings, we assumed that 50 percent of the cost-effective measures would be installed starting in 2003 and that this fraction gradually increases, reaching 100 percent in new buildings constructed in 2010 and thereafter. A high level of implementation is possible in new buildings through the adoption and enforcement of building energy codes. However, our analysis is conservative in that it does not include additional energy efficiency measures beyond those identified as cost-effective today, even though it is nearly certain that additional measures will be developed and commercialized in the future.

In the industrial sector, the Long-Term Industrial Energy Forecasting (LIEF) model was used to analyze cost-effective electricity savings potential. This computer model, developed by Argonne National Laboratory, projects future electricity consumption by industrial sub-sector based on growth in output and changes in energy intensity. Energy intensity is influenced by three key variables in the model related to the cost effectiveness and adoption of energy efficiency measures – the assumed penetration rate, the capital recovery factor (CRF), and projected electricity prices. The LIEF model contains assumptions regarding the cost for achieving different levels of energy savings in 17 industrial sub-sectors.

For the Base Scenario, we assumed a CRF of 33 percent and a penetration rate for cost-effective energy efficiency measures of 3.25 percent. This CRF and penetration rate are typical of decision making in industries today where a host of factors discourages pursuit of energy efficiency measures with more than a 2 or 3 year payback.

For the High Efficiency Scenario, we assumed that industries accept a longer payback period and implement energy efficiency measures more rapidly because they are better informed about energy efficiency opportunities and their potential benefits, the transaction costs for obtaining efficiency measures are reduced, technical assistance is offered, and financial incentives are provided. In particular, the CRF was reduced to 9.6 percent and the penetration rate for cost-effective efficiency measures was increased to 6.5 percent per year in the High

Efficiency Scenario.

Results

Figure ES-1 shows growth in electricity demand in 2010 and 2020 in the Base and High Efficiency Scenarios for the region as a whole. In the Base Scenario, electricity demand increases 59 percent between 2002 and 2020. In the High Efficiency Scenario, the increase in electricity demand is limited to 13 percent during this time period. The overall cost-effective electricity savings potential for the region is about 18 percent (41,400 GWh/yr) by 2010 and 33 percent (99,000 GWh/yr) by 2020 in the High Efficiency Scenario (relative to electricity demand in the Base Scenario).

Figure ES-1. *Total Electricity Consumption in the Base and High Efficiency Scenarios*

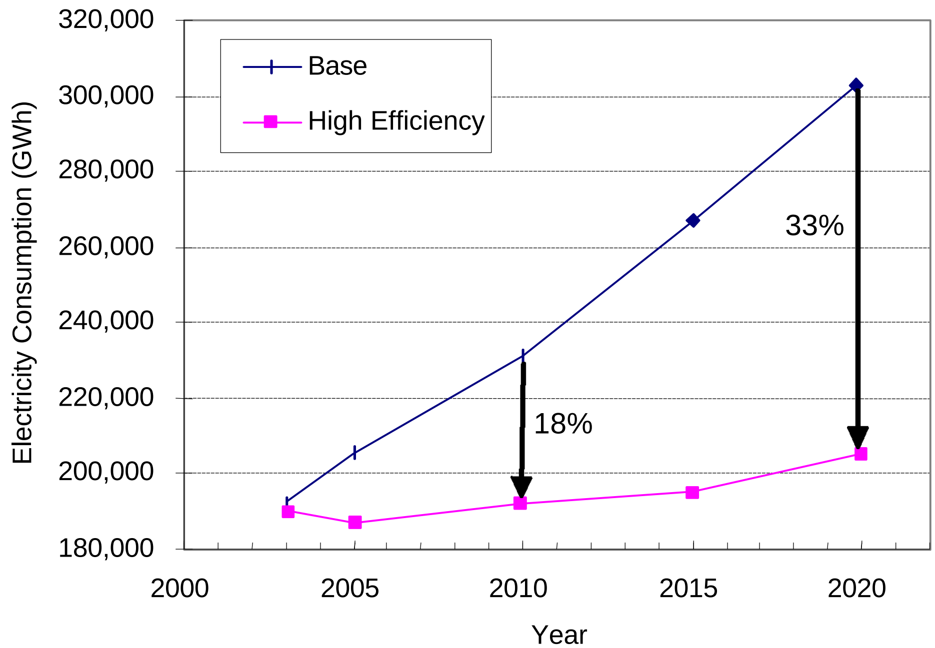


Table ES-1 shows the energy savings potential results for the six states as well as the region in 2020, disaggregated by sector. The savings potential is highest in the commercial sector (37 percent by 2020), followed by the industrial sector (33 percent by 2020), and then the residential sector (26 percent by 2020). The savings potential is approximately the same in percentage terms among states for the commercial sector. However, there is moderate variation in savings potential among states in the residential and industrial sectors due to differences in climate, industrial mix, and electricity prices. The overall savings potential varies from a low of 31 percent in Colorado, Nevada, and Utah to a high of nearly 36 percent in New Mexico and Wyoming.

Table ES-1. *Energy Savings Potential in 2020 by Sector and State*

		Region	AZ	CO	NV	NM	UT	WY
Commercial Sector								
Baseline Consumption	GWh	134,780	50,667	36,903	16,625	11,261	15,645	3,680
Savings Potential	GWh	50,291	18,862	13,655	6,087	4,356	5,866	1,465
Savings Potential	%	**37.3**	**37.2**	**37.0**	**36.6**	**38.7**	**37.5**	**39.8**
Residential Sector								
Baseline Consumption	GWh	93,557	38,602	19,902	14,085	7,488	10,474	3,007
Savings Potential	GWh	24,593	11,546	4,408	3,067	2,319	2,506	748
Savings Potential	%	**26.3**	**29.9**	**22.1**	**21.8**	**31.0**	**23.9**	**24.9**
Industrial Sector								
Baseline Consumption	GWh	74,043	18,522	14,875	14,812	6,122	10,766	8,947
Savings Potential	GWh	24,150	6,180	4,290	5,000	2,220	3,130	3,340
Savings Potential	%	**32.6**	**33.3**	**28.8**	**33.8**	**36.3**	**29.1**	**37.3**
All Sectors								
Baseline Consumption	GWh	302,381	107,790	71,680	45,521	24,871	36,885	15,633
Savings Potential	GWh	99,039	36,584	22,351	14,154	8,896	11,500	5,552
Savings Potential	%	**32.8**	**33.9**	**31.2**	**31.1**	**35.8**	**31.2**	**35.5**

UTILITY ANALYSIS (Chapter 3)

To estimate the energy, economic and environmental benefits of the electricity savings in the High Efficiency Scenario, we used the National Energy Modeling System (NEMS), a computer model developed and routinely used by the Energy Information Administration of the U.S. Department of Energy. For each scenario, NEMS determines the construction and operation of power plants required to meet electricity demand and to comply with various regulations. The difference in costs, energy consumption, water consumption, and emissions between the two scenarios represents the impacts of the energy efficiency measures.

The High Efficiency Scenario leads to a wide range of energy, economic and environmental benefits for the region as a whole including:

- Avoiding the construction of thirty-four 500 MW power plants (or equivalent) during 2003-2020;
- Saving households and businesses $28 billion net during 2003-2020, or about $4,800 per current household in the region;
- Saving nearly 25 billion gallons of water annually by 2010 and 62 billion gallons by 2020; and
- Cutting pollutant emissions during 2003-2020 by:
    - 176 million metric tons of carbon;

- 57,000 tons of SO_2;
- 347,000 tons of NO_x; and
- 2.2 tons of mercury.

Table ES-2 presents more details regarding the regional economic results. The expenditure of almost $8.9 billion on energy-efficient measures in the High Efficiency Scenario results in about $34.7 billion in reduced electricity sector costs and an additional $2.4 billion in reduced natural gas costs, leading to a net benefit of $28 billion and region-wide benefit-cost ratio of about 4.2.

Table ES-2. *Regional Economic Analysis Results (2000 dollars)*

	2010	**2020**	**Cumulative present value 2003-2020**
Cost of Energy Efficiency Measures (billion $)			
Commercial	0.27	0.73	3.04
Residential	0.30	0.71	3.20
Industrial	0.26	0.42	2.60
Total:	0.84	1.86	8.85
Benefits (billion $)			
Avoided Electric Supply Costs[a]	3.32	7.92	34.66
Natural Gas Price Effects[b]	0.18	0.42	2.39
Total:	3.50	8.34	37.06
Net Benefit (billion $)	**2.66**	**6.48**	**28.21**
Net Benefit per household ($)[c]	**451**	**1,100**	**4,788**
Benefit-Cost Ratio	**4.15**	**4.48**	**4.19**

[a] *Represents avoided capital and operating costs in electricity, including generation, transmission and distribution.*
[b] *Accounts for reduced natural gas prices in the residential, commercial, and industrial sectors as a result of less natural gas demand for electricity generation.*
[c] *Calculated as the net benefit, combining benefits to households and businesses, divided by the number of households in the region in 2000.*

Table ES-3 presents the environmental results for the region as a whole. Carbon dioxide (often referred to and measured in terms of tons of carbon) is the main "greenhouse gas" contributing to human-induced global warming. The High Efficiency Scenario reduces carbon emissions by 13 percent in 2010 and 26 percent in 2020 relative to emissions in the Base Scenario. The carbon emission reductions are relatively close to the electricity savings in percentage terms.

Reductions in other pollutant emissions are positive but relatively modest in percentage terms. Sulfur dioxide (SO_2) emissions reductions are regulated under the federal cap and trade program. Utilities respond to lower electricity demand in the High Efficiency Scenario by limiting their investments, compared to the Base Scenario, in measures to reduce SO_2 emissions, such as installing scrubbers or shifting to lower sulfur coal. The utilities save money through these actions but the total amount of SO_2 emissions is only decreased by 1 percent in

2010 and 4 percent in 2020 in the High Efficiency Scenario, relative to emissions in the Base Scenario.

Nitrogen oxides (NO_x) emissions reductions are relatively modest (2 percent by 2010 and 5 percent by 2020) because new power plants generally have much lower NO_x emissions rates than existing plants. Mercury emission reductions are also relatively modest (3 percent by 2010 and 7 percent by 2020) because of the type of power plants and fuels that are avoided, and their level of pollution control.

Table ES-3. *Regional Environmental Results*

	2010		2020	
Pollutant	Reductions	% Change[a]	**Reductions**	% Change[a]
Carbon (MMTCE)	8.40	13	19.84	26
SO_2 (million tons)	0.005	1	0.015	4
NO_x (million tons)	0.016	2	0.036	5
Mercury (tons)	0.110	3	0.275	7

[a] *Reduction in emissions relative to levels in the Base Scenario.*

State-by-state economic and environmental results are presented Table ES-4. While there are not large differences among states in terms of benefit-cost ratio or percentage emissions reductions, there are some differences due to variations in savings potential, the type of generation avoided, and the ratio of savings to total power generation among the states.

Table ES-4. *Economic and Environmental Impacts of the High Efficiency Scenario by State*

Parameter:	State					
	AZ	CO	NV	NM	UT	WY
Economic impacts, cumulative present value during 2003-2020 in billion dollars						
Cost of efficiency measures	3.3	2.0	1.1	0.8	1.1	0.5
Benefits of efficiency measures	13.8	8.5	5.2	3.6	3.9	2.1
Net benefits	10.5	6.4	4.1	2.8	2.9	1.5
Benefit-cost ratio	4.2	4.2	4.6	4.3	3.7	3.9
Environmental impacts, percent reduction in emissions in 2020						
Carbon emissions	36	30	30	20	19	8
SO_2 emissions	11	5	3	3	2	0
NO_x emissions	11	7	7	3	3	1
Mercury emissions	12	17	15	2	12	1

Conventional fossil fuel-based power plants consume a substantial amount of water for power generation, primarily in their cooling systems. We estimate that a typical new coal-fired power plant in the region consumes about 0.67 gallons of water per kWh while a typical new natural gas-fired combined cycle power plant consumes about 0.33 gallons of water per kWh. In addition to water savings from reduced conventional power generation, the High Efficiency Scenario will lead to water savings from the accelerated adoption of resource-efficient clothes washers and other water conservation measures in homes.

Table ES-5 shows the estimated water savings in 2010 and 2020 from both reduced power generation and increased penetration of resource-efficient clothes washers. The overall water savings for the region as a whole reach about 25 billion gallons per year in 2010 (equivalent to about 76,000 acre-feet or the water consumed annually by around 137,000 households). The water savings reach nearly 62 billion gallons per year in 2020 (equivalent to about 189,000 acre-feet or the water consumed annually by around 339,000 households).

Table ES-5. *Water Savings Results (billion gallons per year)*

STATE	**2010**	**2020**
Arizona	8.99	22.41
Colorado	5.78	14.24
Nevada	3.35	8.46
New Mexico	3.26	6.53
Utah	2.25	6.93
Wyoming	1.10	3.00
Region	**24.7**	**61.6**

MACROECONOMIC IMPACTS (Chapter 4)

We used input-output analysis to estimate the potential employment and other macroeconomic impacts of the High Efficiency Scenario, in contrast to the Base Scenario. Input-output analysis considers the direct as well as indirect effects from shifting expenditures in a state or regional economy. For example, it takes into account how a purchase of energy-efficient lighting affects the purchaser, lighting suppliers and manufacturers, utilities, and the economy as a whole through spending energy bill savings on other goods and services.

The analysis finds that shifting expenditures away from electricity purchases and towards energy efficiency measures has a positive effect on state and regional economies. As it turns out, the electric utility industry in the region supports only four to five jobs per million dollars of expenditures, as compared to 11 – 16 jobs in the construction sector, 17 – 27 jobs in the services sector, and 23 – 33 jobs in the retail sector. Likewise the coal mining industry supports relatively few jobs, just 5 – 8 jobs per million dollars of expenditures. Much of the net job creation from energy efficiency improvements is derived from the difference between jobs intensity between the electric utility and other sectors.

Using a state-specific input-output model known as IMPLAN, we estimated the changes in

Gross State Product (GSP), wage and salary compensation, and employment levels that would occur if the High Efficiency Scenario were to occur rather than the Base Scenario. Table ES-6 presents the results in 2010 and 2020 by state and for the region as a whole. Both wage and salary earnings and employment rise as a result of pursuing the High Efficiency Scenario rather than the Base Scenario. By 2020, regional wage and salary earnings increase by $1.34 billion (in 2000 dollars) and regional employment increases by 58,400 jobs. However, regional GSP declines slightly in the High Efficiency Scenario for a number of reasons, primarily due to declining capital investment (see Chapter 4). Even though GSP falls, wage and salary compensation rises as labor payments are substituted for capital investment in the larger economy.

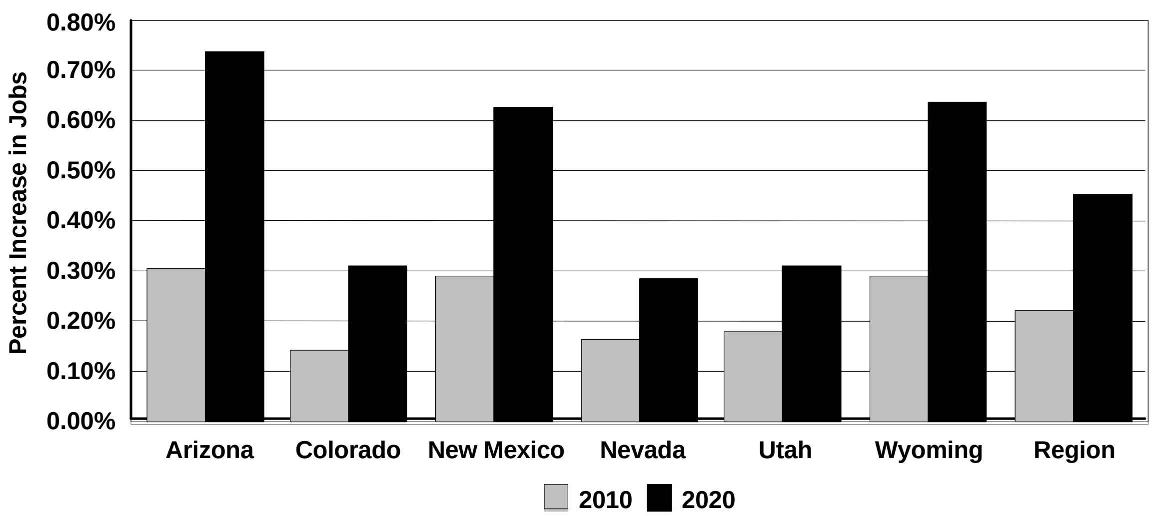
Table ES-6. *Macroeconomic Impacts from the High Efficiency Scenario*

Year	Net Change in Jobs	Change in Wage and Salary Compensation (Million $)	Change in Gross State Product (Million $)
Arizona			
2010	8,100	$180	($130)
2020	24,100	$550	($230)
Colorado			
2010	4,000	$90	($60)
2020	12,200	$280	($100)
New Mexico			
2010	2,600	$50	($50)
2020	6,900	$130	($110)
Nevada			
2010	2,400	$60	($40)
2020	6,300	$180	($90)
Utah			
2010	2,200	$50	$0
2020	6,300	$160	$50
Wyoming			
2010	800	$20	($30)
2020	2,000	$40	($60)
Region			
2010	20,500	$450	($320)
2020	58,400	$1,340	($560)

Notes: *Dollar figures are in millions of 2000 dollars while employment is expressed in full-time equivalent. Region totals are slightly different from the sum of six states due to independent rounding.*

As shown in Figure ES-2, the increase in employment in 2010 averages slightly over 0.2 percent for the region as a whole and ranges from 0.14 percent in Colorado to 0.30 percent in Arizona. By 2020, the increase in employment averages about 0.45 percent for the region as a whole and ranges from 0.28 percent in Nevada to 0.74 percent in Arizona. The variation among states is caused by differences in economic and population structure, electricity savings potential, and projected job growth. Arizona has the highest percent increase in jobs primarily because it has a relatively low employment-to-population ratio (i.e., there are a large number of retirees in Arizona).

Figure ES-2. *Job Increases Due To the High Efficiency Scenario*



Chapter 4 also includes estimates of job gain and loss by sector, for each state and the region as a whole. In general, the utility and energy supply sectors (coal, oil, and gas production) are the only sectors that lose jobs in moving from the Base to the High Efficiency Scenarios. All other sectors including manufacturing, services, retail trade, government, and construction gain jobs. Furthermore, the total regional jobs gain by 2020 (66,000) is about nine times the jobs loss (7,500).

Electric utilities are the main sector that loses jobs in the High Efficiency Scenario. Fewer utility jobs are sustained as fewer new power plants are needed and less electricity is produced. But utilities could mitigate or offset this effect if they move into the energy efficiency business, thereby absorbing some of the job gains assigned to other sectors — such as the construction and service sectors.

Finally, it should be noted that the full economic effects of the efficiency improvements are not accounted for since the analysis ignores electricity bill savings beyond 2020. Nor does the analysis include the non-energy benefits that are likely to result along with energy savings. These can be substantial, especially in the industrial sector. To the extent these "co-benefits" are realized in addition to the energy savings, the macroeconomic benefits would be greater than those reported here.

POLICY REVIEW AND RECOMMENDATIONS (Chapter 5)

Some utility, state, and local energy efficiency programs are advancing energy efficiency in the southwest including but not limited to:

- Utility energy efficiency programs operating in Colorado and Utah;
- Reasonably up-to-date building energy codes in some jurisdictions in Colorado, Nevada, and all of Utah;
- Energy-efficient new home promotion, training, and incentive programs in Phoenix, Tucson, Las Vegas, and Utah;
- Initiatives to upgrade the energy efficiency of public sector buildings (i.e., state and local buildings and schools) in nearly all of the southwest states; and
- Energy audits and technical assistance provided by the three Industrial Assessment Centers in the region.

Presently, these programs are relatively limited in scope and budget, and not adequate for overcoming the barriers inhibiting widespread improvements in efficient electricity use. More important, many critical policies and programs are absent in parts of the region. As a result, inefficient electricity use is commonplace in homes, commercial buildings, and industries. The status of energy efficiency policies and programs in each of the six states is reviewed in Chapter 5. In addition, we recommend a broad set policy initiatives that would lead to greater adoption of cost-effective energy savings measures in the region. These recommendations are summarized below.

Recommendation: ***Adopt Systems Benefit Charges or Energy Efficiency Performance Standards to Expand Utility-based Energy Efficiency Programs***

A Systems Benefit Charge (SBC) is a small surcharge paid by all electric utility consumers to fund energy efficiency programs implemented by either utilities or other program administrators. About 20 states across the country have adopted SBCs. We recommend that the southwest states adopt SBC mechanisms (or in some cases expand existing SBC mechanisms) to greatly increase funding for utility energy efficiency programs, except perhaps in Utah where utility efficiency programs are expanding already. Doing so could increase funding for energy efficiency programs in the region by 9 times or more, and could result in 10-15 percent electricity savings in the region by 2020.

The adoption of an Energy Efficiency Performance Standard (EEPS), which Texas has pioneered, is an alternative approach to achieving these savings. An EEPS would specify energy savings targets and timetables for electric utilities, rather than specifying funding levels. As part of this policy, it may be possible to establish a market for energy savings certificates or credits, thereby enabling independent developers of energy efficiency projects (e.g., energy service companies) to participate in and benefit from the energy savings requirements.

Recommendation: ***Undertake Energy Efficiency and Load Management Efforts to Help Defer Transmission and Distribution (T&D) System Investments***

Geographically-targeted energy efficiency improvements and peak load reduction efforts can help to defer costly investments in T&D systems and can help to improve power reliability in areas with heavily loaded T&D lines. Utility regulators in the region should insist that utilities undertake targeted DSM efforts if this appears to be technically and economically feasible as a means for deferring T&D system investments. A targeted DSM program would attempt to achieve high participation rates in a particular neighborhood or community. It might involve additional efficiency measures and/or program delivery mechanisms, increased financial incentives, and enhanced marketing.

Recommendation: ***Provide Utilities with Financial Incentives to Implement Effective Energy Efficiency Programs***

Many utilities resist operating vigorous end-use energy efficiency programs because it reduces their sales and revenues in the short run. Therefore, utility regulators or legislatures in states such as California, Massachusetts, Minnesota, New York, and Oregon have offered utilities the opportunity to benefit financially from operating effective energy efficiency programs. These financial incentives, sometimes known as shareholder incentives, reward utilities based on the level of energy savings produced and/or cost effectiveness of their energy efficiency programs. We recommend offering shareholder incentives to all investor-owned utilities that operate substantial and cost-effective energy efficiency programs in the southwest region. An incentive level of 15-25 percent of the net economic benefits provided by the programs should be adequate. This recommendation is consistent with the energy policy approved by the Western Governors' Association.

Recommendation: ***Reform Utility Rates to Encourage Greater Energy Efficiency***

Today residential and smaller commercial customers in the southwest states generally pay flat rates; i.e., they pay the same amount per kWh of electricity consumed. Instead of flat rates, customers could pay tiered rates (also known as inverted block rates), whereby rates increase as usage increases. This would give consumers and businesses an additional financial incentive to reduce their overall electricity consumption.

Time-of-use rates charge more for electricity use during high load, high cost periods (and less during off-peak, low cost periods). As much as a 10 percent average electricity savings has occurred in well-designed time-of-use rates programs, due in part to providing participants with practical load control devices. We recommend adopting tiered rates and time-of-use rates in the southwest states, in conjunction with expanded utility (or state-based) energy efficiency programs and financial incentives to reward utilities for operating effective programs.

Recommendation: ***Upgrade to State-of-the-Art Building Energy Codes***

State-of-the-art energy codes such as the latest version of the International Energy Conservation Code (IECC) will reduce electricity use and peak load in new homes and commercial buildings. State-of-the-art building energy codes should be adopted statewide in New Mexico, Nevada, and Wyoming since these are not home rule states. Likewise, state-of-the-art codes should be adopted at the local level where this has not yet been done in Arizona (especially in Phoenix) and Colorado (especially in the Denver and Colorado Springs areas) given that these are home rule states. All of these states and localities should consider enhancing the IECC or ASHRAE standards with modifications that further improve energy efficiency in a hot, dry region.

Recommendation: ***Expand Training and Technical Assistance Efforts to Achieve High Levels of Code Compliance***

Training and assisting architects, builders, contractors, and building code officials is critical to the successful implementation of building energy codes. Training and technical assistance is needed in a variety of areas including integrated building design, proper sizing and installation of HVAC systems, proper air tightness and insulation procedures, and the use of state-of-the-art technologies and design strategies. We recommend that state energy agencies, local energy offices, utilities, and private organizations in the southwest expand their efforts related to energy code training and enforcement. Utilities in particular should support code implementation as part of their energy efficiency programs, in addition to encouraging construction of highly efficient "beyond code" new homes and commercial buildings.

Recommendation: ***Expand Efforts to Promote the Construction of Highly Efficient New Buildings that Exceed Minimum Code Requirements***

It is possible to reduce the energy consumption of new homes and commercial buildings by 30 to 50 percent relative to code requirements, and do so in a cost-effective manner, through an integrated design approach. This potential is not speculative; it has been proven in Civano, AZ, and in the housing developments of Ence, Pulte, and other leading builders in the region. We recommend that energy agencies and utilities in the region replicate the training, promotion, financial incentive, and energy bill guarantee programs that are leading to large numbers of highly efficient new homes in the Phoenix, Tucson, and Las Vegas areas. Also, we recommend expansion and replication of exemplary commercial building new construction programs such as Utah's state buildings design assistance and incentive program or the Energy Design Assistance Program implemented on a pilot scale by Xcel Energy in Denver.

Recommendation: ***Adopt Minimum Efficiency Standards on Products not yet covered by National Standards***

Appliance efficiency standards adopted at the state and federal levels have been a very effective energy conservation strategy. We recommend that the southwest states emulate the appliance efficiency standards recently adopted in California if the federal government does not do so. In addition, the southwest states should follow California's lead on standards pertaining to the standby and/or active mode power consumption of electronic devices, should California move ahead with standards in this area.

Recommendation: ***Provide Sales Tax Waivers or Income Tax Credits for Innovative Energy-Efficient Technologies***

We recommend that the southwest states adopt either sales tax waivers or income tax credits on highly energy-efficient products and new buildings, preferably modeled on the successful tax credits program in Oregon. These tax credits can and should be justified based on the net economic benefits they would provide to all consumers and businesses in a state, not just to those that participate. Tax credits should be carefully designed to avoid a high number of "free riders" and consequently high loss of tax revenue and/or small energy benefits, as occurred with the tax credit for alternative fuel vehicles in Arizona. Implementing this policy may be difficult given that most states are now experiencing budget deficits, but the policy merits consideration and implementation once the state budget outlook improves.

Recommendation: ***Adopt "Best Practices" in Public Sector Energy Management***

States and municipalities in the southwest region have adopted a number of useful policies that are cutting energy use and energy bills in public buildings. We recommend that all states and major municipalities adopt "Best Practices" already demonstrated somewhere in the region including: 1) establishing energy savings goals for state and municipal agencies and tracking progress towards the goals; 2) providing technical and financial assistance for implementation of energy savings projects in existing buildings and facilities; 3) constructing new buildings that are exemplary and surpass minimum energy code requirements by a wide margin; and 4) purchasing only Energy Star® labeled products where available.

Recommendation: ***Expand Education and Training in the Buildings Sector***

Many efforts are underway in the southwest region to educate and train consumers and businesses about ways to improve energy efficiency in residential and commercial buildings. We recommend that energy agencies and utilities undertake additional training and technical assistance efforts including training of HVAC contractors in order to improve air conditioner sizing and installation practices and training to improve the skills of the managers and operators of commercial buildings. Also, public agencies and utilities should collaborate and expand efforts to promote Energy Star® products and buildings, as well as state-of-the-art energy efficiency measures such as new types of evaporative cooling devices, sealing thermal distribution systems, use of reflective roofing materials, and daylighting techniques.

Recommendation: ***Expand Industrial Voluntary Commitment Programs***

Some major companies such as BP, DuPont, and Johnson & Johnson have made significant quantitative commitments for improving energy efficiency and/or reducing greenhouse gas emissions. We recommend initiating or expanding industrial voluntary commitment programs at the state level in the southwest, and/or encouraging greater participation in national commitment programs such as EPA's Climate Leaders program. In all cases, companies would agree to accelerate the implementation of cost-effective efficiency measures and make quantitative energy savings, energy intensity reduction, or carbon emissions reduction commitments. Energy agencies or programs in the region could provide technical assistance to companies that need help, as well as recognition to outstanding companies.

Recommendation: ***Expand Training and Technical Assistance Programs for the Industrial Sector***

We recommend that state energy offices and utilities expand their support for industrial energy efficiency efforts in general by sponsoring additional training courses for industrial energy managers. This training could include well-regarded courses and tools such as the courses, software, and manuals developed by the U.S. Department of Energy (DOE) Motor Challenge and Compressed Air Challenge programs. Training and technical assistance should be offered to all companies, large and small. Also, states and utilities should consider providing supplemental funding to the DOE-sponsored Industrial Assessment Centers in the region.

Recommendation: ***Incorporate Energy Efficiency Initiatives into Air Pollution Control Strategies***

As demonstrated in this study, end-use energy efficiency improvements can reduce pollutant emissions from fossil fuel-based power plants in a cost-effective manner. Environmental officials should support the initiation or expansion of energy efficiency efforts in their states, and incorporate these efforts in their air quality and emissions reduction plans. Environmental agencies, energy agencies, and energy efficiency program managers should work together to develop reasonable estimates of future energy savings and the emissions reductions associated with these savings. In addition, both state and local energy efficiency initiatives should be incorporated into the regional haze reduction plan being developed by the Western Regional Air Partnership.

Achieving the Savings in the High Efficiency Scenario

From the discussion above, it is clear that a wide range of policies and programs can be implemented to promote greater adoption of cost-effective energy efficiency measures. In the final section of this study, we present quantitative estimates of the savings that could result from six of our recommended policies and programs. In addition, we include a modest "market transformation" effect from expanding the energy efficiency supply infrastructure and changing consumer awareness and behavior as a result of implementing these (and other) policies and programs. This means that households and businesses will adopt efficiency measures to a greater degree in the market without incentives or other program-related assistance.

Table ES-7 shows the range of savings from each policy, assuming either moderately aggressive or very aggressive implementation, along with the market transformation effect. The overall savings potential is 28-47 percent by 2020, demonstrating that a combination of policies could result in achievement of the full cost-effective savings identified in this study--33 percent savings by 2020.

Table ES-7. *Potential Electricity Savings from Different Policy Options*

Policy or program	Electricity savings potential in 2020 (%)
Utility-based Energy Efficiency Programs	10 – 15
Utility Rate Reform	3 – 6
Building Codes	4 – 8
Appliance Standards	4
Tax Incentives	1 – 2
Public Sector Investment	1 – 2
Market Transformation Effect	5 – 10
Total	28 – 47

CONCLUSION

This study shows that there is large potential for increasing the efficiency of electricity use and reducing load growth in the southwest region, and doing so cost effectively in spite of the relatively low electricity prices in the region. It does not appear that end-use efficiency improvements can eliminate all the load growth anticipated over the next 18 years, but they can eliminate most of this growth. This study also shows that accelerating energy efficiency improvements will save consumers and businesses money while leading to a net increase in employment and personal income. Thus increasing energy efficiency can be an important economic development strategy for the region.

Accelerating energy efficiency improvements will also help to mitigate other problems associated with high electricity demand growth including rising water consumption, increasing risk of power outages, local and regional air pollution, and greenhouse gas emissions. Many new power plants can be avoided if vigorous energy efficiency improvements occur, thereby eliminating the need for the most contentious power plants and associated T&D facilities. Thus increasing energy efficiency is a "win-win" strategy from the perspective of saving money, boosting the region's economy, conserving precious water resources, and protecting the environment.

The High Efficiency Scenario, and its benefits, will not be realized without the adoption and implementation of new policies and programs to advance energy efficiency. Fortunately, many of these policies and programs have been proven either within the southwest or in other regions. We urge policy makers throughout the southwest to make increasing energy efficiency a high priority. The time has come for the southwest to "mine" this most attractive energy resource.

CHAPTER 1—INTRODUCTION

A. Background on Electricity Use in the Region

The southwest region, consisting of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming, is the fastest growing region of the country in terms of both population and electricity demand. Table 1-1 shows the change in electricity consumption in the region during 1990-2000. For the overall region, electricity demand rose 3.7 percent per year on average during this decade. Electricity consumption increased 5.4 percent per year in Nevada, 4.2 percent per year in Utah, 3.9 percent per year in Arizona, 3.4 percent per year in Colorado, and 3.1 percent per year in New Mexico on average. For comparison, national electricity consumption increased 2.5 per year on average during the 1990s.

Table 1-1. *Electricity Consumption in the Southwest Region in 1990 and 2000*

State	1990 Electricity Consumption (GWh/yr)	2000 Electricity Consumption (GWh/yr)	Change during 1990-2000 (%)
AZ	41,500	61,000	47.0
CO	30,800	43,000	39.6
NV	16,400	27,800	69.5
NM	13,800	18,800	36.2
UT	15,400	23,200	50.6
WY	11,800	12,400	5.1
Region	**129,700**	**186,200**	**43.6**

Sources: *EIA 2001a; EIA 2002a.*

Electricity use is broadly distributed in the southwest region. Households consumed about 33 percent of the total, the commercial sector (including public authorities) about 38 percent of the total, and industries about 29 percent of the total as of 2000 (EIA 2002a). Compared to the nation as a whole, the commercial sector in the region is above average and the industrial sector below average with respect to their shares of total electricity consumption.

Regarding fuel sources and types of power plants, the Southwest region is “coal country” and is rich in natural gas resources as well. Coal-fired power plants provided 72.5 percent of the 269,000 GWh of electricity generated in the six-state region as of 1999 (see Table 1-2). Coal-fired power plants provided 96 percent of the electricity generated in Wyoming, 94 percent of that generated in Utah, 86 percent in New Mexico, 82 percent in Colorado, 58 percent in Nevada, and 46 percent in Arizona. Coal-fired power plants serve load in the region and also produce a substantial amount of electricity that is transmitted to nearby states such as California.

Table 1-2. *Electricity Generation in the Southwest Region in 1999 (GWh)*

State	Coal-fired	Natural gas-fired	Hydro power	Nuclear/other	All sources
AZ	38,300	5,100	10,100	30,400	84,000
CO	32,900	5,000	1,600	-	39,500
NV	19,200	9,400	2,800	1,400	32,800
NM	28,100	4,200	200	-	32,600
UT	34,700	700	1,300	200	36,800
WY	42,000	400	1,200	-	43,600
Region	195,200	24,800	17,200	32,000	269,300

Source: *EIA 2002b.*

With plentiful and inexpensive fuels, electricity is relatively inexpensive in the southwest region. Table 1-3 shows the average retail price of electricity for different types of consumers by state as of 2000. For the region as a whole, the weighted-average electricity price is about 7.7 cents/kWh for residential consumers, 6.4 cents/kWh for commercial sector consumers, 4.4 cents/kWh for industrial consumers, and 6.2 cents/kWh for all consumers (EIA 2002a). For comparison, the average price of electricity for the United States as a whole was 6.8 cents/kWh as of 2000. Within the region, prices are above average in Arizona and New Mexico mainly because of the expensive nuclear power capacity co-owned by utilities in these states.

Table 1-3. *Electricity Prices and Expenditures in the Southwest Region in 2000*

State	Residential price (cents/kwh)	Commercial price (cents/kwh)	Industrial price (cents/kwh)	Overall avg. price (cents/kwh)	Total Expenditure (billion $)
AZ	8.4	7.4	5.3	7.3	4.43
CO	7.3	5.6	4.2	5.9	2.53
NV	7.3	6.7	5.0	6.2	1.72
NM	8.4	7.1	4.7	6.6	1.24
UT	6.3	5.2	3.4	4.8	1.12
WY	6.5	5.3	3.4	4.3	0.54
Region	7.7	6.4	4.4	6.2	11.58

Source: *EIA 2002a.*

Table 1-3 also shows the total cost of electricity purchases by state. The region as a whole spent $11.6 billion on electricity purchases as of 2000. This is equivalent to about $2,100 per household (i.e., the sum includes the money spent by businesses and households on electricity, not just direct household purchases). For comparison, this is slightly more than property taxes paid in these states and about half what state and local governments spend on education in these states (U.S. Census Bureau 2002). Furthermore, electricity expenditures are increasing due to both rising electricity prices and growing consumption.

B. Consequences of High Demand Growth

High electricity demand growth over the past decade eliminated most of the surplus generating capacity built up in the region during the late 1970s and 1980s. As a result, many new power plants and associated transmission and distribution (T&D) facilities are under construction or proposed in the region. Utilities are mainly constructing gas-fired power plants, but some new coal-fired power plants have been proposed as well.[1] High electricity demand growth and the resulting need for new power plants and associated T&D facilities causes a number of problems including:

- placing upward pressure on electricity and natural gas prices,
- causing power plant and transmission line siting controversies,
- increasing the risk of power outages and diminished electrical reliability,
- increasing air pollution and other adverse environmental impacts,
- increasing social and monetary costs associated with pollution-related illnesses,
- increasing water consumption, and
- increasing the "greenhouse gas" emissions that are contributing to global warming.

Regarding cost issues, electricity from new power plants (along with associated T&D facilities) is generally more costly than power from existing power plants.[2] This can lead to the need to increase electricity rates. For example, Xcel Energy asked the Colorado Public Utilities Commission for a 15.4 percent rate hike in June, 2002, citing investment required to serve the growth in electricity demand in recent years as the main reason for the rate hike (Draper 2002).[3] Also, given that many new power plants are fueled with natural gas, there is greater cost volatility associated with new power plants being built (or electricity purchases) to serve growing electricity demand. In fact rate increases were approved in Nevada and Utah in 2002 in large part because of the price volatility and high cost of natural gas and wholesale electricity purchases in 2000-2001.

As will be illustrated in this study, high electricity demand growth in the region is projected to lead to higher natural gas prices in the future compared to projected prices with low electricity demand growth. This in turn will affect all gas users, not just electric utilities and electricity prices.

Regarding siting problems, nobody wants a new conventional power plant "in their backyard." In some cases this forces utilities to site new plants in rural areas, which can add to power

[1] For example, new coal-fired power plants have been proposed or are undergoing planning in Arizona, Colorado, and New Mexico.
[2] This is true in part because existing plants are often older plants that have been depreciated to a large degree. Also, new plants require more sophisticated pollution controls that add to their cost, compared to older, dirtier plants. In Arizona, for example, regulators are requiring that new natural gas-fired power plants include costly catalytic oxidation technology to minimize pollutant emissions.
[3] Xcel Energy is the main utility operating in Colorado.

transmission costs and create controversy if new transmission lines are needed. Local residents object to new power plants or transmission lines because of their adverse impacts on visibility, noise, environmentally sensitive lands, Native American lands or religious sites, and/or wildlife. For example, two proposed power plants were rejected by the Arizona Corporation Commission (ACC) in late 2001 and early 2002 due in large part to siting concerns (see ACC web site, www.cc.state.az.us/news/index.htm).

High electricity demand growth can result in an increased level of power outages due to overloaded transmission and distribution lines or substations. In the southwest region, this has been a significant problem in Utah recently, for example. Power outages result in financial losses for businesses as well as inconvenience. Overloaded transmission lines are also a major issue in Arizona (ACC 2001).

Regarding environmental concerns, new fossil fuel-based power plants have relatively low emissions of the so-called "criteria pollutants" such as SO_2, NO_x, and particulates due to environmental regulations and the current generation of emissions control technologies. But new power plants still have some level of emissions and thus adverse environmental impacts. For example, PacifiCorp and its subsidiaries are in the process of constructing 320 MW of new gas-fired generating capacity in the Salt Lake Valley in Utah. The plants will emit NO_x and other pollutants that contribute to ozone in an area already confronting serious air pollution problems (Fahys 2002). New power plant construction is also of concern with respect to its impact on air quality in the Denver and Phoenix areas.

In addition to the pollutant emissions from power plants, natural gas wells are another significant source of pollutant emissions, especially of volatile organic compounds (VOCs). VOCs from these wells are contributing to urban ozone (smog) problems in some parts of the region including Denver and northwestern New Mexico (Hartman 2002). Natural gas drilling can also disturb sensitive lands and wildlife. High growth in electricity demand is one factor contributing to expanding natural gas drilling and production in the region.

Fossil fuel-based power plants are a major source of the fine particulates (particles less than 2.5 microns in diameter) that are harming public health (Clean Air Task Force 2000).[4] One study estimates that particulate air pollution caused significantly more deaths in metropolitan areas in the southwest states than deaths caused by auto accidents as of the early 1990s (see Table 1-4). Particulates and other forms of air pollution also contribute to asthma, bronchitis, and other forms of respiratory disease. The American Lung Association has estimated that Colorado could save more than $224 million each year in health costs if it lowered its particulate pollution to levels required in California (LAW Fund 1996). While particulate emissions have declined somewhat since the early 1990s, particulates are still a major public health hazard.

[4] Current air quality regulations limit emissions of larger particulate matter known as PM-10. Regulation of fine particulates (PM-2.5) is under review by the U.S. EPA.

Table 1-4. *Estimates of Cardiopulmonary Deaths due to Particulate Air Pollution in Cities in the Southwest*

City	Annual Cardiopulmonary Deaths Due to Particulate Air Pollution[a]		Annual Deaths from Auto Accidents
	Point estimate	Range	
Albuquerque	97	57-135	120
Denver	375	221-517	267
Las Vegas	350	210-476	154
Phoenix	1,110	667-1,507	411
Salt Lake City	295	176-404	169
Tuscon	195	115-269	115

Notes: [a] *average for 1990-94 period.*
Source: *Shprentz 1996.*

Growth in conventional power generation is also of concern because the Environmental Protection Agency has issued regulations to improve visibility in national parks and wilderness areas, a policy known as the Regional Haze Rule (WRAP 1999). States in the Southwest region must develop implementation plans by the end of 2003 for cutting emissions of fine particles and other haze-causing pollutants. High growth in electricity use and fossil fuel-based power generation would make it more difficult and costly for states to comply with the Haze Rule.

Conventional fossil fuel-based power plants consume large quantities of water. For example, existing power plants in New Mexico consume 68,000 acre-feet of water annually, about five times the water consumption of Santa Fe (Hume 2002). Building new power plants will add to water demand, and water is an increasingly scarce resource in the region. For example, the 34 new power plants which either entered into operation recently, are under construction, or for which regulatory approval has been received in Arizona would consume about 98,000 acre-feet of water per year (ACC 2001). In fact, current levels of total water consumption are already straining water resources in the region, leading to tensions among states as well as tensions between metropolitan areas and agricultural interests. High growth in conventional power generation would add to these tensions.

New fossil fuel-based power plants also emit carbon dioxide (CO_2), the primary gas causing global warming according to the vast majority of experts on the subject (IPCC 2001). There are no practical or cost-effective controls for CO_2 emissions at the present time, other than taking steps to reduce the need to burn fossil fuels. Efforts to limit the emissions of CO_2 and other greenhouse gases are expanding worldwide particularly as industrial nations other than the United States accept caps on their emission via the Kyoto Protocol.[5] A "carbon-constrained world" appears inevitable, meaning that utilities constructing new coal- or natural gas-fired power plants face the possibility of future CO_2 emissions limits or taxes. High electricity

[5] The European Union, Japan, and a number of other countries have ratified the Kyoto Protocol. Russia has announced its intention to ratify. Once this occurs, the Kyoto Protocol will enter into force.

demand growth exacerbates this risk as well as the region's contribution to U.S. and global greenhouse gas emissions.

C. Reducing Load Growth through Greater Energy Efficiency

This study shows that there is large potential for increasing the efficiency of electricity use and reducing load growth in the southwest region, and doing so cost effectively in spite of the relatively low electricity prices in the region. End-use efficiency improvements cannot eliminate all the load growth anticipated over the next 18 years, but they can eliminate most of it. This study also shows that accelerating energy efficiency improvements will save consumers and businesses money while leading to a net increase in employment and personal income in the region. Thus, increasing energy efficiency can be an important economic development strategy in a region that is strongly impacted by the current economic recession.

Accelerating energy efficiency improvements will also help to mitigate the other problems associated with high electricity demand growth including local and regional air pollutant emissions, water consumption, greenhouse gas emissions, and increased risk of power outages. Many new power plants can be avoided if vigorous energy efficiency improvements occur, thereby eliminating the need for the most contentious power plants and associated T&D facilities. Thus, increasing energy efficiency is a "win-win" strategy from the perspective of saving money, boosting the region's economy, reducing water demand, and protecting the environment.

The remainder of this study examines these themes in detail, providing quantitative estimates of the impacts by state as well as for the region as a whole. Chapter 2 analyzes the technical and economic potential for improving the efficiency of electricity use in the residential, commercial, and industrial sectors. It then develops a High Efficiency Scenario considering aggressive but achievable implementation of cost-effective efficiency measures. The High Efficiency Scenario is compared to a Base Scenario that assumes continuation of current policies and trends.

Chapter 3 analyzes the impacts that the High Efficiency Scenario would have on the region's electricity sector during 2003-2020. It considers the avoided investment in power plants and T&D facilities as well as the avoided fuel and operating costs associated with the High Efficiency Scenario (relative the Base Scenario) and contrasts these savings with the estimated costs for implementing the efficiency measures. It also examines the pollutant (SO_2, NO_x, CO_2, and mercury) emissions reductions and water savings that would result from the High Efficiency Scenario (relative to the Base Scenario).

Chapter 4 analyzes the impacts the High Efficiency Scenario would have on employment levels, personal income, and economic output (relative to the Base Scenario). It also shows which sectors of the economy would expand and which would contract due to pursuit of the electricity savings in the High Efficiency Scenario.

Chapter 5 reviews policies and programs currently underway in the region that are promoting more efficient electricity use. It recommends new or expanded policies that would accelerate the implementation of cost-effective efficiency measures, and it presents a set of policies that if implemented together could result in all of the cost-effective electricity savings identified in the High Efficiency Scenario.

CHAPTER 2—ENERGY EFFICIENCY POTENTIAL

The goals of this chapter are to: 1) estimate base-year electricity consumption in the buildings and industrial sectors in the six southwest states, 2) develop a Base Scenario on how electricity use is likely to change over the next two decades assuming that current policies and trends continue, and 3) examine energy savings potential by developing a High Efficiency Scenario. The High Efficiency Scenario assumes widespread adoption of cost-effective energy efficiency measures during 2003-2020. The analysis is conducted using a "bottom up" approach which considers a wide range of efficiency measures for different end uses and building types.

A. Buildings Sector Analysis

In the buildings sector, energy use characteristics at the end-use level are highly dependent on the type (and/or purpose) of each building. For example, an office building has greater lighting or office equipment use than a restaurant, which has less lighting or computer use but more energy use for food storage and preparation. Multi-family homes tend to be smaller on a per-household basis than single family homes, therefore having less space to heat, illuminate, or cool.

In order to perform a "bottom-up" analysis of potential energy savings, we developed several building prototypes with energy use characteristics that represent major building types in the southwest region. Four residential and eight commercial building prototypes were developed. The residential building prototypes include:

- Existing single family detached,
- New single family detached,
- Existing multifamily apartment, and
- New multifamily townhouse.

The commercial building prototypes include:

- Existing office,
- New office,
- Existing retail,
- New retail,
- Existing school,
- New school,
- Existing food service/sales, and
- New food service/sales.

In the real world there are many other building types such as hotels, hospitals, and mobile homes. However, we limit the number of prototypes in order to make the analysis manageable, and we assume that savings opportunities for these other building types can be derived from one or more of the twelve prototypes that were analyzed. For example, many of the energy efficiency technologies used in single family homes are also applicable to mobile homes.

For each building type, we conducted electricity consumption analysis using the DOE-2.2 building energy simulation program. The DOE-2.2 model was used to evaluate baseline consumption and also to make energy savings estimates for a number of energy efficiency measures. Modifications were made to the prototypes to reflect the characteristics of buildings and building practices in the region. Weather patterns for Denver, CO for the northern three states (Wyoming, Colorado, and Utah) and Las Vegas, NV for the southern three states (Nevada, Arizona, and New Mexico) were used for the purpose of analyzing heating and cooling energy consumption by the building prototypes. Appendix A explains the methodology used to analyze electricity savings potential in both residential and commercial buildings in greater detail.

The residential building simulation analysis was augmented by analysis of the costs and savings of a variety of appliance efficiency improvements including but not limited to efficiency measures for water heaters, clothes washers, dishwashers, refrigerators, lighting, and electronics. Appendix B describes these measures and the key assumptions about them in greater detail.

In order to determine aggregate energy savings potential, we applied state-by-state saturation and usage rates for many of the end-uses in the residential analysis. These rates were obtained from data collected by the U.S. Energy Information Administration (EIA 1999) as well as from communications with utilities and state energy offices in the region. After adjusting for appliance saturation and usage patterns, baseline consumption for the residential building prototypes was calibrated to the average electricity consumption per household as of 1997 in each state (EIA 1998a).

1. Base Year Electricity Use

The next challenge was to estimate total electricity use by building type in each state in the base year. We used 1997 as the base year because it is the most recent year for which residential survey data are available from the Energy Information Administration (EIA). For residential buildings, we applied 1990 Census data on housing occupancy and the ratio of single and multifamily homes, and applied these ratios to 1997 Census housing estimates to obtain estimates of the number of occupied single and multifamily units in 1997 (see Table 2-1).

Table 2-1. *Estimated Occupied Single and Multi Family Units in 1997*

	Region	AZ	CO	NV	NM	UT	WY
1997 Total housing units (thousand)	6,872	1,944	1,678	729	728	710	211
1990 Occupancy rate	85.8%	82.5%	86.8%	89.9%	85.9%	89.8%	83.0%
1990 % of one unit housing	63.5%	58.9%	65.8%	50.7%	65.9%	69.7%	66.6%
1990 % of multi-unit housing	36.5%	41.1%	34.2%	49.3%	34.1%	30.3%	33.4%
1997 Occupied single family units	3,745,374	944,463	958,253	332,092	412,203	444,398	116,756
1997 Occupied multi-family units	2,152,853	659,040	498,059	322,922	213,295	193,295	58,554

Source: *U.S. Census Bureau 2002; ACEEE estimates.*

We then obtained average per household electricity consumption in 1997 from EIA data (EIA 1999), with adjustments for each building type in each state based on appliance saturation and usage data obtained from the Residential Energy Consumption Survey (EIA 1999) and sources within the region. These baseline electricity consumption values for the building prototypes are summarized in Table 2-2.

Table 2-2. *Estimated Electricity Consumption of Residential Building Prototypes (kWh/year)*

	AZ	CO	NV	NM	UT	WY
Overall average	11,688	7,548	11,316	6,588	8,184	9,468
Existing Single Family	14,126	8,945	13,836	7,853	9,542	11,181
New Single Family	17,654	12,006	16,879	10,772	12,430	14,023
Existing Multi Family	8,193	4,860	8,725	4,144	5,060	6,051
New Multi Family	10,261	6,650	9,540	5,829	6,907	7,793

Source: *ACEEE and SWEEP estimates.*

For commercial buildings, we first disaggregated building floor space by building type and state using state employment data (BEA 2002). The number of employees and the estimated floor space in 1999 are summarized in Table 2-3. We then multiplied the Base Scenario energy intensity of the building prototypes (shown in Table 2-4) by the estimated floor space for each building type in order to calculate aggregate electricity use by building type and state.

Table 2-3. *Number of Employees and Estimated Floor Space by Building Type in 1999*

	Region	AZ	CO	NV	NM	UT	WY
Number of employees in 1999							
Office	12,159,787	3,134,109	3,272,784	1,554,776	1,098,235	1,486,977	309,985
Retail	993,963	247,894	256,847	104,277	93,924	130,102	32,303
Food Service/Sales	843,761	223,195	222,515	86,942	77,643	101,655	24,616
School	137,214	30,614	38,598	5,256	12,951	31,364	2,417
Floor space in 1999 (Million square feet)							
Office	928	239.2	249.8	118.7	83.8	113.5	23.7
Retail	1,164	290.3	300.8	122.1	110.0	152.4	37.8
Food Service/Sales	164	43.4	43.3	16.9	15.1	19.8	4.8
School	758	169.1	213.2	29.0	71.5	173.3	13.4

Source: *BEA 2002; ACEEE estimates.*

Table 2-4. *Base Case Electricity Intensity of the Commercial Building Prototypes (kWh/ft²/year)*

Building Type	Southern States (AZ, NM, NV)	Northern States (CO, UT, WY)
Existing Medium Office	27.56	23.42
New Medium Office	21.59	19.19
Existing Retail	19.01	14.25
New Retail	15.25	12.32
Existing School	15.77	12.00
New School	12.99	10.40
Existing Food Service/Sales	50.69	39.50
New Food Service/Sales	40.40	31.89

Source: *DOE 2.2 building simulation analysis.*

Finally, we calibrated total electricity consumption in each sector and state to actual consumption data in 1997 obtained from the State Energy Data Report (EIA 2001a). Table 2-5 shows our estimates of electricity consumption in 1997 in each state and the region by building type. Office buildings use the most electricity in the commercial sector, followed closely by retail stores. Single family homes account for about two-thirds of total residential electricity use. For the region as a whole, our selected building types represent 85 percent of total electricity use in the commercial sector and 91 percent of total electricity use in the residential sector. We assume that the cost-effective electricity savings potential in the category of "other" building types is equal to the weighted-average savings potential in the building types analyzed in each sector.

Table 2-5. *Estimated Annual Electricity Consumption in 1997 by State and Building Type (GWh)*

	Region	**AZ**	**CO**	**NV**	**NM**	**UT**	**WY**
Commercial							
Office	23,080	7,874	6,211	3,005	2,515	2,468	1,008
Retail	19,340	6,922	4,789	2,175	2,345	2,148	961
School	9,341	3,013	2,613	423	1,111	1,913	268
Food Sales/Service	7,339	2,712	1,892	780	868	757	331
Subtotal	59,101	20,520	15,506	6,383	6,839	7,285	2,568
Residential							
Single family	38,836	14,724	9,561	4,836	3,536	4,600	1,579
Multi family	14,079	5,959	2,700	2,965	966	1,061	428
Subtotal	52,915	20,683	12,261	7,801	4,502	5,661	2,007
TOTAL	**112,016**	**41,203**	**27,767**	**14,184**	**11,341**	**12,946**	**4,575**

2. Base Scenario

Starting with the base-year estimates described above, we estimated how electricity use is likely to grow given current policies and trends. To project overall electricity use in buildings by state, we started with the regional growth projections in 2002 Annual Energy Outlook produced by the

Energy Information Administration (EIA 2001b). We then developed state-by-state growth projections based on gross state product (GSP) forecasts for the commercial sector, and population growth forecast for the residential sector. The assumed annual growth rates are shown in Table 2-6. Table 2-7 shows the resulting state-by-state projections of electricity consumption.

Table 2-6. *Projected Annual Growth Rates of Electricity Consumption (%)*

State	**Residential**	**Commercial**
Arizona	2.6	3.9
Colorado	2.0	3.5
Nevada	2.5	4.2
New Mexico	2.3	2.0
Utah	2.5	3.2
Wyoming	1.9	1.5
Region	2.4	3.5

Table 2-7. *Base Scenario Forecast of Electricity Consumption in the Buildings Sector (GWh)*

	Region	**AZ**	**CO**	**NV**	**NM**	**UT**	**WY**
Commercial electricity consumption							
1997	59,101	20,520	15,506	6,383	6,839	7,285	2,568
1999	65,810	22,688	17,919	7,007	7,430	8,074	2,692
2005	80,603	28,542	22,027	8,969	8,367	9,754	2,944
2010	95,565	34,559	26,161	11,017	9,238	11,417	3,171
2015	113,431	41,845	31,071	13,534	10,200	13,365	3,416
2020	134,780	50,667	36,903	16,625	11,261	15,645	3,680
Residential electricity consumption							
1997	52,915	20,683	12,261	7,801	4,502	5,661	2,007
1999	56,940	22,517	13,131	8,386	4,645	6,236	2,025
2005	65,602	26,266	14,788	9,725	5,324	7,232	2,267
2010	73,831	29,863	16,327	11,003	5,965	8,182	2,491
2015	83,105	33,952	18,026	12,449	6,683	9,257	2,737
2020	93,557	38,602	19,902	14,085	7,488	10,474	3,007

The final step was allocating future electricity use in a particular sector and state among different building types. For the commercial sector, we used recent data on the number of employees in each building type to calculate an annual rate of growth. We then extrapolated these growth rates to the future. For the residential sector, we used population growth projections by state (U.S. Census Bureau 2002). Next we applied these growth rates to the aggregate electricity use by building type in the base year, and then adjusted the projections so that the totals by sector and state matched the values shown in Table 2-7.

3. High Efficiency Scenario

For each building prototype, we applied a series of energy efficiency measures and estimated how much energy would be saved using the DOE-2.2 simulation model. Aggregate energy savings potential is estimated by applying the measure in the proportion of the building stock for which the measure is appropriate (i.e., had not been installed yet, is technically feasible, and is cost-effective to consumers on a life-cycle cost basis).

Measures are deemed cost effective if their cost of saved energy is less than the retail electricity price in a particular state and sector. The cost of saved energy is calculated using a societal discount rate of 5 percent real; i.e., above inflation. Measures were applied sequentially in order of cost effectiveness up to the cost-effectiveness limit (i.e., the retail electricity price). The energy savings of each measure is the incremental savings not achieved by any previous measure. Appendix A includes tables reporting the savings results for each of the building prototypes and city. The savings potential in residential end-uses other than cooling and heating (e.g., appliances, lighting, and water heating) was evaluated separately. The assumptions and results are explained in detail in Appendix B.

Tables 2-8 and 2-9 summarize the maximum cost-effective savings potential in each building prototype obtained from the building simulation and appliance analyses. The technically feasible and cost-effective savings potential is in excess of 50 percent for most of the commercial building types that we considered. The savings potential is lower in food service/sales buildings because air conditioning and lighting account for a smaller share of total electricity use in these buildings, and our analysis found the highest electricity savings potential in air conditioning and lighting. The savings potential for residential buildings is generally less than that for commercial buildings because approximately 35 percent of electricity use in housing is attributed to “miscellaneous” end-uses (active-mode consumption of TVs, VCRs, computers, and other electronic devices, evaporative coolers, water pumps, etc.) for which we did not analyze savings potential. However, there are efficiency opportunities in these areas, and thus our estimates of residential savings potential in the High Efficiency Scenario are conservative.

Table 2-8. *Maximum Savings potential for commercial buildings (percent)*

Building Type	Southern States (AZ, NM, NV)	Northern States (CO, UT, WY)
Existing Medium Office	59	59
New Medium Office	54	54
Existing Retail	52	57
New Retail	52	50
Existing School	53	54
New School	50	47
Existing Food Service/Sales	39	33
New Food Service/Sales	38	27

Table 2-9. *Maximum Savings potential for residential buildings (percent)*

Building Type	Southern States			Northern States		
	AZ	NV	NM	CO	UT	WY
Existing Single Family	46	39	48	34	38	33
New Single Family	35	29	34	26	29	29
Existing Multi Family	48	39	49	30	34	30
New Multi Family	35	27	44	27	31	33

The next step is the estimation of aggregate savings potential in the High Efficiency Scenario, based on the analysis of savings potential for the prototype buildings. To do this, we make assumptions concerning the implementation rate for each package of efficiency measures, assuming aggressive but potentially achievable implementation of cost-effective measures. For existing buildings, we assume that cost-effective measures would be gradually installed during 2003-2020. Implementation is assumed to follow a linear path, resulting in installation of 80 percent of cost-effective efficiency measures by 2020. Thus, over the 18-year analysis period, we assume that 4.4 percent of cost-effective efficiency measures are implemented each year.

For new buildings, we assume that 50 percent of the cost-effective measures are installed starting in 2003 and that the fraction of cost-effective efficiency measures implemented in new buildings gradually increases and reaches 100 percent in new buildings constructed in 2010 and thereafter. A high level of implementation is possible in new buildings through the adoption and enforcement of building energy codes. The implementation rates for cost-effective efficiency measures are summarized in Table 2-10. However, our analysis is conservative in that it does not include additional energy efficiency measures beyond those identified as cost-effective today, even though it is nearly certain that additional measures will be developed and commercialized in the future.

Table 2-10. *Implementation of Cost-effective Efficiency Measures (percent)*

	2003	2004	2005	2010	2015	2020
Cumulative Efficiency Measure Implementation in Existing Buildings	4	9	13	36	58	80
Efficiency Measure Implementation in New Buildings	50	57	64	100	100	100

Combining all of these inputs and assumptions leads to the results shown in Figures 2-1, 2-2, and 2-3. In the commercial sector, electricity consumption in the six states is reduced 20 percent by 2010 and 37 percent by 2020 in the High Efficiency Scenario (see Fig. 2-1). Electricity use still increases 12 percent during 2003-2020 in the High Efficiency Scenario, but this is far less than the 79 percent increase during this period in the Base Scenario. The overall savings potential in the commercial sector is approximately the same in all six states (see Tables 2-11A and 2-11B).

In the residential sector, electricity consumption in the six states is reduced 14 percent by 2010 and 26 percent by 2020 in the High Efficiency Scenario (see Fig. 2-2). Electricity use increases 10 percent during 2003-2020 in the High Efficiency Scenario, again far less than the 50 percent increase during this period in the Base Scenario. Unlike the commercial sector, there are significant differences in overall savings potential among the six states in the residential sector (see Tables 2-11A and 2-11B). The overall savings potential is higher in states with more air conditioning (e.g., Arizona and New Mexico) because the cost-effective savings potential is above average in percentage terms for this end use. Nevada has very high air conditioning loads but less overall savings potential because it is believed that there is relatively little electric space and water heating in Nevada (Lopez 2002). Electric space and water heating are also end uses that have high savings potential in percentage terms.

Figure 2-1. *Commercial Sector Electricity Consumption in the Base and High Efficiency Scenarios*

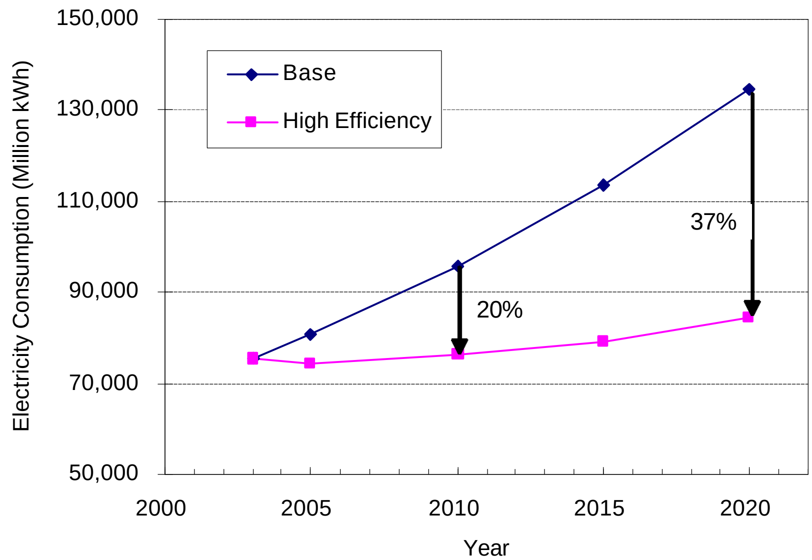
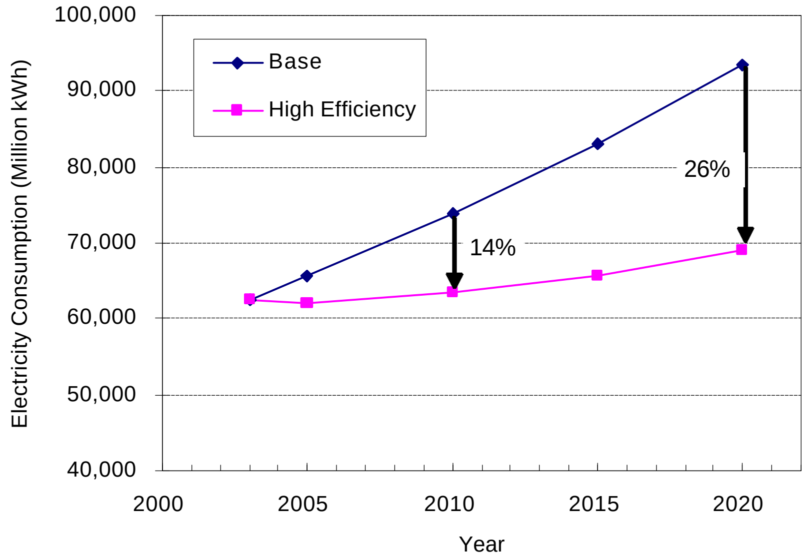


Figure 2-2. *Residential Sector Electricity Consumption in the Base and High Efficiency Scenarios*



The overall cost-effective savings potential in all buildings in the region is 17 percent by 2010 and 33 percent by 2020, relative to projected electricity use in the Base Scenario (see Fig. 2-3). The overall savings potential by 2020 ranges from 30 percent in Nevada to 36 percent in New Mexico due mainly to the differences in the residential sector. For the region as a whole, electricity use in buildings increases 11 percent during 2003-2020 in the High Efficiency Scenario compared to a 66 percent in the Base Scenario.

These savings potential estimates are consistent with the estimates in similar studies done for other regions. A study for the Mid-Atlantic region completed in 1997 found 30-35 percent electric savings potential in buildings by 2010 (Nadel et al. 1997). A study for Illinois completed in 1998 found even higher savings potential in buildings, about 35-40 percent by 2015 (Goldberg et al. 1998).

Figure 2-3. *All Buildings Electricity Consumption in the Base and High Efficiency Scenarios*

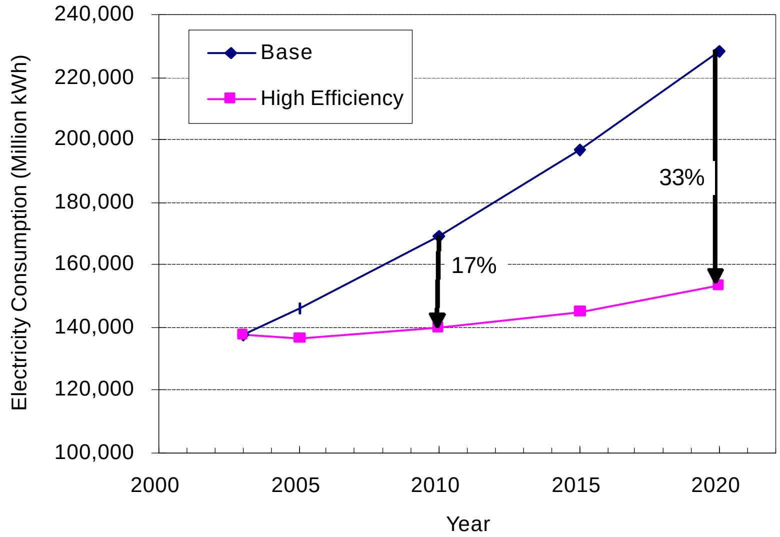


Table 2-11A. *Achievable Energy Savings Potential in Buildings in 2010*

		Region	**AZ**	**CO**	**NV**	**NM**	**UT**	**WY**
Commercial Sector								
Baseline Consumption	GWh	95,565	34,559	26,161	11,017	9,238	11,417	3,171
Savings Potential	GWh	19,107	6,954	5,210	2,238	1,815	2,269	621
Savings Potential	%	**20.0**	**20.1**	**19.9**	**20.3**	**19.6**	**19.9**	**19.6**
Residential Sector								
Baseline Consumption	GWh	73,831	29,863	16,327	11,003	5,965	8,182	2,491
Savings Potential	GWh	10,451	4,801	1,901	1,413	987	1,058	292
Savings Potential	%	**14.2**	**16.1**	**11.6**	**12.8**	**16.5**	**12.9**	**11.7**
Total Buildings Sector								
Baseline Consumption	GWh	169,396	64,422	42,488	22,021	15,203	19,600	5,662
Savings Potential	GWh	29,559	11,754	7,111	3,651	2,801	3,328	912
Savings Potential	%	**17.4**	**18.2**	**16.7**	**16.6**	**18.4**	**17.0**	**16.1**

Table 2-11B. *Achievable Energy Savings Potential in Buildings in 2020*

		Region	AZ	CO	NV	NM	UT	WY
Commercial Sector								
Baseline Consumption	GWh	134,780	50,667	36,903	16,625	11,261	15,645	3,680
Savings Potential	GWh	50,291	18,862	13,655	6,087	4,356	5,866	1,465
Savings Potential	%	**37.3**	**37.2**	**37.0**	**36.6**	**38.7**	**37.5**	**39.8**
Residential Sector								
Baseline Consumption	GWh	93,557	38,602	19,902	14,085	7,488	10,474	3,007
Savings Potential	GWh	24,593	11,546	4,408	3,067	2,319	2,506	748
Savings Potential	%	**26.3**	**29.9**	**22.1**	**21.8**	**31.0**	**23.9**	**24.9**
Total Buildings Sector								
Baseline Consumption	GWh	228,338	89,268	56,805	30,710	18,750	26,118	6,687
Savings Potential	GWh	74,884	30,408	18,063	9,154	6,674	8,372	2,214
Savings Potential	%	**32.8**	**34.1**	**31.8**	**29.8**	**35.6**	**32.1**	**33.1**

4. Specific Savings Opportunities

There are many specific energy savings measures that are cost effective in the buildings sector. Here we describe some of the major savings measures and their cost effectiveness. For a more detailed description of specific savings opportunities, see Appendix A-2 for commercial buildings and residential HVAC equipment, and Appendix B for residential appliances and other residential equipment.

Commercial Sector

For commercial buildings, large energy savings can be achieved through: 1) installing more efficient lighting systems, 2) replacing HVAC equipment with more efficient units, 3) testing and sealing air distribution ducts, and 4) replacing inefficient office equipment with more energy-efficient products. In addition, savings are also possible from commissioning new buildings and retro-commissioning (i.e., adjusting energy management systems and other devices) in existing buildings. When implemented together, these measures can provide electricity savings of 50 percent or greater.

Replacing lighting systems with more efficient fixtures, lamps, ballasts, and improved controls can save more than 50 percent of lighting energy use. Lighting not only consumes electricity on its own, but also creates heat that adds to the cooling load of the building. Since lighting accounts for one-third to more than half of the total building electricity use depending on the building type, this can yield 20 to 45 percent total electricity savings. For example, installing highly efficient lighting in a new office building in Denver, Colorado (instead of standard lighting) can save 60 percent of lighting energy use, which represents about 27 percent of the building's total electricity consumption (see Appendix A). The incremental cost for the more efficient lighting system is estimated to equal $0.39 per square foot ($ft^2$) of floor area, while annual energy savings equal $0.29/$ft^2$ implying a simple payback of only 1.3 years. If the average life of the efficient lighting system is 15 years, the discounted benefit-cost ratio is 7.8.[1]

Replacing HVAC equipment such as fans, chillers, and packaged air-conditioning units also yields significant energy savings. According to the building modeling completed for this study, an existing medium-sized office building in Las Vegas can reduce its overall electricity consumption by 18% through installing more efficient HVAC equipment. The average incremental cost is $0.36/$ft^2$, while annual savings equal $0.27/$ft^2$ – also resulting in a short simple payback period of 1.3 years. The same measures adopted in office buildings in Denver would save about 14% and have a payback of about 2.0 years. Assuming the more efficient HVAC equipment has a life of 15 years, the discounted benefit-cost ratio is 5 to 8 in these examples.

Testing and sealing air distribution ducts save both electricity and natural gas. In an existing retail store in either Denver or Las Vegas, we estimate that duct testing and sealing can save 9 to 15 percent of the building's total electricity consumption. It also saves approximately 25 percent of natural gas consumption (assuming the building is heated with natural gas). The installed cost for this efficiency measure is about $0.38/$ft^2$, while the annual energy savings are worth about $0.11-14/$ft^2$ (electricity and natural gas combined). Based on these values, the typical simple payback period is 2.8 to 3.4 years and the discounted benefit-cost ratio is 3.0 to 3.7.

For office buildings, office equipment such as computers, printers, copiers, and fax machines consume a significant amount of electricity, and also generate heat that adds to the cooling load. Our analysis shows that an office building can cut its total electricity consumption by 15 to 20 percent through upgrading to more efficient office equipment and enabling all energy saving features (e.g., sleep modes for devices not in use). The estimated incremental cost is relatively low ($0.11/$ft^{2)}$, while the energy savings are worth $0.21/$ft^2$ (including the additional natural gas consumed for space heating). This yields a simple payback period of 0.5 years and a benefit-cost ratio of 8.2 assuming an average life of 5 years for the energy-efficient devices.

Residential Sector

In the residential sector, the major electricity savings opportunities are in the areas of lighting, water heating, and air conditioning. In addition, there is significant savings potential in ventilation (ceiling fans), central heating (electric resistance units), and electronic products (TVs, VCRs, etc.). Substantial electricity savings also will occur when an older refrigerator or freezer is replaced with a newer model. But this savings is occurring due to the national appliance efficiency standards, and presumably is captured in the Base Scenario. For a summary of savings

[1] This estimate and other benefit-cost ratios in this section are based on a 5 percent real discount rate. Also, it is assumed that the upgrade to more efficient equipment is made at the time of equipment replacement in existing buildings, thereby reducing the incremental cost.

potential by end-use in the residential sector, see Appendix B, Table B-1.

Use of more energy efficient lamps in residential homes can save approximately 630 kWh per year, over two-thirds of the energy used for lighting. Efficient lamps include energy-saving incandescent lamps, compact fluorescent lamps (CFLs), and CFL-based torchiere-style lamps. The estimated incremental cost to install six CFL lamps, one CFL torchiere lamp, and replace all other regular incandescent lamps with energy-saver lamps is $115 per household. The value of the annual electricity savings from adopting these measures is $48, resulting in a simple payback period of 2.4 years. The average life varies from 2 years for energy-saver lamps to 8-10 years for CFLs, and the overall benefit-to-cost ratio is 2.3.

Various measures to reduce hot water use and increase the efficiency of water heating can yield significant electricity savings for households with electric water heaters. Measures to reduce hot water use include, but are not limited to, efficient clothes washers, dishwashers, low-flow showerheads, and faucet aerators. Use of more efficient water heaters, such as a high-efficiency electric resistance water heater or a heat pump water heater, can save electricity used for water heating. The combination of the water saving measures and a high-efficiency water heater can save 1,384 kWh per year per household on average, around 57 percent savings for this end use. The combined incremental cost is $258, resulting in a simple payback period of 2.3 years. The average life of the efficiency measures varies from 10 to 14 years, and the overall benefit-to-cost ratio is 3.7.

There are many techniques for reducing electricity use for air conditioning electricity including measures that reduce cooling load (e.g., reflective "cool" roofs, Energy Star windows, programmable thermostats, and more efficient lighting) and measures that increase cooling system efficiency (e.g., high efficiency air conditioners, air conditioner tune-ups, duct testing and sealing, and conversion to evaporative cooling). The overall savings potential from a combination of these measures is 70 percent or greater. Since households in the southwest and mountain states with a central air conditioning consume about 2,290 kWh per year on average for cooling (EIA 1999), the savings potential from a combination of efficiency measures averages at least 1,600 kWh per year. The total incremental cost from a combination of cost-effective measures is $338, yielding a simple payback period of 3.2 years on average. The estimated life of these measures varies from 8 to 30 years, and the overall benefit-to-cost ratio is 3.9.

B. Industrial Sector

1. Characterization of Industrial Electricity Use

Comprehensive, highly disaggregated data on industrial electricity use are not available at the state level. To estimate electricity consumption in this study, we drew upon a number of resources, all using the same classification system. The major data sources available for each state were the 1997 Census of Agriculture (USDA 2000) and the 1997 Economic Census Subject

Series for Construction, Mining and Manufacturing (Bureau of Census 2000). The Census of Agriculture and construction series report electricity purchases by the sub-sector for each state while the mining and manufacturing series report net electricity consumption. The electricity purchase data were converted to kWh consumption using average industrial electricity prices for each state (EIA 2001c).

Because of the magnitude and diversity of manufacturing, it is important to disaggregate manufacturing to the sub-sector level. To do this, we used national industry electricity intensities derived from industry group electricity consumption data reported in the *1998 Manufacturing Energy Consumption Survey* (MECS) (EIA 2001d) and value of shipments data reported in the *1998 Annual Survey of Manufacturing* (ASM) (DOC 2000). Other sub-sectors have less diversity or are significantly smaller than manufacturing, so less effort was applied to disaggregation. Value of shipments (mining), sales (agriculture), or construction work (construction) were used to characterize these sub-sectors.

These various data sources were used to estimate the share of the industrial sector electricity consumption for each sub-sector and group. Total industrial electricity consumption by state comes from the State Energy Data Report (EIA 2001a).

For the region as a whole, manufacturing is the most important broad sub-sector accounting for 57 percent of total industrial electricity use. But mining is also very important accounting for 37 percent of regional electricity use in the industrial sector, and a significant fraction of the industrial load in every state. For comparison, mining only accounts for 5 percent of industrial electricity use nationwide, signifying the disproportionate role of mining in the overall economic mix in the southwest states. Agriculture and construction each account for about 3 percent of industrial electricity use in the region.

Arizona

Total industrial electricity use in Arizona in 1998 was about 12.2 TWh. Manufacturing comprised 54 percent of the industrial load, followed by mining at 39 percent, and agriculture and construction at 3 percent each. Copper mining in particular is an important industry and source of electricity demand in Arizona. Regarding manufacturing, primary metal manufacturing is the largest sub-sector representing 21 percent of total industrial electricity consumption. Other important manufacturing sub-sectors include nonferrous metals (except aluminum) production and processing (17.0 percent), and chemical manufacturing (7.8 percent).

Colorado

Total industrial electricity use in Colorado in 1998 was about 9.3 TWh. Manufacturing comprised 68 percent of the industrial load, followed by mining at 18 percent, agriculture at 10 percent, and construction at 4 percent. Regarding manufacturing, chemical manufacturing represents 12 percent of the total industrial electricity consumption. Primary metal manufacturing is the next largest industry group (11.5 percent). Mining in Colorado is fairly diverse and includes both hard rock and coal mining.

Nevada

Total industrial electricity use in Nevada in 1998 was about 10.6 TWh. Mining accounted for 65 percent of the total industrial load, followed by manufacturing at 30 percent, construction at 4 percent, and agriculture at 1 percent. Most of the mining electricity consumption comes from the gold and silver industries. Regarding manufacturing, cement and concrete production is the single largest sub-sector representing 11 percent of the total industrial electricity consumption.

New Mexico

Total industrial electricity use in New Mexico in 1998 was about 5.9 TWh. Manufacturing comprised 61 percent of the industrial load, followed by mining at 36 percent. Construction accounts for about 3 percent of industrial electricity use in the state. Regarding manufacturing, computer and electronic manufacturing represented 19 percent of the total industrial electricity consumption. Primary metal manufacturing is the next largest sub-sector (12 percent).

Utah

Total industrial electricity use in Utah in 1998 was about 7.5 TWh. Manufacturing represented 74 percent of the industrial load, followed by mining at 23 percent, and construction at 3 percent. Regarding manufacturing, primary metal manufacturing represents 24 percent of total industrial electricity consumption. Most of this is non-ferrous metals such as copper and magnesium processing and smelting. After metals manufacturing, petroleum and coal products manufacturing account for about 8 percent of industrial electricity use.

Wyoming

Total industrial electricity use in Wyoming in 1998 was about 6.9 TWh. Mining accounted for 55 percent of the total industrial load, followed by manufacturing at 43 percent and agriculture at nearly 2 percent. Regarding mining, oil and gas extraction is the predominant sub-sector representing approximately 30 percent of the total industrial electricity use.

2. Base Scenario

The Long-Term Industrial Energy Forecasting (LIEF) model, developed by Argonne National Laboratory (Ross et al. 1993), was used to construct a Base and a High Efficiency Scenario for the six states in the southwest. In particular, we used a recent update to the model that includes internal parameters based on industrial electricity data from the 1990s (Boyd 2002). The key inputs into the model include the base year output (value of shipments) for each of the 17 sub-sectors in the model,[2] the base year electricity demand for each of the sectors, and the growth

[2] The 17 sub-sectors are general manufacturing, fast-growing manufacturing, pulp and paper, organic and inorganic chemicals, petroleum refining, glass, cement, stone and clay, iron and steel, primary aluminum, nonferrous metals, agriculture, mining, oil and gas extraction, construction, feedstocks, and uranium. However, two sub-sectors,

rate of output over the analytical period (1998-2020). Estimates of output growth were obtained from economy.com, an economic forecasting firm. Appendix C provides further details regarding the LIEF model and this methodology.

With these inputs, the model estimates future electricity consumption for each sub-sector. The basic methodology is that electricity consumption will grow as output grows, tempered by internal modeling parameters that change electricity intensity for each sector over time. Electricity intensity is influenced by three key variables related to the cost effectiveness and adoption of energy efficiency measures – the assumed penetration rate, the capital recovery factor (CRF), and projected electricity prices. It is assumed that electricity prices remain constant at 1999 prices in real dollars (i.e., prices are adjusted for inflation only). The Base and High Efficiency scenarios were created by making differing assumptions about the CRF and penetration rate.

For the Base Scenario, the CRF was assumed to be 33 percent, corresponding to an implicit discount rate of about 32 percent and assumed average lifetime of 15 years for efficiency measures. In addition, the penetration rate for cost-effective energy efficiency measures is assumed to be 3.25 percent per year. This means that 3.25 percent of the cost-effective efficiency potential in any particular sector is implemented annually. The cost effectiveness threshold and level of adoption are typical of decision making in industries today where a host of barriers lead to high "hurdle rates" that inhibit pursuit of energy efficiency measures with more than a 2 or 3 year payback based on energy savings alone. These barriers include insufficient information and expertise, energy cost representing a small fraction of the total cost of owning and operating an industry in most cases, lack of capital, and decision makers being preoccupied with other priorities (Brown 2001; DeCanio 1993; Megdal, Bensch and Schauf 2002).

The projections of electricity demand growth by the LIEF model in the Base Scenario also are adjusted to correspond to overall industrial electricity demand growth for the region as projected in the 2002 Annual Energy Outlook (EIA 2001b). This was done because the NEMS model is used to carry out the overall Scenario analysis in this study, and the Annual Energy Outlook uses NEMS. In effect, the LIEF model was used to disaggregate the load growth by sub-sector and industry group, as well as to estimate electricity savings in the High Efficiency Scenario.

Table 2-12 shows the overall industrial electricity use in 2010 and 2020 in the Base Scenario, as well as the growth rates by major area in each state. Overall industrial electricity consumption increases in all the states. In several states, such as Arizona, Colorado and Utah, shifts occur in the relative ranking of some industries due to the rapid growth of some non-energy intensive industries such as food, pharmaceuticals, aerospace, and computers, and the relative decline of traditional energy-intensive industries such as steel and petroleum refining.

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feedstocks and uranium, were either not present in the southwest states or data for them were unavailable. Therefore, these two sub-sectors were excluded from the analysis.

__Table 2-12.__ Base Scenario Results for the Industrial Sector by State

	Electricity Use (GWh/yr)			1998-2020 Growth Rate (%/yr)		
State	1998	2010	2020	Manufacturing	Mining	Total
AZ	12,240	15,330	18,520	3.61	0.09	1.91
CO	9,250	12,030	14,880	3.08	1.16	2.15
NV	10,650	12,780	14,810	2.97	1.51	1.49
NM	5,930	6,030	6,120	-0.08	0.55	0.16
UT	7,490	9,100	10,770	2.78	0.35	1.69
WY	6,870	8,000	8,950	1.11	1.95	1.13
Region	**52,410**	**63,260**	**74,040**	**2.61**	**1.05**	**1.59**

3. High Efficiency Scenario

In the High Efficiency Scenario, it is assumed that industries accept a much lower rate of return (i.e., longer payback period) on energy efficiency measures because they are better informed about these opportunities and their potential benefits (including non-energy benefits), the transaction costs of obtaining efficiency measures are reduced, and financial incentives are provided through energy efficiency and market transformation programs. In addition, it is assumed that cost-effective efficiency measures are implemented more rapidly in the High Efficiency Scenario, for the same reasons. In particular, the capital recovery factor (CRF) is reduced from 33 percent in the Base Scenario to 9.6 percent in the High Efficiency Scenario. The latter corresponds to a 5 percent discount rate and 15 year measure lifetime, reflecting a societal investment perspective. Also, the penetration rate for cost-effective efficiency measures is doubled from about 3.25 percent per year in the Base Scenario to 6.5 percent per year in the High Efficiency Scenario.

Table 2-13 shows the electricity use in 2010 and 2020 in each scenario by industry sub-sector, along with the savings achieved in the High Efficiency Scenario. Fast-growing manufacturing, which consists of computer and electronics manufacturing industries, other hi-tech equipment, appliance manufacturing, and printing, is the sector showing the largest savings potential—50 percent by 2020. Agriculture, mining, construction, and oil and gas production are the sub-sectors with the next highest savings potential (38 percent by 2020) while "General manufacturing" is close behind (35 percent savings potential by 2020). All sub-sectors except cement, primary aluminum, and stone and clay production exhibit at least 20 percent savings potential by 2020. In these three industries, structural shifts within the industries and a shift from fuel to electricity (according to the LIEF model) results in negligible electricity savings, although there would be some fuel savings.

Table 2-13. *Industrial Sector Electricity Use in the Base and High Efficiency Scenarios*

Industry	Base Scenario Electricity Use (TWh)		High Efficiency Scenario Electricity Use (TWh)		Savings Potential (%)	
	2010	**2020**	**2010**	**2020**	**2010**	**2020**
General Manufacturing	10.90	14.52	8.38	9.39	23	35
Fast-Growing Manufacturing	2.84	3.74	1.94	1.87	32	50
Pulp and Paper	2.15	2.97	1.87	2.37	13	20
Organic & Inorganic Chemicals	5.40	6.47	4.64	5.09	14	21
Petroleum Refining	2.68	3.6	2.25	2.74	16	24
Glass	0.22	0.25	0.19	0.19	14	24
Cement	4.49	4.59	4.49	4.59	-	-
Stone and Clay	1.32	1.65	1.32	1.65	-	-
Iron and Steel	0.34	0.32	0.29	0.24	15	25
Primary Aluminum	1.40	1.55	1.40	1.55	-	-
Nonferrous	4.53	4.61	3.78	3.46	17	25
Agriculture	3.07	4.28	2.31	2.66	25	38
Mining	24.65	23.95	18.55	14.85	25	38
Oil and Gas	7.69	6.70	5.78	4.16	25	38
Construction	2.29	2.44	1.72	1.51	25	38

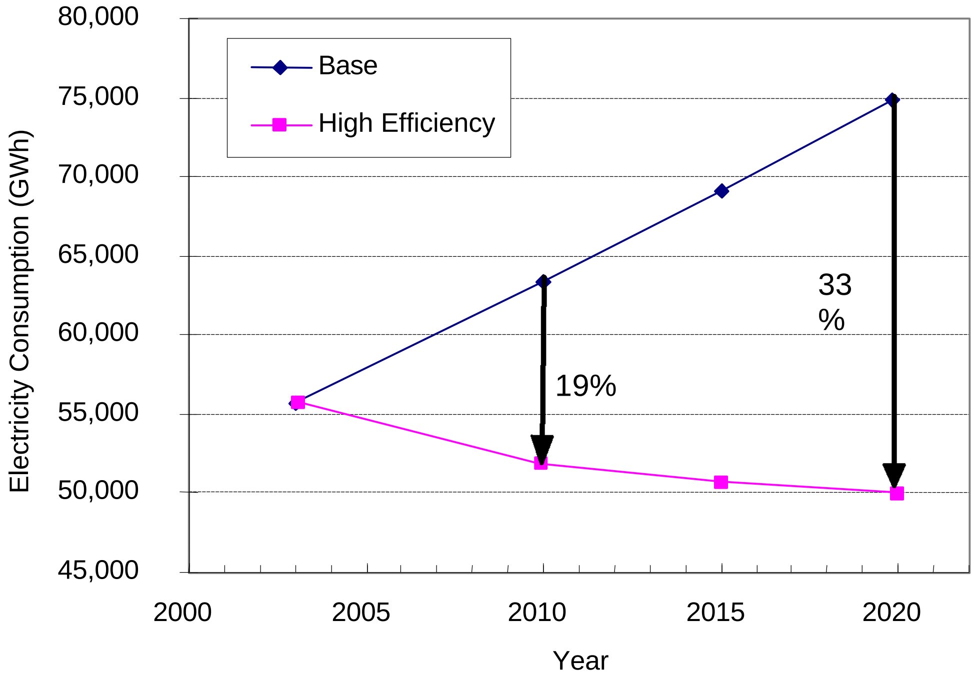
Table 2-14 shows the level of savings in the High Efficiency Scenario by state. The savings in 2010 range from 16 percent in Colorado and Utah to 21 percent in New Mexico and Wyoming. The savings in 2020 range from 29 percent in Colorado and Utah to 37 percent in Wyoming. The savings are higher in states such as New Mexico, Nevada, and Wyoming mainly because these states contain a greater presence of sub-sectors with high savings potential (e.g., fast-growth manufacturing or mining).

Table 2-14. *Energy Savings Potential in the Industrial Sector in the High Efficiency Scenario by State*

Industrial Sector		**Region**	**AZ**	**CO**	**NV**	**NM**	**UT**	**WY**
2010								
Baseline Consumption	GWh	63,262	15,333	12,028	12,777	6,026	9,103	7,995
Savings Potential	GWh	11,879	2,935	1,963	2,479	1,268	1,498	1,735
Savings Potential	%	**18.8**	**19.1**	**16.3**	**19.4**	**21.0**	**16.5**	**21.7**
2020								
Baseline Consumption	GWh	74,043	18,522	14,875	14,812	6,122	10,766	8,947
Savings Potential	GWh	24,154	6,177	4,289	5,001	2,222	3,128	3,339
Savings Potential	%	**32.6**	**33.3**	**28.8**	**33.8**	**36.3**	**29.0**	**37.3**

Figure 2-4 shows industrial electricity use over time in the Base and High Efficiency Scenarios. As mentioned previously, overall electricity use increases about 1.6 percent per year on average in the Base Scenario. On the other hand, absolute industrial electricity use declines slightly during 1999-2020 (-0.32 percent per year on average) in the High Efficiency Scenario.

Figure 2-4. *Overall Industrial Electricity Consumption in the Base and High Efficiency Scenarios*



These results are within the range of savings estimated in other studies of industrial energy savings potential, assuming strong efforts are made to remove barriers inhibiting the implementation of cost-effective measures. For example, a similar study for three Mid-Atlantic region states (New Jersey, New York, and Pennsylvania) found a 40-43 percent electricity savings potential in the industrial sector (Nadel et al. 1997). The savings potential in Mid-Atlantic study is somewhat greater than in this study because electricity prices are higher in the Mid-Atlantic states compared to the Southwest region, meaning that there are more cost-effective efficiency measures in the Mid-Atlantic region. Likewise, a national study found that implementing a comprehensive set of policies to advance energy efficiency could reduce industrial electricity use in 2020 by about 22 percent (Interlaboratory Working Group 2000). This study uses a different methodology that is less detailed and comprehensive concerning efficiency options compared to analysis using the LIEF model.

4. Specific Opportunities for Efficiency Improvement

The preceding discussion and analysis considered industrial electricity use and efficiency potential at the sector and sub-sector levels. But energy savings are realized through the adoption of more efficient technologies and better operating practices in factories, mines, farms, and construction sites. This section reviews some of the more common electricity savings opportunities in the industrial sector. While it is not possible to derive overall savings potential values from the examination of specific measures, it is helpful to understand some of the measures underlying the savings potential estimates.

Table 2-15 presents a matrix listing some of the more common efficiency measures and their likely importance in key industrial sub-sectors in the Southwest region. The efficiency measures include those that apply to motor systems, lighting, and key industrial processes such as chemicals processing and silicon chip fabrication.

Table 2-15. *Key Energy Efficiency Measures and their Importance in Different Sub-sectors*

Industry	Motor Management	Advanced Lubricants	Compressed Air System Optimization	Fan System Optimization	Pump System Optimization	Efficient Lighting Technologies	Lighting Controls	Lighting Design	Sensor and Controls	Evaporative Cooling	Efficient Clean Room Designs	Advanced Silicon Technologies	Membrane Technologies
Food mfg	**A**	**A**	**A**	**B**	**A**	**B**	**B**	**B**	**A**	**A**			**A**
Converted paper product mfg	**A**	**A**	**A**	**B**	**C**	**A**	**A**	**A**	**A**				
Printing & related support Activities	**A**	**A**	**B**	**C**	**B**	**A**		**A**	**A**	**B**			
Petroleum refineries	**A**	**A**	**A**	**B**	**A**	**C**	**C**	**C**	**A**	**A**			
Basic chemical mfg	**A**	**A**	**B**	**A**	**A**	**B**	**B**	**C**	**A**	**A**			**A**
Nonferrous metal (except Aluminum) production	**B**	**A**	**B**	**B**	**B**	**C**	**C**	**C**	**A**	**B**			**A**
Computer & electronic Product mfg	**A**	**B**	**B**	**B**	**B**	**A**	**B**	**A**	**A**	**A**	**A**	**B**	**B**
Aerospace product & Parts mfg	**A**	**A**	**B**	**B**	**B**	**A**	**A**	**A**	**A**	**B**	**B**		
Mining			**B**	**A**	**A**	**A**	**B**	**C**	**B**				

Note: *A means high importance, B moderate importance, and C low importance.*

Motors and Motor Systems

Motors consume about two-thirds of the electricity used in the industrial sector in general (XENERGY 1998). Furthermore, motors represent about 90 percent of the electricity consumed in the mining industry. Savings opportunities exist in both the motor, the motor-driven device (e.g., fan, compressor, or pump), and in the application.

Motors use many times their original purchase cost in electricity. Furthermore, small changes in motor efficiency and operating conditions can have significant impacts on electricity consumption. All new motors must meet minimum efficiency standards, but savings from the purchase of a premium efficiency motor can be on the order of 1 to 3 percent (Nadel et al. 2002).

Good maintenance is important to the efficient and reliable operation of motors. Among the most important areas are insuring that proper electric supply conditions are maintained and that motors are properly lubricated. Under-voltage or unbalanced phase-voltages can reduce the efficiency of motors by more than the efficiency gain that is achieved with a premium efficiency motor. Likewise, under- or over-lubrication can increase energy losses in the motor and drive components by several percentage points (Nadel et al. 2002).

A related measure is the replacement of conventional petroleum-based oils and greases with synthetic, engineered lubricants. Synthetic lubricants reduce energy consumption and equipment wear while extending lubricant life. Lubricants are a critical element of every motor-driven system, reducing the friction in equipment and minimizing component wear. While friction is a relatively small loss in motors themselves, friction can represent a large loss in mechanical equipment like compressors, pumps, and gear drives. Synthetic lubricants can reduce electricity use in gear reducers, compressors, pumps, and motors by 2 to 30 percent (Nadel et al. 2002).

Motor systems are made up of a range of components centered on a motor-driven device such as a pump or fan. While some savings can be realized by selecting more efficient components, the greatest savings can be realized through optimizing motor-driven systems, principally fan and pump systems, to meet end-use requirements and reduce losses in piping and ducts. For example, a national market survey and analysis concluded that system improvements offer two-thirds of the cost-effective savings potential in motor systems (XENERGY 1998).

Measures for improving the efficiency of motor systems include replacing oversized motors, cutting unnecessary flows and friction losses in fluid systems, improving gear ratios, changing fan pulleys or trimming pump impellers, and replacing throttling valves with adjustable speed drives (ASDs) or other speed control devices. These measures can reduce electricity use by 5-50 percent depending on the characteristics of the initial system (Nadel et al. 2002; XENERGY 1998).

Compressed air systems represent a significant opportunity for systems improvement. Energy savings can result from cutting leaks and inappropriate uses, reducing operating pressure, improving maintenance, and installing better controls. Typical savings achieved through compressed air system optimization range from 25 to over 60 percent (Nadel et al. 2002). A national initiative known as the Compressed Air Challenge has been developed to improve the performance of compressed air systems.[3]

Lighting

Lighting efficiency measures are discussed in greater detail in the buildings sector. However, technologies such as improved high intensity discharge lamps, lighting controls, and electronic ballasts for fluorescent lighting, now common in commercial buildings, are still not widely used in the industrial sector. This means that significant energy savings can be realized from lighting upgrades in the industrial sector. For example, lighting efficiency measures accounted for 44 percent of the total electricity savings achieved in the industrial sector in PacifiCorp's 1999

[3] Additional information about the Compressed Air Challenge is available on the initiative's web site at http://www.compressedairchallenge.org.

FinAnswer conservation program (Quantec 2002). In addition, better lighting design such as careful use of task lighting can both improve lighting quality and save a significant amount of energy in manufacturing applications (Martin et al. 2000).

Sensors and Controls

Control systems are often not solely designed for energy efficiency, but rather for improving productivity, product quality, and the efficiency of a production line. Applications of advanced control systems can be found in all industrial sectors. Improved control systems can result in reduced downtime, reduced maintenance costs, reduced processing time, reduced energy and other resource consumption, and lower pollutant emissions. Typical energy savings from better process control range from 2 to 18 percent (Martin et al. 2000). In addition, many modern industrial processes depend on precise control of process variables, e.g. for strip casting in the steel industry and process integration in the chemical industries.

Process Cooling/Cooling Towers

The arid southwestern United States presents an ideal climate for evaporative cooling. Many industrial facilities rely heavily on process cooling water generated by compressor-based chillers. These chillers often operate continuously at a constant load, thereby consuming a tremendous amount of electricity. Evaporative process cooling utilizes a water-to-water heat exchanger in parallel with a chiller. When the outdoor air is dry enough and cooling water temperature requirements permit, the heat exchanger uses water from the chiller cooling tower to cool the process water. Since chillers are the predominant energy user in a process cooling system, electricity savings of up to 50 percent are possible.

Laboratories and Clean Rooms

Within the manufacturing sector, a variety of high tech facilities such as laboratories and clean rooms use a significant amount of energy to operate heating, ventilation, and air-conditioning (HVAC) equipment. In the case of laboratory facilities, a leading cause of energy loss is fume hoods, which use a large amount of electricity to power fans and also exhaust vast quantities of conditioned air. New variable volume fume hoods substantially reduce electricity use in laboratories and have been adopted by energy-conscious companies such as Johnson & Johnson (Energy Design Resources 2001).

Clean rooms play a critical role in the pharmaceuticals and electronics industries, important and fast-growing industries in southwest region. Much of this energy is used to ensure that production facilities are free from pollutants that could damage products. These facilities have energy intensities that can range from 5 to 50 times greater than that of typical commercial buildings (Tschudi 2000, Mills et al. 1996). Measures for reducing HVAC energy consumption in clean rooms include air re-circulation when conditions permit, use of improved filters, and sophisticated pollutant sensors and air flow controls (Tschudi 2000). Combined, these technologies have the potential to reduce electricity consumption in clean rooms by 25-30 percent (Martin et al. 2000).

C. Non-Energy Benefits

Increasing energy efficiency can provide a variety of non-energy benefits in addition to saving energy. For example, sealing and properly sizing air distribution ducts as well as properly sizing air conditioning systems can greatly improve thermal comfort within homes (Swartz and deKieffer 2002). Use of daylighting and other energy efficiency measures can enhance worker productivity and/or increase retail sales in the commercial sector (Romm 1999; Okura, Heschong, and Wright 2000). Also, use of daylighting can improve student performance in schools (Heschong, Wright, and Okura 2000). Likewise, industrial process efficiency improvements can improve productivity, reduce waste, and save energy (Romm 1999; Pye 1998). These non-energy benefits were not considered or included in this study, further suggesting our results are conservative.

CASE STUDIES FROM THE SOUTHWEST

Pulte Homes – Arizona and Nevada

Production builder Pulte Homes is a leader in energy-efficient homes in Arizona, Nevada and other states. The builder has partnered with Engineered for Life to build quality, energy-efficient homes that are 30-50 percent more efficient than the 1995 Model Energy Code with little or no additional cost. This impressive result is obtained by using a systems engineering approach to design and construction. Pulte builds exterior walls with 2x6 construction at 24 inches-on-center rather than conventional 2x4 construction 16 inches on center, thereby creating more space for insulation without significantly increasing lumber requirements. Pulte uses high efficiency windows, sealed ductwork, and other measures to reduce the cooling load, but then is able to reduce air conditioning system size and capacity to lower costs. Pulte also provides home buyers with utility bill and comfort guarantees.

Artistic Homes – Albuquerque, New Mexico

Artistic Homes is a major home builder in Albuquerque. In 2001, it partnered with the Department of Energy's Building America program to improve the performance, comfort and efficiency of its homes. More than 700 homes built by Artistic Homes in 2001 are 30-50 percent more efficient than the state's Model Energy Code. Key features include a tightly-sealed building envelope, efficient ventilation systems with sealed ductwork, 2 x 6 framing that results in an R-21 wall, R-38 attic insulation, and energy-efficient air conditioning. The energy-efficient homes typically cost about 4 percent more than homes without these features, but the energy savings lead to a net reduction in monthly costs for the homeowner assuming the efficiency improvements are financed through a 30-year mortgage.

Nevada State Capitol Complex – Carson City, Nevada

Nevada selected CMS Viron, an energy service company, to conduct an equipment lease-purchase and energy savings performance contract at its State Capitol Complex. The project included installing T8 lamps and electronic ballasts, compact fluorescent and halogen lighting, occupancy sensors, LED exit signs, and the recommissioning of HVAC systems. About $1.9 million in energy efficiency measures were implemented over a six month period in 20 buildings (approximately 1.8 million square feet) at the complex. CMS Viron projects savings of more than $3 million in energy costs, $148,000 in water costs, and $69,000 in operation and maintenance costs over the 12-year contract period. In the first year of the project, energy cost savings alone were significantly higher than projected, so the state should realize even greater cost savings.

Big Horn Home Improvement Center – Silverthorne, Colorado

Completed in 2000, the 43,000 square foot Big Horn Home Improvement Center in the mountains of Colorado was designed to be 60 percent more efficient than an identical building built to the ASHRAE Standard 90.1-89. Daylighting via skylights, in combination with compact fluorescent lights and motion sensors, led to a 79 percent reduction in total lighting energy use. A variety of technologies monitor and control occupant comfort. In the summer, windows on the roof and at lower levels are computer-controlled to allow warm air to escape and to let cool air in. In the winter, a transpired solar collector on the south side of the building heats ventilation air drawn into the building with fans, and works in tandem with a radiant heat floor system. Window overhangs provide shade in the summer. The building features an energy-efficient envelope with double-layered Styrofoam walls and R-34 insulation in the roof. With this combination of measures, the building does not need mechanical air conditioning. A 9kW integrated photovoltaic system can provide up to 25 percent of the building's total electric demand, with excess electricity sold to the utility. While the energy-efficient design resulted in a 10 percent increase in design and construction costs, the utility bill savings are expected to pay back the extra cost in five years.

Thomas O. Price Service Center Building One – Tucson, Arizona

The Thomas O. Price Service Center Building One is a one-story, 23,400 square foot City of Tucson office building which houses 80 employees. Energy efficiency upgrades began in 1995 with a lighting retrofit. By May 2001, several additional efficiency projects had been completed at a cost of $128,200, including the addition of an energy management and control system and the changeover of a dual duct air handling system to a variable air volume system. With estimated electricity savings of $22,400 per year, the simple payback period of these efforts is 5.7 years. A "cool roof" was added to Building One as part of Tucson's Creating Cool Communities program in June 2001. This measure is expected to have a simple payback period of just over six years, in part because previous efficiency efforts have already lowered cooling energy use. As a result of this series of efficiency retrofits, total electricity use for Building One declined from around 432,000 kWh per year in the early 1990s to about 162,000 kWh per year in 2001, a reduction of more than 60 percent.

Alcoa North American Extrusions Plant – Spanish Fork, Utah

Alcoa's plant in Spanish Fork, Utah produces extruded aluminum products for the automotive industry, electrical equipment, and miscellaneous other uses nationwide. About 300 employees are involved in processing 82 million pounds of extruded products annually. In July 2000, the Industrial Assessment Center (IAC) at Colorado State University conducted an energy assessment of the plant. Measures implemented as of September 2002 reduced electric energy consumption by around 454,300 kWh/year; natural gas energy consumption by 24,087 million Btu/year; and non-hazardous solid waste generation by 640,500 lbs/year. The total cost savings is estimated to be $244,960 per year, with an implementation cost of $104,730. Thus, the simple payback period on average was just over five months.

CHAPTER 3—UTILITY ANALYSIS

A. Methodology

1. Regional Integration of Demand and Supply

The benefits (avoided costs and avoided emissions) of the High Efficiency Scenario are computed using the National Energy Modeling System (NEMS). NEMS is the primary energy forecasting and policy analysis model developed and used by the Energy Information Administration (EIA), a branch of the U.S. Department of Energy. NEMS models electricity demand and supply interactions by dividing the US into 13 National Electricity Reliability Council (NERC) regions, some of which embody or approximate power pools. The model ensures that supplies are developed and dispatched to meet the demands in each region, taking account of system reliability, the capital, fuel and O&M costs of new power plant options, the operating costs of existing units, the efficiencies and outage rates of all power plants, transmission and distribution system costs and losses, inter-regional sales and purchases, state renewable energy requirements, national and regional emissions requirements, and pollution cap and trade systems. For each region, NEMS provides information on:

- Amounts and types of electricity generation, including non-utility generation, fuel use, imports, and exports;
- Carbon dioxide, SO_2 , NO_x, and mercury emissions; and
- Costs for new capital investments, fuel and operations, transmission, and distribution.

The NERC regions directly involved in this study are Region 11 (comprising the Southwest states—Wyoming, Utah and part of Nevada—plus Washington, Oregon, Idaho and Montana) and Region 12 (comprising Arizona, New Mexico, Colorado and part of Nevada). The approach for allocating the regional results to individual states is described in section 2b starting on p. 3-2.

We first ran the Base Scenario in NEMS using the assumptions in EIA's 2002 Annual Energy Outlook to determine the evolution of electricity demand and the expansion and operation of electricity supplies in the region. As described in section 2a, we used these projected regional electricity demands as the basis for our projections of state electricity demands. For the High Efficiency Scenario, we re-ran NEMS with reductions in future electricity demands reflecting the results of the residential, commercial and industrial efficiency analyses discussed in Chapter 2. The differences between these two runs reflect the impacts of the electricity demand reductions on electricity supplies (i.e., avoided generation, fuels, costs and emissions). However, we made two additional adjustments for the High Efficiency Scenario.

(1) Although this analysis focuses on the six Southwest states, we were aware that actions taken, or not taken, in other regions could appreciably affect the results on electricity supplies in the southwest region and its states. It is possible that with demands reduced,

electricity generation would not be reduced correspondingly, as the excess electricity could be exported to neighboring regions. We chose to concentrate on the impacts of electricity efficiency net of changes in electricity trade. Imports and export decisions are modeled endogenously within NEMS, so it was impossible to completely control these changes in imports and exports, which presumably would occur on an economic basis as a result of the demand reductions. In order to minimize changes in imports and exports between the two scenarios, we also reduced electricity demands for the neighboring states (Idaho, Montana, Washington, Oregon, and California) included in the relevant NERC regions, using the same percent reductions as for the southwest region. However, we did not consider the costs and benefits of achieving this level of energy savings in the neighboring states.

(2) Some states in the West have adopted policies to promote new renewable electricity generation, and some new renewable generation is included in the Base Scenario. Since the demand reductions of the High Efficiency Scenario will reduce the need for new plants, there would tend to be less renewable energy generation in the High Efficiency Scenario. However, we assumed that states continue to support renewable energy development in the High Efficiency Scenario, and thus we maintained the fraction of electricity generation from non-hydro renewables at close to the levels in the Base Scenario.

2. Allocation of Benefits to States

Since NEMS does not directly represent the individual Southwest states, but rather the interconnected electricity supply systems that cross state boundaries, we needed to allocate the regional emissions, generation and costs to each state. Emissions and generation in each state start at the historic 1999 levels, and are assumed to grow over time based on that state's share, based on electricity demand, of the regional change in emissions/generation. Reductions in emissions/generation are based on the state's contribution to regional electricity demand reductions.

a) Base Scenario

The Base Scenario annual emissions projections start at EIA's historical values for each pollutant in each state. Following the base-year, the regional emissions are allocated to the states according to each state's growth in electricity demand as a fraction of regional growth. In other words, we assume that emission rates from new electricity sources are the same in all states, but we use the actual emissions as of 1999 as the starting point.

$$Emissions_{stbase} = EIA_{s1999} + \left(\frac{Electricity_{srt}}{Electricity_{rt}} * emissions_{rt} - \frac{Electricity_{sr1999}}{Electricity_{r1999}} * emissions_{r1999} \right)$$

(sum this equation over all regions that contain state)

$Emissions_{st}$ – emissions in state *s* in year *t*
$Emissions_{rt}$ – emissions in region *r* in year *t*

EIA_{s1999} – EIA's 1999 value for emissions in each state (Electric Power Annual, Vol. II.)
$Electricity_{srt}$ – portion of total electricity demand growth from 1999 to year *t* from region *r* in state *s*
$Electricity_{rt}$ – total electricity demand growth from 1999 to year *t* in region *r*

b) High Efficiency Scenario

The regional emissions reductions are allocated to the states in direct proportion to each state's share of the region's electricity demand reductions.

$$Emissions_{steffic} = Emissions_{stbase} - \left(\frac{Electricity_{srtbase} - Electricity_{srteffic}}{Electricity_{rtbase} - Electricity_{rteffic}} \right) * (emissions_{rtbase} - emissions_{rteffic})$$

(sum this equation over all regions that contain state)

The above equations are applied for each type of emission (carbon, SO_2, NOx and mercury) and each type of electricity generation.

c) Avoided Costs

Similarly, the economic benefits (avoided costs) of the High Efficiency Scenario are allocated from the regions to the states in direct proportion to each state's share of the region's electricity demand reductions. These include avoided power plant capital, fuel and O&M costs, avoided transmission and distribution costs, and avoided purchased costs (or net incremental sales). Also, lower natural gas use for electricity generation slightly reduces natural gas prices for all consumers, which saves consumers and businesses money on their direct natural gas purchases. These savings are determined from NEMS output and allocated to states using this procedure.

$$Costs_{st} = \left(\frac{Electricity_{srtbase} - Electricity_{srteffic}}{Electricity_{rtbase} - Electricity_{rteffic}} \right) * Costs_{rt}$$

(sum this equation over all regions that contain state)

$Costs_{st}$ – change in costs in state *s* in year *t*
$Costs_{rt}$ – change in costs in region *r* in year *t*

B. Energy Results

1. Base Scenario

We first developed electricity demand projections for each state and sector in the Base Scenario, starting with actual electricity use in 1999 as provided in EIA's State Energy Data Report (EIA 2001a). Our projections of future electricity demands account for: (i) residential, commercial and industrial activity growth in each state, and (ii) the evolution of electricity-using technologies (including stock turnover and improved efficiencies), reflected in changes over time in the electricity intensities (kWh per activity level) for each sector in the regional demand modules of NEMS (EIA 2001b).

Electricity demand growth is projected using a different activity indicator for each sector. For the residential sector, we multiplied the NEMS regional intensity trends (in kWh per capita) by projected state *population.* In the commercial sector, we multiplied the NEMS regional intensity trends (in kWh per commercial Gross State Product or GSP) by projected commercial *GSP*. For the industrial sector, we developed projections using the Long-term Industrial Energy Forecasting (LIEF) model, taking into account industrial electricity prices and the projected Value of Shipments for the various industrial sub-sectors in each state. Also, we benchmarked the overall industrial electricity growth rates for the region to the regional growth rate in NEMS.

Base year (i.e., 1999) electricity consumption levels are shown in Table 3-1. The year 1999 was chosen as the Base Year because of data availability and to be consistent with the NEMS Base Year as given in the 2002 Annual Energy Outlook.

Table 3-1. *Electricity Use by Sector, 1999 (GWh/yr)*

State	Residential	Commercial	Industrial	Total
Arizona	22,517	22,688	12,456	57,661
Colorado	13,131	17,919	9,521	40,571
Nevada	8,386	7,007	10,861	26,254
New Mexico	4,645	7,430	5,922	17,997
Utah	6,236	8,074	7,568	21,878
Wyoming	2,025	2,692	7,065	11,782
Region	**56,940**	**65,810**	**53,393**	**176,143**

Source: *EIA 2001a.*

Growth rates in state level population, commercial GSP, and industrial value of shipments are summarized in Table 3-2 below. For the region as a whole, population is projected to increase 1.8% per year on average while commercial and industrial activity is projected to grow about 3.5% per year on average.

Table 3-2. *Average growth rates for Population, Commercial GSP, and Industrial Shipments, 1999-2020 (percent per year)*

State	Population	Commercial GSP	Industrial Value of Shipments
Arizona	2.0	4.1	4.4
Colorado	1.4	3.7	3.5
Nevada	2.0	4.4	3.1
New Mexico	1.8	2.2	1.2
Utah	1.9	3.3	3.0
Wyoming	1.3	1.6	1.7
Region	**1.8**	**3.7**	**3.4**

Sources: *Population growth from 1995 U.S. Census; http://www.census.gov/population/www/projections/stproj.html. Commercial GSP growth from www.economy.com. Industrial Value of Shipments growth from 1997 U.S. Economic Census; http://www.census.gov/epcd/www/econ97.html, and the 1997 Census of Agriculture; http://www.nass.usda.gov/census/.*

Based on these inputs, the growth in electricity demand by state and sector in the Base Scenario is summarized in Table 3-3. Electricity demand for the region as a whole is expected to increase about 2.6% per year on average during 1999-2020. The commercial sector is expected to grow at a more rapid rate, while the industrial sector is expected to show below-average electricity demand growth.

Table 3-3. *Average Growth Rates of Electricity Use in the Base Scenario, 1999-2020 (percent per year)*

State	Residential	Commercial	Industrial	All
Arizona	2.59	3.94	1.91	2.97
Colorado	1.96	3.48	2.15	2.68
Nevada	2.54	4.22	1.49	2.55
New Mexico	2.34	1.97	0.16	1.47
Utah	2.51	3.16	1.69	2.47
Wyoming	1.86	1.45	1.13	1.33
Region	**2.39**	**3.47**	**1.57**	**2.61**

These growth rates vary considerably among states, from a low of 1.3 percent per year for Wyoming to about 3.0 percent per year for Arizona. For comparison, EIA projects that electricity demand in the United States as a whole will increase 1.90 percent per year over the same period (EIA 2001a). The Base Scenario electricity demand is shown graphically in Figure 3-1.

__Figure 3-1.__ Base Scenario Electricity Demand (by state)

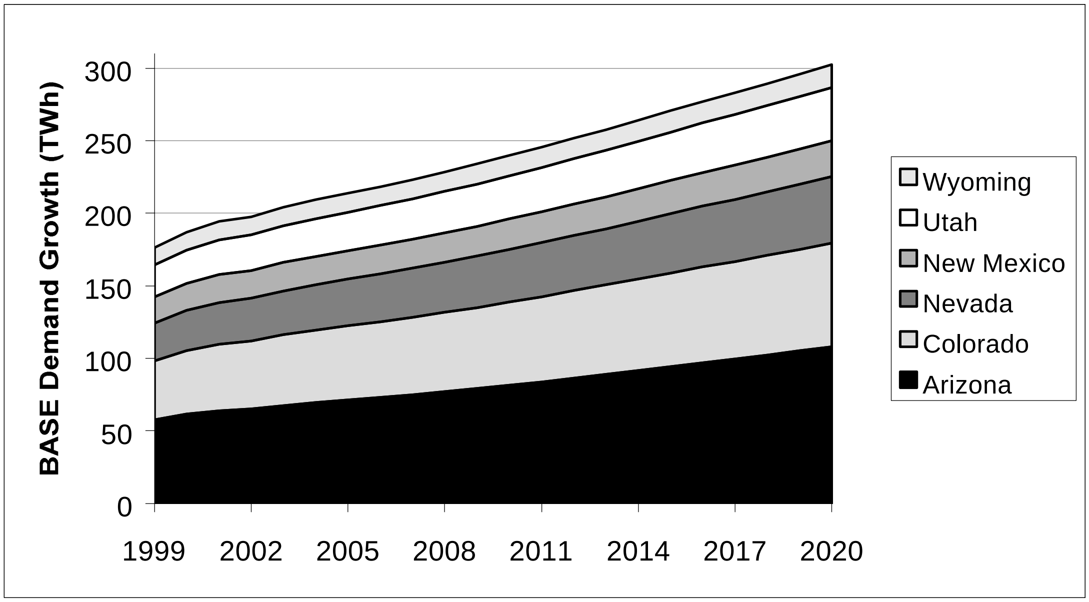
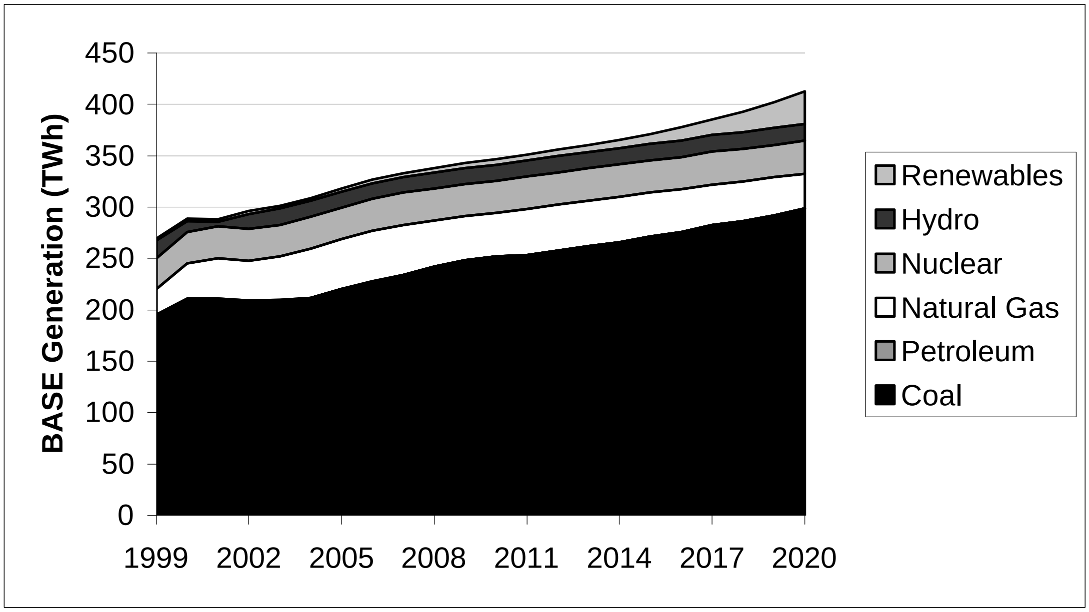


Figure 3-2 shows the projection of electricity generation by power plant type for 1999 to 2020, with electricity generation allocated to states by electricity growth as described in section 1b. Note that this region currently exports about 35 percent of its generated electricity and this amount is expected to decrease only slightly to 27 percent by 2020, so generation exceeds demand throughout the time period. Due to its low cost, historically and based on future expectations, the majority of electricity supply in the region is from coal-fired sources. Natural gas increases strongly in early years, as expected based on current utility plans, and initially maintains its share. However, over time, natural gas prices are expected to increase (about 25 percent between 2002 and 2020) while coal prices decrease (about 30 percent between 2002 and 2020). This change favors coal generation, which provides most of the increased generation after 2005.

Renewable sources modestly increase their share of generation by 2020, largely due to state policies such as renewable portfolio standards. This analysis assumes that existing renewable energy policies will be implemented but does not assume any new or expanded policies. By 2020, the Base Scenario includes 29 TWh of generation from renewable sources – of this, wind accounts for about 79 percent, geothermal 20 percent, and solar 0.8 percent.

Figure 3-2. *Base Scenario Electricity Generation (by fuel source)*



2. High Efficiency Scenario

Table 3-4 presents the electricity demand growth rates in the High Efficiency Scenario. The result is a 0.7 percent per year growth rate across the region, with substantial variation by sector and state. Sources of demand and supply are shown graphically in Figure 3-3 and Figure 3-4. As explained in Chapter 2, the electricity reductions in each state depend on activity growth (population and type of commerce and industry), expected saturation of electricity services (e.g. air conditioning and electric heating), equipment stock turnover and replacement by more efficient units, and the assumed penetration rates for energy efficiency measures. Figure 3-4 shows that electricity generation by natural gas drops in the High Efficiency Scenario and the growth in coal-fired power generation almost halts. By design, renewable generation remains close to the Base Scenario levels, with most of the growth in generation occurring after 2015.

Table 3-5 shows the generation mix by fuel type for both the Base and High Efficiency Scenarios in 2010 and 2020, with comparison to 1999. While the overall mix remains similar in both scenarios, the fraction of natural gas generation does fall. The generation mix is a little misleading since the overall generation also declines. As described later (see Figure 3-6), most of the avoided generation in the High Efficiency Scenario is from coal, rather than natural gas, according to the NEMS model. Similarly, the fraction of nuclear and hydro generation increases because absolute generation by these plants remains the same while overall electricity generation decreases. Hydro and nuclear generation is from existing plants that have low operating costs and are less likely to be impacted by demand reductions.

Table 3-4. *Average Growth Rates of Electricity Use in the High Efficiency Scenario, 1999 – 2020 (percent per year)*

State	Residential	Commercial	Industrial	All
Arizona	0.88	1.62	-0.04	1.01
Colorado	0.79	1.25	0.51	0.94
Nevada	1.31	1.96	-0.48	0.85
New Mexico	0.51	-0.35	-1.97	-0.57
Utah	1.17	0.92	0.04	0.71
Wyoming	0.52	-0.93	-1.09	-0.74
Region	**0.92**	**1.20**	**-0.32**	**0.69**

Figure 3-3. *Electricity Demand by State in the High Efficiency Scenario*

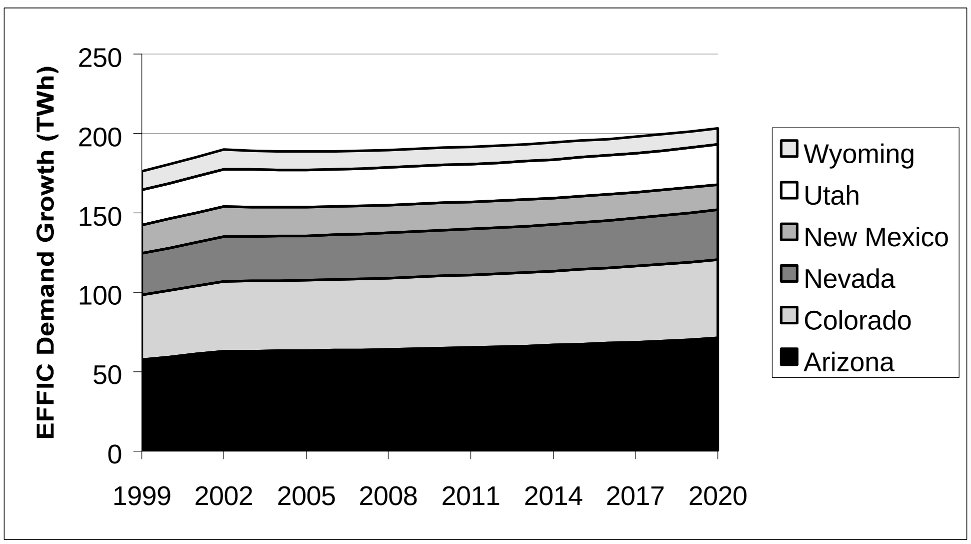


Figure 3-4. *Electricity Generation by Fuel Source in the High Efficiency Scenario*

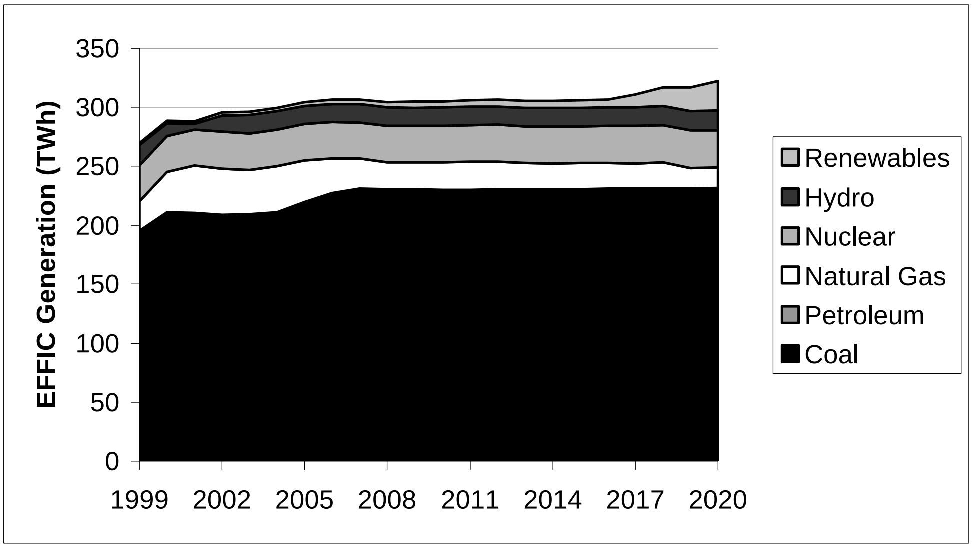


Table 3-5. *Generation Mix by Fuel Type*

	1999	2010		2020	
		BASE	EFFIC	BASE	EFFIC
Coal	72%	73%	75%	72%	72%
Natural Gas	9%	12%	8%	8%	5%
Nuclear	11%	9%	10%	8%	10%
Hydro	6%	4%	5%	4%	5%
Other	1%	2%	2%	8%	8%

Tables 3-6 and 3-7 show the percent and absolute reductions in electricity demand in the High Efficiency Scenario. The High Efficiency Scenario results in progressively greater reductions in the region's annual electricity demand over the 2003-2020 period, reaching about 33 percent by 2020. Each state is projected to reduce its annual electricity demand by 31 to 36 percent below Base Case projections by 2020. Each sector has similar percent reductions, but the commercial sector accounts for more of the absolute reduction due to its larger share of the total in the Base Scenario. Figure 3-5 shows the electricity generation in the Base and High Efficiency Scenarios and the reductions by sector over time. As illustrated in Figure 3-5 and Table 3-6, the commercial sector provides about half the electricity savings and the residential and industrial sectors each provide about one-quarter of the savings for the region as a whole.

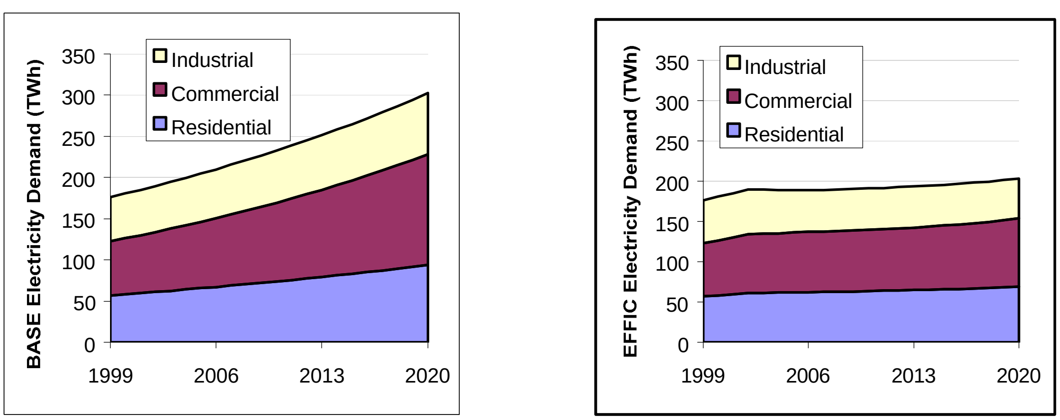
Table 3-6. *Reductions in Electricity Use in the High Efficiency Scenario (%)*

STATE	2010				2020			
	Res	Com	Ind	All	Res	Com	Ind	All
Arizona	16.1	20.1	19.1	18.4	29.9	37.2	33.3	33.9
Colorado	11.6	19.9	16.3	16.6	22.1	37.0	28.8	31.2
Nevada	12.8	20.3	19.4	17.6	21.8	36.6	33.8	31.1
New Mexico	16.5	19.6	21.0	19.2	31.0	38.7	36.3	35.8
Utah	12.9	19.9	16.5	16.8	23.9	37.5	29.1	31.2
Wyoming	11.7	19.6	21.7	19.4	24.9	39.8	37.3	35.5
Region	**14.2**	**20.0**	**18.8**	**17.8**	**26.3**	**37.3**	**32.6**	**32.8**

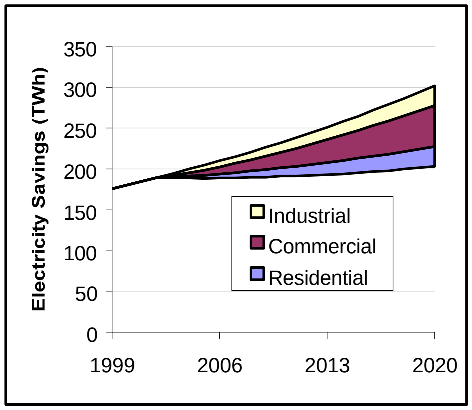
Table 3-7. *Reductions in Electricity Use in the High Efficiency Scenario (TWh/yr)*

STATE	2010				2020			
	Res	Com	Ind	All	Res	Com	Ind	All
Arizona	4.80	6.95	2.94	14.69	11.55	18.86	6.18	36.58
Colorado	1.90	5.21	1.96	9.07	4.41	13.65	4.29	22.35
Nevada	1.41	2.24	2.48	6.13	3.07	6.09	5.00	14.15
New Mexico	0.99	1.81	1.27	4.07	2.32	4.36	2.22	8.90
Utah	1.06	2.27	1.50	4.83	2.51	5.87	3.13	11.50
Wyoming	0.29	0.62	1.74	2.65	0.75	1.47	3.34	5.55
Region	**10.45**	**19.11**	**11.88**	**41.44**	**24.59**	**50.29**	**24.15**	**99.04**

Figure 3-5. *Regional Electricity Use by Sector – Base vs. High Efficiency Scenario*



Base Scenario **High Efficiency Scenario**

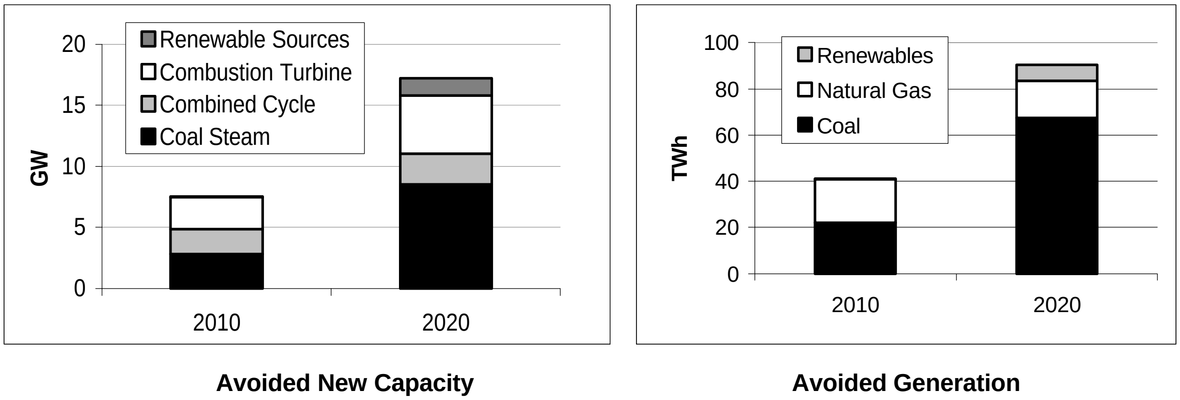


Electricity Savings

Figure 3-6 shows estimates of the avoided construction of new power plants and avoided electricity generation in the High Efficiency Scenario, relative to the Base Scenario. The reductions in electricity demand allow the region to avoid constructing the equivalent of fifteen large power plants by 2010 and nearly thirty-five power plants by 2020 (based on 500 MW power plants). About half the avoided power plants are baseload coal plants, according to the NEMS model. Most of the remaining avoided power plants are gas-fired, both baseload combined cycle plants and peak load simple cycle combustion turbines (see Figure 3-6). In addition, there is a slight reduction in the amount of renewable energy capacity by 2020 in the High Efficiency Scenario. As described in section 1a, the decrease in renewable capacity was limited based on the assumption that states would continue to support renewable energy, and thus renewable generation as a fraction of total generation would remain roughly the same in both scenarios.

The avoided generation in Figure 3-6 includes avoided generation both from the new power plants and from existing plants. Coal accounts for about 75 percent of the avoided generation by 2020, due to its dominance in the Base Scenario generation. Because the avoided coal generation is from both existing and avoided new plants and these plants tend to run at high capacity factors, the fraction of avoided generation is higher than the fraction of avoided capacity from coal-fired power plants. Avoided natural gas generation will come primarily from new plants, and these plants tend to run at lower capacity factors.

Figure 3-6. Avoided Power Plant Construction and Generation in the High Efficiency Scenario



C. Economic Results

1. Region-wide Results

To evaluate the net economic benefits of the High Efficiency Scenario, the incremental cost of the energy efficiency measures is compared to the benefits of the reduced costs for electricity supply. These reduced costs include avoided investment in new power plants, reduced fuel and operating costs for these plants, reduced investment in electricity transmission & distribution, and reduced net purchased power costs. In addition, lower natural gas use for electricity generation reduces natural gas prices, according to the NEMS model. This, in turn, saves consumers and businesses money on their direct natural gas purchases.[1] In other words, the cost effectiveness of the High Efficiency Scenario is evaluated from a total resource cost and benefit perspective.

The regional costs and benefits over time are presented in Figure 3-7; state-by-state results are presented in the appendices. The benefits strongly outweigh the costs, leading to net benefits of $2.7 billion per year by 2010 and $6.5 billion by 2020 (in 2000 dollars).

[1] The electricity prices could also be affected by efficiency measures, but the price could increase or decrease differently depending on the ratio of decreased investment and fuel costs to decreased electricity consumption, the pricing policy of the state (marginal versus average cost), and the policy mechanism for achieving the efficiency savings (e.g., a systems benefit charge could increase prices). For the cost and benefit calculations in this section, electricity prices are not required since we are looking at the social impacts and are less concerned with the financial transfers between the electricity suppliers and consumers. For the macro-economic analysis presented in Chapter 4, these transfers are important and we assume no change in electricity price, either over time or between scenarios, in constant dollars (i.e., electricity prices increase due to general price inflation only).

Figure 3-7. *Annual Costs and Benefits*

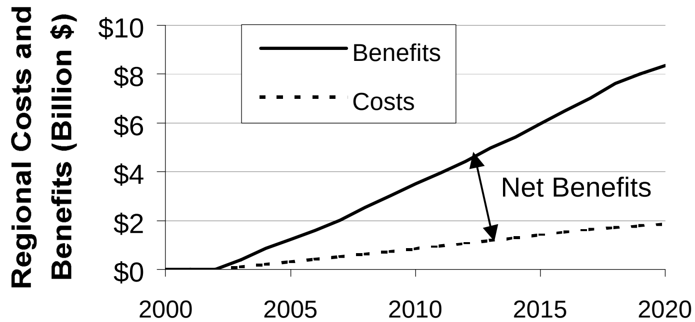


Table 3-8 presents the cost of energy efficiency measures and costs of saved energy by sector. These costs refer to the annualized incremental investments for equipment with greater energy efficiency plus a 10 percent administration cost to account for the implementation of energy efficiency programs. The incremental investment costs have been estimated by sector, based on the equipment characteristics (including costs and electricity consumption) in each sector. These costs amount to $9 billion cumulative present value over the scenario time-horizon, and are similar for each of the three sectors.

The cost of saved energy is the ratio of the investment (plus administration) cost to the amount of electricity saved. The commercial sector has the lowest cost of saved energy, followed by the industrial sector. While the residential sector shows the highest cost of saved energy, the cost is still much below market prices for electricity. The average cost of saved energy of $0.02 per kWh is consistent with the experience in regions such as California and the Pacific Northwest which have had vigorous energy efficiency efforts (Geller 2002b).

Table 3-8. *Costs and Cost of Saved Energy by Sector*

	Investment Costs (Billions, 2000$)	**Cost of Saved Energy** ($/kWh)
Residential	3.20	0.029
Commercial	3.04	0.014
Industrial	2.60	0.021
Total	**8.85**	**0.020**

Table 3-9 summarizes the economic benefits produced by the High Efficiency Scenario. The total economic benefit is $37.1 billion (cumulative present value 2000-2020). This value accounts for both the electric sector savings and natural gas savings outside the electric sector.

The electricity sector savings have been split into generation and transmission & distribution components. The generation component, accounting for $25.5 billion of the $34.6 billion electric sector savings, is further divided into investment savings and fuel/operating savings.

These benefits, as for all the benefits, are the difference between electricity supply expenditures in the Base and High Efficiency Scenarios. In both cases, capital costs are levelized over the lifetime of the new plants (on an annualized capital recovery basis), and costs in future years are discounted to the present using a 5 percent discount rate. The fuel and operating cost savings include reductions in fuel costs, plant operation and maintenance costs, and the net costs of imported/exported electricity. [2] Table 3-9 shows that the avoided fuel and operating cost is about 50 percent higher than the avoided power plant investment cost. In addition, the avoided investment in transmission & distribution is nearly equal in value to the avoided investment in new power plants, indicating that end-use energy efficiency improvements can have significant value in reducing expenditures on electric grid expansion. All of these cost savings were evaluated using the NEMS model.

The reduction in the average natural gas price is relatively small (5 percent on average by 2020), but it affects all natural gas consumption in these states, not only gas consumption for electricity production. The value for Natural Gas Price Benefits in Table 3-9 only refers to lower natural gas bills in the residential, commercial and industrial sectors since the lower cost of natural gas for electricity generation is separately accounted for in the avoided fuel/operating costs. About 6.5 percent of the total economic benefits, and about 9 percent of the net economic benefits, come from lower natural gas bills outside the electric sector.

The benefits shown in Table 3-9 are allocated to each sector based on the contribution of the sector to electricity demand reductions. As noted previously, the commercial sector accounts for approximately 50 percent of the electricity savings and consequently about half of the economic benefits.

Table 3-9. *Economic Benefits in the High Efficiency Scenario (cumulative net present value, billions 2000$)*

	Electric Sector Benefits				**Natural Gas Price Benefits**	**TOTAL**
	Avoided Generation Investment	Avoided Fuel and Operating Costs	Avoided T&D Investment	Total		
Commercial	5.1	7.1	4.4	16.6	1.1	17.7
Residential	2.7	3.7	2.3	8.7	0.6	9.3
Industrial	2.8	4.1	2.5	9.4	0.7	10.1
TOTAL	**10.6**	**14.9**	**9.1**	**34.6**	**2.4**	**37.1**

Table 3-10 presents the regional costs, benefits and benefit-cost ratios by sector. The High Efficiency Scenario yields a net economic benefit of about $28 billion (cumulative present value 2000-2020). This is equivalent to $4,788 per household (based on the number of households in the region in 2000). The differences in costs of saved energy and energy efficiency options in

[2] Although not included in the economic benefits, the SO_2 reductions resulting from the electricity demand reductions would yield a further $8 million benefit (CPV, 2003-2020) from reduced need to purchase SO_2 credits or increased ability to sell the credits.

each sector lead to variations in net benefits across the sectors; the commercial sector net benefits are about twice that of either the residential or industrial sectors. Across all sectors, the High Efficiency Scenario has an overall benefit-cost ratio of 4.2.[3] At the sector level, the benefit-cost ratio is about six for the commercial sector, three for the residential sector, and four for the industrial sector.

Table 3-10. *Costs and Benefits in the High Efficiency Scenario (cumulative net present value, billions 2000$)*

Sector	Energy Efficiency Costs	Overall Benefits	Net Benefits	Benefit-Cost Ratio
Commercial	3.0	17.7	14.7	5.8
Residential	3.2	9.3	6.1	2.9
Industrial	2.6	10.1	7.5	3.9
Total	**8.8**	**37.1**	**28.2**	**4.2**

2. State-specific Results

Each state benefits from increasing the adoption of energy efficiency measures. As with the regional results described above, the costs have been estimated separately by sector and state. On the other hand, the benefits to each state are estimated by allocating to each state a portion of the regional avoided costs, based on each state's share of the regional electricity demand reduction. The state-specific results are presented below as well as in Appendix D.

Figure 3-8 shows the per-household allocation of the supply side benefits, energy efficiency investment costs, and the net benefits for each state. The values are based on the net present value of costs and benefits during 2000-2020, divided by the number of households in each state in 2000. The net benefits range from a low of $3,388 per household in Utah to a high $7,762 per household in Wyoming. The variation among states is due to a variety of factors including the mix of sectors in each state (each sector has different benefit-cost ratio), the mix of industries, building types and electric services within the states, the type of generation avoided, and the ratio of the number of households to total electricity demand (e.g., Wyoming has the fewest households).

[3] This benefit-cost ratio reflects benefits based on the avoided costs to the electric sector rather than avoided electricity prices. Using electricity prices (for comparison with some other efficiency analyses), the benefit-cost ratio would be about 3.5 across all sectors. Due to differences in sectoral electricity prices, the benefit-cost ratios would be 5.0 for commercial, 2.9 for residential and 2.3 for industry.

Figure 3-8. *Costs, Economic Benefits, and Net Benefits by State in the High Efficiency Scenario*

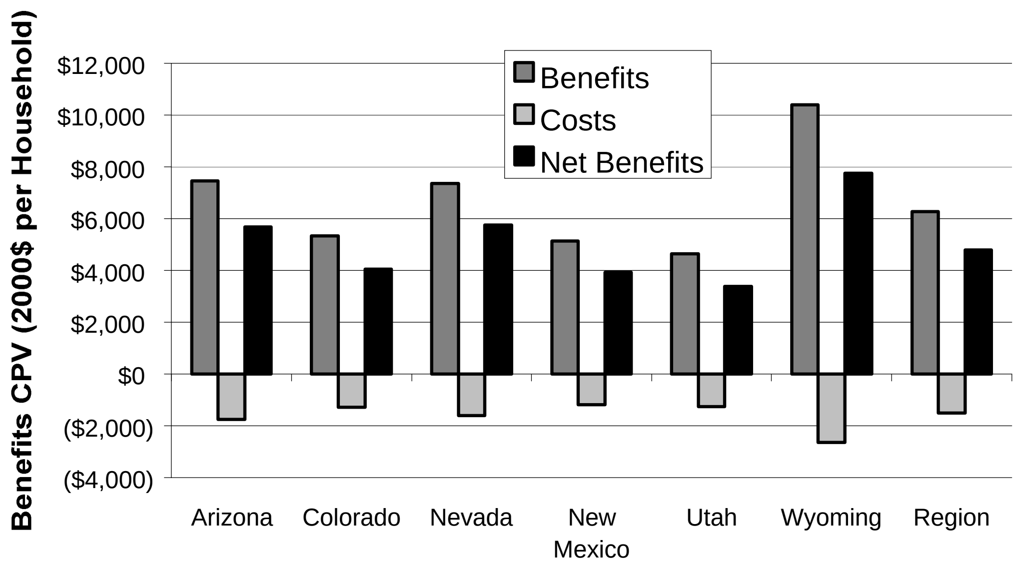
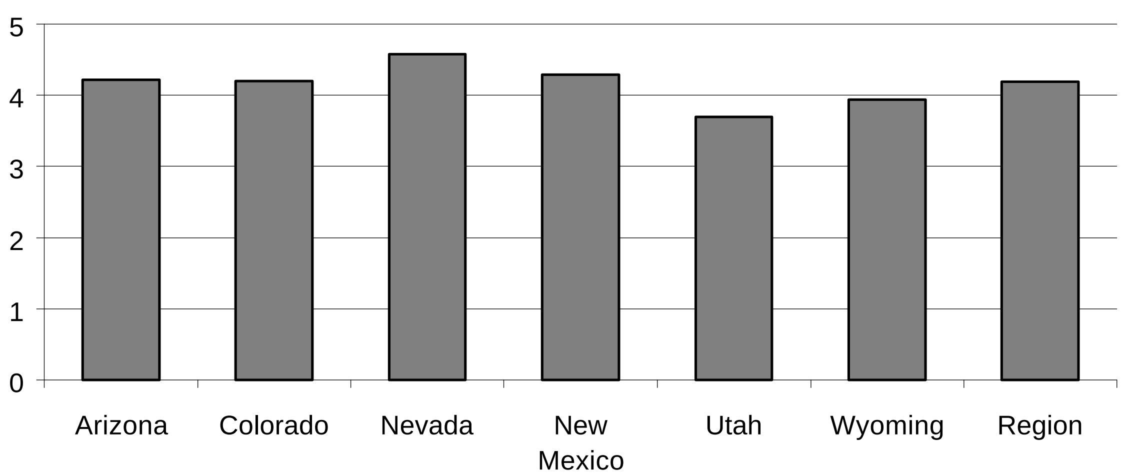


Figure 3-9. *State Benefits-Cost Ratios*



The state-specific benefit-cost ratios are presented by state in Figure 3-9. The ratios range from 3.7 in Utah to 4.6 in Nevada. As reported in Table 3-11,[4] the highest sectoral benefit-cost ratios are in Nevada for industry and in New Mexico for commercial and residential buildings. The lowest benefit-cost ratios are in Colorado for industry, Utah for commercial buildings, and Wyoming for residential buildings. The costs differ due to variations in the mix of industrial sub-sectors and electricity services among states. For example, the penetration of air

[4] They are state-specific in dollar per kWh insofar as each state is in one or a combination of the NERC regions modeled and, of course, insofar as each state saved a different amount of electricity. They are not sector-specific in terms of dollar per kWh, but do reflect the amount of electricity avoided in each sector.

conditioning, space heating and water heating by electricity varies among states, and the cost of saved energy varies among these energy services. The benefits depend in part on the type of generation avoided and the characteristics of avoided transmission & distribution.

Table 3-11. *Costs and Benefits by State in the High Efficiency Scenario (Cumulative Present Value, Billion 2000$)*

	Electric Sector & Natural Gas Price Benefits	Energy Efficiency Costs	Net Benefits	Benefit-Cost Ratio
Region				
Commercial	17.7	3.0	14.7	5.8
Residential	9.3	3.2	6.1	2.9
Industrial	10.0	2.6	7.4	3.9
Total	**37.1**	**8.8**	**28.2**	**4.2**
Arizona				
Commercial	6.7	1.0	5.7	6.5
Residential	4.4	1.5	2.9	2.9
Industrial	2.6	0.7	1.9	3.8
Total	**13.8**	**3.3**	**10.5**	**4.2**
Colorado				
Commercial	5.0	0.9	4.0	5.4
Residential	1.7	0.6	1.2	3.1
Industrial	1.8	0.5	1.2	3.3
Total	**8.5**	**2.0**	**6.4**	**4.2**
Nevada				
Commercial	2.0	0.3	1.7	6.1
Residential	1.2	0.4	0.8	2.9
Industrial	2.0	0.4	1.6	5.0
Total	**5.2**	**1.1**	**4.1**	**4.6**
New Mexico				
Commercial	1.7	0.3	1.4	6.5
Residential	0.9	0.3	0.6	3.0
Industrial	1.1	0.3	0.8	3.7
Total	**3.6**	**0.8**	**2.8**	**4.3**
Utah				
Commercial	1.9	0.4	1.5	4.7
Residential	0.9	0.3	0.5	2.7
Industrial	1.2	0.3	0.8	3.4
Total	**3.9**	**1.1**	**2.9**	**3.7**
Wyoming				
Commercial	0.5	0.1	0.4	4.8
Residential	0.2	0.1	0.1	2.6
Industrial	1.3	0.3	1.0	4.0
Total	**2.1**	**0.5**	**1.5**	**3.9**

D. Environmental Results

Figure 3-10 presents the estimates of regional and state-level emission reductions for carbon dioxide (presented in terms of carbon), SO_2, NO_x and mercury for 2010 and 2020, in the High Efficiency Scenario. The percent reductions in carbon dioxide emissions for the region are similar to the percent reductions in electricity generation, while the SO_2, NO_x, and mercury reductions are much lower in percentage terms.

Unlike the other emissions, carbon dioxide cannot be readily controlled by pollution control equipment added to existing plants. Thus, the amount and type of electricity generation directly determines the carbon dioxide emissions. The regional reduction of carbon dioxide (13 percent in 2010 and 26 percent in 2020) mirrors the regional reduction in electricity generation (11 percent in 2010 and 22 percent in 2020). However, the variation in the state results reflects the amount and type of generation in each state and the carbon dioxide reduction allocated to each state. For example, Wyoming has relatively high levels of carbon dioxide emissions in the Base Scenario due to large amounts of both exports and coal generation. Since carbon dioxide emission reductions are allocated based on the fraction of electricity demand reductions and Wyoming accounts for only a small fraction of the reductions (see Table 3-7), Wyoming's emission reductions are relatively small in absolute amounts and when compared with the Base Scenario. Likewise, Arizona, Colorado and Nevada have relatively high emission reductions.

SO_2 emissions can be controlled by installing scrubbers on new or existing plants but, as seen by the results, there is relatively little incremental SO_2 emissions reduction in the High Efficiency Scenario. The primary reason for this lies in the SO_2 cap and trade system of the national Acid Rain Program. The Acid Rain program sets annual levels for total allowable SO_2 emissions and allocates that amount of SO_2 allowances. Each plant must hold allowances equivalent to the amount of SO_2 emitted. If a plant does not have enough permits to cover its expected emissions, it can either change its own operations (switch to lower sulfur coal, add pollution equipment, run the plant less) or purchase allowances in the market from plants that have more allowances than required. Unless SO_2 caps are also tightened, there will be relatively little incremental reduction in SO_2 emissions from end-use energy efficiency improvements. Under the High Efficiency Scenario, the region’s electric sector uses less low sulfur coal, adds less pollution-control equipment, and/or runs coal plants relatively less than in the Base Scenario. Thus, in the High Efficiency Scenario, there is a relatively small reduction (1 percent by 2010 and 4 percent by 2020) in SO_2 emissions relative to the reduction in electricity generation.[5]

Mercury emissions are not controlled by a cap and trade system, but the SO_2 control equipment and the type of coal that is used also affects mercury emissions. In the Base Scenario, the use of SO_2 control equipment and other activities effectively constrain increases in mercury emissions, even with increased coal-fired generation. Under the High Efficiency Scenario, the utilities

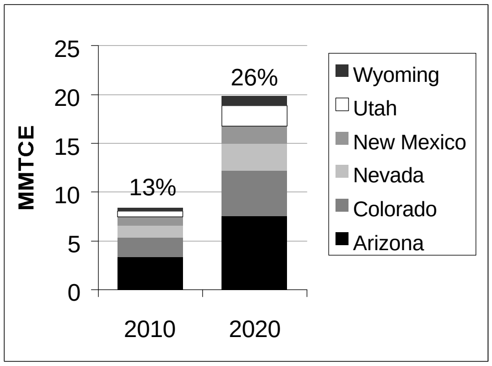
[5] As described in section 4, changes in SO_2 emissions lead to changes in the revenues from buying or selling SO_2 credits but the net revenue gain is small compared with other benefits.

invest less in SO_2 reductions relative to the Base Scenario, resulting in fewer constraints on mercury emissions. The average mercury emission rate (pounds per kWh) is greater in the High Efficiency Scenario than in the Base Scenario, but absolute mercury emissions in the region still drop 3 percent by 2010 and 7 percent by 2020, relative to emissions in the Base Scenario.

NO_x emissions reductions are also relatively limited due to regulations and improved NO_x control equipment employed in newer power plants. Most of the avoided generation in the High Efficiency Scenario would have been provided by new power plants, which have lower emission rates than existing plants. For example, NEMS assumes that new conventional coal plants will have a NO_x emission rate of 0.11 pounds per million Btu of fuel input, while existing plants are able to meet air quality regulations with NO_x emissions of 0.29 – 0.94 pounds per million Btu (depending on the type of boiler). In the Base Scenario, the average NO_x emission rate decreases as new plants (with low emission rates) come on line. However, in the High Efficiency Scenario, new plants contribute less to overall generation and the average NO_x emission rate will be higher than in the Base Scenario. Nevertheless, absolute NO_x emissions from the electric sector are 2 percent less by 2010 and 5 percent less by 2020 in the High Efficiency Scenario, relative to emissions in the Base Scenario.

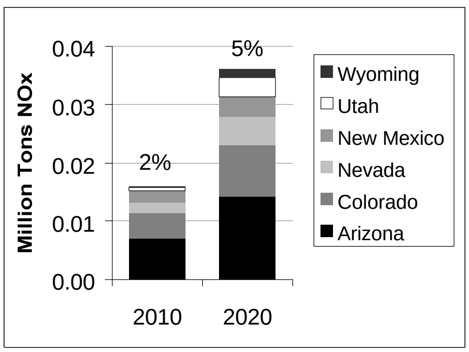
Figure 3-10. *Pollutant Emissions Reductions in the High Efficiency Scenario*

Carbon Savings



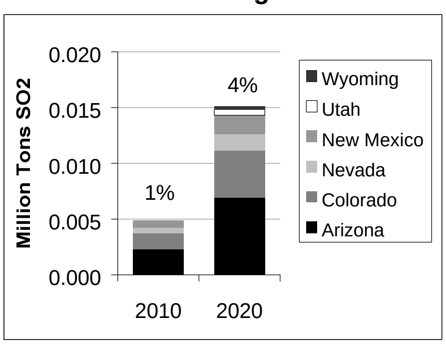
According to the U.S. Climate Action Report 2002, CO_2 accounted for 82 percent of total U.S. greenhouse gas emissions in 1999 and emissions from fossil fuel combustion dominate CO_2 emissions. Greenhouse gas emissions are accumulating in the atmosphere as a result of human activities. Climate change associated with the accumulation of these emissions is expected to exacerbate public health and environmental concerns, such as spread of malaria and other insect-borne diseases, increase the frequency of extreme weather events (storms, droughts, high-temperature days), cause sea-level rise and flooding of low-lying regions, threaten fresh water supplies, agriculture and forests, and harm infrastructures and economies.

Nitrogen Oxides Savings



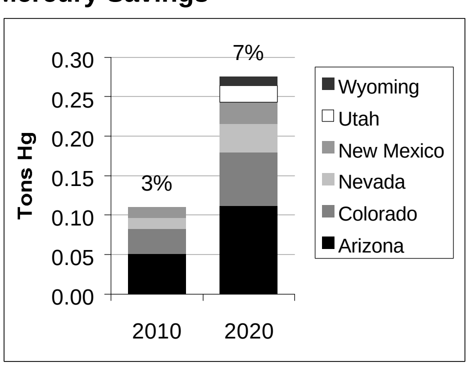
The emission of nitrogen oxides (NO_x) from fossil fuel combustion has numerous environmental, health and welfare impacts. NO_x has adverse health effects including causing headaches, chest tightness, increased susceptibility to respiratory infections, and aggravation of symptoms from existing respiratory disorders. NO_x is a precursor to ozone, an extremely reactive gas that can cause substantial damage to human health, vegetation, rubber and other materials. Nitrogen oxides also contribute to acid rain and to global warming by converting to nitrous oxide (N_2O) which is a greenhouse gas, and by reducing the uptake of methane in certain soils.

Sulfur Dioxide Savings



The emission of sulfur dioxide (SO_2) damages human health, materials and vegetation. The reactions of SO_2 in the atmosphere produce sulfates (SO_4), which are believed to be a significant portion of particulate pollution that degrades visibility and damages human health. Health effects include narrowing of the bronchial passages, producing symptoms such as shortness of breath, chest tightness and wheezing. SO_2 also combines with moisture in the atmosphere and is deposited as acid rain. SO_2 may be carried in the atmosphere for 1 to 10 days, so the damage impacts of acid precipitation, along with sulfate deposition, may be far from the source of emissions.

Mercury Savings



Burning coal in power plants releases mercury to the air, where it is then transported to the land and water. Once mercury enters water, it can bio-accumulate in fish in its most toxic form, methylmercury. Exposure to high levels of elemental mercury vapor can result in nervous system damage including tremors, and mood and personality alterations. Exposure to relatively high levels of inorganic mercury salts can cause kidney damage. Adult exposure to relatively high levels of methylmercury through fish consumption can result in numbness or tingling in the extremities, sensory losses and loss of coordination. Exposure of the developing fetus through maternal intake of contaminated fish can result in neurologic developmental abnormalities that impair cognitive and motor functions.

The state emissions reduction estimates are presented in Table 3-12. Each state shows a reduction in emissions of carbon dioxide, nitrogen oxides, sulfur dioxide, and mercury. The states contained entirely in the Northwest Power Pool (Utah and Wyoming) show a small increase in sulfur dioxide emissions by 2010, although SO_2 emissions are reduced by 2020.

Table 3-12. *State Emissions Reduction Estimates in the High Efficiency Scenario*

	2010		2020	
	Reduction	**% Change**	**Reduction**	**% Change**
Region				
Carbon (MMTCE)	8.4	13	19.8	26
SO_2 (million tons)	0.005	1	0.015	4
NOx (million tons)	0.02	2	0.036	5
Mercury (tons)	0.11	3	0.28	7
Arizona				
Carbon (MMTCE)	3.3	20	7.6	36
SO2 (million tons)	0.002	4	0.007	11
NOx (million tons)	0.01	6	0.01	11
Mercury (tons)	0.05	6	0.11	12
Colorado				
Carbon (MMTCE)	2.1	16	4.6	30
SO2 (million tons)	0.001	2	0.004	5
NOx (million tons)	0.0043	3	0.0087	7
Mercury (tons)	0.032	9	0.068	17
Nevada				
Carbon (MMTCE)	1.1	15	2.7	30
SO2 (million tons)	0.0005	1	0.0015	3
NOx (million tons)	0.0020	3	0.0049	7
Mercury (tons)	0.01	6	0.04	15
New Mexico				
Carbon (MMTCE)	0.9	11	1.8	20
SO2 (million tons)	0.0006	1	0.0017	3
NOx (million tons)	0.0019	2	0.0035	3
Mercury (tons)	0.01	1	0.03	2
Utah				
Carbon (MMTCE)	0.6	6	2.1	19
SO2 (million tons)	-0.0002	-1	0.0005	2
NOx (million tons)	0.0005	1	0.0032	3
Mercury (tons)	0.0001	0.1	0.02	12
Wyoming				
Carbon (MMTCE)	0.3	3	1.0	8
SO2 (million tons)	-0.0001	-0.2	0.0003	0.3
NOx (million tons)	0.0003	0.2	0.0016	1
Mercury (tons)	0.0001	0.01	0.011	1

Note: *MMTCE – million metric tons of carbon equivalent. This is the standard unit of accounting for carbon; other units are U.S. short tons.*

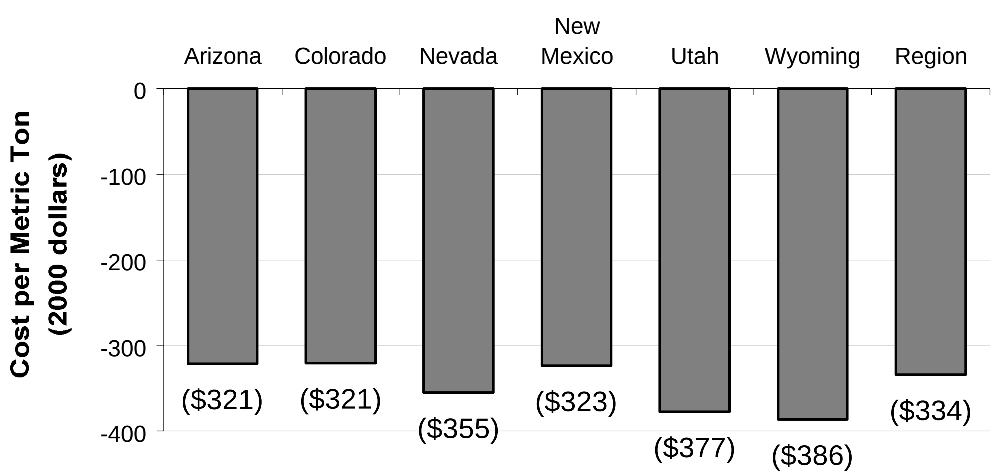
E. Cost of Avoided Carbon Emissions

Cost of avoided carbon emissions is one way of combining net costs and carbon reductions into a useful indicator.[6] The cost-of-saved-carbon (CSC) is defined as the cumulative net present value of net costs divided by the cumulative net present value of carbon savings (again, using a 5 percent discount rate).

As explained in section 3, the net costs include the costs of additional investments in more energy efficient equipment and the benefits of avoided electricity production (here resulting in net benefits – i.e., avoided electricity supply costs greater than the incremental costs of more efficient end-use equipment). All capital costs are levelized over the lifetime of equipment using a 5 percent annual discount rate. Discounting the cost of future carbon emission reductions accounts for the potential commodity value of these reductions in an emissions cap and trading program.

Figure 3-11 shows the cost-of-saved-carbon by state. The negative costs-of-saved-carbon reflects the net economic benefits from the High Efficiency Scenario for all states. The differences between states reflect differences in the types and costs of efficiency measures (e.g., air-conditioning accounting for larger savings in the southern states than in the northern states), different mixes of electricity demand by sector (e.g., northern states tend to have greater contributions by the industrial sectors), and different costs and carbon reductions from avoided electricity generation (e.g., the benefits of avoided generation are greater in the northern states than in the southern states). Overall Wyoming, Utah and Nevada show moderately greater benefits per metric ton of avoided carbon emissions than Arizona, New Mexico and Colorado.

Figure 3-11. *Cost of Avoided Carbon Emissions by State*



[6] We choose carbon dioxide here, as its reduction is far greater than those of the other pollutants. In principle, the net costs could be spread over all the emissions reductions.

The high carbon emissions reductions and high negative cost-of-saved-carbon that can be realized from energy efficiency investments is of great importance for public policy. According to most credible analyses, including the US National Academy of Sciences and the Intergovernmental Panel on Climate Change, a very substantial reduction in global carbon emissions, including U.S. carbon emissions, will be essential for global climate stabilization (IPCC 2001; NAS 2001). Progressively increasing energy efficiency in all sectors will play an essential role in that effort, but it will need to be complemented by other initiatives and measures, including a shift to renewable and low-carbon energy resources. As some of these additional options will have net positive costs (at least in the near term), the net economic savings achieved through energy efficiency will create more "economic space" for implementing these other needed but more costly options. Thus, climate stabilization goals could be met, along with pollution reduction co-benefits, while maintaining a healthy economy if energy efficiency improvement is emphasized (Geller 2002b).

F. Water Savings Results

Conventional fossil fuel-based power plants consume a substantial amount of water for power generation, primarily in their cooling systems. Some efforts have been made to reduce water consumption for power generation in the arid southwest region, but power generation nonetheless utilizes a significant amount of water. Based on a review of the water consumption associated with power generation in the Interior West (LAW Fund 2002) as well as data provided by the Arizona Corporation Commission (ACC 2001), we estimate that a typical new coal-fired power plant in the region consumes about 0.67 gallons of water per kWh produced while a typical new natural gas-fired combined cycle power plant consumes about 0.33 gallons of water per kWh produced.[7] We use these coefficients to estimate the potential water savings from the High Efficiency Scenario.

In addition to water savings from reduced conventional power generation, the High Efficiency Scenario will lead to water savings from the accelerated adoption of resource-efficient clothes washers and other water conservation measures. Resource-efficient clothes washers in particular save about 15 gallons of water per laundry load, or about 5,400 gallons of water per washer per year. We include estimates of the water savings from this efficiency measure below. However, we exclude savings from other water conservation measures as they are of lesser magnitude.

Table 3-13 shows the water savings in 2010 and 2020 given the amount and type of electricity generation avoided in each state in the High Efficiency Scenario, as well as the increased penetration of resource-efficient clothes washers in households with electric water heating. The overall regional water savings reach about 25 billion gallons per year (equivalent to about 76,000

[7] These water coefficients assume use of conventional wet cooling systems. If so-called dry cooling is utilized, the water consumption declines by as much as 90 percent. However, dry-cooled power plants are more costly to build and operate than wet-cooled plants, and there is also some loss of efficiency with dry (i.e., air-based) cooling (LAW Fund 2002).

acre-feet) by 2010 and nearly 62 billion gallons per year (equivalent to about 189,000 acre-feet) by 2020 in the High Efficiency Scenario. Given that a typical household in the southwest consumes about 183,000 gallons of water per year (Wojcik 2002), the regional water savings in 2010 are equivalent to the water consumed by approximately 136,600 households. Likewise, the regional water savings in 2020 are equivalent to the water consumption of approximately 338,800 households. Most of the water savings come from reduced power generation from coal-fired power plants. Avoided generation from gas-fired plants provide about 25 percent of the water savings in 2010 but a much smaller percentage in 2020. Resource-efficient clothes washers provide about 15-18 percent of the total water savings.

Table 3-13. *Water Savings in the High Efficiency Scenario (billion gallons per year)*

	2010				2020			
STATE	Coal plants	NG plants	Res-eff CWs	Total	Coal plants	NG plants	Res-eff CWs	Total
Arizona	6.55	1.16	1.28	8.99	17.93	0.59	3.89	22.41
Colorado	4.05	0.72	1.02	5.78	10.95	0.36	2.92	14.24
Nevada	1.86	1.02	0.47	3.35	6.10	0.94	1.42	8.46
New Mexico	1.82	1.01	0.43	3.26	4.36	0.90	1.27	6.53
Utah	0.23	1.56	0.46	2.25	3.76	1.78	1.40	6.93
Wyoming	0.13	0.85	0.12	1.10	1.81	0.86	0.33	3.00
Region	**14.64**	**6.33**	**3.77**	**24.73**	**44.90**	**5.42**	**11.24**	**61.56**

CHAPTER 4—ECONOMIC IMPACT ANALYSIS

With the High Efficiency Scenario established, the question now posed is: "If these efficiency measures are put in place to decrease the region's electricity consumption, what are the employment and other macroeconomic impacts for the six-state region as a whole, and for each of the individual states?" The tool we use to perform this type of macroeconomic evaluation is referred to as input-output modeling, sometimes called multiplier analysis.

A. INPUT-OUTPUT ANALYSIS

Initially, input-output models were developed to trace supply linkages in the economy. For example, they show how purchases of lighting equipment not only benefit lighting manufacturers but also the fabricated metal industries and other businesses supplying inputs to those manufacturers. The employment that is ultimately generated by expenditures for energy efficiency will depend on the structure of a local economy. States that produce fabricated metal products, for instance, will benefit more from expanded sales of locally manufactured, high-efficiency ballasts; states without such production will benefit less.

Different expenditures support a different level of total employment. Table 4-1 compares the total number of jobs in each state that are directly and indirectly supported for each one million dollars of expenditures made by consumers and businesses. To capture the full economic impacts of the investment in energy efficiency technologies, three separate effects (i.e., direct, indirect, and induced) must be examined for each change in expenditure.[1]

Direct effect refers to the on-site or immediate effects created by an expenditure. In the case of installing the energy efficiency upgrades in a manufacturing plant, the direct effect would be the on-site expenditures and jobs of the electrical or special trade contractors hired to carry out the work.

The indirect effect refers to the increase in economic activity that occurs when a contractor or vendor receives payment for goods or services delivered and he or she is able to pay others who support their own businesses. It includes the equipment manufacturer or wholesaler who provided the new technology. It also includes such people as the banker who finances the contractor, the accountant who keeps the books for the vendor, and the building owner where the contractor maintains local offices.

The induced effect derives from the change in wealth that the energy efficiency investment program creates. Businesses and households are able to meet their power, heating, cooling, and

[1] In this study we have adapted the 1999 IMPLAN model for the analysis. Table 4-1 presents what are referred to as Type I multipliers, incorporating only the direct and indirect effects of an expenditure. Adding the induced effect would generate what are known as Type II multipliers (or Type III multipliers as referenced in the IMPLAN model).

lighting needs at a lower total cost, due to efficiency investments. This lower cost of doing business and operating households makes available greater wealth for firms and families to spend or invest in other areas such as purchase of durable goods, food, or entertainment.

The sum of these three effects yields a total impact that results from a single expenditure. However, since household spending is included as part of the final demand changes in the analysis, the employment and other macroeconomic impacts have been limited to the direct and indirect effects only. This will tend to understate the net effect of the High Efficiency Scenario (Miller and Blair, 1985). Table 4-1 provides employment multipliers for key sectors such as agriculture, construction, manufacturing, utility services, wholesale and retail trade, services, and government.

For purposes of this study, a job is defined as sufficient wages to employ one person full-time for one year. Of immediate interest in Table 4-1 is the relatively small number of jobs supported for each million dollars spent on fuel production and utility services. As it turns out, the electric utility industry supports only four to five jobs per million dollars of expenditures, as compared to 11 – 16 jobs in the construction sector, 17 – 27 jobs in the services sector, and 23 – 33 jobs in the retail sector. Likewise the coal mining industry supports relatively few jobs, just five to eight jobs per million dollars of expenditures. Much of the job creation from energy efficiency improvements is derived by the difference between jobs within the utility supply sectors and jobs that are supported by the spending of energy bill savings in other sectors of the economy.

Table 4-1. *Regional Employment Multipliers for Selected Economic Sectors*

Employment Multipliers (Jobs per $1 Million Expenditures)						
Sector	**AZ**	**CO**	**NM**	**NV**	**UT**	**WY**
Agriculture	23.1	19.2	20.3	24.5	29.4	20.2
Coal Mining	5.5	6.8	7.7	--	8.3	8.4
Construction	13.6	14.3	16.4	11.3	15.8	15.3
Education	30.6	28.5	31.4	23.7	33.3	35.4
Electric Utilities	4.9	4.4	5.2	3.6	4.3	4.9
Finance	14.3	15.8	14.9	16.6	19.1	14.9
Food	11.0	10.1	12.7	8.8	13.6	11.7
Gas Utilities	4.9	5.7	7.3	6.0	4.6	6.8
Government	17.3	16.8	18.4	14.6	20.1	20.4
Insurance and Real Estate	7.2	7.1	9.1	5.2	9.1	9.8
Metals Durable	10.0	9.0	12.4	8.8	10.7	8.8
Motor Vehicles	6.7	7.2	5.9	6.1	9.1	8.0
Oil and Gas Mining	27.0	7.3	9.1	17.0	8.9	6.6
Other Manufacturing	9.0	9.9	10.7	9.7	12.3	11.3
Other Mining	9.1	7.9	7.7	7.3	10.4	5.7
Primary Metals	7.8	8.5	7.7	7.1	8.9	7.5
Pulp and Paper	8.1	8.4	9.3	--	9.9	--
Refining	4.8	5.4	7.1	6.2	3.8	5.8
Retail Trade	25.7	26.4	30.1	23.3	29.0	32.9
Services	22.2	20.1	25.6	17.1	23.5	27.4
Stone, Clay, and Glass	10.2	9.5	11.6	8.6	11.7	9.4
Transportation, Communication, and other Utilities	13.0	8.4	14.3	12.6	14.1	12.6
Wholesale Trade	12.3	11.5	16.8	11.9	14.1	15.8

Source: *Adapted from the 1999 IMPLAN database for the respective states. The employment multipliers represent the direct and indirect jobs supported by a one million dollar expenditure for the goods or services purchased from a given sector.*

B. An Illustration: Jobs from End-Use Efficiency Improvements in Office Buildings

To illustrate how a job impact analysis might be accomplished, we use the simplified example of an office building that installs $1.0 million of efficiency improvements. Office buildings are large users of electricity due to lighting and air-conditioning loads, significant use of electronic equipment, and the large numbers of persons employed and served. Accordingly, they provide substantial opportunities for electricity-saving investments. The results of this example are summarized in Table 4-2.

The assumption used in this example is that the investment has a positive benefit-cost ratio of 3.0. If we anticipate that the efficiency changes will have an expected life of 15 years, then we can establish a 15-year period of analysis. We further assume that the efficiency upgrades take place in the first year of the analysis, while the electricity savings occur in years 1 through 15.

The analysis also assumes that we are interested in the *net effect* of employment and other economic changes. This means we must first examine all changes in business or consumer expenditures — both positive and negative — that result from a movement toward more efficient electricity use. Each change in expenditures must then be multiplied by the appropriate multiplier (a regional average taken from Table 4-1) for each sector affected by the change in expenditures. The sum of these products will then yield the net result that is the aim of the analysis.

In our example there are four separate changes in expenditures identified in Table 4-2, each with their separate multiplier effect. As Table 4-2 indicates, the net impact of the scenario suggests a gain of 43.3 job-years in the 15-year period of analysis. This translates into a net increase of 2.9 jobs each year for 15 years. In other words, the efficiency investment made in large office buildings is projected to sustain an average of just under three additional jobs throughout the economy over a 15-year period compared to a baseline or "business-as-usual" scenario.

Table 4-2. *Job Impacts from Office Building End-Use Efficiency Improvements*

Expenditure Category	Amount ($ Million)	Job Multiplier	Job Impact
Office Building Efficiency Improvements in Year One	$1.0	13.6	13.6
Diverting Expenditures to Fund Efficiency Improvements	-$1.0	22.2	-22.2
Spending of Energy Bill Savings in Years One through Fifteen	$3.0	22.2	66.6
Lower Utility Revenues in Years One through Fifteen	-$3.0	4.9	-14.7
Net Fifteen-Year Change	**$0.0**		**43.3**

Note: *The employment multipliers are derived from the appropriate sectors (average of the six states) found in Table 4-1. The jobs impact is the result of multiplying the row expenditure change by the row multiplier. For more details, see the text.*

C. EVALUATING THE HIGH EFFICIENCY SCENARIO

The employment analysis of the High Efficiency Scenario was carried out in a very similar manner as the example described above. That is, the changes in energy expenditures brought about by investments in energy efficiency technologies were matched with their appropriate employment multipliers. There are several modifications to this technique, however.[2]

First, it was assumed that only 85 percent of the efficiency investments would be spent within the respective states in the six-state region. Interviews with personnel from various state agencies in the region suggest this to be a conservative value since almost all efficiency investments are carried out by local contractors and dealers.

Second, we made an adjustment in the employment impacts to account for specific sector changes in labor productivity. As derived from the Bureau of Labor Statistics *Employment and Output by Industry 1990, 2000, and Projected 2010*, productivity improvements are expected to vary widely among sectors, ranging from a 0.2 percent annual productivity gain in the education sectors to a 6.1 percent annual productivity gain in coal mining (where such gains have already led to significant job losses).[3]

To illustrate the impact of productivity gains, let us assume a typical labor productivity increase of 1 percent per year in manufacturing. This means, for example, that compared to 2000, a one million dollar expenditure in the year 2010 will support only 91 percent of the number of jobs as in 2000.[4]

Third, for purposes of estimating electricity bill savings it was assumed that electricity prices will remain at their 1999 levels. The same assumption was used in the efficiency potential and utility analyses.

Fourth, it was assumed that approximately 40 percent of the investment upgrades will be financed by bank loans that carried an average 10 percent nominal interest rate over a five-year period. To limit the scope of the analysis, however, no parameters were established to account for any changes in interest rates as less capital-intensive technologies (i.e., efficiency investments) are substituted for conventional supply strategies, or in labor participation rates – all of which might affect overall spending patterns.

Finally, it should be noted that the full effects of the efficiency improvements are not accounted for since the electricity bill savings beyond 2020 are not incorporated in the analysis. Nor does

[2] For a more complete review of how this type of analysis is carried out, see Geller, DeCicco, and Laitner 1992.

[3] The productivity trends were calculated by MRG & Associates using data from the Bureau of Labor Statistics (BLS, 2002).

[4] The calculation is $1/(1.01)^{20} * 100$ equals $1/1.10 * 100$, or 91 percent.

the analysis include other productivity benefits that are likely to stem from the efficiency investments. These can be substantial, especially in the industrial sector. Industrial investments that increase end-use efficiency often result in achieving other economic goals such as improved product quality, lower capital and operating costs, increased employee productivity, or capturing specialized product markets (OTA 1993; Romm 1999). To the extent these "co-benefits" are realized in addition to the electricity savings, the economic gains will be amplified beyond those reported here.

D. IMPACTS

The investment and savings data from the High Efficiency Scenario were used to estimate three sets of impacts. The first of the three impacts evaluated here is the net contribution to Gross State Product (GSP) measured in millions of 2000 dollars. In other words, once the gains and losses are sorted out, the analysis provides the net benefit in terms of each state's overall economy and for the region as a whole. The second impact is the net gain to the state's and region's wage and salary compensation, also measured in millions of 2000 dollars. The final impact is the contribution to each state's and the region's employment as measured by full-time jobs equivalent.

Table 4-3 presents the overall results in 2010 and 2020 by state and for the region as a whole. There are a number of aspects of Table 4-3 worth noting. The first is that the impacts of the High Efficiency Scenario are largely positive. In both 2010 and 2020, wage and salary earnings as well as employment are shown to rise in each of the states. By 2020 the regional net increase in total wage and salary earnings reach $1.34 billion (in 2000 dollars) and the net increase in employment reaches 58,400 jobs. At the same time, the regional gross state product declines by $0.56 billion by 2020 (in 2000 dollars).

This apparent contradiction (i.e., rising jobs and earnings with declining GSP) is the result of several different influences at work when energy efficiency improvements are made. First, many of the investments in energy efficiency measures take a number of years to pay for themselves through electricity bill savings. This tends to dampen the growth of GSP within each state. At the same time, as electric utility revenues decrease, the amount of capital investment also decreases (i.e., fewer new power plants are built — displaced by more cost-effective efficiency investments that are also more labor intensive). This, in turn, lowers the overall value-added and GSP, but contributes to an increase in the share of economic output enjoyed by working men and women.

Wage and salary compensation is one category of the elements that comprise GSP, constituting about 60 percent of total GSP. Thus, while overall GSP can fall, wage and salary compensation can rise as labor payments are substituted for investment capital in the larger economy. Finally, the spending of electric bill savings is used for consumer and business purchases that are also more labor intensive.

This tradeoff between labor and capital continues through 2020. The employment impacts start modestly in 2010 with net employment gains of 20,500 (8,100 jobs in Arizona, 4,000 in Colorado, 2,600 in New Mexico, 2,400 in Nevada, 2,200 in Utah, and 800 in Wyoming).[5] The net increase in employment continues to climb to a gain of about 58,400 jobs for the six states combined in 2020. This level of job creation is equivalent to approximately a 0.45% increase in the regional employment level in 2020 (based on a projected employment level of just under 13 million jobs).[6]

Table 4-3. *Macroeconomic Impacts for the Six State Region – 2010 and 2020*

Year	Net Change in Jobs	Change in Wage and Salary Compensation ($ 2000 M)	Change in Gross State Product ($ 2000 M)
Arizona			
2010	8,100	$180	($130)
2020	24,100	$550	($230)
Colorado			
2010	4,000	$90	($60)
2020	12,200	$280	($100)
New Mexico			
2010	2,600	$50	($50)
2020	6,900	$130	($110)
Nevada			
2010	2,400	$60	($40)
2020	6,300	$180	($90)
Utah			
2010	2,200	$50	$0
2020	6,300	$160	$50
Wyoming			
2010	800	$20	($30)
2020	2,000	$40	($60)
Region			
2010	20,500	$450	($320)
2020	58,400	$1,340	($560)

Notes: *Dollar figures are in millions of 2000 dollars while employment reflects the actual job total in full-time equivalents. Region totals are slightly different from the sum of six states due to independent rounding.*

We can think of the net job gains as if they were provided by the relocation of a series of small

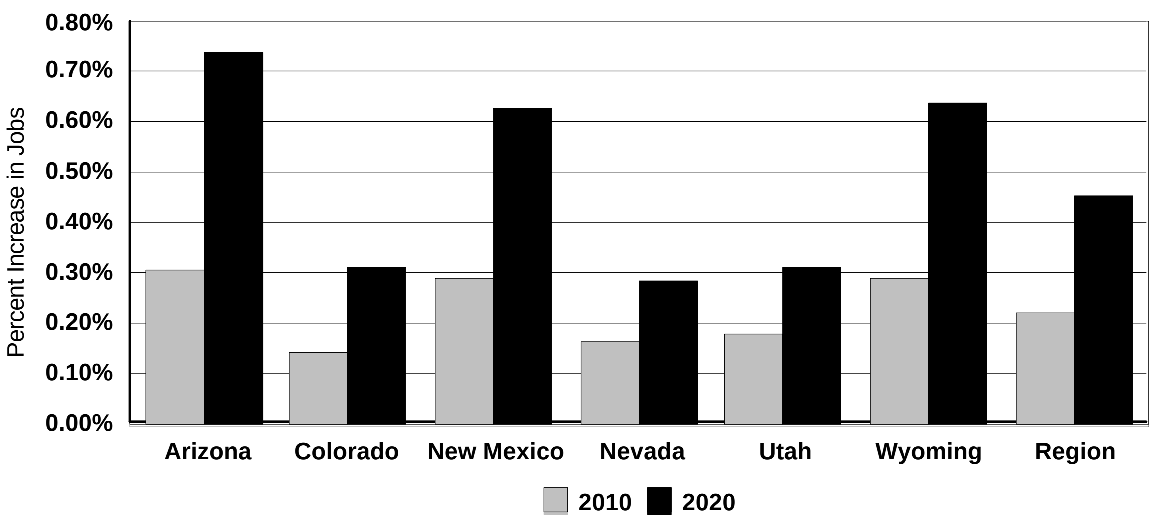
[5] State totals do not add up to regional total due to independent rounding.

[6] This estimate is based on state employment projections using data obtained from the respective states. By 2020, we estimate Arizona employment will grow to 3.33 million, Colorado to 3.91 million, New Mexico to 1.10 million, Nevada to 2.23 million, Utah to 2.02 million, and Wyoming to 0.31 million.

manufacturing plants to the respective states. In that case, we can say that implementing the High Efficiency Scenario will produce new employment that is equivalent to the jobs supported by more than 467 small manufacturing plants that might open in the region by the year 2020.[7] Alternately, we can think of the additional wage and salary compensation resulting from the energy efficiency improvements as an equivalent amount of spending by tourists and visitors in each of the states. In this instance, the efficiency improvements provide the wage and salary equivalent of spending from more than 8.9 million additional visitor days.[8]

As shown in Figure 4-1, the increase in jobs in 2010 for the individual states ranges from 0.14 percent in Colorado to 0.30 percent in Arizona. By 2020, the increase in jobs ranges from 0.28 percent in Nevada to 0.74 percent in Arizona. This variation among states is caused by a number of factors including differences in economic and population structure (e.g., the number of workers as a fraction of total population in each state), electricity savings potential, and expected job growth from state to state. For instance, Arizona has the highest percent increase in jobs primarily because it has a relatively low employment-to-population ratio (i.e., there are a large number of retirees in Arizona). New Mexico and Wyoming exhibit high percent increases because of above-average energy savings potential and high net economic benefits per capita in the case of Wyoming.

Figure 4-1. *Job Increases Due To the High Efficiency Scenario*



Tables 4-4 through 4-10 show how each of the major economic sectors are affected in the year

[7] This estimate assumes a small manufacturing plant employs 50 persons directly. For each job in the manufacturing plant, a total of 2.5 jobs will be supported in the economy for a total impact of 125 jobs.

[8] This estimate assumes tourists and visitors to these states spend approximately $150 per day per person on recreation, eating and drinking, and lodging. Dividing the total increase in wage and salary compensation by 150 suggests the equivalent of 8.93 million visitor-day expenditures within the regional economy. By 2020, we estimate the wage and salary gain in Arizona is the equivalent of 3.67 million tourist-days, in Colorado 1.87 million, in New Mexico 0.87 million, in Nevada 1.20 million, in Utah 1.07 million, and in Wyoming 0.27 million.

2020 in the High Efficiency Scenario. These are sorted according to the anticipated job impacts beginning with those sectors that have the largest employment gains.

Table 4-4. *Macroeconomic Impacts by Sector for the Six State Region – 2020*

Sector	Net Change in Jobs	Change in Wage and Salary Compensation (Million $)	Change in Gross State Product (Million $)
Services	23,800	$880	$1,080
Retail Trade	17,000	$460	$760
Government	13,500	$610	$800
Construction	3,000	$150	$180
Education	2,100	$70	$70
Other Manufacturing	1,600	$150	$230
Agriculture	1,100	$20	$40
Insurance and Real Estate	1,000	$40	$210
Finance	700	$40	$70
Wholesale Trade	600	$60	$100
Food	500	$20	$50
Metals Durable	400	$40	$60
Other Mining	200	$20	$30
Pulp and Paper	100	$10	$10
Motor Vehicles	100	$10	$20
Primary Metals	100	$10	$10
Stone, Clay, and Glass	100	$10	$10
Refining	0	$0	($10)
Transportation, Communication, and other Utilities	(500)	($40)	($80)
Gas Utilities	(600)	($80)	($240)
Oil and Gas Mining	(700)	($60)	($190)
Coal Mining	(800)	($230)	($340)
Electric Utilities	(4,900)	($850)	($3,440)
Total	**58,400**	**$1,340**	**($560)**

Notes: *The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the electric efficiency scenario. All dollar values are in millions of 2000 dollars.*

Table 4-5. *Macroeconomic Impacts by Sector for Arizona – 2020*

Sector	**Net Change in Jobs**	**Change in Wage and Salary Compensation (Million $)**	**Change in Gross State Product (Million $)**
Services	10,400	$380	$470
Retail Trade	7,200	$200	$320
Government	5,800	$260	$340
Education	1,000	$30	$30
Construction	700	$40	$40
Insurance and Real Estate	400	$20	$90
Agriculture	400	$10	$10
Other Manufacturing	400	$40	$60
Wholesale Trade	200	$20	$30
Food	200	$10	$20
Finance	200	$10	$20
Metals Durable	100	$10	$10
Other Mining	100	$10	$10
Pulp and Paper	0	$0	$10
Refining	0	$0	($10)
Motor Vehicles	0	$0	$10
Primary Metals	0	$0	$0
Stone, Clay, and Glass	0	$0	$0
Gas Utilities	(100)	($20)	($60)
Oil and Gas Mining	(200)	($20)	($50)
Transportation, Communication, and other Utilities	(300)	($20)	($40)
Coal Mining	(300)	($80)	($120)
Electric Utilities	(2,100)	($360)	($1,440)
Total	**24,100**	**$550**	**($230)**

Notes: *The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the electric efficiency scenario. All dollar values are in millions of 2000 dollars.*

Table 4-6. *Macroeconomic Impacts by Sector for Colorado – 2020*

Sector	Net Change in Jobs	Change in Wage and Salary Compensation (Million $)	Change in Gross State Product (Million $)
Services	4,800	$180	$220
Retail Trade	3,700	$100	$160
Government	3,000	$130	$180
Construction	700	$40	$40
Education	400	$10	$10
Other Manufacturing	300	$30	$40
Insurance and Real Estate	200	$10	$40
Finance	200	$10	$20
Agriculture	200	$0	$10
Wholesale Trade	100	$10	$20
Food	100	$0	$10
Metals Durable	100	$10	$10
Motor Vehicles	0	$0	$0
Refining	0	$0	$0
Other Mining	0	$0	$10
Pulp and Paper	0	$0	$0
Primary Metals	0	$0	$0
Stone, Clay, and Glass	0	$0	$0
Transportation, Communication, and other Utilities	(100)	$0	($10)
Gas Utilities	(100)	($20)	($60)
Oil and Gas Mining	(200)	($20)	($50)
Coal Mining	(200)	($60)	($90)
Electric Utilities	(1,000)	($160)	($670)
Total	**12,200**	**$280**	**($100)**

Notes: *The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the electric efficiency scenario. All dollar values are in millions of 2000 dollars.*

Table 4-7. *Macroeconomic Impacts by Sector for Nevada – 2020*

Sector	Net Change in Jobs	Change in Wage and Salary Compensation (Million $)	Change in Gross State Product (Million $)
Services	2,500	$90	$110
Retail Trade	1,900	$50	$80
Government	1,400	$60	$80
Construction	400	$20	$20
Other Manufacturing	300	$30	$40
Agriculture	200	$0	$10
Education	200	$10	$10
Metals Durable	100	$10	$20
Insurance and Real Estate	100	$0	$20
Finance	100	$10	$10
Food	100	$0	$10
Wholesale Trade	0	$10	$10
Coal Mining	0	$0	$0
Pulp and Paper	0	$0	$0
Refining	0	$0	$0
Motor Vehicles	0	$0	$0
Other Mining	0	$0	$10
Primary Metals	0	$0	$0
Stone, Clay, and Glass	0	$0	$0
Transportation, Communication, and other Utilities	(100)	($10)	($10)
Oil and Gas Mining	(100)	($10)	($30)
Gas Utilities	(100)	($10)	($30)
Electric Utilities	(700)	($110)	($460)
Total	**6,300**	**$180**	**($90)**

Notes: *The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the electric efficiency scenario. All dollar values are in millions of 2000 dollars.*

Table 4-8. *Macroeconomic Impacts by Sector for New Mexico – 2020*

Sector	Net Change in Jobs	Change in Wage and Salary Compensation (Million $)	Change in Gross State Product (Million $)
Services	3,000	$110	$130
Retail Trade	2,000	$50	$90
Government	1,500	$70	$90
Construction	300	$10	$20
Education	200	$10	$10
Other Manufacturing	200	$20	$20
Wholesale Trade	100	$10	$10
Insurance and Real Estate	100	$10	$30
Finance	100	$0	$10
Metals Durable	100	$10	$10
Agriculture	100	$0	$0
Food	100	$0	$10
Other Mining	0	$0	$0
Pulp and Paper	0	$0	$0
Refining	0	$0	$0
Stone, Clay, and Glass	0	$0	$0
Transportation, Communication, and other Utilities	0	$0	($10)
Motor Vehicles	0	$0	$0
Primary Metals	0	$0	$0
Gas Utilities	(100)	($10)	($30)
Oil and Gas Mining	(100)	($10)	($30)
Coal Mining	(100)	($30)	($50)
Electric Utilities	(600)	($100)	($430)
Total	**6,900**	**$130**	**($110)**

Notes: *The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the electric efficiency scenario. All dollar values are in millions of 2000 dollars.*

Table 4-9. *Macroeconomic Impacts by Sector for Utah – 2020*

Sector	Net Change in Jobs	Change in Wage and Salary Compensation (Million $)	Change in Gross State Product (Million $)
Services	2,400	$80	$100
Retail Trade	1,700	$50	$70
Government	1,400	$60	$80
Construction	500	$20	$30
Education	200	$10	$10
Other Manufacturing	200	$20	$30
Wholesale Trade	100	$10	$10
Insurance and Real Estate	100	$0	$20
Finance	100	$10	$10
Agriculture	100	$0	$0
Food	100	$0	$10
Primary Metals	0	$0	$0
Other Mining	0	$0	$0
Oil and Gas Mining	0	$0	($10)
Pulp and Paper	0	$0	$0
Refining	0	$0	$0
Stone, Clay, and Glass	0	$0	$0
Transportation, Communication, and other Utilities	0	$0	($10)
Motor Vehicles	0	$0	$0
Metals Durable	0	$0	$10
Gas Utilities	(100)	($10)	($30)
Coal Mining	(100)	($30)	($50)
Electric Utilities	(400)	($60)	($270)
Total	**6,300**	**$160**	**$50**

Notes: *The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the electric efficiency scenario. All dollar values are in millions of 2000 dollars.*

Table 4-10. *Macroeconomic Impacts by Sector for Wyoming – 2020*

Sector	Net Change in Jobs	Change in Wage and Salary Compensation (Million $)	Change in Gross State Product (Million $)
Services	800	$30	$30
Retail Trade	500	$10	$20
Government	400	$20	$20
Construction	300	$20	$20
Other Manufacturing	200	$10	$20
Agriculture	100	$0	$0
Education	100	$0	$0
Pulp and Paper	0	$0	$0
Wholesale Trade	0	$0	$10
Oil and Gas Mining	0	$0	($10)
Insurance and Real Estate	0	$0	$10
Finance	0	$0	$0
Food	0	$0	$0
Metals Durable	0	$0	$10
Refining	0	$0	$0
Transportation, Communication, and other Utilities	0	$0	$0
Motor Vehicles	0	$0	$0
Other Mining	0	$0	$0
Primary Metals	0	$0	$0
Stone, Clay, and Glass	0	$0	$0
Coal Mining	(100)	($20)	($20)
Gas Utilities	(100)	($10)	($20)
Electric Utilities	(200)	($40)	($160)
Total	**2,000**	**$40**	**($60)**

Notes: *The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the electric efficiency scenario. All dollar values are in millions of 2000 dollars.*

As might be expected, the utilities sectors and energy-related industries incur overall losses in jobs, compensation, and GSP. This loss of jobs assumes a traditional economic structure for electric utilities through 2020. Thus, as fewer conventional power plants are needed and less power is produced as a result of end-use efficiency improvements, fewer utility jobs are sustained. But this result may be tempered somewhat as new opportunities emerge and the energy industries themselves undergo internal restructuring.

For example, as electric utilities engage in more energy efficiency services and other efficiency-related investment activities, they will undoubtedly employ more people from the business and service sectors, as well as the construction and engineering sectors. Hence, the negative employment impacts should not necessarily be seen as job losses; rather they might be more appropriately seen as opportunities for a redistribution of jobs in the overall economy and future occupational tradeoffs.

Explained differently, while the electric utilities in the six state region may lose an estimated 4,900 traditional jobs (Arizona would lose 2,100, Colorado would lose 1,000, Nevada would lose 700, New Mexico would lose 600, Utah would lose 400, and Wyoming would lose 200) due to selling less electricity, they can gain many of those jobs back if they move aggressively into the energy efficiency business, thereby absorbing some of the job gains assigned to other sectors — such as the construction and service sectors. In effect, if utilities expand their participation in the energy efficiency market, their job totals could increase relative to the estimates based on a more conventional definition of an electric utility as only an energy supplier.

Tables 4-4 through 4-10 show three big "winners" under the electric efficiency scenario. These are the service sector with total gains of 23,800 jobs (10,400 jobs in Arizona, 4,800 in Colorado, 3,000 in New Mexico, 2,500 in Nevada, 2,400 in Utah, and 800 in Wyoming), retail trade with gains of 17,000 jobs (7,200 jobs in Arizona, 3,700 in Colorado, 2,000 in New Mexico, 1,900 in Nevada, 1,700 in Utah, and 500 in Wyoming), and government with gains of 13,500 jobs (5,800 jobs in Arizona, 3,000 in Colorado, 1,500 in New Mexico, 1,400 in Nevada, 1,400 in Utah, and 400 in Wyoming).

Retail trade and the service sectors are winners largely for two reasons. First, they benefit from the actual investments in efficiency measures. Second, they benefit from the higher level of goods and services sold in each state as ratepayers and businesses spend their electric bill savings elsewhere in the economy. The government sector is a winner because it benefits from the state and local taxes collected in each state as ratepayers and businesses purchase new energy-efficient appliances, materials, and equipment, and spend their electric bill savings. Alternately, if the government were to use these revenues to cut other taxes, additional jobs would be created as consumers spend their tax savings on a variety of goods and services.

Although not as significant as the three sectors noted above, the construction sector also gains a substantial number of jobs. This is because it is the industry that benefits most directly as contractors and others are hired to increase the energy efficiency of new homes and commercial buildings, and make the requisite efficiency upgrades in existing buildings and factories. The construction sector alone accounts for about five percent of the net job increase in the year 2020.

E. SUMMARY

Our analysis indicates that making efficiency improvements can lower electricity bills for residents and businesses. These lower energy bills, in turn, promote overall economic efficiency and create additional jobs.

The High Efficiency Scenario provides significant macroeconomic benefits for each of the states and the region as a whole. By 2020, we estimate the efficiency investments and energy bill savings add more than $1.3 billion in new wage and salary income (in 2000 dollars) and support a net increase of 58,400 jobs for the region as a whole. These income and jobs gains reflect differences between the business-as-usual Base Scenario and the High Efficiency Scenario.

Although the job gains are distributed throughout much of the economy, several sectors, including services, retail trade, and government show the largest gains. Not surprisingly, the energy industries (electric and gas utilities, and coal mining) exhibit the largest losses. A total job loss of 7,500 jobs is projected to occur in the region by 2020 in the High Efficiency Scenario, compared to a total job gain of about 66,000 jobs and a net increase of 58,400 jobs. Furthermore, the projected losses can be overcome if the energy industries recognize the new and expanding opportunities and transition to providing more efficiency-related products and services. In short, accelerating energy efficiency improvements can help to create a strong economic future in the southwest region.

CHAPTER 5—POLICY REVIEW AND RECOMMENDATIONS

The Southwest states have made limited progress in improving the efficiency of electricity use over the past 10-15 years. As noted in Chapter 1, electricity use region-wide increased 3.7 percent per year on average during 1990-2000. Electric utilities in the region report saving only 1.1 TWh in 1999, equivalent to 0.6 percent of their electricity sales, as a result of their energy efficiency programs cumulatively (EIA 2001f). For comparison, utilities in states with vigorous energy efficiency programs, such as utilities in California, Oregon, Washington, Wisconsin, Minnesota, and New England states, report savings in 1999 that are equivalent to 3-9 percent of their electricity sales.

There clearly are valuable utility, state, and local energy efficiency programs that are advancing energy efficiency in each of the southwest states. But in general these programs are relatively limited in scope and budget, and are not adequate for overcoming the pervasive barriers inhibiting widespread improvements in the efficiency electricity use in the southwest. As a result, inefficient electricity use is commonplace in homes, commercial buildings, and industries in the region. And while some builders in the region are constructing energy-efficient new homes and commercial buildings, most new buildings are not energy-efficient compared to the current state-of-the-art.[1] These buildings will waste energy for many years if not decades.

This chapter reviews the status of energy efficiency policies and programs in each of the six southwest states. It then recommends new and expanded initiatives that would lead to greater adoption of cost-effective energy savings measures. In addition, it examines the set of policies and programs that if implemented together could result in the achievement of the full cost-effective savings potential identified and analyzed in previous chapters.

A. Utility Energy Efficiency Programs

1. Current Status

Electric utilities have implemented a wide variety of energy efficiency programs including information and training, financing, financial incentive (e.g., rebate), bidding, performance contracting, and direct installation programs (Nadel and Geller 1996). Utility spending on energy efficiency programs in the southwest region reached its peak during the early 1990s. Since then, the energy restructuring movement and other factors have resulted in less spending on energy efficiency programs. According to the Energy Information Administration (EIA), utilities in the southwest region spent about $16 million on energy efficiency programs as of 1999, only about 0.14 percent of their total revenues (EIA 2001f). For comparison, utilities in California, Oregon, and Washington spent 1.25 percent and utilities in New England spent 1.42 percent of their revenues on energy efficiency programs in 1999.

[1] As noted below, building energy codes are not up-to-date in most states and major cities in the region. And even in locales where state-of-the-art energy codes have been adopted, there is evidence of relatively low levels of code compliance.

Utility funding of energy efficiency programs increased since 1999 in a few southwest states, most notably in Colorado and Utah. But funding for energy efficiency programs declined in other states, most notably Arizona. Table 5-1 estimates the budget for utility-sponsored energy efficiency programs in each state as of 2001-2002. Total spending on energy efficiency programs in the region–about $32 million per year–is equivalent to only about 0.27 percent of utility revenues as of 2002. This is far below what is justified given the tremendous cost-effective energy savings potential in the southwest region.

Table 5-1. *Utility Spending on Energy Efficiency Programs as of 2001-02*

State	Energy efficiency program budget (million $ per year)
AZ	3
CO	10
NV	3
NM	2
UT	12
WY	2
Region	**32**

Arizona

Utilities in Arizona reported spending $4.5 million on their efficiency programs in 1998 and $6.4 million in 1999 (EIA 2001b). In September 1999, the Arizona Corporation Commission (ACC) instructed utilities to include a Systems Benefit Charge (SBC) in their restructuring plans. Initially the SBC was intended to fund renewable energy, environmental, energy efficiency, low-income assistance, consumer education, R&D, nuclear fuel disposal, and power plant decommissioning programs. However, the SBC is being used mainly to support renewable energy development in Arizona at the present time.

In May 2000, the ACC adopted an Environmental Portfolio Standard that requires utilities to derive at least 0.2 percent of their electric power from new solar and other renewable energy sources as of 2001, with the renewable energy fraction increasing to 1.1 percent by 2007. Half of this renewable generation must come from solar electric technologies. To support this renewable energy mandate, utilities were allowed to transfer SBC funds, with the exception of low-income assistance programs, to the Environmental Portfolio Standard budget. The total SBC budget as of 2001 was approximately $28 million per year, including expenditures by investor-owned utilities (IOUs), the Salt River Project, and rural electric coops (Kushler and Witte 2001). Most of this funding is devoted to acquiring renewable energy generation.

The upshot is that while utilities in Arizona are supporting renewable energy sources, most notably solar photovoltaic power development, they are carrying out very modest energy efficiency programs. It is estimated that electric utilities in Arizona spent only about $3 million (less than 0.1 percent of total revenues) on energy efficiency programs in 2001-02 (Schlegel 2002). And much of this went to promotion and financial assistance for energy-efficient new home construction, tied to home builders using electric space and water heating.

The ACC oversees the implementation of the SBC, and has opened a regulatory proceeding to investigate the implementation of utility restructuring in Arizona in general, including the effect that restructuring has had on energy efficiency efforts. The ACC or legislature could review and modify the SBC in order to expand the budget and scope of utility energy efficiency programs in Arizona.

Colorado

Colorado has not yet approved electric utility restructuring legislation and has no SBC or general policy on energy efficiency programs for electric utilities. In July 2000, the Public Utilities Commission accepted a settlement proposed by Xcel Energy (formerly known as Public Service of Colorado) and other parties regarding demand-side management (DSM) programs as part of an Integrated Resource Planning proceeding. Xcel is the largest utility in Colorado and is responsible for about 60 percent of the power sold in the state. The Settlement calls for Xcel to spend up to $75 million over five years on energy efficiency and load management programs, with a goal of reducing peak load in 2005 by 124 MW.[2]

Regarding energy efficiency programs, Xcel Energy offers financial incentives for energy efficiency improvements in commercial buildings through a bidding program. Building owners, contractors, or ESCOs propose projects and incentive levels, and Xcel selects the most attractive projects to support. The program goal is to achieve 22 MW of peak load reduction in the 2001-2002 program cycle, but only about 11 MW had been implemented and verified as of October, 2002 (Xcel Energy 2002). Consequently, the program was revamped in order to make it easier for businesses and ESCOs to participate. Xcel also provides rebates to consumers who purchase high efficiency air conditioners. And Xcel has started pilot programs aimed at improving the efficiency of new commercial buildings as well as existing commercial buildings through a process known as retro-commissioning.

Some of Colorado's municipal utilities and rural electric cooperatives are conducting energy efficiency programs. Fort Collins Light and Power provides zero-interest loans for home weatherization projects and is considering significantly expanding the scope and budget of its efficiency programs. In September, 2002, the Board of this municipal utility approved a new electricity policy that includes goals of reducing electricity consumption 10 percent and peak

[2] The DSM Settlement Agreement was approved by two of three PUC commissioners but was strongly opposed by Chairman Gifford who questioned the legality and viability of such programs in Colorado.

demand 15 percent by 2012 (City of Ft. Collins 2002b). The Platte River Power Authority provides rebates on Energy Star air conditioners and other measures that reduce peak electric demand to municipal utility customers in Fort Collins, Loveland, Longmont, and Estes Park. Colorado Springs Utilities offers low-interest loans for a wide range of residential energy efficiency measures. And the Delta Montrose Electric Association subsidizes the purchase of geothermal heat pumps by its customers.

Nevada

Nevada is the highest growth state in the country in terms of population and electricity demand. In July 1997, Nevada adopted utility restructuring legislation. This legislation encourages utilities to promote energy efficiency, carry out R&D, and undertake renewable energy development, but it does not call for a formal SBC or require energy efficiency programs. In 2001, the legislature repealed this bill and enacted a new law that includes a small SBC on retail electricity and natural gas sales in order to support bill assistance and weatherization programs for low-income households.

The investor-owned utilities in Nevada, Nevada Power Co. and Sierra Pacific Power Co., have merged and together account for about 90 percent of electricity sales in the state. The utilities reported spending no money on energy efficiency and load management programs in 1999 but restarted some modest programs in 2000. In 2001, the two utilities spent a total of about $3 million on:

- bill discounts for residential AC cycling,
- rebates for lighting efficiency measures implemented by commercial customers,
- incentives for customer-designed efficiency projects in the commercial sector,
- residential energy audits,
- grants for weatherization of low-income households, and
- energy efficiency education and promotion efforts.

With the repeal of the original restructuring legislation, the Nevada PUC again is requiring utilities to submit integrated resource plans (IRPs) every three years. As part of an IRP proceeding, SWEEP and the Land and Water Fund of the Rockies proposed a collaborative process for developing and analyzing a wide range of additional DSM program options. The utilities accepted this proposal and a DSM collaborative was launched in November, 2001. Based on the work of the collaborative, the Nevada utilities proposed expanding their DSM programs starting in 2003. After further discussions, an agreement concerning the budget and focus of new programs was reached by all parties to the IRP proceeding. The Nevada PUC approved this proposal, which should result in $11.2 million in utility-funded energy efficiency and load management programs in 2003. New programs would include:

- promotion of Energy Star appliances and lighting products,
- incentives for high efficiency air conditioning systems, air conditioner tune-ups, and duct sealing,
- a recycling program for older refrigerators,
- incentives for various efficiency measures implemented by small businesses,
- a vending machine energy efficiency program,
- technical and financial assistance to enhance low-income home weatherization in the state, and
- time-of-use rates.

New Mexico

Utilities in New Mexico reported spending about $1.5 million on energy efficiency programs in 1998 and 1999 (EIA 2001b). In April 1999, New Mexico adopted utility restructuring legislation. This law creates a small SBC of 0.3 mills/kWh to fund energy efficiency, low-income assistance, renewable energy, and consumer education programs. The SBC, which totals about $6 million statewide, was scheduled to begin in 2002. But implementation of the restructuring legislation was postponed by the legislature due to the electricity crisis in California.

In the mean time, utilities in New Mexico are operating relatively minimal energy efficiency programs. Public Service Co. of New Mexico, the largest utility in the state, only provides information on energy savings options through bill inserts and the internet. Xcel Energy, which bought Southwestern Public Service Co. (the second largest utility in the state), provides low-interest loans for energy projects implemented by its commercial and industrial customers. Xcel also sells compact fluorescent lamps at a discount and is starting some energy efficiency incentive programs in 2002.

Utah

Utah has not yet approved electric utility restructuring legislation and has no systems benefit charge or general policy on utility energy efficiency programs. Utah does have IRP requirements. In May, 2000, the state utility commission established an SBC task force that was charged with evaluating the cost-effective energy efficiency potential in Utah, the success of previous utility efficiency programs, and the desirability of an SBC mechanism. The task force hired a consultant to carry out an efficiency potential study. The study concluded that there is substantial cost-effective energy savings as well as cogeneration potential in the state (Nichols and von Hippel 2001).

PacifiCorp, the main electric utility operating in the state through its Utah Power and Light subsidiary, spent only about $2 million per year on energy efficiency programs in recent years.[3]

[3] PacifiCorp is headquartered in Portland, OR and operates in five states. Its Utah service area is its largest and fastest growing in terms of electricity sales.

But due in large part to the efficiency potential study and testimony filed in the last IRP proceeding, PacifiCorp launched an expanded set of energy efficiency programs in mid-2001 including:

- a residential compact fluorescent lamp distribution program;
- a prescriptive rebate program for a wide range of energy-efficient lighting, HVAC, and other efficiency measures implemented by commercial and industrial customers;
- incentive payments per unit of energy and peak demand saved for customized efficiency projects implemented by larger commercial and industrial customers.

The total budget for these programs is around $12 million per year. In addition, PacifiCorp worked with SWEEP and other organizations to develop and analyze further DSM program options during 2002. PacifiCorp is expected to start four of five new programs in 2003 including a high efficiency air conditioning and evaporative cooling incentive and education program, a refrigerator and freezer recycling program, an air conditioner cycling program, and a bidding program for curtailable loads in the commercial and industrial sectors. If PacifiCorp proceeds with these new programs, its total budget for energy efficiency and load management programs in Utah would increase to about $25 million per year (Bumgarner 2002). This is equivalent to about 3 percent of its retail revenues.

Wyoming

Wyoming has not approved electric utility restructuring legislation and has no systems benefit charge or general policy on utility energy efficiency programs. PacificCorp is the largest investor-owned utility in Wyoming and is responsible for 70 percent of retail electricity sales. Utilities in Wyoming are conducting limited energy efficiency programs, estimated to be in the range of $1 to $2 million per year in budget. PacifiCorp, however, is preparing a new IRP in 2002 that is expected to incorporate demand-side options to a greater extent. This planning process could lead to initiation of new DSM programs in Wyoming as well as Utah.

2. Recommendations

Adopt Systems Benefit Charges or Energy Efficiency Performance Standards to Expand Utility-based Energy Efficiency Programs

A Systems Benefit Charge (SBC) is a small charge paid by all electric utility consumers to fund energy efficiency, renewable energy, low-income assistance, and other “public benefits” activities. About 20 states across the country have adopted SBCs (Kushler and Witte 2001). Many did this as part of utility sector restructuring, but a few states enacted this policy independent from restructuring. The SBC approach has proven to be an effective public policy for expanding the adoption of cost-effective energy efficiency measures in many states including California, New York, Wisconsin, and various New England states (York et al. 2002).

States in the southwest region should adopt SBC mechanisms (or in some cases expand existing SBC mechanisms) to greatly increase funding for utility energy efficiency programs. In Arizona, New Mexico, and Nevada, a new SBC could be added to the small surcharges that already exist through utility commission action. In the case of Colorado and Wyoming, new legislation is needed to establish a SBC mechanism. In the case of Utah, a SBC may not be needed given the willingness of PacifiCorp to expand its energy efficiency and load management programs voluntarily.

Some utilities in the southwest region strongly oppose utility-based energy efficiency programs and in fact may be incapable of operating effective programs. In these cases, state agencies or independent third party administrators should operate the efficiency programs. This approach to energy efficiency program implementation is successfully used in a number of states including New York, Vermont, and Wisconsin (York et al. 2002). If third party program administrators are used, the state utility commission could select the organization(s) through a competitive process and oversee implementation.

With respect to funding for energy efficiency programs, a SBC of 0.15 cents per kilowatt-hour (kWh) is roughly the median for states that have already adopted this policy, while a SBC of 0.3 cents per kWh is upper end of the funding range (Kushler and Witte 2001).[4] Given the large cost-effective electricity savings potential in the southwest states, we suggest adopting a SBC of 0.15-0.225 cents per kWh for the purpose of funding energy efficiency programs. This is especially needed in states where efficiency programs are limited or modest (i.e., in all states besides Utah). The upper bound of 0.225 cents per kWh was selected in order to limit the surcharge to no more than about 3.5 percent of the average price of electricity in the region, which was 6.2 cents per kWh as of 2000 (EIA 2001e).[5]

If this policy were adopted in all six states, the total amount of funding for efficiency programs would increase to $291-427 million per year (see Table 5-2). This is about 9-13 times the level of funding as of 2001-02. Energy efficiency program spending would increase by at least a factor of 30 in Arizona and a factor of 10 or more in Nevada, New Mexico, and Wyoming.

Imposing and maintaining a SBC at this level would result in 10-15 percent electricity savings in the southwest region by 2020 according to an analysis prepared by SWEEP, as shown in Table 5-2 (Geller 2002a). These savings levels are incremental to the savings from the modest energy efficiency programs that were underway in 2001-02. The savings are above average in percentage terms in Arizona and Nevada because these state have very limited energy efficiency programs at the present time. The savings are below average in Utah mainly because of the significant programs already underway there.[6]

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[4] This is the level of funding for energy efficiency programs only; the total amount of the SBC is usually greater than this due to the SBC funding other activities besides energy efficiency programs. But efficiency programs receive the majority of SBC funds in most states.
[5] A higher SBC may be justified and appropriate in states with above-average electricity prices such as Arizona and New Mexico.
[6] Since existing programs are assumed to continue under the SBC, less money would be dedicated to new programs in states

Table 5-2. *Program Funding Levels and Estimated Incremental Electricity Savings from the Proposed SBC*

State	Efficiency program budget under the proposed SBC (million $ per yr)	Electricity savings in 2020	
		(GWh/yr)	(%)
AZ	95 - 139	10,700 – 15,700	11.1 - 16.3
CO	66 - 97	6,200 – 9,100	9.9 - 14.5
NV	45 - 66	5,100 – 7,500	10.7 - 15.7
NM	29 - 43	2,900 – 4,300	10.6 - 15.5
UT	37 - 54	2,800 – 4,100	7.5 - 11.0
WY	19 - 28	1,800 – 2,600	10.1 - 14.8
Region	**291 - 427**	**29,500 – 43,300**	**10.2 - 15.0**

Note: *Funding level based on a SBC range of 0.15-0.225 cents per kWh and projected electricity use in each state in 2003.*
Source: *Based on Geller 2002a.*

The adoption of an Energy Efficiency Performance Standard (EEPS) is an alternative approach to achieving much greater energy efficiency through utility-sponsored programs in the southwest states. An EEPS would specify energy savings targets and timetables for distribution utilities, rather than specifying funding levels. It would then be left to the utilities to achieve the savings targets, spending as little money as necessary. As part of this policy, it may be possible to establish a market for energy savings certificates or credits, thereby enabling independent developers of energy efficiency projects (e.g., energy service companies, ESCOs) to participate in and benefit from the energy savings requirements.

A variation on the EEPS concept is being implemented in Texas where utility restructuring legislation adopted in 1999 requires that electric utilities implement energy programs sufficient to save at least 10 percent of their projected load growth (Kushler and Witte 2001). The EEPS approach is also being implemented in some European countries including the United Kingdom and Italy (Pavan 2002). It is a promising approach in that it could lead to substantial electricity savings at lower cost than the SBC approach. In order to effectively implement an EEPS, both reliable and practical procedures for monitoring and verifying energy savings are needed. Considerable progress has been made in the United States and other countries in developing such procedures due to the need to evaluate the energy savings from projects implemented by ESCOs as well as energy efficiency programs more generally (DOE 2001).

where significant activity is already occurring.

Undertake Targeted Energy Efficiency and Load Management Efforts to Help Defer Transmission and Distribution System Investments

As noted in Chapter 1, there are a number of areas in the southwest region with transmission and distribution (T&D) capacity problems. Utilities in the southwest should consider targeting their energy efficiency and load management programs in areas with significant T&D constraints. End-use energy efficiency improvements can help to defer costly investments in T&D systems and can help to improve power reliability in areas with overloaded T&D lines (Cowart 2001). Also, the prospect of T&D investment deferral can enhance the cost effectiveness of geographically-targeted energy efficiency and load management efforts. Utility regulators in the region should insist that utilities undertake targeted DSM initiatives if this appears to be cost-effective and feasible for deferring T&D system investments.

Geographically-targeted DSM was successfully implemented by Pacific Gas & Electric Co. in a well-documented demonstration project in the early 1990s (EPRI 1992). A geographically-targeted DSM program would attempt to achieve high participation rates in a particular neighborhood or community. It might involve additional efficiency measures and/or program delivery mechanisms, increased financial incentives, and enhanced marketing. To be successful, it is important that such programs begin well in advance of the alternative T&D system upgrade. Moreover, geographically-targeted efficiency programs should complement rather than substitute for broad-based energy efficiency programs in the southwest states.

Provide Utilities with Financial Incentives to Implement Effective Energy Efficiency Programs

Many utilities resist operating vigorous end-use energy efficiency programs because it reduces their sales and revenues in the short run (Cowart 2001). Therefore, utility regulators or legislatures in states such as California, Massachusetts, Minnesota, New York, and Oregon have adopted policies that allow utilities to benefit financially from operating effective energy efficiency programs. These financial incentives, sometimes known as shareholder incentives, reward utilities based on the level of energy savings produced and/or cost effectiveness of their energy efficiency programs. For example, utilities in California, Massachusetts, New York, and Oregon were allowed to keep 8-27 percent of the net economic benefits produced by their energy efficiency programs during the mid-1990s (Stoft, Eto, and Kito 1995). In practical terms, this meant a very small rate increase once the net benefits and shareholder incentive level were determined. In most states, the financial incentives are offered in conjunction with energy efficiency program spending or savings requirements.

To illustrate how this policy can work, Pacific Gas and Electric Co. spent $224 million on energy efficiency and load management programs in 1992 (2.9% of their revenues). After the impacts and net benefits of the program were analyzed and approved by the California PUC, the utility was allowed to collect $44.9 million in shareholder incentives in addition to recovering program costs. The incentive represented about 17 percent of the estimated net benefits these programs provided to consumers and businesses in California (Stoft, Eto, and Kito 1995). This incentive level meant the utility obtained a 20 percent "return" on it energy efficiency and load management expenditures, well above what it earned on other investments. In addition, the utility could have incurred a financial penalty if it failed to provide a specified minimum net societal benefit from its DSM programs.

In the southwest region, the Arizona Corporation Commission adopted a bonus mechanism that applied to utility energy efficiency and load management programs in the early 1990s. The incentive was specified in terms of dollars per kW saved, based on the estimated value of the return on supply-side investments that would have been made had the DSM programs not been implemented. For example, Arizona Public Service Co. received an incentive payment of $0.3 million on its $3.4 million DSM program in 1992 (Stoft, Eto, and Kito 1995). In addition, two major utilities operating in the region (Xcel Energy and PacifiCorp) have experience with shareholder incentives for DSM programs in their home states of Minnesota and Oregon.

We recommend offering shareholder incentives to all investor-owned utilities that operate substantial and cost-effective energy efficiency programs in the southwest region. An incentive level of 15-25 percent of the net societal economic benefits provided by the programs should be adequate given experience with these incentives throughout the country as well as the expected net benefits of these programs in the southwest. This recommendation is consistent with the energy policy approved by the Western Governors' Association in 2001 (WGA 2001).

In order to implement this policy, it will be critical to carefully evaluate the energy savings, peak load reductions, and economic benefits of all major DSM programs. These programs should be evaluated by credible, independent experts. Also, the energy and peak demand savings claimed by utilities should be thoroughly reviewed and approved by state utility commissions prior to awarding any shareholder incentives. This type of rigorous program evaluation can be useful for improving the design of DSM programs as well as for determining reasonable shareholder incentives.

Reform Utility Rates to Encourage Greater Energy Efficiency

Today residential and smaller commercial customers in the southwest states generally pay flat rates; i.e., the same amount per kWh of electricity consumed. For example, residential customers in Arizona consumed about 1,050 kWh per month on average and paid 8.44 cents per kWh as of 2000 (EIA 2001c).[7] Instead of flat rates, customers could pay tiered rates, whereby rates increase as usage increases. This is also known as inverted block rates.[8] For example, residential customers in Arizona could pay 4.22 cents/kWh for their first 350 kWh per month, 8.44

[7] This is the average rate across the different utilities in Arizona.
[8] The Utah Public Service Commission approved an inverted block rate for residential consumers in 2001. But the price differential for consumption over 400 kWh per month is small (0.78 cents per kWh) and it applies only in the summer months (May – Sept.).

cents/kWh for their next 350 kWh, and 12.66 cents per kWh for consumption over 700 kWh per month. The total revenue paid by all households would remain about the same as with the flat rate (to first order before consumers respond to the new rates), but high usage customers would have a greater economic incentive to use electricity more efficiently.

Various empirical studies show a typical short run price elasticity of –0.2 to –0.3, meaning a 2-3 percent reduction in electricity use for each 10 percent increase in price (Faruqui and George 2001). Continuing with the example above and assuming a price elasticity of –0.25, the 50 percent increase in price for the last 350 kWh consumed by a typical household would lead to electricity savings of about 44 kWh per month (4 percent) on average. This is a reasonable estimate of savings potential. One recent study estimates that adoption of five-step tiered rates in California in 2001 along with a significant increase in the average rate resulted in a 10 percent reduction in average residential electricity use (Reiss and White 2002).

Time-of-use rates that charge more for electricity use during peak load, high cost periods (and less during off-peak, low cost periods) can also stimulate energy savings. While time-of-use rates primarily shift electricity use from peak to off-peak periods, experience shows that there tends to be a larger reduction in peak period electricity use than the increase in electricity use during off-peak periods, meaning some level of energy savings at least for residential time-of-use programs (Faruqui and George 2001). As much as a 10 percent average electricity savings has occurred in a well-designed time-of-use rates program implemented by Gulf Power Company in Florida, due in part to providing participants programmable thermostats that can respond to price signals (Eggart 2002).

We recommend adopting tiered rates and time-of-use rates in the southwest states, in conjunction with expanded utility (or state-based) energy efficiency programs and financial incentives to reward utilities for operating effective programs. These new rates should be designed based on lessons from California, Florida, Washington, and other states that have had considerable experience with time-of-use and tiered rates. Also, the new rates should be accompanied by efforts to educate consumers and businesses on how they can benefit from the new rates, as well as dissemination of technologies such as programmable and intelligent thermostats to facilitate consumer response.

B. Building Energy Codes and other Initiatives Related to New Construction

State-of-the-art yet cost-effective building energy codes typically reduce electricity use in new commercial buildings by 15-30 percent, and even more if the new building is well-designed and optimized (Johnson and Nadel 2000). State-of-the-art energy codes can cost effectively reduce the electricity use for space heating and cooling in new homes by 30-40 percent through improvements in the building envelope, the thermal distribution system, and other measures (see new homes analysis in Chapter 2). Window efficiency requirements alone could reduce air conditioning electricity use by 1,100-1,400 kWh/yr (on the order of 10 percent of total household electricity consumption) in new homes in Arizona, New Mexico, and Nevada (Prindle and

Arasteh 2001).

Building energy codes need to be both stringent and practical in order to be successful. State-of-the-art codes are usually based on one of the model codes such as the International Energy Conservation Code (IECC) or the most recent ASHRAE model standards (ASHRAE 90.1-1999 for commercial buildings and 90.2 for residential buildings). In order to achieve maximum energy savings, architects and builders need to understand how to comply in a cost-effective manner; builders need to control the quality of their buildings (e.g., by avoiding mistakes such as thermal bypasses, leaky HVAC ducts, or poor air conditioner installation). Also, code officials need to rigorously enforce the codes.

There are examples where this ideal situation has been approached in the southwest. But there are also locales where building energy codes are non-existent or routinely ignored and where efficient new buildings are the exception rather than the rule. Fortunately, most of these locales are not experiencing substantial growth in new housing or commercial construction. And there are some high growth areas in the southwest where market competition and other forces are resulting in good energy performance in spite of outdated or nonexistent energy codes. This range of experience is summarized below, followed by our policy and program recommendations in this area.

1. Current Status

Arizona

Arizona is the most populous state in the region. It also has the highest rate of growth in electricity demand in the "Base Scenario" and is adding the largest number of new homes each year. Arizona has state legislation calling for the *voluntary* adoption of the 2000 IECC for residential buildings and ASHRAE 90.1-1999 for commercial codes statewide. However, since Arizona is a "home rule" state—which in practice means that it's quite difficult to pass statewide mandatory energy codes—local jurisdictions decide whether or not to adopt building codes and if so what codes to adopt. Many municipalities have adopted building energy codes including Tucson and neighboring Pima County. But the City of Phoenix, one of the fastest growing urban areas in the nation, still has no energy code.

The absence of an energy code in Phoenix does not mean that all new dwellings and commercial buildings are poor energy performers. The State Energy Office has sponsored builder training in Phoenix, Tucson, and elsewhere. Also, the Arizona utilities provide marketing and financial incentives to encourage energy-efficient new home construction. A representative of a major HVAC company estimates that at least half of the homes being built in the Phoenix and Tucson areas are relatively energy-efficient homes (Colgan 2002). Another building specialist estimates that almost 6,000 of the 35,000 new homes built in the Phoenix area each year are Energy Star homes (Wastchak 2002). Indeed, U.S. EPA data shows that Arizona accounted for about 20 percent of all Energy Star homes in the nation as of 2001 (Rashkin 2002). The strategy that has led to this level energy-efficient new construction includes training to stimulate builder know-how, utility promotion and incentives, third party inspection to verify performance, and consumer education and energy bill guarantees to stimulate demand.

Meanwhile, Phoenix and surrounding areas are in the process of adopting energy codes. Scottsdale was considering adoption a recent version of the IECC in 2002, and Phoenix is planning to adopt a variation of the new comprehensive National Fire Prevention Association (NFPA) 5000 building code by early 2003. NFPA includes ASHRAE Standard 90.2-2001 as a residential energy code and ASHRAE Standard 90.1-2001 as a commercial code, although at present it is unclear what portions of these energy codes will ultimately be adopted. In addition, the Maricopa County Association of Governments has established a codes committee that is likely to recommend that all municipalities in the Phoenix-Scottsdale area adopt and implement building energy codes.

Tucson, which is also experiencing a housing boom, previously adopted the 1995 Model Energy Code (MEC) and was in the final stages of updating to the 2000 IECC as of September, 2002. Formal adoption awaits action by the city council and mayor. In addition, 21 communities in the area around Tucson (Pima County) have adopted the International Residential Codes (which include the IECC by default), or IECC codes.

Tucson Electric Power Co., the electric utility in Tucson, sponsors a program that encourages builders to build homes that are 30 percent better than the current energy code. These homes have two important qualities that make them exceptional: they are all required to have controlled mechanical ventilation and *every* home is thoroughly tested by well-trained technicians provided by the utility (Rald 2002). Testing includes blower door and duct blaster tests to ensure that neither the building envelope nor duct work is unduly leaky. These requirements ensure indoor air quality and little chance of backdrafting of appliances.

Another noteworthy development in the Tucson area stems from the work of an intentional community, Civano, which was formed in the 1970s. The community developed what it calls "IMPACT (Integrated Method of Performance and Tracking) Standards." According to Civano, "the IMPACT Standards explore how it is possible, over time, to reach a balance between growth, affordability, and achieving a greater integration with our environment. The Standards address energy efficiency, resource and environmental awareness, and community-strengthening goals, and provide a means of measuring progress toward attaining them." (www.civano.com). Under IMPACT, all homes in the Civano community are built to use less than 50% of the energy of a dwelling designed to just meet the 1995 MEC standards.

Colorado

Colorado is a home rule state, so local jurisdictions preside over energy code adoption and implementation. About ten jurisdictions have adopted the 2000 IECC residential energy code and

ASHRAE 90.1 1999 commercial code (see the SWEEP web site for details).[9] In addition, a number of jurisdictions are in the process of considering adoption of state-of-the-art energy codes. Other jurisdictions, including the City of Denver, adopted the 1995 MEC as a residential energy code as well as a version of the ASHRAE 90.1-1989 code for commercial buildings. Denver has begun to consider updating its energy codes, but the process was stalled as of September 2002. The state energy office and U.S. Department of Energy are supporting local code revisions through technical assistance and training via the E-Star organization.

Colorado Springs is the second largest city in Colorado. It also has adopted the 1995 MEC and the ASHRAE 90.1-1989 standards Also, there are indications that building energy codes are not well enforced in Colorado Springs (Andrews 2002). Colorado Springs began a review of its energy codes in 2002 and plans to adopt the 2000 IECC and ASHRAE 90.1-99 standards (Andrews 2002).

There is relatively little data on the actual characteristics and performance of new homes or commercial buildings in many parts of the region. One exception is in the city of Fort Collins, CO, which implemented a modified version of the 1995 MEC in 1996. The Ft. Collins municipal utility co-sponsored a study of new housing built between 1994 and 1999. The study indicated that the energy code adopted in 1996 is saving an average of 175 therms per year, about half the predicted savings from code-driven improvements. The study, which included instrumented field inspections, revealed a pattern of leaky duct work, oversized HVAC equipment, and poor-quality air sealing that together account for the somewhat disappointing energy savings (Swartz and deKieffer 2002). As a result of this study, the city is in the process of both updating and simplifying the energy codes and expanding builder training and technical assistance.

Nevada

The population of the Las Vegas metropolitan area has doubled to 1.5 million since 1990 and Clark County adds about 7,000 new citizens each month. This makes Las Vegas the fastest growing metropolitan area in the United States.

Nevada has a statewide mandatory energy code consisting of modified versions of 1986 MEC for both new residential and commercial buildings. State-owned facilities must comply with the 1989 version of ASHRAE 90.1. Given that the statewide code is very outdated, a number of the key local jurisdictions have adopted more recent versions of the MEC. Clark County, the City of Las Vegas, the City of North Las Vegas, the City of Henderson, the City of Mesquite, and Boulder City all have adopted the 1992 version of MEC. The 1995 version of MEC is in place in Northern Nevada, including the City of Reno and Lyons County.

Energy Rated Homes of Nevada and the U.S. DOE Building America Program are active in Nevada, with support from the Nevada State Office of Energy. Only a few large builders in the

[9] www.swenergy.org/programs/colorado/energycodes.htm

Las Vegas area were building Energy Star homes until an effort was made to add others in mid-2002 and co-brand Energy Star and Building America homes. This effort resulted in features on various builders in the local newspapers, and a healthy competition ensued. As a result, 13 builders are now part of the Energy Star program, many of which are now producing only Energy Star homes (Gilmore 2002). Some builders, like Pulte, are building very tight, well-insulated homes with air handlers and duct work inside the thermal envelope in the attic. This improves overall energy performance to the point that the air conditioner size can be cut in half, thereby saving enough money to pay for the somewhat more expensive insulation work (Ence 2002).

New Mexico

New Mexico has adopted the 1992 MEC (with state amendments) as a mandatory minimum energy code for all new homes in the state. But implementation is spotty in most areas except for the fast-growing Albuquerque area, where the building permitting and inspection process is rigorous (Hagan 2002). Statewide, new homes are going in at the rate of about 700 per month, over half of which are in the Albuquerque area.

All new state-owned commercial buildings must comply with ASHRAE Standard 90.1-1989. All other new commercial buildings must only comply with older codes, ASHRAE 90A-1980 and 90B-1975. Some local jurisdictions do not have staff qualified to enforce the code, so the State's Construction Industries Division undertakes both plan reviews and inspections. The Construction Industries Division relies on the Energy, Minerals and Natural Resources Department (where the state energy office is housed) for technical assistance.

There is an effort underway to adopt the 2000 IECC in New Mexico. The Energy, Minerals and Natural Resources Department has formed a working group to develop a version of this code suitable for New Mexico. The Department hopes to have this new code ready for adoption by the end of 2002, with implementation starting in 2003.

Utah

Effective January 1, 2002, the 2000 IECC is the mandatory energy code for all new residential and commercial buildings in Utah.[10] Implementation and enforcement of the code is largely a local matter. Most jurisdictions ask builders to do a "MECcheck" analysis with their plans as part of the building permit process (Wilson 2002). Likewise, owners or builders of smaller commercial buildings are asked to do a "COMcheck" analysis and submit the results with their plans.[11]

The Utah Energy Conservation Coalition, a non-profit agency funded by the state energy office,

[10] Commercial builders have the choice of complying with ASHRAE 90.1-1999 or the 2000 IECC.
[11] MECcheck and COMcheck are building code compliance software tools sponsored by the U.S. Department of Energy. They can be obtained from the DOE's codes and standards website, www.energycodes.gov

trains both code officials and builders in attaining code compliance. Much of the Coalition's work is in the field where testing for air tightness, duct leakage, thermal bypasses, etc. is employed both to test structures and demonstrate to builders areas that need more attention. The Coalition reports that many new homes are satisfactory on paper but not in practice (Wilson 2002).

There are several builders in Utah that are doing exemplary work, including Ence Builders which operates in the south of the state and in Nevada, building about 200 homes each year. Ence builds only Energy Star homes and advertises the fact heavily in their sales literatures. They have won two major awards from the U.S. EPA in the past three years, most recently the Energy Star Builder of the Year award.

Regarding commercial buildings, the state has implemented an exemplary energy efficiency program for new state buildings. The program features design assistance and incentive payments to building designers based on the level of energy efficiency achieved. Also, the program strives to achieve energy savings without increasing first cost through an integrated design approach. It is estimated that seven new buildings constructed during 1996-98 achieved 22-50 percent energy cost savings (relative to buildings complying with the ASHRAE-90.1-1999 standards) as a result of the program (Case and Wingerden 1998).

Wyoming

The Wyoming State Fire Marshal's office develops building codes and standards for the state. The 1997 Uniform Building Code (UBC) is the current statewide code and while it references the 1995 Model Energy Code (MEC) in an Appendix, the Fire Marshal's office would have to specifically adopt that Appendix in order for the 1995 MEC to be in effect. This has not been done.

There were a total of 1392 housing starts in Wyoming in 2000, the most recent year for which data are available. Although the number of housing starts is increasing, there are no national builders currently operating in Wyoming. The state energy office reports that they have no indication of energy-efficient building activity in the state. Energy use per household is very high in Wyoming, due in part to the very weak energy codes. But energy prices are also very low in the state, making it more difficult to justify and sell energy efficiency improvements.

2. Recommendations

Upgrade to State-of-the-Art Building Codes

State-of-the-art energy codes such as the latest version of the IECC can help states and municipalities raise energy efficiency and reduce electricity consumption and peak demand in a cost-effective manner. As noted in the discussion above, it is critical to complement code adoption with training and technical assistance as well as rigorous code enforcement efforts in order to maximize the energy savings and other benefits. These implementation-oriented activities are addressed in the second recommendation in this section.

Adopting a recent version of the IECC (i.e., 2000 or more recent) is especially important in the southwest region because this model energy code has a window efficiency requirement pertaining to maximum solar heat gain for warmer regions with 3,500 heating degree-days or less. This requirement, if followed, will lead to substantial cooling load reductions and thus air conditioning electricity use and peak demand savings in hotter states such as Arizona, New Mexico, and Nevada (Prindle and Arasteh 2001).

In the southwest region, state-of-the art building codes should be adopted statewide in New Mexico, Nevada, and Wyoming since these are not home rule states. Likewise state-of-the-art codes should be adopted at the local level where this has not yet been done in Arizona (especially in the Phoenix area) and Colorado (especially in the Denver and Colorado Springs areas) given that these are home rule states. In addition, Colorado should adopt the IECC or ASHRAE 90.1-1999 standard for all new state-owned buildings, as recommended by a commercial buildings energy efficiency advisory group that met in Colorado in 2001 (E-Star Colorado 2001). Last but not least, all of these states and localities should consider enhancing the IECC or ASHRAE standards with modifications that further improve energy efficiency in a hot, dry region, such as considering the additions to the Title 24 building standards that California adopted in 2001 (Mahone et al. 2002).

Expand Training and Technical Assistance Efforts to Achieve High Levels of Code Compliance

Training and assisting architects, builders, building contractors, and building code officials is critical to the successful implementation of new building codes. Various studies have shown that such activities can significantly improve code compliance and can be very cost-effective in terms of energy savings per program dollar (Halverson et al. 2002; Johnson and Nadel 2000; Smith and Nadel 1995; Stone et al. 2002). Training and technical assistance is needed in a variety of areas including integrated building design, proper sizing and installation of HVAC systems, proper air tightness and insulation procedures, and the use of state-of-the-art technologies and design strategies such as daylighting, duct sealing, air infiltration reduction, indirect-direct evaporative cooling, and reflective roofing options.

We recommend that state energy agencies, local energy offices, and utilities in the southwest expand their efforts related to energy code implementation. Utilities in particular should support code implementation as part of their energy efficiency programs, in addition to encouraging construction of highly efficient "beyond code" new homes and commercial buildings. Energy agencies and utilities should also consider providing technical support to building code inspectors (e.g., help in reviewing commercial building plans) and possibly providing supplementary funding to enhance code enforcement efforts in jurisdictions where such capability is limited. Building code inspectors typically have relatively little energy expertise as well as relatively little time to review energy issues during either plan reviews or field inspections (Smith and Nadel 1995).

Expand Efforts to Promote the Construction of Highly Efficient New Buildings that Exceed Minimum Code Requirements

The review of building codes and new construction programs in the region pointed out a number of examples where new homes or commercial buildings far exceed the energy performance requirements of building energy codes. Through an integrated design approach as advocated in the Energy Star and Building American programs, it is possible to reduce energy consumption by 30 to 50 percent relative to code requirements, and do so in a cost-effective manner. This potential is not speculative; it has been proven in Civano, AZ, and in the housing developments of Ence, Pulte, and other leading builders in the region.

In order to foster increased construction of highly efficient new homes and commercial buildings, energy agencies and utilities should expand technical and financial assistance efforts, demonstration and promotion programs, and performance guarantee efforts, including:

- Replication of the training, promotion, financial incentive, and energy bill guarantee programs that are leading to large numbers of highly efficient new homes in the Phoenix and Tucson areas as well as in Nevada. Programs like the one conducted by Tucson Electric Power Co. that promote 30 percent beyond-code new homes and provide builders with free inspection services merit emulation.

- Expansion and replication of exemplary commercial building new construction programs such as Utah's state buildings design assistance and incentive program or the Energy Design Assistance Program implemented in 2002 on a pilot scale by Xcel Energy in Denver. Regarding the latter, Xcel provides modeling and design support, follow-up during construction, financial incentives, and monitoring and verification assistance in order to reduce energy use in new commercial buildings by at least 30 percent relative to the level resulting from the ASHRAE 90.1-1989 minimum energy code (Xcel Energy 2002).

C. Other Building Sector Options

1. Appliance Efficiency Standards

Appliance efficiency standards can have predictable and significant effects on the development and implementation of energy-efficient technologies. National appliance standards already enacted reduced U.S. electricity consumption by about 2.5 percent as of 2000; the savings are expected to increase to 6.5 percent of projected electricity use by 2010 as the stock of appliances turns over and recently-adopted standards take effect (Nadel 2002). Furthermore, it is estimated that these standards will save consumers about $186 billion net (energy bill savings minus any increased initial cost for covered products).

It is technically feasible and cost-effective to adopt efficiency standards on a variety of products not yet covered by federal standards including electronic products such as TVs, VCRs, and audio equipment, battery chargers, furnace fans, commercial refrigeration equipment, and transformers. One analysis estimates that standards on these products could reduce projected national electricity use in 2020 by 167 TWh or about four percent (Kubo, Sachs and Nadel 2001). Ideally the federal government would enact these standards at the national level via rulemakings or new legislation. But if the federal government is unwilling to act, then states can adopt these standards on their own.[12] In fact, California adopted standards on eight products not currently covered by federal standards in early 2002, and other states are expected to follow California's lead.

Adopt Minimum Efficiency Standards on Products not yet covered by National Standards

We recommend that the southwest states copy the standards recently adopted in California (assuming the federal government does not do so). In addition, the southwest states should follow California's lead on standards pertaining to the standby and/or active mode power consumption of electronic devices, should California move ahead with standards in this area.

2. Tax credits

Tax credits are another type of incentive used to promote energy efficiency and renewable energy technologies in various countries. Tax credits were provided for energy efficiency improvements by households and businesses in the United States in the late 1970s and early 1980s. Studies of these tax credits found that most participants would have installed the measures in the absence of the incentives due to the small size of the tax credit and focus on conventional efficiency measures (Quinlan, Geller, and Nadel 2001). Partly as a result of this experience, new tax credits have been proposed that are focused on innovative technologies such as highly efficient appliances, highly efficient new homes and commercial buildings, or hybrid and fuel cell vehicles (Quinlan, Geller, and Nadel 2001).

A few states including Arizona, Maryland, and Oregon have adopted tax incentives to stimulate the adoption of energy-efficient technologies (Brown et al. 2002). Arizona's incentive is a small tax credit for purchasers of highly efficient new homes, but the amount of the credit is limited to a maximum of $250. Maryland has enacted a sales tax waiver for consumers who purchase Energy Star appliances as well as qualifying highly efficient vehicles. Oregon provides income tax credits on a wide range of energy-efficient products purchased by households or businesses including highly efficient appliances furnaces, and air conditioners, duct sealing, and ground-source heat pumps. Oregon also offers tax credits to stimulate the construction of energy and resource-efficient new buildings based on the U.S. Green Building Council's LEED rating system. The total cost to the state for the relatively successful Oregon tax credit program is about $35 million per year (Brown et al. 2002; Stephens 2002).

[12] States are preempted from adopting efficiency standards on products already covered by national standards, but states are allowed to adopt standards on non-covered products.

Provide Sales Tax Waivers or Income Tax Credits for Innovative Energy-Efficient Technologies

We recommend that the southwest states adopt either sales tax waivers or income tax credits on highly energy-efficient products and new buildings, preferably modeled on the successful Oregon program. These tax credits can and should be justified based on the net economic benefits they would provide to all consumers and businesses in a state, not just those that participate. Also, the tax credits should be carefully designed to avoid a high number of "free riders" and consequently high loss of tax revenue and/or small energy benefits, as occurred with the tax credit for alternative fuel vehicles in Arizona. But as long as the eligibility levels and list of qualifying products are carefully developed, this policy can be a success. Implementing this policy may be difficult in the current budget deficit climate, but the policy merits consideration and implementation once state budget outlooks improve.

3. Public Sector Efforts

States and municipalities in the southwest region have undertaken a number of initiatives aimed at cutting energy use and energy bills in public buildings.[13] These efforts include:

- The Governor of Arizona issued an Executive Order in 2001 directing state agencies and employees to implement energy conservation measures. The state also encourages municipalities to adopt energy management plans and provides matching grants for municipal energy efficiency projects. The city of Tucson has made significant progress in improving the energy efficiency of its buildings and facilities (see example in Chapter 3).

- The Colorodo Governor's Office of Energy Management and Conservation is supporting the use of ESCOs to carry out energy efficiency projects in state and local government buildings as well as schools throughout the state. The city of Denver is striving to meet the voluntary standards of the Leadership in Energy and Environmental Design (LEED) certification program in new and renovated city-owned buildings. Denver also has been a leader in the adoption of light-emitting diode (LED) traffic signals.

- The Governor of Nevada issued an Energy Conservation Plan for State Government in 2001. Among its features, it directs state agencies to perform energy audits on all buildings; incorporate energy efficiency guidelines for all new construction and all building retrofits; and purchase only Energy Star® labeled equipment. The city of Las Vegas and Clark County have also undertaken significant energy efficiency programs.

- The Governor of New Mexico has issued Executive Orders directing state agencies to reduce their energy consumption. The Energy Conservation and Management Division of the State's Energy, Minerals and Natural Resources Department provides technical and

[13] These initiatives are profiled on the SWEEP web site, www.swenergy.org

financial assistance to help state agencies improve their energy performance. The Department also tracks energy consumption by agency. Energy consumption by all state agencies fell about 20 percent between 1994 and 1999.

- The Utah Energy Office provides technical and financial assistance to help state agencies reduce their energy consumption. The State has also committed to designing and constructing new state buildings that are highly energy efficient and consume 25 percent less energy than if designed to meet the state's building energy code. Eight new buildings are already achieving over $290,000 in annual energy bill savings (Case and Wingerden 1998). The state also provides grants or zero-interest loans to help municipalities upgrade the energy efficiency of their facilities.

Adopt "Best Practices" in Public Sector Energy Management throughout the Region

The efforts described above are laudable and are achieving results. We recommend that all states and major municipalities adopt the "Best Practices" demonstrated in one or more of the southwest states and cities, including:

1) Establishing energy savings goals for state and municipal agencies and tracking progress towards the goals;
2) Providing technical and financial assistance for the implementation of energy savings projects in existing buildings and facilities;
3) Constructing new buildings that are exemplary and surpass minimum energy code requirements by a wide margin; and
4) Purchasing only Energy Star® labeled equipment in categories where such products are designated.

By implementing these policies, states and municipalities will save energy and money, and will also "lead by example."

4. Education and Training

Many efforts are underway in the southwest region to educate and train consumers and businesses about ways to improve energy efficiency in residential and commercial buildings. For example, the U.S. Department of Energy and a number of state energy offices sponsor "Rebuild" programs that help commercial building owners identify energy savings opportunities.[14] The U.S. EPA and DOE are promoting Energy Star® homes, commercial buildings, and products in the region, often working with state agencies or utilities. And a number of state energy offices, utilities, and municipalities in the region sponsor or co-sponsor education and/or training for consumers and builders regarding techniques for constructing energy- and resource-efficient new buildings. While these efforts are valuable, public agencies could do more to increase energy efficiency through training and technical assistance.

[14] The SWEEP web site provides further information about the ongoing energy efficiency programs mentioned in this section.

Expand Education and Training in the Buildings Sector

We recommend that energy agencies undertake additional targeted training and technical assistance efforts. For example, studies have shown that there is a high degree of over-sizing of air conditioning systems and poor installation of heating and air conditioning systems in parts of the region (Swartz and deKieffer 2002). State energy offices, utilities, and/or municipal energy agencies should sponsor training of HVAC contractors in order to improve air conditioner sizing and installation practices. Likewise, training should be provided to improve the skills of commercial building managers based, for example, on the successful building operator training and certification program initiated in the Pacific Northwest and now being replicated elsewhere (Putnam et al. 2002). Also, public agencies and utilities could collaborate to a greater degree to expand promotion of Energy Star® products and buildings, as well as innovative energy efficiency measures such as new types of evaporative cooling devices, sealing thermal distribution systems, reflective roofing materials, and use of daylighting.

D. Industrial Sector Options

1. Voluntary Commitments

Various organizations in the southwest region are providing businesses with information and technical assistance, and encouraging them to accelerate their implementation of energy efficiency and emissions reduction measures. For example, the Colorado Business Environment Partnership (CBEP) helps Colorado companies identify cost-effective strategies to boost energy efficiency. CBEP is also encouraging companies to make voluntary commitments to increase energy efficiency and/or reduce their carbon emissions. Likewise, pollution prevention partnership programs in Colorado, New Mexico, and other states are helping companies identify ways of cutting pollutant emissions in cost-effective ways. While these efforts are likely of some value, most do not involve quantitative commitments by companies to increase energy efficiency or reduce emissions.

A number of major companies have made significant quantitative commitments for improving energy efficiency and reducing emissions. For example, Johnson & Johnson set a goal in 1995 of reducing energy costs 10 percent by 2000 through adoption of “best practices” in its 96 U.S. facilities. As of April 1999, J&J was 95 percent of the way towards this goal, with the vast majority of projects providing a payback of 3 years or less (Kauffman 1999). British Petroleum (BP) set a goal of reducing its carbon emissions 10 percent below 1990 levels by 2010, representing nearly a 40 percent reduction compared to projected emissions under a “business-as-usual” scenario. BP already met this goal in 2002, eight years ahead of schedule (Geller 2002b). And DuPont also established quantitative goals to reduce energy intensity, increase renewable energy use, and cut greenhouse gas emissions.

A number of countries including Germany, the Netherlands, and Denmark have formal programs whereby government and industry enter into voluntary agreements aimed at reducing energy intensity in the industrial and in some cases commercial sectors. The agreements are either with individual companies or entire sectors, and the agreements include quantitative energy savings targets. Governments provide technical and financial assistance to help companies meet their targets, and in some cases postpone new taxes or regulations if a large fraction of industries make and comply with the voluntary commitments. This type of policy led to a 20 percent reduction in the average energy intensity of most industries in The Netherlands during 1989-99 (van Luyt 2001). Based on the success of voluntary commitment programs in Europe, implementation of this type of policy has been called for in the United States (Nadel and Geller 2001a).

Expand Industrial Voluntary Commitment Programs

We recommend initiating or expanding industrial voluntary commitment programs at the state level in the southwest, and/or encouraging greater participation in national commitment programs such as the U.S. EPA's Climate Leaders program. State-based programs could be housed within current partnership programs such as the CBEP effort mentioned above, or they could be new initiatives started by state governments and local businesses. In all cases, companies would agree to accelerate the implementation of cost-effective efficiency measures and make quantitative energy savings, energy intensity reduction, or carbon emissions reduction commitments, presumably including both fuel and electricity savings measures. Energy agencies and programs in the region could provide technical assistance to participating companies, and recognition to outstanding companies.

2. Training and Technical Assistance

The state energy offices in the southwest provide some training and technical assistance to industries in the area of energy efficiency improvement. For example, the Utah state energy office is assisting companies in key sectors in the state including companies in the mining, metal casting, and chemicals industries. In addition, the state operates a low-interest loan program to help capital-limited companies finance energy efficiency projects. Likewise, at least one utility in the region (PacifiCorp) provides energy audits and financial assistance to encourage industries in Utah to implement energy efficiency measures.

The U.S. Department of Energy is helping small- and medium-size manufacturing facilities in the southwest region through its Industrial Assessment Centers (IACs) based at Arizona State University in Tempe, AZ, Colorado State University in Ft. Collins, CO, and the University of Utah in Salt Lake City, UT. The IACs provide facilities with on-site assessments and detailed recommendations for improving energy efficiency, reducing materials consumption and waste, and increasing productivity.[15] The IAC at Colorado State University reports that it recommended projects that are estimated to yield $2.8 million in savings annually with an average payback period of 0.83 years in the 25 facilities it evaluated in 2000. Follow-up interviews indicated that about 50 percent of recommended projects were implemented within 1.5 years (Kostrzewa

[15] For more information on the Industrial Assessment Centers, see IAC web site, www.oit.doe.gov/iac/.

2002). However, the three IACs in the region are only able to assist about 75 manufacturing facilities annually due to budget limitations, and are restricted to serving small- and medium-size firms.

Expand Training and Technical Assistance Programs for the Industrial Sector

We recommend that state energy offices as well as utilities expand their support for industrial energy efficiency efforts in general by sponsoring additional training courses for industrial energy managers. This training could include well-regarded courses and tools such as the courses, software, and manuals developed by the U.S. Department of Energy Motor Challenge and Compressed Air Challenge programs. Training and technical assistance should be offered to all companies, large and small. Training and technical assistance should strive to expand the expertise and infrastructure for providing energy efficiency services in the region, as well as produce direct energy savings.

States or utilities could help in part by providing supplemental funding for the IACs in the region so that they can provide additional plant assessments (e.g., the state of Texas has done this). Another option would be to provide direct financial or technical assistance, possibly in conjunction with a voluntary commitment program (see recommendation above). For example, state energy agencies could hire energy efficiency experts in particular sectors of interest in the region (e.g., mining) to help companies that request such assistance. This type of service has been successfully implemented in New York and Wisconsin, for example (Shipley, Elliott, and Hinge 2002).

E. Environmental Policies

Air quality regulations require states to develop State Implementation Plans (SIPs) to demonstrate compliance with national ambient air quality standards. States can integrate energy efficiency initiatives into these plans, in part by modifying electricity demand growth estimates as a result of new or enhanced energy efficiency efforts. This will make it easier for states to meet emissions and air quality targets through more conventional pollution control technologies. Energy efficiency initiatives can also be explicit measures in SIPs. For example, Texas has included improved building energy codes as an explicit measure in its recent NO_x SIP (Vine 2002). In order to implement this sort of policy, environmental officials must derive (or be given) credible estimates of avoided emissions from energy efficiency improvements.

The Regional Haze Rule issued by the U.S. EPA in 1999 is of particular relevance to the southwest region. The Rule requires all 50 states to establish goals and emissions reduction strategies for improving visibility in the nation's 156 Class 1 national parks and wilderness areas, of which a significant number are located in the southwest (WRAP 1999). States must submit initial SIPs under the Regional Haze Rule to the EPA by the end of 2003. Furthermore, the Rule directs states to consider expanded energy efficiency efforts as part of their SIPs and to include the emissions reduction benefits of such efforts in their analyses and plans (Vine 2002). In addition, the nine western states that participated in the Grand Canyon Visibility Transport Commission are now part of a Western Regional Air Partnership (WRAP) that allows these states to implement a regional approach to reducing haze. All six states addressed in this study are part of the WRAP, along with California, Idaho, and Oregon. Southwestern states are actively involved in the WRAP and are starting to develop SIPs (or participate in a regional plan).

In addition to current air pollution requirements, tougher emissions reduction standards are under discussion at the federal level. The Bush Administration has proposed tougher emissions standards on SO_2, NO_x, and mercury via a cap-and-trade approach (its “Clear Skies Initiative”). Some members of Congress support legislation that would cap utility sector carbon dioxide emissions as well as cover these other three pollutants. Most notably, the Senate Environment Committee has approved a four-pollutant bill (S. 556, the Clean Power Act of 2001). Adoption of new emissions standards could provide further impetus for end-use energy efficiency efforts in the region.

Incorporate Energy Efficiency Initiatives into Air Pollution Control Strategies

As demonstrated in this study, end-use energy efficiency improvements can reduce pollutant emissions from fossil fuel-based power plants in a cost-effective manner. Efficiency improvements save consumers and businesses money, unlike conventional emissions control technologies that increase electricity bills overall. Thus, it makes sense to expand energy efficiency efforts as part of air pollution control strategies, and to take credit for emissions reductions due to efficiency efforts as part of plans such as the SIPs being prepared under the Regional Haze Rule.

We recommend that environmental and air quality officials in the southwest states seize this opportunity and support expanded energy efficiency efforts in their jurisdictions. In other words, environmental planners should advocate expansion of utility and state-based energy efficiency programs, rate reform to encourage greater energy efficiency, stronger building codes, tax credits for innovative energy-efficient technologies, etc. Environmental officials should explicitly incorporate new and expanded energy efficiency initiatives in their air quality and emissions reduction plans. Environmental agencies, energy agencies, and energy efficiency program managers should work together to develop reasonable estimates of future energy savings and the emissions reductions associated with these savings. In addition, both state and regional energy efficiency initiatives should be incorporated into the regional haze plan being developed by the WRAP.

F. Achieving the Savings in the High Efficiency Scenario

From the discussion above, it is clear that many policies and programs can be implemented to promote greater adoption of cost-effective energy efficiency measures. Here we present quantitative estimates of the savings that could result from six of our recommended policies and programs. We emphasize state and utility initiatives, but also include federal appliance efficiency standards and tax incentives since both of these policies are likely to be adopted in the future. Many of these policy options have been implemented within the southwestern region to a limited degree and outside of the region more extensively.

We provide a range of savings potential for each policy or program option. The lower end of the range represents an estimate of the savings that could be achieved by 2020 assuming moderately aggressive implementation. The upper end of the range is based on very aggressive implementation. It represents "best practice" achievement given real world experience in most cases. In making these estimates, we have attempted to avoid double counting savings across different policies although the policies have not been analyzed in an integrated manner. This analysis shows that the full electricity savings identified in the High Efficiency Scenario can be realized by adopting a mix of policies together with a modest market transformation effect.

1. System Benefit Charge (SBC) or other Mechanisms for Funding Utility (or State-Based) Energy Efficiency Programs

The analysis presented in section A above showed that adopting a SBC of 0.15-0.225 cents per kWh to fund energy efficiency programs could reduce electricity consumption in the region in 2020 by 10-15 percent. The same level of energy savings could be achieved through the adoption of Energy Efficiency Performance Standards (EEPSs) if this approach is preferred.

Reducing electricity consumption 10-15 percent in 18 years is consistent with the experience in states that have implemented well-funded utility and/or state-based energy efficiency programs. For example, utility and state energy efficiency programs in California were reducing electricity consumption by around one percent per year as of 2000. The level of policy and program-induced savings jumped to about five percent in 2001 when the programs were significantly expanded due to the electricity crisis that occurred that year (Goldman, Eto and Barbose 2002). Likewise, utilities in Connecticut are reducing statewide electricity use about 0.9 percent per year as a result of efficiency programs funded through the state's SBC (ECMB 2001). And Xcel Energy is achieving electricity savings of 0.85 percent per year through its energy efficiency programs in Minnesota (Davis 2002).

2. Utility Rate Reform

Based on the experience with time-of-use rates and the estimate of the potential savings from tiered rates cited in section A above, we estimate that time-of-use rates and/or tiered rates can reduce overall electricity use by 3-6 percent if widely implemented in the southwest states. The savings estimate assumes that these new rate designs lead to 5-10 percent savings among residential and smaller commercial customers, but less savings among industrial and larger commercial customers. This level of savings is possible with time-of-use rates when residential consumers are given programmable thermostats and other load control technologies that facilitate their ability to shift loads and reduce energy consumption during high price periods (Faruqui and George 2001). Also, it is consistent with estimates of the impacts from new five-step tiered residential rates in California (Reiss and White 2002).

3. Building Energy Codes

California estimates that recently enacted building codes will reduce electricity consumption in the state by about 11.2 TWh (around 4 percent) within 10 years (Stone et al. 2002). Considering the high growth in new construction in the southwest states and the fact that many jurisdictions either lack energy codes altogether or have outdated codes, we estimated that state-of-the-art building energy codes could reduce electricity consumption in the southwest in 2020 by 4-8 percent. This savings range is reasonable if not modest considering that 40 percent or more of regional electricity use in 2020 will occur in buildings or factories that will be built or renovated during the next 18 years.

4. Appliance Efficiency Standards

As noted above, new appliance efficiency standards on products not yet covered by federal standards could reduce national electricity use in 2020 by four percent. We assume these standards would also yield four percent electricity savings in the southwest states. In fact the savings could be greater than this in the southwest because of the high growth and thus above-average equipment purchase rates in the region.

5. Tax Incentives for Innovative Energy-Efficient Technologies

As noted in section C above, states have begun to adopt tax incentives on a variety of innovative energy saving technologies. The federal government is considering adopting tax incentives on a wide range of innovative energy saving technologies as part of national energy legislation. The tax incentives would support the commercialization and market development of technologies such as highly efficient new buildings (i.e., buildings that go well beyond meeting state-of-the-art building codes), highly efficient appliances and air conditioners, and heat pump water heaters. ACEEE estimates that a broad set of tax incentives for innovative energy efficiency measures could reduce national electricity use in 2020 by 78 TWh, or about 1.6 percent of projected national electricity use that year (Quinlan, Geller and Nadel 2001). Based on this national analysis, we estimate that tax incentives for innovative energy efficiency measures adopted at either the federal or state level could reduce regional electricity use in 2020 by 1-2 percent, in addition to the savings from other policies and programs.

6. Public Sector Investment in Energy Efficiency

Federal, state and local governments can adopt the "Best Practices" related to energy management and conservation recommended in section C above. We estimate that such practices adopted at all levels of government in the region could reduce total electricity use in 2020 by 1-2 percent. To support this estimate, we note that state and local buildings (including schools) account for about 10 percent of commercial sector electricity use in Colorado or about 4 percent of overall electricity use in the state. It is technically and economically feasible to reduce this electricity consumption by 25-50 percent based on experience in Arizona, New Mexico, Nevada, and elsewhere (see case studies in Chapter 2).

7. Market Transformation Effect

The policies and programs described above will help to transform the energy efficiency market to some degree. In other words, they will help to establish an energy efficiency supply infrastructure as well as change consumer awareness and behavior such that efficiency measures will be adopted to a greater degree in the market without incentives or other program-related assistance. Efficiency programs often strive for market transformation as one of their goals, a phenomenon also known as the "spillover effect."

We estimate that the market transformation effect could result in at least 5-10 percent electricity savings by 2020. To support this estimate, the U.S. EPA/DOE Energy Star labeling and promotion programs (a type of market transformation effort) estimates that it cut electricity use in buildings by about 75 TWh (over 3 percent) as of 2001, and the savings are growing about 25 percent per year (EPA 2001). Also, a rigorous analysis of the changes in the national fluorescent lighting technology market during 1986-2000 determined that about 40 percent of the non-price related efficiency improvement could be attributed to utility demand-side management programs and 60 percent to "market transformation effects" (Horowitz 2001). If this pattern is extrapolated to the future, then it is quite conservative to assume 5-10 electricity savings due to market transformation effects in conjunction with 10-15 percent savings from SBC-funded (i.e., utility or state-based) energy efficiency programs, along with savings from other energy efficiency initiatives.

Table 5-3 summarizes the contribution that each policy discussed above could make towards energy savings in the region. The overall savings potential from this set of options and effects is 28-47 percent. In addition, other polices such as expanded education and training or industrial voluntary commitments could contribute additional savings. Thus, implementing a combination of these policies along with the resulting market transformation effect could result in achievement of the full cost-effective savings identified in this study--33 percent savings by 2020. In fact not all the policies and programs need to be implemented, and some can be implemented at a more moderate level of aggressiveness and impact, in order to realize the 33 percent savings target. However, a number of policies will need to be implemented and kept in place for up to 18 years in order to realize this substantial savings.

Table 5-3. *Potential Electricity Savings from Different Policy Options*

Policy or program	Electricity savings potential in 2020 (%)
SBC-based Energy Efficiency Programs	10 – 15
Utility Rate Reform	3 – 6
Building Codes	4 – 8
Appliance Standards	4
Tax Incentives	1 – 2
Public Sector Investment	1 – 2
Market Transformation Effect	5 – 10
Total	**28 – 47**

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