Energy Efficiency and Economic Development in New York, New Jersey, and Pennsylvania

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PREFACE

The American Council for an Energy-Efficient Economy (ACEEE) is a non-profit research organization dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection. It is based in Washington, DC.

ACEEE has been conducting a series of national, state, and regional studies to examine the potential employment and macroeconomic benefits of increased investments in energy efficiency technologies. Primary funding for this study was provided by the Pew Charitable Trust. Additional support was provided by The Energy Foundation.

Many people worked together to produce this report. Steven Nadel led the overall project. Skip Laitner conducted the macroeconomic analysis. Steve Nadel and Robert Mowris conducted the buildings and appliances energy efficiency analyses. Neal Elliott and John DeCicco conducted the industrial and transportation efficiency analyses, respectively. Marshall Goldberg provided background data and analysis on the region's energy and economic profile. Howard Geller provided the company profiles and overall guidance and review.

Assistance in helping the authors to understand the energy situation in the three Mid-Atlantic states was provided by many people, including: Brian Henderson and Peter Smith at the New York State Energy Research and Development Authority; David Wooley, Tom Bourgeois, and Dan Rosenblum at the Pace Energy Project; Ashok Gupta at the Natural Resources Defense Council; and Fred Gordon of Pacific Energy Associates.

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EXECUTIVE SUMMARY

The purpose of this report is to better understand how additional investments in energy efficiency technologies can contribute to lower energy expenditures and new employment opportunities for residents of New York, New Jersey, and Pennsylvania, as well as generally strengthen economic activity and quality of life.

Energy is the lifeblood of the Mid-Atlantic economy. It provides light, heat, and air conditioning for homes, schools, and businesses. It is needed to power office equipment and high-tech production facilities, to transport both people and agricultural goods, and to support all aspects of the region's tourist industry. Energy is also a critical ingredient in many other goods consumed in the region ranging from medicines and children's toys to food, appliances, and automobiles.

However, energy that is used inefficiently will constrain the economy. High energy costs make the region's businesses less competitive and high energy bills reduce the amount of money the region's consumers can spend on goods and services. When money is spent on energy, much of it leaves the region and the nation. When money is spent on other goods and services, much more stays in the region, creating economic growth and jobs.

In spite of significant reductions in energy use and real energy prices in the past two decades, significant opportunities for cost-effective, energy-efficient investments exist in all sectors of the economy. Furthermore, many of these investments offer opportunities to improve product quality and productivity and lower operating and maintenance costs. Investments in energy-saving products and practices can lower energy bills for residents and businesses. Lower energy bills, in turn, will promote overall economic efficiency and create jobs in all of the states in the region. Investments in energy efficiency can increase cash flow and operating margins, providing businesses a critical competitive edge. Moreover, accelerated investments in energy efficiency will enhance the region's air quality by reducing emissions associated with energy production and use. Such investments will also help diversify the mix of energy resources available to homes and businesses, helping to ensure a stable and reliable resource base to meet future energy needs. Investments in energy efficiency can encourage the development of new, clean, energy-saving technologies and industries in the Mid-Atlantic region. Improvements in energy efficiency can also help protect the region against the impacts of possible new taxes on pollutants contributing to global climate change and other air quality problems.

In 1993, consumers in New York, New Jersey, and Pennsylvania spent approximately $70 billion to provide heat, light, power, and transportation for their homes, schools, and businesses, including approximately $30 billion in New York, $23 billion in Pennsylvania, and $16 billion in New Jersey. To put these totals in perspective, on a regional basis, energy bills are 15 percent higher than state tax collections. Many community and business leaders are looking for ways to use state tax dollars more efficiently. The size of each state's total energy bill suggests that Mid-Atlantic policy makers may also want to explore ways to use energy more efficiently.

This report examines the current energy consumption patterns and expenditures within each of the states and the regional economy. It projects what "business-as-usual" or "baseline" energy patterns might look like through the year 2010. These findings suggest that by 2010 the region as a whole will be approximately 7 percent more efficient in how much energy it uses to support a dollar of economic activity (compared to 1993 as measured by Gross State Product [GSP]) due primarily to the fact that new equipment and buildings are generally more efficient than aging equipment and facilities that will be replaced over the next decade. But the findings also show that total energy consumption will increase by 21 percent as a result of a growing economy.

The study then develops two high-efficiency scenarios (one for total energy consumption and one for electricity consumption only) for the region through the year 2010. These high-efficiency scenarios are based upon detailed analysis of energy efficiency potential in buildings in the residential, commercial, and industrial sectors as well as efficiency improvements in light duty vehicles in the transportation sector. The analysis provides estimates of the investments needed to achieve these additional energy savings as well as the resulting economic and environmental benefits.

The findings of the study show that by 2010, cost-effective investments in energy efficiency in the three Mid-Atlantic states can:

- Reduce energy use in the region by more than 20 percent, reducing consumer and business energy bills by more than $150 billion cumulatively over the 1997-2010 period;

- Create 164,000 jobs in the region; and

- Reduce emissions of critical air pollutants by up to 24 percent, helping to improve environmental quality.

In other words, the untapped potential for energy efficiency represents a critical economic development and environmental protection strategy for the Mid-Atlantic states. Increased investments in energy efficiency are an important step toward promoting a sustainable energy future for the Mid-Atlantic region. More specific findings of the report include:

- Cost-effective investments in energy efficiency technologies can reduce regional energy use by 24 percent in 2010 relative to the baseline, including 33 percent reductions in electricity use and 20 percent in fossil and other fuels outside of the utility sector.

- The additional investment in energy efficiency will increase the Mid-Atlantic region's employment base — from a net increase of 24,600 jobs in the year 2000 to a net increase of 164,300 jobs by the year 2010. The rise in employment, driven largely by the spending of energy bill savings, is equivalent to the number of jobs supported by the expansion or relocation of 1,095 small manufacturing plants in Mid-Atlantic region. Wage and salary compensation would similarly rise by a net of $3.5 billion by 2010 (in 1993 dollars), the equivalent of tourist expenditures from approximately 16.9 million visitor days.

- As a result of these additional energy savings, Mid-Atlantic ratepayers would enjoy cumulative energy bill savings of $153 billion over the 1997-2010 period. The high-efficiency scenario will require a $66 billion cumulative investment over the same period of time. This relatively small level of investment (less than 1 percent of the region's cumulative GSP over the period) can be achieved by redirecting a small portion of other investments toward productive energy investments. Only a small portion of these investments will be financed by government or through electricty rates; the vast majority of funds will come from homeowners and businesses making cost-effective investments in their homes and facilities. With all values in 1993 dollars, the energy efficiency scenario generates a positive benefit-cost ratio of 2.35 over the 14-year period of analysis. But even this value understates the cost effectiveness of the energy savings investments since the energy savings and environmental benefits will continue for many years after the year 2010.

- Under the baseline projections, the regional economy — represented by the change in GSP — will grow from $1,022 billion in 1993 to $1,327 billion in 2010 (measured in constant 1993 dollars). Under the high-efficiency scenario, the regional economy will grow an additional $612 million in 2010.

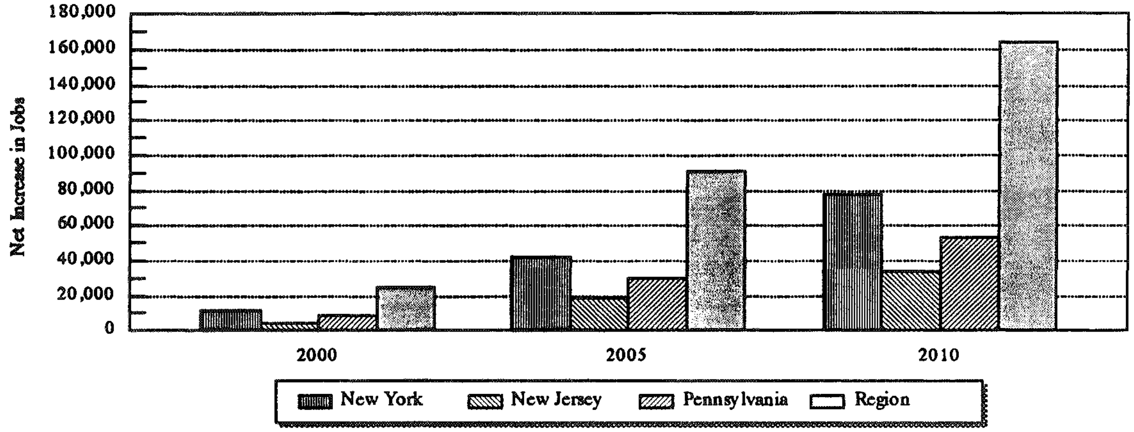
- The alternative energy strategy would have a positive benefit for the region's air quality as well. Carbon dioxide emissions, which contribute to global climate change, would be reduced by 161 million short tons in 2010, a 29 percent decline over baseline 2010 emissions. Energy-related pollutants such as sulfur and nitrogen oxides would decline by over 400 thousand short tons in the year 2010, also providing significant reductions over the baseline use.

Many of these findings are illustrated in Figure ES-1 and Table ES-1.

Table ES-1. Summary of Input-Output Analysis For 2010				
	New York	New Jersey	Pennsylvania	Region
Baseline Scenario				
GDP (Billion 1993$)	$651	$313	$364	$1,327
Jobs (Thousands)	10,693	5,123	7,351	23,167
Income (Billion 1993$)	$397	$185	$219	$802
Energy (Trillion Btu)	4,515	2,781	4,520	11,816
Btu/GDP (1993$)	6,938	8,889	12,426	8,902
Carbon Dioxide Emissions (Thousand Short Tons)	240,832	143,730	286,451	671,013
High-Efficiency Scenario				
GDP (Billion 1993$)	$651	$313	$364	$1,328
Jobs (Thousands)	10,771	5,157	7,404	23,332
Income (Billion 1993$)	$399	$186	$220	$805
Energy (Trillion Btu)	3,288	2,185	3,475	8,948
Btu/GDP (1993$)	3,109	5,662	7,009	4,614
Carbon Dioxide Emissions (Thousand Short Tons)	171,713	110,729	227,815	510,257
Net Efficiency Gains				
GDP (Million 1993$)	$407	$73	$132	$612
Jobs (Thousands)	77	34	53	164
Income (Million 1993$)	$1,796	$749	$950	$3,495
Energy (Trillion Btu)	(1,227)	(597)	(1,045)	(2,868)
Btu/GDP (1993$)	(3,829)	(3,227)	(5,417)	(4,288)
Carbon Dioxide Emissions (Thousand Short Tons)	(69,119)	(33,001)	(58,636)	(160,756)

Notes: Individual columns may not add up due to rounding.

Figure ES-1. Net Increase in Jobs From the High-Efficiency Scenario in 2010



However, achieving these benefits will not be easy. Policy makers and business leaders will need to play an active role in helping to develop and implement a series of initiatives to make the high-efficiency scenario a reality. The types of actions that will be needed include:

- Strong policies to make sure that energy efficiency services play a major role in a restructured utility industry — including establishment of a public benefit charge to fund energy efficiency, low-income, and other public benefit programs — and structuring remaining regulatory authority over distribution utilities so that these utilities have incentives to pursue cost-effective investments in energy efficiency;

- State-of-the-art building energy codes plus training and support for the effective implementation of residential and commercial building codes;

- Additional policies to improve the efficiency of the buildings sector, such as home energy rating and energy-efficient mortgage programs and equipment efficiency standards;

- Expanded technical and financial support to accelerate energy and process efficiency improvements in the industrial sector;

- Policies that improve the fuel economy of cars and light trucks, such as variable state taxes on new vehicles based on fuel economy and purchase of 'best in class" vehicles for state fleets; and

- Creation of Sustainable Energy Development Agencies in New Jersey and Pennsylvania that would complement the New York State Energy Research and

Development Authority and fund research and development (R&D), demonstration, economic development, and promotion activities in support of energy efficiency and renewable energy implementation.

As a first step, in 1997 officials in all three states will have opportunities to implement the first two actions.

Specifically, in New York and New Jersey, regulations and legislation are now being developed to restructure the electric utility industry. Regulatory proposals in both states propose to establish small public benefit charges to fund energy efficiency, renewable energy, low-income and research and development programs. These proposals are a good start but can be improved by increasing funding to the level of 1993-94 programs in New York (approximately $250 million per year for energy efficiency programs statewide), and to an equivalent level per kWh in New Jersey (approximately $150 million for energy efficiency programs). In other words, recent budget cuts made by New York utilities to prepare for restructuring should not be sustained once restructuring takes place. In Pennsylvania, restructuring legislation passed last year includes a small "universal service" fund for special programs for low-income households and includes energy efficiency programs among the list of permitted services. This universal service fund could be expanded to include energy efficiency programs for other residential customers as well as small commercial and industrial firms. Alternatively, as part of future utility commission proceedings on how to regulate distribution companies following restructuring, expanded energy efficiency programs should be explicitly addressed. Experience in other countries where restructuring has taken place indicates that following restructuring, market-based energy efficiency services for homes and small businesses are practically nonexistent and thus government must play a role to ensure that these services are provided.

In addition, in 1997 all three states will likely be deciding on future regulatory structures for distribution companies. All three states are considering price cap regulation. As part of such regulation, it is important to modify the basic price cap so that distribution companies have incentives to reduce costs but do not have incentives to build sales. If improperly structured, price caps will give distribution companies a profit incentive to build loads and scuttle energy efficiency efforts. Likewise, all three states should direct distribution companies to periodically prepare resource plans that examine investment and contracting needs over the short- and medium-terms and identify cost-effective ways energy efficiency programs and distributed utility resources can help defer future distribution system investments and meet future resource needs (for customers who continue to use the distribution utility to procure generation services). These distributed utility plans will be simpler and shorter term than the Integrated Resource Plans previously prepared by many vertically integrated monopoly utilities. The New Jersey Board of Public Utilities (BPU) draft Energy Master Plan includes the nucleus of such a distribution-utility planning effort.

Similarly, in 1997 the New Jersey Department of Consumer Affairs (DCA) and the Pennsylvania legislature will consider adoption of the 1996 Building Officials and Code Administrators International, Inc. (BOCA) Building Code that incorporates the 1995 version of the national Model Energy Code. Pennsylvania's energy code and New Jersey's residential energy code are based on national model codes developed nearly 20 years ago. Changes in energy-saving technologies and energy prices over the past two decades justify updating these codes. More than half the states in the United States, including New York, have adopted updated energy codes based on the 1992 and subsequent versions of the national Model Energy Code (or their equivalent). Costs of meeting these codes are relatively modest and the benefits in terms of lower energy bills over the lifetime of new homes and buildings are many times greater than the costs. Legislation adopting the 1996 BOCA code was adopted by the Pennsylvania House of Representatives in 1996 but died in the Senate at the end of the session. Both the House and Senate should pass this legislation in 1997. In New Jersey, DCA is planning to adopt the 1996 BOCA code but is considering whether to delete the latest energy provisions from this code, leaving the New Jersey residential energy code at approximately 1980 levels. This would be a major mistake — experience in other states amply demonstrates that modern energy codes are both workable and cost effective.

Thus, 1997 finds all three states at a critical crossroad — whether to make energy efficiency an important component of electric industry restructuring and building code efforts, or whether to pass up the valuable benefits such policies can provide. Failure to take the critical steps outlined above will put the region on a course under which critical economic development and environmental protection benefits will be lost. But by taking these actions this year, regional leaders will be laying a strong foundation for saving their citizens and businesses billions of dollars annually while creating thousands upon thousands of jobs.

I. INTRODUCTION

Energy is the lifeblood of the economic process. It is needed to power office equipment and production machinery and to transport both people and freight. It provides light, heat,and air conditioning for homes, schools, and businesses. Energy is also a critical ingredient for a diverse set of consumer goods that range from medicines and children's toys to food and automobiles.

In the Mid-Atlantic states of New Jersey, New York, and Pennsylvania (as elsewhere), many of these energy needs traditionally have been met by oil, coal, and natural gas resources; and hydro and nuclear power plants. But the inefficient or inappropriate use of those energy resources constrains the economic activity of a state or region. This, in turn, will limit the region's capacity to provide new employment opportunities for its residents. Moreover, the inefficient use of energy will also accelerate environmental degradation.

Residents and businesses in the Mid-Atlantic region are faced with some of the highest electric utility rates in the nation. Despite the size of their electricity bills, few people in the region understand the magnitude of energy expenditures within their individual state. One interesting way to underscore the importance of those expenditures is to compare them with the amount of taxes collected by state government.

One recent study notes that the combined states of New York, New Jersey, and Pennsylvania spent $69.8 billion for their total energy use in 1993. In contrast, the legislatures in those respective states authorized the collection of an estimated $60.9 billion in state-generated taxes each year. Thus, energy bills in the three states are approximately 15 percent greater than state taxes in these states.[1] While citizens and public officials are asking good questions about how better to spend their state tax dollars, they may be ignoring the equally important issue of how to more efficiently use their energy resources.

As a result, the inefficient use of energy will continue to act as a brake on the state and regional economies — offsetting other economic development and environmental initiatives that are now underway. For those reasons, efforts to accelerate investments in energy efficiency technologies are generating interest both in the Mid-Atlantic region and throughout the nation.

1. See *Comparing State Energy Expenditures with State Government Tax Collections*, Economic Research Associates, Alexandria, VA, 1996. The data are for calendar year 1993, the latest year for which information on both energy expenditures and tax revenues are available. The energy bill as a percent of state taxes for the individual states are 126 percent, 97 percent, and 138 percent for New Jersey, New York, and Pennsylvania (respectively). Taxes and energy bills overlap to a moderate degree as approximately 8 percent of regional energy bills go to state energy taxes.

The importance of maximizing energy efficiency as a strategy for enhancing both environmental quality and economic development opportunities is evidenced by the findings of many recent studies. Promoting energy efficiency investments not only cuts costs for the user, but it reduces pollutant emissions and yields positive benefits for the larger economy.[2]

In spite of the economic benefit documented by these recent studies, many states have been slow to develop and implement energy efficiency technologies and renewable energy resources. One reason is the significant up-front investment needed in order to reap full advantage of these alternative resources. In short, it takes money to make money.

Unfortunately, alternative energy strategies are also forced to compete against the significantly larger federal and state tax subsidies given traditional energy resources such as coal, oil, and nuclear.[3] Also, in contrast to many other business investments, the benefits of energy efficiency investments tend to be diffuse, accruing to many people over the long run rather than for a few investors in the short run.

New policy initiatives can go a long way to overcome the bias of present energy subsidies and provide energy efficiency and renewable energy technologies with the level playing field needed to encourage their widespread adoption. These same policies can also help bolster public trust in energy decision making. In survey after survey, when voters are asked to rank energy sources from those most to least in need of government encouragement, energy efficiency and renewable energy come out at the top of the list and fossil fuels and nuclear power at the bottom of the list. For example, in a December 1996 survey by the Republican pollster Research/Strategy/Management, Inc., when asked to select the energy source that should be the highest priority for U.S. Department of Energy funding, two-thirds selected energy efficiency or renewable energy and only one-third selected natural gas, other fossil

2. Among others, see *America's Energy Choices: Investing in a Strong Economy and a Clean Environment*, The Union of Concerned Scientists, Cambridge, MA, 1991; H. Geller, J. DeCicco and S. Laitner, *Energy Efficiency and Job Creation: The Employment and Income Benefits from Investing in Energy Conserving Technologies*, American Council for an Energy-Efficient Economy, Washington, DC, 1992; S. Clemmer, *The Economic Impacts of Renewable Energy Use in Wisconsin*, Wisconsin Energy Bureau, Madison, WI, 1994; and S. Laitner, J. DeCicco, N. Elliott, H. Geller, M. Goldberg, R. Mowris, and S. Nadel, *Energy Efficiency and Economic Development in the Midwest*, American Council for an Energy-Efficient Economy, Washington, DC, 1995.

3. See, for example, D.N. Koplow, *Federal Energy Subsidies: Energy, Environmental, and Fiscal Impacts*, Alliance to Save Energy, Washington, DC, 1993. According to this study, federal energy subsidies alone totaled $39 billion in 1989. Fossil and nuclear resources received 88 percent of this amount, while energy efficiency and renewable energy resources received only 12 percent of the benefit.

fuels, or nuclear power. [4] Still, government energy policies lean in the opposite direction, contributing to voter concerns about the responsiveness of government.

The need for new programs and policies has been confirmed in numerous studies and many state initiatives. As Brian Castelli, former executive director of the Pennsylvania Energy Office, notes, "Government needs to act as the catalyst to initiate programs and policies which will change direction and make a difference."[5]

The purpose of this report is to better understand how additional investments in energy efficiency technologies can contribute to lower energy expenditures, new employment opportunities for residents of the Mid-Atlantic region, and a generally strengthened economic activity and quality of life. Recognizing that energy consumption and expenditure patterns depend upon the social and economic makeup of a state or region, Appendix A provides a brief economic profile of the region and background information on the region's energy use patterns. It includes information on energy resources, expenditures, and electricity consumption for each of the states in the region.

We see that energy expenditures play an important role in each of the states. Although energy intensity (energy use per dollar of Gross State Product) is lower in the region than the national average (9,600 Btu per $GSP versus 13,400 Btu per $GSP in 1993[6]), energy prices are higher than the national average— 14 percent higher in 1993. Overall, the region spent a combined total of $69.8 billion on energy in 1993. New York's residents and businesses spent $30.4 billion on energy. In New Jersey, the energy bill was $16.4 billion and in Pennsylvania almost $23 billion. These same expenditures represent the equivalent of 6.8 percent of the region's combined GSP. In Pennsylvania, due to high energy use, energy expenditures total 8.1 percent of GSP — above the national average of 7.9 percent.[7]

During that same year, New York had the second highest electricity prices in the nation and New Jersey and Pennsylvania were both far above the national average. The region's electricity bill was almost $30 billion, followed by petroleum ($27.4 billion) primarily for

4. R. Hinckley and V. Breglio, *America Speaks Out on Energy: A Survey of 1996 Post-Election Views*, Research/Strategy/Management Inc., Lantham MD and Sustainable Energy Coalition, Takoma Park, MD, Dec. 1996.

5. See *Pennsylvania Energy*, Pennsylvania Energy Office, Vol. 7, No. 2, Spring 1993, page 3. Since these comments, Castelli left Pennsylvania to become the chief of staff for Christine Ervin, the Assistant Secretary for Energy Efficiency and Renewable Energy in the U.S. Department of Energy.

6. There is also substantial variation in energy intensity within the region, ranging from a low of 7,200 Btu per $GSP in New York to 10,600 in New Jersey and 13,000 in Pennsylvania.

7. Comparable figures for New York and New Jersey are 5.9 percent and 7.2 percent, respectively.

transportation uses. Energy policies designed to increase energy efficiency can go a long way towards reducing these expenditures. These same policies can reduce economic leakages for imported fuels, foster a more competitive environment for the states' industries, and provide environmental benefits for all.

The balance of this report amplifies on these themes. Section II provides a profile of some of the manufacturers and suppliers of these energy efficiency technologies and services in the Mid-Atlantic region. Section III develops both a business-as-usual (baseline scenario) and a series of two high-efficiency scenarios for the region through the year 2010. It provides an estimate of the investment needed to achieve the resulting energy bill savings in the high-efficiency scenario based upon detailed analysis of the energy efficiency potential in each end-use sector.

Section IV summarizes the analytical method used to identify the net employment gains and other net economic benefits from the high-efficiency scenario. Section V presents the results of the economic impact analysis. Section VI identifies some of the past and current policy initiatives designed to promote energy efficiency improvements. It then offers specific policy recommendations to ensure that the region is able to secure the full benefits of greater energy efficiency.

Finally, Section VII draws some brief conclusions and summarizes the policy recommendations needed to capture the greater efficiency potential. The analysis contained in the report confirms the hypothesis that aggressive implementation of energy efficiency improvements throughout the Mid-Atlantic economy could yield significant economic and environmental benefits to the region.

II. Profiles of Manufacturers and Suppliers of Energy Efficiency Technologies and Services in New York, New Jersey, and Pennsylvania

Saving energy creates jobs directly from manufacturing, selling, and installing energy efficiency measures, in addition to the jobs indirectly created when consumers respend energy bill savings in sectors of the economy that are more labor-intensive then producing and supplying electricity and fossil fuels. Many companies in New York, New Jersey, and Pennsylvania manufacture and/or install energy efficiency technologies. The following brief profiles demonstrate that energy efficiency technologies are a growth area for many manufacturers. In some cases, entire new plants have been built for the purpose of producing high-efficiency products. In other cases, existing plants have been or are now being expanded due to rising demand for high-efficiency products. There are even examples of floundering companies that have become revitalized and profitable through the introduction of new energy-efficient products. The case studies presented below cover both Fortune 500 corporations and small entrepreneurial firms in order to give a flavor of the direct job creation and job retention potential from energy efficiency technologies and services.

1. New York

Carrier Corp.

Carrier, headquartered in Syracuse, New York, is a major manufacturer of compressors, air conditioning systems, chillers, and refrigeration equipment. Carrier has about 4,300 employees in manufacturing and engineering in the Syracuse area. Employment rose slightly in recent years as a result of nearly $100 million of investment in new compressor and chiller technologies. These new technologies both improve energy efficiency and replace CFCs with alternative refrigerants. Had Carrier not made this substantial investment, employment in the Syracuse area would have declined due to productivity improvements, further outsourcing, and the general downsizing occurring in many major corporations.[8]

Osram Sylvania Inc.

Osram Sylvania Inc., the U.S. subsidiary of the Siemans conglomerate, has built a factory in Maybrook, New York solely for the purpose of manufacturing compact fluorescent lamps (CFLs). Osram Sylvania greatly expanded this factory over the past five years and it is currently operating near full capacity. The factory is highly automated and operates with about 220 employees. The CFLs produced at this plant are sold throughout North America

8. M. Chadderdon, Carrier Corp., personal communication, Syracuse, NY, April 1996.

as well as exported to Europe, Asia, and South America. Osram Sylvania is developing new high-efficiency lighting products and is planning to further expand this plant.[9]

Philips Lighting Corp.

Philips operates a major lamp manufacturing facility in Bath, New York which produces different types of high-intensity discharge (HID) lamps. Products made at this plant include energy-efficient sodium vapor and metal halide lamps. The plant, which employed about 800 workers as of early 1996, was significantly expanded in recent years as Philips introduced new high-efficiency products. Among these products are the *Retrolux* line of high-pressure sodium lamps and the *Mastercolor* line of metal halide lamps. The latter, developed at the Bath plant and introduced in 1994, replaces incandescent reflector lamps in retail store applications. This lamp substitution cuts electricity use by about 65 percent while increasing light output and maintaining high light quality.[10]

Trigen Energy Corp.

Trigen, based in White Plains, New York, owns and operates cogeneration facilities and district heating and cooling systems throughout North America. As of early 1996, Trigen owned 4,000 MW of thermal energy systems and 350 MW of electric generation at 13 locations. At a number of its facilities, Trigen purchases normally "wasted heat" from electric utility power plants in order to supply steam and chilled water to end users. These cogeneration systems significantly cut fuel use and pollutant emissions compared to separate electric and thermal generation. In fact, Trigen's mission is to "Heat and cool multiple buildings using one half or less of the fuel and producing one half or less of the pollutants of conventional generation." The company has grown rapidly in the past decade, with 640 employees as of early 1996, three times the number of employees in 1992. Approximately 250 of these workers are based either at the headquarters in White Plains or at Trigen facilities in Philadelphia, Pennsylvania; Trenton, New Jersey; or Nassau County, New York. Recently, Cogen announced a joint venture to install a 36 MW cogeneration plant in Mexico and plans to develop additional cogeneration systems overseas.[11] In December, 1996 Trigen announced a joint venture with CINergy, a major Midwestern utility, to develop cogeneration plants at appropriate sites around the country. Trigen's performance and plans recently attracted the attention of *Business Week* and the company was featured in the January 13, 1997 issue.[12]

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9. L. Klein, Osram Sylvania Inc., personal communication, Maybrook, NY, March 1996.

10. S. Goldmacher, Philips Lighting Corp., personal communication, Somerset, NJ, March 1996.

11. S. Odiseos, Trigen Energy Corporation, personal communication, White Plains, NY, April 1996.

12. Peter Coy, "Steam is Money," *Business Week*, January 13, 1997, p. 118.

Comfortex, Inc.

Comfortex, based in Cohoes and Watervliet, New York, manufactures energy-efficient insulating window treatments. Their window shades more then double the insulating value of a typical double pane window. Comfortex, which now has about 240 employees, tripled its business and number of workers since it started making these insulating shades in 1990. The original plant in Cohoes has doubled in size in recent years, a new plant was opened in Watervliet in 1995, and manufacturing plants were also set up in Florida and Nevada. Sales of the insulating shades are increasing about 30 percent per year. Comfortex received financial support from the New York State Energy Research and Development Authority (NYSERDA) for the development of the window insulation technology.[13]

EnviroMaster International Corp.

EnviroMaster International (EMI) of Rome, New York also received support from NYSERDA for the development and testing of key components of an innovative energy efficiency technology — ductless split air conditioning systems. EMI is the largest U.S. manufacturer of this technology, which is popular in Japan and other countries. Ductless split air conditioning is used in smaller office buildings, retail stores, health care facilities, and residential applications. It allows for zoned control of air conditioning, thereby saving energy by cooling different portions of a building as needed. EMI, which now employs about 80 people, began producing the technology in 1987. Awareness and adoption of ductless split air conditioning systems is now increasing rapidly in the United States, with the market growing about 25 percent per year. Consequently, EMI is expanding its factory.[14]

Enersave

Enersave is a full-service energy services company. Formed in 1989, Enersave offers engineering, construction management, and financing services associated with energy-related performance contracting. Enersave's customers range from commercial office building owners (14 Wall Street, 9 West 57th Street) to health care facilities (NYU Medical Center, St. Lukes Hospital) to high technology (MCI, Capital Cities/ABC) to heavy industrial (Frigidaire, Anheuser-Busch). Approximately half of Enersave's work has been performed under demand-side management contracts with utilities, including Consolidated Edison (New York), Public Service Electric & Gas (New Jersey), Rochester Gas & Electric (New York), and Pacific Gas & Electric (California). As a result of these contracts, Enersave has delivered more than 20 megawatts of measured demand reduction under utility contracts. Enersave has 24 employees,

13. J. McRee, Comfortex, Inc., personal communication, Cohoes, NY, April 1997.

14. S. Vivirito, EnviroMaster International Corp., personal communication, Rome, NY, April 1996.

mostly in New York, plus it makes extensive use of local contractors. Through 1996, Enersave projects have resulted in cumulative energy bill savings of approximately $30 million, all in New York and New Jersey. Recently, the company has begun actively marketing its services in Pennsylvania and California. In recent years Enersave's business has grown by more than 50 percent annually. While the company began business primarily working with utility demand-side management programs, currently the vast majority of its work is outside of utility programs. In the future, as the electric industry restructures, Enersave is planning to combine its traditional energy-saving services with power agent services that will assist customers in choosing their power provider.[15]

2. Pennsylvania

York International Corp.

York is a major manufacturer of air conditioning and refrigeration systems. Improving the energy efficiency of its products has become a strategic focus for York and has contributed to steady revenue and employment growth over the last several years. The company employs nearly 2,000 workers at its York, Pennsylvania headquarters operation. Chillers for commercial and industrial air conditioning systems are one of the main products produced there. In late 1995, York introduced its new Millennium line of high-efficiency chillers. These centrifugal chillers features a built-in variable speed drive, which greatly improves energy efficiency during part-load operation. York substantially modernized its manufacturing facility to produce this new chiller line. York also makes the Triathalon gas-fired heat pump, which can provide heating and cooling at high efficiency for residences and smaller commercial facilities, as well as high-efficiency gas-engine-driven chillers.[16]

PPG

PPG is probably the largest manufacturer of glass in the United States and among the top three or four largest manufacturers worldwide. It is headquartered in Pittsburgh and has four manufacturing plants in Pennsylvania, located in Carlisle, Meadville, Creighton, and Tipton. The Carlisle plant produces flat glass, including glass with energy-saving low-emissivity coatings that reduce heat loss through the glass. The Meadville plant produces glass for homes, commercial buildings, and automobiles, including advanced low-emissivity and spectrally selective glazings that let desired parts of the light spectrum in and reflect less desirable parts of the spectrum back outside. These glazings allow windows to be developed

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15. C. Wissemann, Enersave, personal communication, New York, NY, February 1997.

16. R. Burt and C. Manners, York International Corp., personal communication, York, PA, March 1996.

that are most appropriate for local climates and market niches so that one set of products permit heat-producing solar energy to enter buildings in applications where heating is a major concern and another set of products reflect this energy outside for applications where cooling is the primary concern. The Creighton and Tipton plants produce glass for automobiles including low-emissivity, spectrally selective, and light-weight products that reduce air conditioning loads as well as vehicle weight, both contributing to improved fuel economy. The four plants employ more than 500 people. Production at these plants has been growing gradually. In addition to producing energy-saving products, the company also has an aggressive campaign to improve the energy efficiency of their plants, thereby reducing energy use per unit of product produced.[17]

Engelhard/ICC

Engelhard/ICC, based in Philadelphia, manufactures dessicant-based commercial air conditioning systems as well as dessicant wheels used by other manufacturers. Dessicant-based cooling is a relatively new technology that relies on natural gas, steam, or waste heat as its primary energy source. It is very energy efficient on a primary energy basis compared to conventional electricity-driven air conditioning. The main applications so far have been in supermarkets, factories, restaurants, schools, and warehouses. The market for dessicant-based air conditioning is growing rapidly. This company, which employed about 30 people three years ago, now employs about 200, including 80 at its headquarters and manufacturing facility in Philadelphia (it also has a manufacturing plant in Miami).[18]

Owens-Corning Fiberglass

Owens-Corning Fiberglass (OCF) has a plant in Huntingdon, Pennsylvania that primarily manufactures fiberglass composites. These are intermediate products used in the production of a wide range of final goods including specialty insulation products, circuit boards, and some consumer goods. Applications for fiberglass composites continue to increase and this OCF plant, which employed approximately 550 workers at the end of 1995, was expanded in mid-1996. With the expansion, employment increased by 50 and output from the plant is expected to grow by one-third.[19]

17. M. Bulger, PPG, personal communication, Creighton, PA, February 1997.

18. D. Chevron, Engelhard/ICC, personal communication, Philadelphia, PA, April 1996.

19. M. Lemmond, Owens-Corning Fiberglass Corp., personal communication, Washington, DC, April 1996.

CertainTeed

CertainTeed is a major manufacturer of insulation products. It has multiple plants around the eastern half of the United States, including one in Mountaintop, Pennsylvania. The Mountaintop factory produces fiberglass products including duct board (often used in commercial buildings to build insulated ducts that carry conditioned air to rooms in a building) and building insulation such as rolls and batts of fiberglass insulation as well as blowing insulation.[20]

Lutron Electronics

Lutron, with headquarters in Coopersburg, Pennsylvania, is one of the U.S.' largest manufacturers of lighting controls. Many of their products are produced at their plant in Albertis, Pennsylvania. Lutron products range from dimmer switches to sophisticated timer, daylighting, and occupancy sensor controls. For example, the new Pennsylvania Convention Center in Philadelphia makes extensive use of Lutron controls, such as controls that automatically turn off lights at the end of the day except for lights in individual rooms in which occupants override the cutoff for a set period of time. Lutron also manufacturers dimmable ballasts for fluorescent lamps and a variety of non-energy products. The company is privately held and employment and performance information is not generally available.[21]

3. New Jersey

AstraLite

AstraLite, which is based in Annandale, New Jersey, is a division of Computer Power, Inc. In the words of Les Listwa, one of its senior staff, Computer Power was a dying business five years as it was unable to compete with large manufacturers of inverters and uninterruptible power supplies. In 1993, Computer Power formed the AstraLite division to manufacture and market light-emitting diode (LED) retrofit exit sign kits. An LED exit sign consumes just 2 Watts of power, compared to 12 Watts for a typical compact fluorescent exit sign or 40 Watts for an incandescent-based sign. The lifetime of the LED light source is also far longer then that of the alternatives. AstraLite in short revived the company. The market for LED retrofit exit signs is growing about 50 percent per year. AstraLite and its parent company now

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20. *Mountaintop Plant Standard Product Listing*, CertainTeed, Valley Forge, PA, 1996.

21. B. Rocco, Lutron, personal communication, Coopersburg, PA, February 1997.

employ about 100 workers and are steadily adding employees as a result of this successful new venture.[22]

SYCOM Enterprises

SYCOM, whose corporate headquarters is in South Plainfield, New Jersey, is an energy services company or "ESCo." With over 40 employees in three locations (New Jersey, Washington, DC, and California), SYCOM offers industrial, commercial, institutional, and governmental energy users a comprehensive range of services to help reduce energy costs, lower environmental emissions, and improve operations management. SYCOM's energy-savings projects include the traditional lighting improvements and upgrades, as well as larger scale equipment and energy production process changes such as fuel switching, natural gas cooling, efficient electric motor upgrades, and on-site cogeneration. Like other ESCOs, SYCOM provides financing (shared savings, guaranteed lease financing, or project financing) that involves no up-front costs for its customers. The financing produces net positive cash flow and the investment is recovered over time from the energy savings produced. Over the last decade, SYCOM has retrofitted over 630 buildings, installing over $100 million worth of energy-saving retrofit technologies. As a result of its energy conservation projects, SYCOM customers have experienced an annual reduction of approximately 300 million kWh of energy use and their energy demand has fallen by around 55 megawatts. Many of SYCOM's projects have been located in the New Jersey, working primarily with Public Service Electric & Gas's "Standard Offer" program. Since 1993, annual sales have increased by a factor of eight. It is now building on its experience and expanding its customer base to include the other Mid-Atlantic states as well as Connecticut, Florida, and Iowa. In addition, it sees tremendous potential for investing in energy savings at federal facilities nation-wide. Over the next five years SYCOM expects sales to increase 15-20 percent annually.[23]

Duro-Test

Duro-Test is a leading manufacturer of specialty lighting products, with headquarters in Fairfield, New Jersey. They have manufacturing plants located in Clifton and North Bergen, New Jersey. Energy-saving products are a significant emphasis in much of their product line including energy-saving incandescent, fluorescent, halogen, metal halide, and high-pressure sodium lamps. In September 1996 they began production of compact fluorescent lamps in Clifton, introducing the country's first spiral-shaped lamp, the *Spir-A-Lux*, which has a fluorescent tube coiled in the shape of an ice cream cone. This design, which can substitute for conventional incandescent lamps in many applications, is one of the most compact fluorescent lamps on the market today. Duro-Test has nearly 1,000 employees nationwide,

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22. L.Listwa, AstraLite, personal communication, Annandale, NJ, April 1996.

23. R. Dower, SYCOM, personal communication, Washington, DC, February 1997.

including approximately 200 in New Jersey. In their 1996 fiscal year, Duro-Test had record sales, and sales during the 1997 fiscal year are running ahead of the 1996 pace.[24]

Schuller International

Schuller is another one of the nation's largest insulation manufacturers. It has a plant in Penbryn, New Jersey, which produces fiberglass batts, rolls, and encapsulated insulation. They employ more than 175 people at this plant.[25]

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24. K. Kersting, Duro-Test, personal communication, Fairfield, NJ, February 1997.

25. C. Carberry, Schuller International, personal communication, Penbryn, NJ, February 1997.

III. ENERGY CONSUMPTION SCENARIOS

This section of the study offers an insight into what an energy-efficient future might look like - both in terms of the needed investment to develop energy efficiency technologies and in terms of the energy bill savings that might accrue from such investments.

The section begins by mapping out three energy scenarios: a baseline growth projection and two high-efficiency scenarios. The baseline projection of energy consumption in the Mid-Atlantic states builds on historic energy use patterns and then adapts projections for residential, commercial, and industrial building growth trends as well as projections for vehicle fuel economies and miles traveled.

The first alternative scenario includes efficiency investments among all major energy resources in the period 1997-2010. The second examines efficiency investments only in electricity end-uses. It should be noted that the intent of the analysis is not to "forecast" energy trends but to "project" reasonable energy use patterns for purposes of evaluating the impact of a high-efficiency scenario.

A. BASELINE ENERGY CONSUMPTION SCENARIO

We began by establishing a baseline projection of energy consumption patterns in the period 1993-2010, assuming current trends and policies are continued. A variety of Energy Information Administration (EIA) and Census data from the *City and County Data Book* were used for this purpose.[26] The starting point for the state and regional baseline projection was the actual primary energy use patterns in New York, New Jersey, and Pennsylvania. These statistics covered energy use in the residential, commercial, industrial, and transportation sectors in 1993.[27]

The projected changes in energy consumption in the residential and commercial sectors reflect an analysis of residential and commercial building prototypes. This analysis was developed by ACEEE using the DOE-2.1E building energy simulation computer program.[28] For each

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26. *City and County Data Book*, U.S. Department of Commerce, U.S. Census Bureau, Washington, DC, 1995.

27. See *State Energy Data Report 1993*, Energy Information Administration, U.S. Department of Energy, Washington, DC, 1994.

28. Use of the DOE-2.1E model and the data assumptions that underpinned the analysis are documented in a June 1994 unpublished technical memorandum prepared for ACEEE by Robert Mowris, a consulting engineer based in Berkeley, CA. More details of the buildings analysis are provided in Appendix B of this report.

prototype, average 1993 energy use was estimated and then multiplied by the number of buildings of that type in each of the Mid-Atlantic states.

In this regional analysis total energy use in the residential sector is forecast to grow at a rate of 0.5 percent annually in the period 1993-2010. The annual growth rates range from approximately 0.5 percent in New York and Pennsylvania to 0.7 percent in New Jersey. These trends are slightly lower than the annual 0.8 percent national growth estimate for the residential sector contained in the Energy Information Administration's *Annual Energy Outlook 1996* (AEO96) and reflect state-specific growth trends in homes in each of the states in the region over the 1980-90 period. The growth in housing stock was adjusted by a 0.6 percent demolition and replacement rate.[29]

The energy growth rate for the commercial sector was based on trends in new floor area in the region for 1990-92, taken from the *Commercial Building Energy Consumption and Expenditures 1992* (CBECS).[30] The energy growth rate for the commercial sector in each of the states and the region as a whole was forecast to increase approximately 0.45 percent annually. This rate is somewhat less that the national growth rate of 0.9 percent annually in the AEO96.

Based on the respective states' transportation plans, transportation energy growth was forecast to grow approximately 2.0 percent annually for the region, ranging from a low of 1.6 percent annually in New Jersey, to 1.9 percent in Pennsylvania, to 2.5 percent in New York. These rates are somewhat higher than the 1.4 percent national growth rate in the AEO96, although in recent years the AEO has underforecast transportation energy use. Transportation uses of electricity were omitted in this analysis.

For electricity only, it was found that the annual energy growth rate for residential uses would increase approximately 0.3 percent for the region as a whole, with New York increasing 0.23 percent, Pennsylvania increasing 0.26 percent, and New Jersey increasing 0.39 percent. Commercial uses were forecast to increase approximately 0.5 percent annually for each of the states and the region as a whole. Our baseline estimates project that electricity consumption in both of these sectors will increase significantly slower than the AEO96 forecasts for the nation of 1.5 and 1.3, respectively.

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29. These rates are based on information contained in the *Annual Energy Outlook 1996*, Energy Information Administration, U.S. Department of Energy, Washington, DC, 1995, and S. Nadel and H. Tress, *The Achievable Electricity Conservation Potential: The Role of Utility and Non-Utility Programs*, American Council for an Energy-Efficient Economy, Washington, DC, 1990.

30. *Commercial Buildings Energy Consumption and Expenditures 1992*, Energy Information Administration, U.S. Department of Energy, Office of Energy Markets and End Use, Washington, DC, 1995.

Because the industrial sector represents a group of end-users that is significantly different at the regional level than at the national level, a different approach was used. As described in more detail below, the result was a projected annual industrial growth rate for the region of 1.2 percent for total energy and 2.0 percent for electricity use. The AEO96 shows a similar increase of 1.0 percent for all end-uses in the industrial sector and a relatively smaller 1.1 percent increase for electricity end-uses only. Growth in industrial energy use for the individual states varies widely, however, with New Jersey increasing at 0.24 percent annually, New York increasing 1.26 percent, and Pennsylvania increasing 1.55 percent. In spite of these differences in total energy use, industrial electricity is projected to increase approximately 2.0 percent annually for each of the states. The average annual growth rate in total primary energy use for all sectors combined is projected at 1.1 percent for the region as a whole. Individually, New Jersey is projected to grow 0.82 percent, New York 1.17 percent, and Pennsylvania 1.24. These rates compare with the AEO96 national growth trend of 1.0 percent annually. The growth rate for electricity only, however, is estimated to be 0.9 percent for the region, slightly lower than our total energy growth rate for the region and the AEO96 national electricity growth trend of 1.1 percent annually.[31] Similar to the total energy growth, New Jersey and New York are projected to have a slower growth in electricity, 0.8 percent and 0.83, respectively, and Pennsylvania will increase 1.05 percent annually.

Figures 1 through 3 highlight the overall regional trends for the baseline projections and alternative efficiency scenarios in the period 1993-2010. Figure 1 identifies total energy consumption, Figure 2 shows electricity only consumption, and Figure 3 displays transportation fuels consumption. Most of the differences between the projections for the three states are due to differential energy growth rates in the individual sectors. This is in turn due to differences in the mix of industry groups between the three states.

Using the sectoral growth assumptions, we project that total primary energy use in the three-state region will rise from 9,793 TBtu in 1993 to 11,816 TBtu in 2010, a 20.7 percent increase in consumption over that period. This trend is illustrated as the "Baseline Projection" in Figure 1.

Electricity use in the region is projected to rise from 314 billion kilowatt-hours (kWh) in 1993 to 366 billion kWh in 2010, a 16.6 percent increase in consumption over that same period. The baseline electricity trend is illustrated as the "Baseline Projection" in Figure 2. Finally, the growth of transportation fuels was projected to increase from 21.1 billion gallons in 1995 to 28.6 billion gallons in 2010, a 34.6 percent increase. The baseline growth in these transportation fuels is illustrated as the "Baseline Projection" in Figure 3.

31. It should be noted that the intent of the analysis was not to "forecast" energy trends but to "project" reasonable energy use patterns for the purpose of evaluating the impact of a high-efficiency scenario.

FIGURE 1. MID-ATLANTIC REGION TOTAL ENERGY SCENARIO (IN TBTUS)

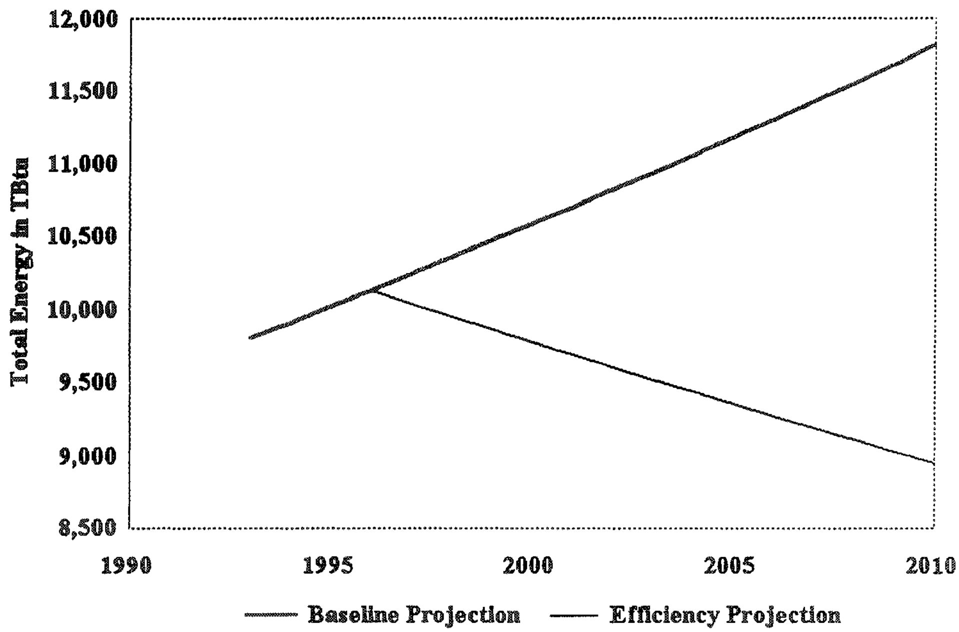


FIGURE 2. MID-ATLANTIC REGION ELECTRICTY SCENARIO (IN BILL. KWH)

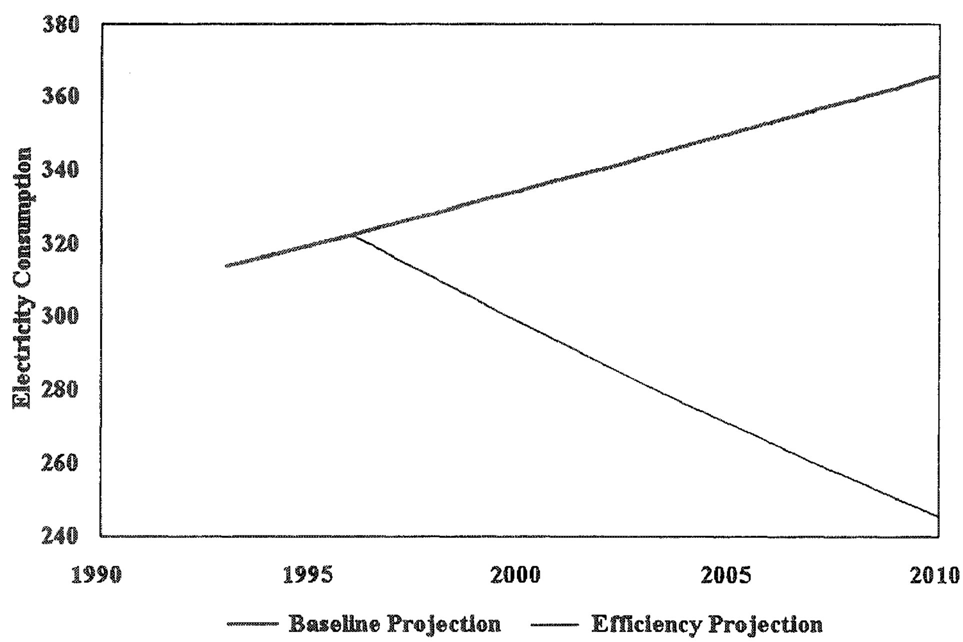
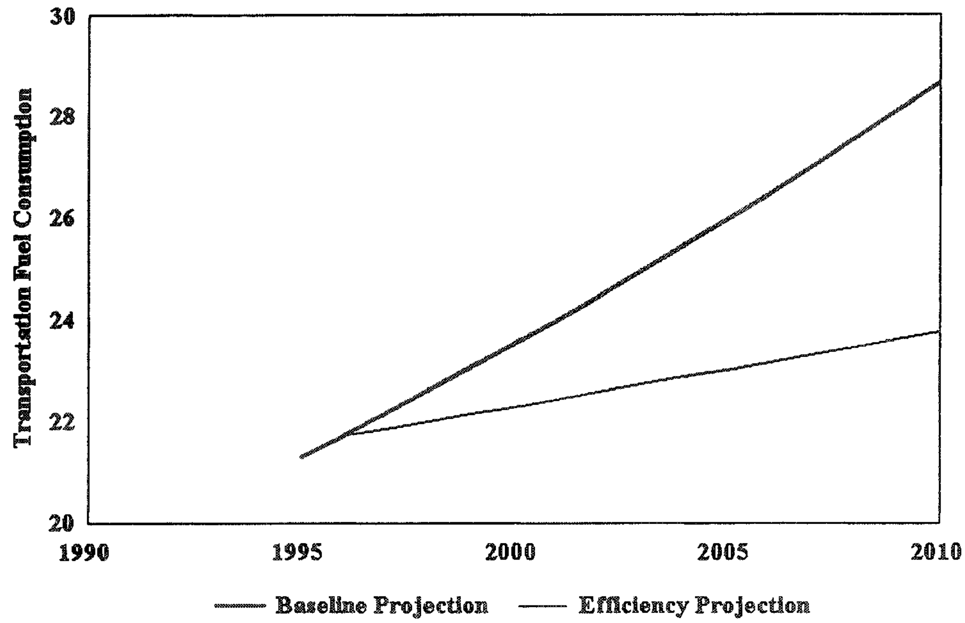


FIGURE 3. MID-ATLANTIC REGION TRANSPORTATION SCENARIO (IN BILLION GALLONS)



Source: Data for all three figures were developed by the American Council for an Energy-Efficient Economy based upon assumptions described in the text.

B. HIGH-EFFICIENCY SCENARIOS

The efficiency trends for both the total energy and the electricity-only scenarios were adapted from scenarios that build on assumptions about cost-effective energy efficiency investments. The data are taken from a variety of industry and other published sources. For the most part, the efficiency scenarios are based upon technologies that are now cost-effective and available in the marketplace. A few of the energy efficiency measures are advanced technologies that are expected to be available in the near future.

To build the energy efficiency scenarios, the economy was disaggregated into the four basic end-use sectors as in the baseline projections. These are: (1) residential buildings, (2) commercial buildings, (3) industrial applications in the agricultural, mining, construction, and manufacturing sectors; and (4) automobiles and light-duty trucks within the transportation sector. Analytical models unique to each of the four end-use sectors were used to construct the efficiency scenarios.

The analysis attempted to identify an optimum level of cost-effective energy efficiency improvements that could be obtained by the year 2010. The economic analysis (for energy efficiency) assumed the amortized cost of saved energy for a given energy efficiency technology would be less than or equal to the long-run retail cost of conventional energy resources. For the purpose of this analysis, long-run energy prices in real terms are assumed to be level with the 1993 price paid by each end-use sector in the Mid-Atlantic region for each energy resource. This assumption is broadly consistent with the latest Energy Information Administration forecast contained in AEO97, which forecasts that energy prices in 2010 will on average remain at approximately 1993 levels.[32]

Each efficiency investment is assumed to be amortized over its effective life using a 5 percent real discount rate. For example, installing more efficient lighting fixtures in an existing office building might reduce electricity consumption annually by about 4.85 kWh per square foot of occupied space at a cost of $0.50 per square foot. Once the change is made, the equipment can be expected to last 20 years.

At a 5 percent discount rate, the investment would be amortized at a rate of 8.02 percent annually.[33] Thus, the annualized cost is $0.50 times 0.0802, or $0.0401 per square foot. Saving 4.85 kWh implies a cost of saved energy (CSE) of $0.0401 divided by 4.85, or $0.0083 per kWh. Since the 1993 commercial cost of electricity in the Mid-Atlantic region ranged from a low of $0.084 per kWh in Pennsylvania to a high of $0.112 per kWh in New York, this particular measure would clearly be considered cost effective. All technology choices were treated in this manner. A more complete description of the end-use analyses and the assumptions that feed into that analysis follows.

An important caveat should again be noted at this point. The intent of the high-efficiency scenarios is to construct a reasonable profile of investments and energy use impacts, assuming that cost-effective efficiency measures are widely adopted over the 14-year period of the analysis. Hence, this analysis is not a forecast of what will likely occur given current trends. The high-efficiency scenarios represent, however, a highly possible energy future and, as we will show, a desirable economic future for the Mid-Atlantic region.

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32. While overall energy prices will be level, EIA's latest forecast estimates that electricity prices will decline by an average of 0.6 percent annually, natural gas prices will decline by an average of 0.2 percent annually, and petroleum product prices will increase by an average of 0.2 percent annually. See *Annual Energy Outlook 1997*, Energy Information Administration, U.S. Department of Energy, Washington, DC, 1996, Table A-3.

33. This is based upon the standard amortization formula, $I/(1-(1/(1+I)^n))$, where I is the discount rate and n is the life of the measure.

The "Efficiency Scenario" shown in Figure 1 suggests that consumption for total primary energy in the year 2010 could be lowered by 24 percent, from 9,793 TBtus to only 8,948. This would put the Mid-Atlantic region's energy consumption at about 8.6 percent below its 1993 level. The "Efficiency Scenario" for electricity shown in Figure 2 suggests that electricity consumption could be reduced by 33 percent, or about 22 percent below the 1993 levels. The transportation "Efficiency Scenario" shown in Figure 3 suggests that transportation fuels could be reduced by 17 percent, or about 11.7 percent below the 1993 levels.

Table 1 summarizes both the cumulative regional investment required for each major end-use sector to achieve the 24 percent total energy savings, the 33 percent electricity savings, and the 17 percent savings in transportation fuels over the 14-year period from 1997-2010. It also highlights the cumulative energy bill savings for the region as well as the benefit-cost ratios associated with each end-use sector. This ratio understates the overall cost-effectiveness (from the consumer perspective) of the energy efficiency investments in the region because energy savings will continue well beyond 2010.

1. Building Efficiency

ACEEE developed residential and commercial building prototypes using the DOE-2.1E building energy simulation program.[34] Building prototypes were developed using prototypes from a 1995 ACEEE study on the Midwestern states modified with data from the New York State Energy Office, and previous ACEEE studies on New York State.[35] The residential prototypes were augmented by an ACEEE analysis of the costs and savings of a variety of appliance efficiency improvements pertaining to water heaters, clothes washers and dryers, refrigerators, freezers, and lighting.

Four residential and eight commercial building prototypes were developed. The residential prototypes include Existing Multifamily Apartment, New Multifamily Apartment, Existing Single Family Attached, and New Single Family Attached. The commercial prototypes included Existing Medium Office, New Medium Office, Existing Medium Retail, New Medium Retail, Existing School, New School, Existing Warehouse, and New Warehouse.

34. Use of the DOE-2.1E model and the data assumptions that underpinned the analysis are documented in Appendix B of this report.

35. See S. Laitner et al., *Energy Efficiency and Economic Development in the Midwest*, American Council for an Energy-Efficient Economy, Washington, DC, 1995; A. Miller, J. Eto, and H. Geller, *The Potential for Electricity Conservation in New York State*, 89-12, New York State Energy Research and Development Authority, Albany, NY; and S. Nadel et al., *Gas DSM and Fuel-Switching: Opportunities and Experiences*, 94-10, New York State Energy Research and Development Authority, Albany, NY.

TABLE 1. CUMULATIVE EFFICIENCY INVESTMENTS AND SAVINGS: 1997-2010 (IN BILLIONS OF 1993 DOLLARS)

	Residential	Commercial	Industrial	Transportation	Total
Full-Efficiency Scenario					
Investment					
New York	$11.9	$4.5	$4.8	$5.9	$27.1
New Jersey	$6.9	$1.9	$3.2	$3.6	$15.5
Pennsylvania	$9.7	$2.0	$7.1	$4.1	$22.9
Region	$28.5	$8.4	$15.1	$13.6	$65.6
Savings					
New York	$27.1	$20.0	$9.0	$16.3	$72.4
New Jersey	$12.0	$8.7	$4.9	$6.9	$32.5
Pennsylvania	$16.8	$8.2	$12.6	$11.4	$49.0
Region	$55.9	$36.8	$26.6	$34.6	$153.9
Benefit-Cost Ratio	1.96	4.39	1.76	2.55	2.35
Electricity Only Scenario					
Investment					
New York	$3.9	$3.7	$3.3	$0.0	$11.0
New Jersey	$2.5	$1.6	$2.1	$0.0	$6.2
Pennsylvania	$3.5	$1.7	$4.6	$0.0	$9.9
Region	$9.9	$7.1	$10.1	$0.0	$27.1
Savings					
New York	$12.6	$18.0	$6.5	$0.0	$37.1
New Jersey	$6.0	$8.0	$3.6	$0.0	$17.6
Pennsylvania	$7.7	$7.5	$8.9	$0.0	$24.1
Region	$26.3	$33.5	$19.0	$0.0	$78.8
Benefit-Cost Ratio	2.65	4.74	1.88	NA	2.91

Notes: Energy investments, savings, and benefit-cost ratios are based on the 14-year study period. Had the analysis been extended to include the savings over the life of the measures, rather than limited to the study period, the respective savings and benefit-cost ratios would have been greater

For weather-sensitive heating and cooling loads, weather patterns for Harrisburg, PA, were used to adapt the DOE-2.1E model.

Each prototype incorporates average 1993 saturation levels of many energy efficiency measures. For each prototype we then applied a series of additional energy efficiency measures, and estimated using DOE-2.1E how much energy would be saved. Aggregate energy savings potential is estimated by applying that measure in the proportion of the building stock for which that measure was appropriate (i.e., had not been installed yet, was technically feasible, and cost effective to consumers on a life-cycle cost basis). Measures were applied sequentially in order of cost effectiveness (as measured by cost of saved energy) up to the cost-effectiveness limit (i.e., when cost of saved energy equals current retail energy prices). Savings estimates for each measure are incremental savings not achieved by any previous measure. Tables reporting these results for each of the prototypes are contained in Appendix B. Key summary information for each of the prototypes are reported in Table 2 for New York, Table 3 for New Jersey, and Table 4 for Pennsylvania.

Savings from these analyses of prototype buildings were then applied to projected energy use in each state, based on new construction trends in each state (for the new building prototypes) and an ACEEE estimated implementation rate for each package of measures, assuming an aggressive set of policies in each state to encourage implementation of cost-effective energy-saving measures. For the existing building prototypes, we assumed that measures would be gradually installed over the 1997-2010 period on a linear path, resulting in installation of 80 percent of the measures by 2010. Thus, over the 14-year analysis period, nearly 6 percent of the measures are implemented each year (80 percent per 14 years). For the new building prototypes, we assumed that updated building codes that incorporate all of the measures become effective in each state in 2003, with voluntary adoption of these efficiency levels gradually growing from 10 percent of new buildings in 1997 to 75 percent in 2002.

The result of all of these assumptions is that by the year 2010, residential energy consumption would be almost 35 percent lower than the baseline projections. In order to achieve these savings substantial investments will be required, primarily by energy users. These investments will be repaid with energy savings but the investments are significant none the less. For the residential sector, based on the average costs of saved energy reported in Table 1, investment over the 1997-2010 period will total $28.5 billion. However, cumulative energy bill savings from these measures, during the same period, will total $55.9 billion. Hence, the benefit-cost ratio to residents (i.e., savings divided by investment) for the residential building scenario is 1.96.

For the commercial sector, by 2010 energy use will be 25 percent lower than the baseline projections. The savings are not as large (in percentage terms) as in the residential sector because savings opportunities in the commercial sector for natural gas are limited. Nevertheless, the commercial sector has a very large electricity saving potential — 35 percent.

Table 2. Summary Data from Building Efficiency Analysis for New York State.

Building type	Baseline Electric kWh/unit	Baseline Gas kBtu/unit	Electric Saved kWh/unit	Gas Saved kBtu/unit	Electric Savings (%)	Gas Savings (%)	Total Savings (%)	Effic. Invest. ($/unit)	1st yr Savings ($/unit)	Simple Payback (years)	Cost of Svd Energy ($/MMBtu)
Residential (units = dwelling units)											
Existing											
Sf home	7,277	131,900	2,729	68,852	37.5%	52.2%	46.8%	$3,891	$904	4.3	$3.44
Apartment (elec)	14,482	--	7,531	0	52.0%	0.0%	52.0%	$1,914	$991	1.9	$2.26
Apartment (fossil)	4,743	70,400	1,835	33,510	38.7%	47.6%	43.9%	$615	$507	1.2	$1.09
New											
Sf home	7,391	85,600	1,959	29,960	26.5%	35.0%	30.9%	$2,024	$495	4.1	$3.45
Townhouse (heat pump)	12,399	0	3,621	0	29.2%	0.0%	29.2%	$1,492	$476	3.1	$3.36
Townhouse (fossil)	5,134	48,400	1,684	17,860	32.8%	36.9%	34.7%	$1,293	$363	3.6	$3.13
Commercial (units = sq. ft. of floor area)											
Existing											
Office	17.44	62.89	9.16	16.16	52.5%	25.7%	45.7%	$1.49	$1.12	1.3	$1.10
Retail	12.21	38.99	5.93	-1.21	48.6%	-3.1%	36.6%	$0.98	$0.66	1.5	$1.44
School	8.68	70.15	2.04	7.86	23.5%	11.2%	18.2%	$0.67	$0.28	2.4	$1.80
Warehouse	6.02	52.81	2.50	5.44	41.5%	10.3%	27.4%	$0.73	$0.31	2.3	$1.96
New											
Office	12.54	31.61	6.60	-1.83	52.6%	-5.8%	41.4%	$0.86	$0.73	1.2	$1.05
Retail	10.41	20.83	3.87	-1.04	37.2%	-5.0%	30.5%	$0.50	$0.43	1.2	$1.14
School	7.73	52.7	1.78	4.69	23.0%	8.9%	17.5%	$0.71	$0.23	3.1	$2.37
Warehouse	5.1	39.65	1.95	2.66	38.3%	6.7%	24.9%	$0.45	$0.23	1.9	$1.65

Notes: All energy values and prices reflect primary rather than end-use perspectives. Electricity was converted using the average heat rate in 1993 - 10,600 Btu/kWh. The simple payback periods are based on 1993 weighted average sectoral energy prices. The cost of saved energy reflects the cost of the efficiency investment (in dollars per million Btus) as amortized over the life of the investment, using a five percent real discount rate.

Table 3. Summary Data from Building Efficiency Analysis for New Jersey.

Building type	Baseline Electric kWh/unit	Baseline Gas kBtu/unit	Electric Saved kWh/unit	Gas Saved kBtu/unit	Electric Savings (%)	Gas Savings (%)	Total Savings (%)	Effic. Invest. ($/unit)	1st yr Savings ($/unit)	Simple Payback (years)	Cost of Svd Energy ($/MMBtu)
Residential (units = dwelling units)											
Existing											
Sf home	7,502	131,900	2,258	67,929	30.1%	51.5%	43.5%	$3,124	$835	3.7	$2.94
Apartment (elec)	14,568	--	7,575	0	52.0%	0.0%	52.0%	$1,926	$997	1.9	$2.26
Apartment (fossil)	4,833	70,400	1,870	33,510	38.7%	47.6%	43.9%	$620	$511	1.2	$1.09
New											
Sf home	7,391	85,600	1,959	29,960	26.5%	35.0%	30.9%	$2,024	$495	4.1	$3.45
Townhouse (heat pump)	12,399	0	3,621	0	29.2%	0.0%	29.2%	$1,492	$476	3.1	$3.36
Townhouse (fossil)	5,134	48,400	1,684	17,860	32.8%	36.9%	34.7%	$1,293	$363	3.6	$3.13
Commercial (units = sq. ft. of floor area)											
Existing											
Office	17.44	62.89	9.16	16.16	52.5%	25.7%	45.7%	$1.49	$1.12	1.3	$1.10
Retail	12.21	38.99	5.56	-2.57	45.5%	-6.6%	33.4%	$0.47	$0.61	0.8	$0.75
School	8.68	70.15	2.04	7.86	23.5%	11.2%	18.2%	$0.67	$0.28	2.4	$1.80
Warehouse	6.02	52.81	2.50	5.44	41.5%	10.3%	27.4%	$0.73	$0.31	2.3	$1.96
New											
Office	12.54	31.61	6.60	-1.83	52.6%	-5.8%	41.4%	$0.86	$0.73	1.2	$1.05
Retail	10.41	20.83	3.87	-1.04	37.2%	-5.0%	30.5%	$0.50	$0.43	1.2	$1.14
School	7.73	52.7	1.78	4.69	23.0%	8.9%	17.5%	$0.71	$0.23	3.1	$2.37
Warehouse	5.1	39.65	1.95	2.66	38.3%	6.7%	24.9%	$0.45	$0.23	1.9	$1.65

Notes: All energy values and prices reflect primary rather than end-use perspectives. Electricity was converted using the average heat rate in 1993 - 10,600 Btu/kWh. The simple payback periods are based on 1993 weighted average sectoral energy prices. The cost of saved energy reflects the cost of the efficiency investment (in dollars per million Btus) as amortized over the life of the investment, using a five percent real discount rate.

Table 4. Summary Data from Building Efficiency Analysis for Pennsylvania.

Building type	Baseline Electric kWh/unit	Baseline Gas kBtu/unit	Electric Saved kWh/unit	Gas Saved kBtu/unit	Electric Savings (%)	Gas Savings (%)	Total Savings (%)	Effic. Invest. ($/unit)	1st yr Savings ($/unit)	Simple Payback (years)	Cost of Svd Energy ($/MMBtu)
Residential (units = dwelling units)											
Existing											
Sf home	7,502	131,900	2,813	68,852	37.5%	52.2%	46.7%	$3,926	$915	4.3	$3.44
Apartment (elec)	14,568	--	7,575	0	52.0%	0.0%	52.0%	$1,926	$997	1.9	$2.26
Apartment (fossil)	4,833	70,400	1,870	33,510	38.7%	47.6%	43.9%	$620	$511	1.2	$1.09
New											
Sf home	7,391	85,600	1,959	29,960	26.5%	35.0%	30.9%	$2,024	$495	4.1	$3.45
Townhouse (heat pump)	12,399	0	3,621	0	29.2%	0.0%	29.2%	$1,492	$476	3.1	$3.36
Townhouse (fossil)	5,134	48,400	1,684	17,860	32.8%	36.9%	34.7%	$1,293	$363	3.6	$3.13
Commercial (units = sq. ft. of floor area)											
Existing											
Office	17.44	62.89	9.16	16.16	52.5%	25.7%	45.7%	$1.49	$1.12	1.3	$1.10
Retail	12.21	38.99	5.56	-2.57	45.5%	-6.6%	33.4%	$0.47	$0.61	0.8	$0.75
School	8.68	70.15	2.04	7.86	23.5%	11.2%	18.2%	$0.67	$0.28	2.4	$1.80
Warehouse	6.02	52.81	2.50	5.44	41.5%	10.3%	27.4%	$0.73	$0.31	2.3	$1.96
New											
Office	12.54	31.61	6.60	-1.83	52.6%	-5.8%	41.4%	$0.86	$0.73	1.2	$1.05
Retail	10.41	20.83	3.87	-1.04	37.2%	-5.0%	30.5%	$0.50	$0.43	1.2	$1.14
School	7.73	52.7	1.78	4.69	23.0%	8.9%	17.5%	$0.71	$0.23	3.1	$2.37
Warehouse	5.1	39.65	1.95	2.66	38.3%	6.7%	24.9%	$0.45	$0.23	1.9	$1.65

Notes: All energy values and prices reflect primary rather than end-use perspectives. Electricity was converted using the average heat rate in 1993 - 10,600 Btu/kWh. The simple payback periods are based on 1993 weighted average sectoral energy prices. The cost of saved energy reflects the cost of the efficiency investment (in dollars per million Btus) as amortized over the life of the investment, using a five percent real discount rate.

Commercial sector investments are also large (although significantly lower than in the residential sector), totaling $8.4 billion over the 1997-2010 period. However, cumulative energy bill savings from these measures are estimated to be $36.8 billion, resulting in a commercial building benefit-cost ratio to businesses of 4.39.

2. Industrial Efficiency

The industrial sector represents a diverse grouping of entities including: farming, agricultural services, forestry, fisheries, mining, construction, and manufacturing. Because of this diversity and the fact that energy use is an integral part of many of the operations performed in this sector, a different approach was required from that used for buildings.

ACEEE has developed a methodology for the estimation of baseline energy consumption in the industrial sector at the state level and the potential for cost-effective energy efficiency improvements; this methodology is discussed in Appendix C.[36]

Information on energy consumption within the industrial sector at any level other than the national level has been difficult to obtain and is of varying quality. Energy end-use varies widely among the different industry groups, and even among industries within some of those groups, so the energy efficiency opportunities also vary substantially.[37]

Among the states, the distribution of industries can vary widely, and this is true of the Mid-Atlantic states. This results in different distributions of fuels and electricity consumption for each state. Because of these differences, it is important to have representative disaggregations of energy use within the industrial sector in order to make meaningful estimates of the potential for energy efficiency improvements and identify areas of greatest opportunity for energy savings. This study uses state employment data to apportion *State Energy Data Report*[38] estimates of industrial energy consumption at the state level to eleven industrial groupings. The distribution of industries among these states is quite different with the chemicals and metals fabrication industries being the only common trend (Figures 4 and 5).

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36. This analysis methodology was developed for a previous study by S. Laitner et al., *Energy Efficiency and Economic Development in the Midwest*, American Council for an Energy-Efficient Economy, Washington, DC, 1995.

37. R. N. Elliott, *Electricity Consumption and the Potential for Electric Energy Savings in the Manufacturing Sector*, American Council for an Energy-Efficient Economy, Washington, DC, 1994; M.H. Ross, P. Thimmapuram, R.E. Fisher, and W. Maciorowski, *Long Term Industrial Energy Forecasting (LIEF) Model (18 Sector Model)*, Argonne National Laboratory, Argonne, IL, 1993.

38. *State Energy Data Report 1993*, op. cit.

FIGURE 4. ESTIMATED 1991 INDUSTRIAL FUEL CONSUMPTION

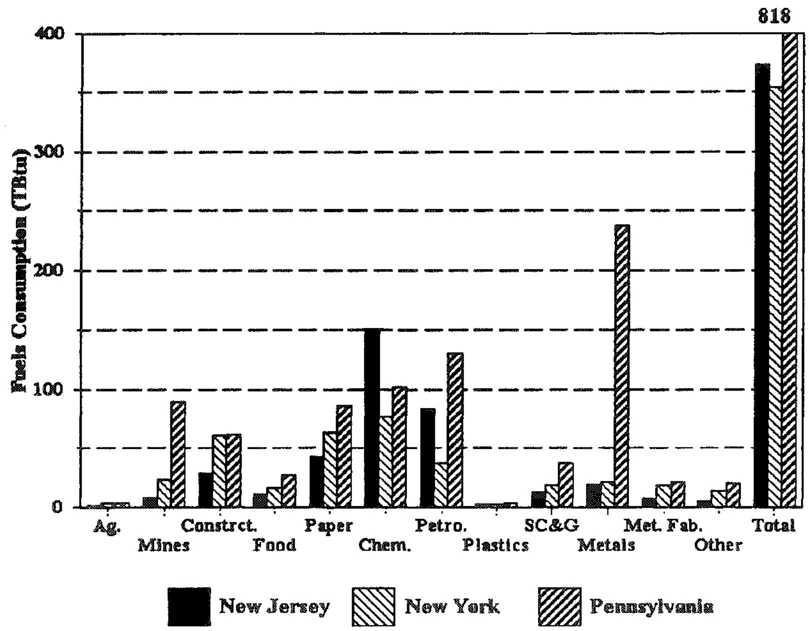
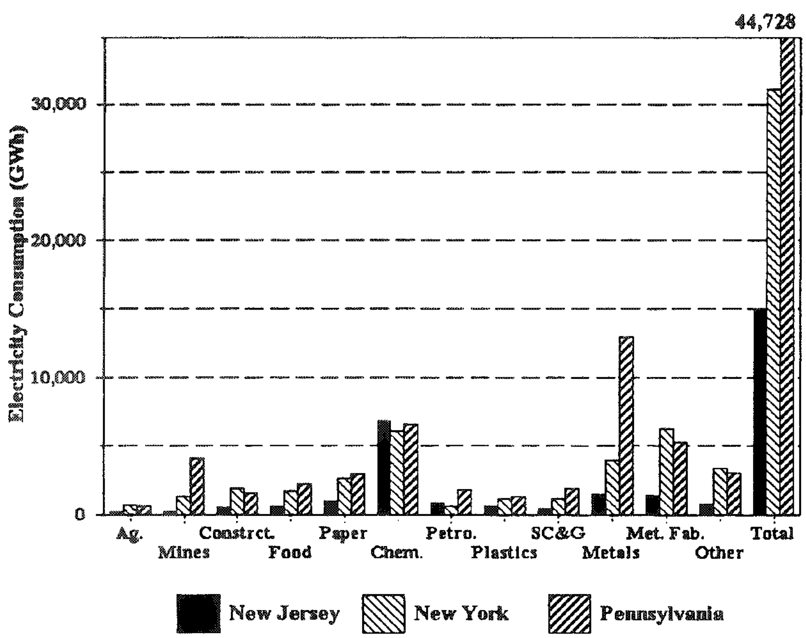


FIGURE 5. ESTIMATED 1991 INDUSTRIAL ELECTRICITY CONSUMPTION



Source: Calculations by the American Council for an Energy-Efficient Economy based upon assumptions described in the text.

Pennsylvania's industrial sector is the largest of the three in both value of shipments and energy use. Resource extraction and primary manufacturing dominate the state's industries. The largest industry groups are mining (dominated by coal mining), food products, a broad range of chemicals, and primary metals (dominated by primary steel production). Both fuel and electricity consumption are dominated by the primary metals group, which accounts for almost 30 percent of both fuels and electricity. Other significant fuel consumers include mining, paper, chemicals, and petroleum refining, while other large electricity consumers include mining, chemicals, and metals fabrication.

New York's industrial sector is more manufacturing focused, and is dominated by food products, printing and publishing, and metal fabrication industries. Chemicals and metal fabrication industries each account for about 20 percent of electricity use. Drugs and soap account for a large fraction of the chemicals industry group, and technology-intensive products like computers, electronic components, medical equipment, and optics are significant among the metals fabrication industries. Other notable electricity-consuming industry groups include printing, apparel and textiles (reported in the other category), and primary metal industries such as foundries and nonferrous rolling mills. Much of the apparel industry is located in the garment district of New York City. The construction, chemicals, and paper industries each account for about a fifth of the industrial fuels consumption.

Chemicals is the most important industry in New Jersey, accounting for over a quarter of the industrial value added. This is also reflected in the energy consumption with chemicals accounting for 45 and 40 percent of electricity and fuels consumption, respectively. Petroleum refining and paper are the other major fuel-consuming sectors, while ferrous and nonferrous primary metals, a broad range of metals fabrication industries, and paper account for much of the additional electricity consumption.

The energy efficiency potential was estimated using conservation supply curves derived from the Long-Term Industrial Energy Forecasting (LIEF) model.[39] Most conservation supply curves have been developed by combining various characteristic measures for a particular market. Such an approach is impractical for the industrial sector because of the complexity and site-specific nature of many efficiency measures. The LIEF curves were developed from a historical analysis of sectoral energy intensities and prices.

Industrial fuel prices vary significantly between the Mid-Atlantic states and are in general higher than the national average. As a result, state specific energy savings estimates are based on the average energy prices for each state as summarized in Table 5. The results of the analysis for the three states are reported in Table 6. By 2010, primary energy consumption in the industrial sector is reduced from 25 percent in New Jersey to almost 35 percent in New

39. Ross et al., op. cit.

TABLE 5. 1993 MID-ATLANTIC STATE INDUSTRIAL FUEL PRICES AND CONSUMPTION				
Fuel Prices (1)	**National Avg.**	**New Jersey**	**New York**	**Pennsylvania**
Electricity ($/kWh)	0.049	0.081	0.067	0.060
Residual ($/MBtu)	2.41	2.71	2.88	2.54
Distillate ($/MBtu)	4.78	4.52	4.67	5.09
LPG ($/MBtu)	4.74	10.95	9.32	9.52
Nat. Gas ($/MBtu)	4.73	3.57	5.03	3.71
Coal ($/MBtu)	1.66	1.50	1.70	1.63
1993 Consumption (2)				
Electricity (GWh)		14,597	30,187	44,949
Fuel (TBTU)				
Coal		6	76	385
Natural Gas		196	166	255
Petroleum (3)		294	177	236

Notes: (1) Source: *State Energy Data Report 1993*, op. cit..
(2) Source: *State Energy Price and Expenditure Report 1993*,Energy Information Administration, U.S. Department of Energy, Washington, DC, 1994.
(3) Petroleum consumption weighting is applied to distillate, residual, and LPG.

York compared to the baseline projections. The variation in savings potential among the states result from the differing mix of industries that have different savings potential and growth characteristics. Total electricity consumption decreases over time in the high-efficiency scenario, resulting in a 40 to 44 percent reduction in electricity consumption in 2010 compared to baseline projections. The potential for conserving industrial fuels is a more modest 20 percent. In large part, this is because average fuel prices are relatively low in key industries such as primary metals, pulp and paper, chemicals, and petroleum refining.

The high-efficiency scenario requires $15 billion in energy efficiency investments in the region over the period 1997-2010 (in constant 1991 dollars). Cumulative bill savings (based upon

1991 energy prices)[40] would be almost $27 billion. Hence, the benefit-cost ratio for the industrial sector scenario ranges from 1.55 in New Jersey to 1.86 in New York.[41]

TABLE 6. ESTIMATED CUMULATIVE ENERGY SAVING AND EFFICIENCY INVESTMENT 1997-2010			
	New Jersey	**New York**	**Pennsylvania**
Fuel	17.2%	25.4%	19.4%
Electricity	42.1%	43.4%	40.1%
Primary Energy (1)	25.0%	34.5%	27.3%
Bill Savings (million$) (2)	4,923	9,035	12,624
Efficiency Investment (million$)	3,185	4,847	7,101
Benefit-Cost Ratio (3)	1.55	1.86	1.78

Notes: (1) based on a electricity system heat rate of 11,063 Btu/kWh.
(2) calculated using industry consumption-weighted, average fuel prices and state average industrial electricity prices as presented above
(3) Ratio of cumulative bill savings to cumulative capital investment in efficiency improvements. Energy savings after 2010 that result from investments made before 2010 are not considered in this calculation.

3. Transportation Efficiency

As throughout the nation, the transportation sector accounts for major portions of energy use and energy-related emissions in the Mid-Atlantic region. Moreover, the transportation sector is almost wholly dependent on petroleum. A breakdown of energy use by transportation mode is not available for the region; indeed, such a breakdown is difficult to define since a

40. 1991 energy prices are used for the analysis to agree with the consumption data used for this study.

41. At first glance, the industrial benefit-cost ratio may appear to be unusually low. But we need to make a distinction between the benefit-cost ratio of a project and of a scenario. A single project with a payback of 4 years and a life of 10 years will have a benefit-cost ratio of 2.5. But a scenario with investments made annually over a 16-year period will always be incurring new investments, especially in the outlying years, which may never pay for themselves within the time frame of the scenario but which may be excellent investments as individual projects. This is all the more important to understand within the industrial sector since many projects may have effective lives of less than 10 years (compared to commercial buildings, for example, which may last 20, 30, 40 or more years). This means that in the 11th year, not only will a new investment be required to achieve a new level of efficiency, but the investments made in the 1st year will have to be made yet again to keep the same level of efficiency benefit.

significant portion of the traffic, particularly freight, crosses state and national boundaries. Nevertheless, using national statistics as a guide, light duty vehicles (LDVs, i.e., cars and light trucks) account for the majority of transportation energy use. Thus, our analysis focuses on LDVs, taken here to include passenger cars and 2-axle, 4-tire, light trucks, as defined in the U.S. Department of Transportation's *Highway Statistics* reports, Table VM-1.[42] Nationally, LDVs account for 92 percent of highway vehicle miles of travel (VMT) and 80 percent of highway energy consumption, and about 60 percent of overall transportation energy use.

Transportation energy efficiency, particularly for light vehicles and for aircraft, has improved substantially over the past two decades. Today, however, ongoing improvements are only being seen in aircraft, and even those improvements are insufficient to keep up with rising travel demand. Efficiency improvements have completely halted for the largest contributor to transportation energy use, cars and light trucks. Thus, motor vehicle energy use is now rising in step with increased driving, which, as we note below, is expected to grow at an average rate of 1.7 per year for the New Jersey, New York, and Pennsylvania region.

Previous work indicates a substantial energy savings opportunity for improving vehicle efficiency using technologies already available for conventional cars and light trucks.[43] Our analysis is based on estimating the potential energy savings obtainable through vehicle efficiency improvement. We do not examine the use of alternative fuels, such as natural gas, biofuels, hydrogen, or electricity, which have a long-term potential for displacing petroleum. These alternative technologies are still entering the early stages of commercialization and further research and development is needed for many of them. Battery-powered electric vehicles (EVs) are just now becoming commercially available but are still inhibited by battery technology limitations and associated price premiums. Therefore, we restrict our analysis to conventional vehicle technologies, which still have considerable unmet potential for low-cost energy savings and pollution reduction over the time horizon of this study.

Also critical for improving transportation system efficiency are measures to reduce VMT by shifting to more efficient modes, including higher vehicle occupancy, transit, walking, and bicycling; reducing the need to travel through more efficient planning or use of electronic communications; and reforming transportation pricing and spending policies that subsidize car and truck travel. These broader aspects of transportation planning transcend energy concerns

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42. *1993 Highway Statistics*, FHWA-PL-94-023, Federal Highway Administration of the U.S. Department of Transportation, Washington, DC, 1994.

43. J.M. DeCicco and M. Ross, *An Updated Assessment of the Near-Term Potential for Improving Automotive Fuel Economy*, American Council for an Energy-Efficient Economy, Washington, DC, 1993.

and fall beyond the scope of this analysis; these issues are well covered in the study by Ketcham and Komanoff.[44]

A key factor underlying energy analysis for the transportation sector is expected growth in travel demand for the region. Figure 6 shows the recent history of VMT growth for New Jersey, New York, and Pennsylvania along with the projected growth assumed for our analysis. Although this growth can — and for efficiency reasons, should be — dampened through policy and planning reforms, we take it as given for the purposes of estimating the potential energy savings from vehicle efficiency improvements.

For projections of travel growth, we adopted state-specific VMT forecasts obtained by reviewing recent state transportation plans; details are provided in Appendix D. Since these state forecasts are for total highway VMT and we are analyzing efficiency improvements for LDVs only, we multiplied the total VMT forecasts by 92.36 percent, based on the ratio of light duty VMT to total VMT from FHWA, Table VM-1.[45] Another adjustment made to all three VMT forecasts was to expand them from the daily traffic volume to annual values. Both New Jersey and New York daily traffic volumes were multiplied by 365 to obtain an annual VMT estimate. Pennsylvania statistics represent daily summer time VMT and thus were modified in a slightly different manner, as detailed in Appendix D. The resulting forecast is for 1990-2010 VMT growth of 0.8 percent per year in New Jersey, 2.2 percent per year in New York, and 1.4 percent per year in Pennsylvania, averaging 1.7 percent per year for the three-state region. Consistent with nationwide trends (largely influenced by demographic changes), the expected future growth rate is slower than over the past two decades, when the region's VMT growth rate averaged 2.1 percent per year.

The transportation energy savings calculation involves combining projections of annual VMT, new car miles per gallon (mpg), the per unit cost to achieve that efficiency level, and annual new LDV sales. For our analysis, base year data were compiled for 1993 and vehicle efficiency improvements were assumed to begin in 1997. Base year car sales by state[46] were scaled up to estimate car and light truck sales by applying the ratio of LDV VMT to car VMT as reported in FHWA, Table VM-1.[47] Estimates of annual new LDV sales for future years were made in proportion to growth in VMT. The energy and fuel cost savings were calculated relative to a baseline assumption of frozen vehicle efficiency, accounting for the vehicle stock

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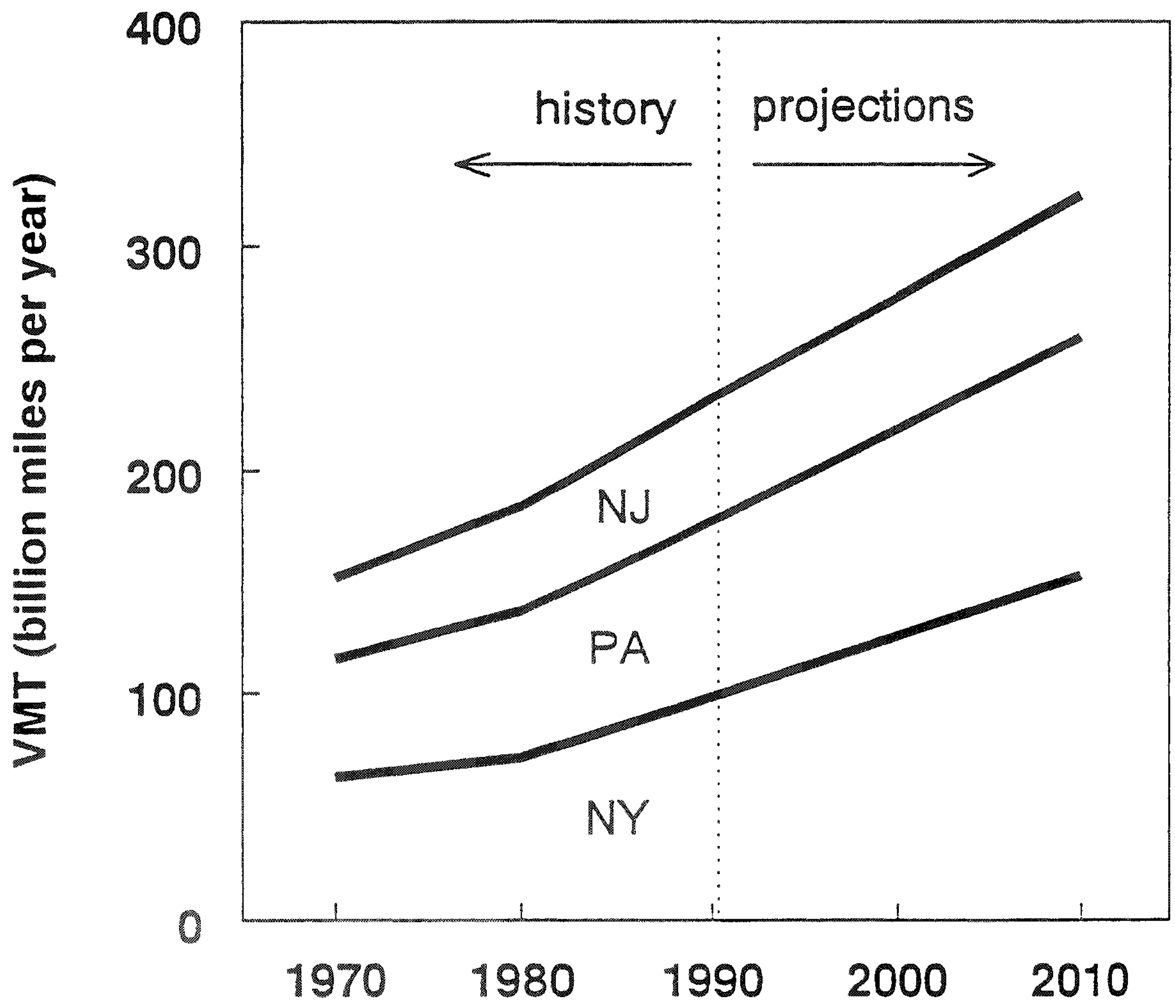
44. B. Ketcham, and C. Komanoff., *Win-Win Transportation: A No-Losers Approach to Financing Transport in New York City and the Region*, Transportation Alternatives, New York, NY, 1992.

45. *1993 Highway Statistics*, op. cit.

46. *AAMA Motor Vehicle Facts and Figures*, American Automobile Manufacturers Association, Washington, DC, 1994.

47. *1993 Highway Statistics*, op. cit.

Figure 6. Past and Projected Light Duty Vehicle Travel in the Mid-Atlantic Region



(all cars and trucks, new and used, in service within a given year) and its turnover. The same fuel economy levels were assumed for all states in the region.

The stock retirement model uses vehicle usage and scrappage statistics from Davis and Strang,[48] further described by DeCicco.[49] Because on-road fuel economy is lower than EPA-rated fuel economy, a 20 percent downward adjustment is made to account for the shortfall, based on estimates by Mintz, Vyas, and Conley.[50] Fuel savings estimates were also adjusted downward to account for the takeback (rebound) effect of greater driving because higher fuel economy lowers the cost per mile, using an elasticity of travel with respect to fuel cost of -0.1 based on Greene.[51] The result is a series of estimates of the projected real-world average fuel economy of all cars and light trucks on the road (new and used) in each future year.

DeCicco and Ross[52] estimated the costs of achieving higher new car fuel economy under varying assumptions about technology availability. The analysis examined a set of conventional car and light truck technologies, including engine improvements, transmission improvements, and measures to reduce mass, rolling resistance, and aerodynamic drag. Measures were screened for cost and ranked in a "cost curve" representing the slate of technical options for improving new vehicle efficiency without reducing average vehicle size and performance or compromising safety. (In fact, adjustments were made to account for potential safety improvements that might add some mass back to the vehicles.) The DeCicco and Ross mid-range estimates indicate that a 65 percent improvement in new car fuel economy is achievable with about 10 years of lead time at an average added cost of retail $770 per car (1993$). This improvement corresponds to an average new car improving fuel economy to 46 mpg from a current level averaging 27.8 mpg.

With additional time, further technology improvements would be possible, as indicated by a higher ("Level 3") set of estimates developed by DeCicco and Ross. This higher level of

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48. S. Davis and S. Strang, *Transportation Energy Data Book: Edition 13*, ORNL-6743, Oak Ridge National Laboratory, Oak Ridge, TN, 1993.

49. J. DeCicco, "Projected Fuel Savings and Emissions Reductions from Light Duty Vehicle Fuel Economy Standards," *Transportation Research* 29A(3): 205-228, 1995.

50. M. Mintz, A. Vyas, and L. Conley, *Differences Between EPA-Test and In-Use Fuel Economy: Are the Correction Factors Correct?* 931104, Transportation Research Board, Washington, DC, 1993.

51. D. Greene, "Vehicle Use and Fuel Economy: How Big is the 'Rebound' Effect?" *Energy Journal* 13(1), 1992.

52. J.M. DeCicco and M. Ross, *An Updated Assessment of the Near-Term Potential for Improving Automotive Fuel Economy,* American Council for an Energy-Efficient Economy, Washington, DC, 1993.

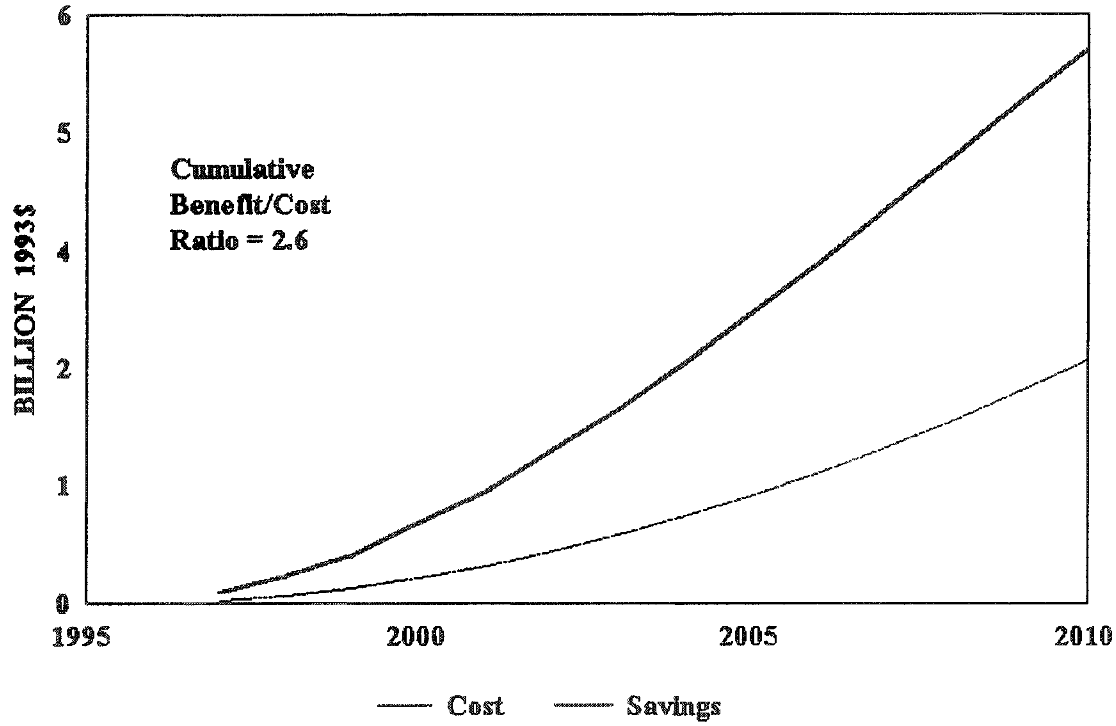
improvement indicates an average new car fuel economy of 51 mpg (84 percent above the current level) attainable at an average added cost of retail $840 per car. We adopt this higher improvement level as attainable by 2010. The average cost of conserved energy for the higher improvement level is $0.51/gallon (1993$, based on a 5 percent real discount rate and a 12-year vehicle lifetime), showing that these efficiency improvements are quite cost effective even compared to the relatively low price of gasoline, which is projected to rise only to $1.38 per gallon by 2010 using DOE's recent forecasts. Similar degrees of improvement are also achievable in light trucks (pickups, minivans, sport utilities), relative to their current (lower) average efficiency levels.

For our analysis, we assume the efficiency improvements are phased-in at an average rate of 1.5 mpg per year, relative to a combined new car and light truck average fuel economy of 25 mpg (the most recent new fleet average, based on NHTSA[53]). Given the assumption of improvements starting in 1997, the result is average new light vehicle efficiency levels of 38.5 mpg by 2005 and 46.0 mpg by 2010. The costs of achieving the phased-in higher fuel economy levels in each year were calculated using an analytic form of the DeCicco and Ross cost curve, which is given in Appendix D. Total annual costs region wide are shown in Figure 7. Costs grow in accordance with our assumption of ongoing efficiency improvements through the horizon of analysis.

Improvements in new car and light truck efficiency take time to "trickle-down" throughout the total on-road stock of vehicles new and used, since the average vehicle lifetime is about 12 years. Results from the stock model show that the 84 percent improvement in new light duty fleet efficiency by 2010, compared to the current level, will have induced a 49 percent improvement in stock average efficiency by that time. The result is a roughly one-third savings in light vehicle fuel use per mile of driving. The resulting region wide savings stream is shown as the upper curve in Figure 7. Savings exceed investments from the start since the initial technological improvements have payback times of less than one year. The cumulative investment in vehicle technology improvements, realized as modest increases in the average price of new cars and light trucks, would amount to $13.6 billion over 1997-2010. The cumulative value of the resulting fuel savings would be much larger, at $34.6 billion over 1997-2010. The resulting benefit/cost ratio is 2.6. This ratio would, moreover, continue to grow as years went on, since the overall consumer savings from higher vehicle efficiency will keep growing as improved vehicles continue to replace older, less efficient vehicles in the on-road stock in the post-2010 period.

53. *Summary of Fuel Economy Performance.* Semi-annual report filed in NHTSA Docket No. FE-GR-013, U.S. Department of Transportation, National Highway Traffic Safety Administration, Washington, DC, 1996.

Figure 7. Transportation Sector Costs and Savings Results for Light Vehicle Efficiency Improvements in the Mid-Atlantitc Region.



IV. Economic Impact Analysis

With both the baseline projection and the efficiency scenarios established, the question now posed by this analysis is: "What are the employment and other macroeconomic impacts for the Mid-Atlantic region and each of the individual states if the baseline energy use were reduced by 24 percent, or about 2,868 TBtus, by the year 2010?"

In effect, we are examining the benefits of lowering energy consumption from a projected growth rate of about 1.1 percent annually to a growth rate of a negative 0.53 percent annually. One way to understand this issue is to think of it as increasing the productivity of each state's economy by reducing its overall energy costs. One tool that can assist in this type of macroeconomic evaluation is referred to as input-output modeling, sometimes called multiplier analysis.

A. Input-Output Analysis

Input-output models initially 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 likely benefit from expanded sales of locally manufactured, high-efficiency ballasts; states without such production will not benefit in the same way.

Different expenditures support a different level of total employment. Table 7 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.[54]

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

54. In this study we have adapted the 1993 IMPLAN model for the analysis. See, for example, *Micro IMPLAN User's Guide*, Minnesota IMPLAN Group, Stillwater, MN, 1993. Table 7 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 the Type II multipliers (or Type III multipliers as referenced in the IMPLAN model).

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 its 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, lighting, and transport 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 the state economies.

The sum of these three effects yields a total effect 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 efficiency scenario.[55] Table 7 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 7 is the relatively small number of jobs supported for each one million dollars spent on fuel production (with the exception of coal in Pennsylvania) and utility services. As it turns out, much of the job creation from energy efficiency programs is derived by the difference between jobs within the utility supply sectors and jobs that are supported by the respending of energy bill savings in other sectors of the economy.

B. An Illustration: Jobs from Energy Improvements in Government

To illustrate how a job impact analysis might be done, we will use the simplified example of a state agency that installs $1.0 million of efficiency improvements. Government agencies, traditionally large users of energy due to heating and air-conditioning loads, significant use

55. For more information on this point, see R.E. Miller and P.D. Blair, *Input-Output Analysis: Foundations and Extensions*, Prentice-Hall, Inc., Englewood, NJ, 1985, pages 25-30.

Table 7. Mid-Atlantic Region Employment Multipliers for Selected Economic Sectors

Sector	Employment Multipliers (Jobs per $1 Million of Expenditures)		
	New York	New Jersey	Pennsylvania
Coal Mining	0.0	0.0	9.5
Oil Refining	2.2	1.6	2.4
Natural Gas Utilities	4.3	3.9	5.0
Motor Vehicles	6.3	4.5	7.1
Electric Utilities	5.7	5.5	6.7
Food Processing	7.6	6.1	9.4
Other Mining	7.3	6.7	8.7
Primary Metals	7.1	7.8	8.2
Insurance/Real Estate	6.4	7.6	8.5
Pulp and Paper Mills	8.1	7.5	8.1
Metal Durables	8.8	9.1	10.8
Other Manufacturing	9.5	8.1	11.4
Stone, Glass, Clay	10.5	11.5	11.8
Transportation, Communication, and Utilities	11.6	10.6	13.7
Construction	11.5	11.2	13.8
Oil/Gas Mining	14.6	11.7	14.1
Finance	8.0	12.9	14.2
Wholesale Trade	14.7	14.5	17.9
Services	19.4	19.0	23.5
Government	24.1	23.7	27.2
Agriculture	27.0	27.9	25.5
Education	27.3	25.5	29.4
Retail Trade	30.0	29.5	36.3

Source: Adapted from the 1993 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.

of electronic office equipment, and the large numbers of persons employed and served, provide substantial opportunities for energy-saving investments. The results of this example are summarized in Table 8.

The assumption used in this example is that the investment has a positive benefit-cost ratio of 2.00. This ratio is comparable to those shown in Table 1. If we anticipate that the efficiency changes will have an expected life of 15 years or more, 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 energy 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 energy efficiency. Each change in expenditures must then be multiplied by the appropriate multiplier (taken from Table 7) for each sector affected by the change in expenditures. The sum of these products will then yield the net result for which we are looking.

In our example there are four separate changes in expenditures identified in Table 8, each with their separate multiplier effect. As Table 8 indicates, the net impact of the scenario suggests a gain of 25.2 job-years in the 15-year period of analysis. This translates into a net increase of 1.7 jobs each year for 15 years. In other words, the efficiency investment made in government facilities is projected to sustain an average of just under two jobs each year over a 15-year period compared to a baseline or "business-as-usual" scenario.[56]

C. Evaluating the Alternative Energy Scenario

The employment analysis of the alternative energy 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.[57]

56. The estimate may be conservative when we recall that the commercial sector as a whole was shown to have a benefit-cost ratio of almost 4.4 (noted earlier in Table 1), which compares with the benefit-cost ratio assumption of 2.0 used in this example.

57. For a more complete review of how this type of analysis is carried out, see H. Geller, J. DeCicco, and S. Laitner, *Energy Efficiency and Job Creation: The Employment and Income Benefits from Investing in Energy Conserving Technologies*, American Council for an Energy-Efficient Economy, Washington, DC, 1992.

Table 8. Job Impacts from Government Energy Efficiency Improvements			
Expenditure Category	**Amount ($ Million)**	**Job Multiplier**	**Job Impact**
Government Efficiency Improvements in Year One	$1.0	12.2	12.2
Diverting Government Expenditures to Fund Efficiency Improvements	-$1.0	25.0	-25.0
Respending of Energy Bill Savings in Years One through Fifteen	$2.0	25.0	50.0
Lower Utility Revenues in Years One through Fifteen	-$2.0	6.0	-12.0
Net Fifteen-Year Change	$0.0		25.2

Note: The employment multipliers are derived from the appropriate sectors (average of the three states) found in Table 7. The jobs impact is the result of multiplying the row expenditure change by the row multiplier. For more details, see the text.

First, it was assumed that only 80 percent of the efficiency investments would be spent within the respective states in the Mid-Atlantic 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.

As it turns out, the level of locally installed efficiency upgrades does matter, especially in the early years of the analysis; that is, before the energy bill savings begin to show a significant return. For example, in 1997 the employment benefits for the region would turn negative if more than 50 percent of the upgrades were performed by out-of-region contractors or other businesses. By 2010, however, this level would have to rise to more than 90 percent before the employment gains are fully eroded. Thus, to maximize employment within the region, investments in the early years should emphasize the use of locally based businesses as much as possible.

Second, we made an adjustment in the employment impacts to account for specific sector changes in labor productivity. As outlined in the Bureau of Labor Statistics *Outlook 1995-2005*, productivity rates are expected to vary widely among sectors, ranging from a 0.1 percent annual productivity gain in the service sectors (which will experience a large influx of employment as those sectors become more important to the economy) to a 4.0 percent annual productivity gain in coal mining (where such gains have already led to significant job losses).[58]

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 1997 a one million dollar expenditure in the year 2010 will support only 88 percent of the number of jobs as in 1997.[59]

Third, for purposes of estimating energy bill savings it was assumed that energy prices would remain at their 1993 levels. This is, in part, to simplify the matching of energy prices with an input-output model based upon 1993 price relationships but also in line with the Energy Information Administration's new 1997 price forecasts. The 1997 forecast is substantially lower than previous forecasts in order to recognize the price-lowering impacts associated with utility restructuring.[60]

There are two important exceptions to the presumption that energy prices would remain at 1993 levels: (1) that a decline in consumption would cause a downward pressure in the variable costs of supplying energy resources, and (2) that in the early years of the study the fixed costs associated with producing energy would prompt a small increase in energy prices.[61] While this might represent a "deadweight loss" in some respects, the effect will be overcome by a reduction in energy consumption that is larger than the very small energy price increase.

Fourth, it was assumed that approximately 80 percent of the investment upgrades would 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.

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58. The productivity trends were calculated by Economic Research Associates using data from the Bureau of Labor Statistics employment projections, *Outlook 1995-2005*, as downloaded from the BLS FTP site <ftp.bls.gov/pub/special.requests/ep>, U.S. Department of Labor, Washington, DC, February 1996.

59. The calculation is $1/(1.01)^{13} * 100$ equals $1/1.138 * 100$, or 88 percent.

60. *Annual Energy Outlook 1997*, op. cit.

61. This is a working estimate by Economic Research Associates for use in this analysis. Based upon a 40 percent average fixed cost, energy prices would go up by an estimated 7 percent in the year 2010, for example. On the other hand, a 24 percent drop in consumption would put a similar downward pressure on energy prices that would likely offset this trend – particularly in later years as fixed costs are fully depreciated.

While the higher cost premiums associated with the energy efficiency investments might be expected to drive up the level of borrowing (in the short term) and, therefore, interest rates, this upward pressure would be offset to some degree by the investment avoided in new power plant capacity, exploratory well drilling, and new pipelines. Similarly, while an increase in demand for labor would tend to increase the overall level of wages (and thus lessen economic activity), the modest job benefits are small compared to the current level of unemployment or underemployment. Hence the effect would be negligible.

Fifth, for the buildings and industrial sectors it was assumed that a program and marketing expenditure would be required to promote market penetration of the efficiency improvements. This was set at 15 percent of the efficiency investment for those sectors.[62] For the transportation scenario it was assumed that, since the efficiency improvements would be an integral part of all new vehicle purchases, a "program" expenditure would not be necessary. Finally, it should again be noted that the full effects of the efficiency investments are not accounted for since the energy bill savings beyond 2010 are not incorporated in the analysis.

Nor does 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 energy 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.[63] To the extent these "co-benefits" are realized in addition to the energy savings, the economic impacts would be amplified beyond those reported here.

62. For example, this was the same value as used in *Energy Efficiency and Job Creation*, op. cit.

63. Office of Technology Assessment, *Industrial Energy Efficiency*, Congress of the United States, Washington, DC, 1993, page 65. For a more complete discussion on this point, see S. Laitner, *Energy Efficiency as a Productivity Strategy for the United States*, Economic Research Associates, Alexandria, VA, 1995; and J. J. Romm, *Lean and Clean Management: How to Boost Profits and Productivity by Reducing Pollution*, Kodansha American, Ltd., 1994.

V. Macroeconomic Results

The investment and savings data from the efficiency scenario were used to estimate three sets of impacts for the five-year periods of 2000, 2005, and 2010. The procedure was similar to the steps outlined in Section IV(B) of this report, and as modified by the assumptions Section IV(C). For each benchmark year, each change in a sector's spending pattern for a given year was matched to the appropriate sectoral multiplier. These negative and positive changes were summed to generate a net result shown in the tables that follow.

The first of the three impacts evaluated here is the net contribution to Gross State Product (GSP) measured in millions of 1993 dollars. In other words, once the gains and losses are sorted out in each scenario, the analysis provides the net benefit of a scenario in terms of each state's overall economy. The second impact is the net gain to the state's wage and salary compensation, also measured in millions of 1993 dollars. The final category of impact is the contribution to each state's employment base as measured by full-time jobs equivalent. The following parts of this section identify these impacts for the total energy efficiency scenario as well as for electricity only. In addition, the final part of this section presents the estimated reductions in air emissions that result from the efficiency scenario.

A. Full Efficiency Scenario

Table 9 summarizes the economic impacts of the alternative energy scenario for selected benchmark years. It provides the estimated economic benefits of the accelerated use of energy efficiency technologies in all sectors. While these increases are significant, the impacts are relatively small in comparison to overall activity of the respective state economies. By the year 2010, for instance, New York state's GSP might grow to $651 billion (in 1993 dollars). Thus, adding $407 million to the state's GSP in the year 2010 represents an increase of just over 0.06 percent. Similarly, the increases in wage and salary compensation and jobs in 2010 represent an increase of only 0.4 and 0.7 percent, respectively, by 2010.[64]

On the other hand, if the impacts are small in relation to the larger economy, it is only because the scale of investment is also relatively small. The anticipated $65.6 billion in cumulative efficiency investments (from Table 1) are well under 1 percent of the region's cumulative GSP in the period 2000-2010.

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64. These projections are taken from *BEA Regional Economic Projections to 2045: States*, U.S. Department of Commerce, Bureau of Economic Analysis, 1995. The projections were originally reported in 1987 dollar values by BEA but have been adjusted to reflect 1993 dollar values for our analysis.

Table 9. Impact of the Full Efficiency Scenario			
Year	**Change in Gross State Product (Million$)**	**Change in Wage and Salary Compensation (Million$)**	**Net Jobs Gain**
New York			
2000	($248)	$183	11,045
2005	$50	$913	42,501
2010	$407	$1,796	77,457
New Jersey			
2000	($116)	$75	4,760
2005	($8)	$390	18,291
2010	$73	$749	33,583
Pennsylvania			
2000	($173)	$79	8,756
2005	($24)	$479	29,980
2010	$132	$950	53,280
Region Total			
2000	($532)	$337	24,561
2005	$18	$1,782	90,772
2010	$612	$3,495	164,319

Notes: Dollar figures are in millions of 1993 dollars while employment reflects the actual job total. The implied benefit-cost ratio across the 14-year period is 2.16. The calculations are based upon a working analysis by Economic Research Associates, July 1996. They assume a 29 percent reduction in energy use over the year 2010 forecasted values and a displacement of conventional electric-generating resources by the use of energy efficiency technologies. Totals may not equal the sum of components (as shown) due to independent rounding.

There are a number of different aspects of Table 9 worth noting before commenting on the impacts in more detail. The first is that the impacts are largely positive. By the year 2010, GSP for each of the states is projected to increase despite initial losses in the year 2000 for all of the states and losses in 2005 in New Jersey and Pennsylvania. Wage and salary earnings as well as employment are also shown to rise in 2010 for each of the states — by a regional net total of $3.5 billion (in 1993 dollars) and 164,319 jobs, respectively.

This apparen contradiction (i.e., rising earnings with declining GSP) is the result of two different influences at work in the economy. First, the initial outlay for energy efficiency investments has not begun to pay for itself in terms of energy bill savings. This tends to dampen the growth of GSP within each state. At the same time, changes in the production recipe of the economy — largely the turn toward more labor-intensive purchases in the efficiency scenario — increase the share of benefit enjoyed by working men and women.

Wage and salary compensation is one category of the elements that comprise GSP, constituting about 60 percent of the GSP total. Thus, while overall GSP can fall, wage and salary compensation can rise as labor payments are substituted for investment capital in the larger economy. By 2010 both values are strongly positive although the tradeoff between labor and capital continues. The employment impacts start modestly in 2000 with net employment gains of over 11,000 jobs in New York, 4,700 in New Jersey, and 8,700 in Pennsylvania. The annual totals for each of the states continues to climb to a net gain of more than 164,000 jobs for the three states combined in 2010.

We can think of the net job gains as if they were provided by the relocation of a series of small manufacturing plants to the respective states. In that case, we then can say that a 24 percent energy savings would produce new employment that is equivalent to the jobs supported by about 516 small manufacturing plants that might open in New York in the year 2010, 224 plants in New Jersey, and 355 plants in Pennsylvania.[65] Alternately, we can think of the additional wage and salary compensation from the energy savings as an equivalent amount of spending by tourists and visitors in each of the states. In this instance, the 24 percent energy savings would provide the dollar equivalent of spending from over 16.9 million visitor days.[66]

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65. This estimate is based on the net gain of 77,457 jobs in New York in the year 2010, 33,583 jobs in New Jersey, and 53,280 jobs in Pennsylvania. It assumes that a small manufacturing plant would employ 50 persons directly. For each job in the manufacturing plant, a total of 3.0 jobs would be supported in the economy for a total impact of 150 jobs. Therefore, each 150 jobs created by the alternative energy scenario is equivalent to the output of one small manufacturing plant. Dividing each state's total jobs created by 150 suggests the equivalent of a total of 1,095 (516+224+355) small manufacturing plants equivalent within the combined Mid-Atlantic economy.

66. This estimate is based on the net gain in wage and salary compensation of $1.796 billion in New York in the year 2010, $749 million in New Jersey, and $950 million in Pennsylvania. It assumes that tourists and visitors to these states spend approximately $207 per day per person on recreation, eating and drinking, and lodging. Dividing each states gain in wage and salary compensation by 207 suggests the equivalent of 16.9 million visitor day

Perhaps another way to look at this issue is to see how the alternative energy future would change the unemployment rate. In November 1996 the region's unemployment rate was estimated at 5.4 percent (New York's unemployment rate was 5.7 percent, New Jersey's rate was 5.8 percent, and Pennsylvania's rate was 4.5 percent).[67] If that continues through the year 2010 when total employment in the region is estimated to rise to approximately 23 million jobs,[68] then the region's unemployment level would be about 1.5 million persons. Adding another 164,319 jobs to the regional economy would be sufficient to lower the average unemployment rate from 6.6 percent to 5.5 percent (New York's unemployment rate would be 5.8 percent, New Jersey's 5.8 percent, and Pennsylvania's 4.9 percent).

Tables 10 through 13 offer yet another insight into the projections. They show how each of the major economic sectors are affected in the year 2010 in the alternative energy scenario. These are sorted according to the anticipated job impacts beginning with those sectors that have the largest employment gains.

As elsewhere it should be noted that the results in these tables are not intended to be precise forecasts but rather approximate estimates of overall impact. Indeed, while the aggregate totals offer reasonable insights into the benefits of energy efficiency, some of the individual sectors show impacts that are sufficiently small that the results may swing one way or the other depending upon even modest changes in the assumptions.

As might be expected, the energy industries (including wholesale trade that delivers bulk petroleum products) incur overall losses in jobs, compensation, and GSP. But this result must be tempered somewhat as the industries themselves are undergoing internal restructuring. For example, as the electric utilities engage in more energy efficiency services and other alternative energy investment activities, they will undoubtedly employ more people from the business services and engineering sectors. Hence the negative employment impacts should not necessarily be seen as job losses; rather they might be more appropriately seen as a redistribution of jobs in the overall economy and future occupational tradeoffs.

Explained differently, while the electric utilities may lose an estimated 20,221 traditional jobs (New York would lose 9,504, New Jersey would lose 4,360, and Pennsylvania would lose 6,357) due to selling less energy, they could gain many of those jobs back if they move ag-

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expenditures within the combined Mid-Atlantic economy. Visitor expenditures are based on data provided by Ruth Nadler at the New York City Convention and Visitor Bureau, Research Office. Ms. Nadler can be reached at (212) 484-1221.

67. The unemployment statistcs for November 1996 (the most recent available) were downloaded from the U.S. Department of Labor Bulletin Board, at http://stats.bls.gov/cgi-bin on January 22, 1997.

68. *BEA Regional Economic Projections*, op. cit. New York's total non-farm labor force in 2010 is estimated to be 10.6 million, New Jersey's is estimated to be 5.1 million, and Pennsylvania's is estimated to be 7.3 million.

Table 10. Energy Efficiency Impacts in New York by Sector in 2010

Sectors	Jobs	Compensation	GSP
Services	41,279	$1,183	$1,745
Retail Trade	16,269	$369	$584
Government	13,690	$554	$557
Construction	5,616	$185	$335
Education	3,161	$112	$112
Finance	2,766	$301	$442
Other Manufacturing	2,429	$147	$279
Motor Vehicles	2,260	$240	$336
Insurance and Real Estate	1,308	$70	$423
Agriculture	1,083	$15	$32
Transportation, Communication, and Utilities	836	$57	$101
Metal Durables	756	$82	$136
Food Processing	477	$27	$64
Pulp and Paper	240	$15	$26
Stone, Glass, and Clay	233	$15	$25
Primary Metals	184	$15	$23
Other Mining	114	$8	$22
Refining	8	$1	$4
Coal Mining	0	$0	$0
Oil/Gas Mining	(590)	($36)	($53)
Wholesale Trade	(933)	($18)	($75)
Natural Gas Utilities	(4,223)	($499)	($1,254)
Electric Utilities	(9,504)	($1,049)	($3,457)
Total	77,457	$1,796	$407

Notes: The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the alternative energy scenario. Jobs refer to the net jobs created or lost in each sector. Compensation refers to the net gain in wage and salary income by sector. GSP refers to the net gain or loss in New York's Gross State Product created in each sector. All dollar values are in millions of 1993 dollars.

Table 11. Energy Efficiency Impacts in New Jersey by Sector in 2010

Sectors	Jobs	Compensation	GSP
Services	17,559	$533	$760
Retail Trade	6,558	$163	$241
Government	5,725	$221	$240
Construction	3,552	$123	$234
Finance	2,434	$143	$184
Education	978	$40	$40
Motor Vehicles	818	$82	$138
Other Manufacturing	788	$57	$118
Insurance and Real Estate	587	$28	$145
Transportation, Communication, and Utilities	335	$25	$45
Agriculture	269	$4	$10
Metal Durables	234	$25	$39
Food Processing	151	$10	$22
Stone, Glass, and Clay	88	$6	$8
Pulp and Paper	64	$4	$8
Primary Metals	54	$5	$7
Other Mining	17	$1	$4
Refining	4	$1	$2
Coal Mining	0	$0	$0
Oil/Gas Mining	(148)	$0	($8)
Wholesale Trade	(274)	($17)	($25)
Natural Gas Utilities	(1,850)	($205)	($503)
Electric Utilities	(4,360)	($499)	($1,634)
Total	33,582	$749	$74

Notes: The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the alternative energy scenario. Jobs refer to the net jobs created or lost in each sector. Compensation refers to the net gain in wage and salary income by sector. GSP refers to the net gain or loss in New Jersey's Gross State Product created in each sector. All dollar values are in millions of 1993 dollars.

Table 12. Energy Efficiency Impacts in Pennsylvania by Sector in 2010

Sectors	Jobs	Compensation	GSP
Services	28,194	$697	$955
Retail Trade	8,745	$164	$258
Construction	6,344	$165	$324
Government	6,193	$212	$224
Finance	3,161	$152	$221
Other Manufacturing	2,378	$121	$217
Education	1,806	$60	$60
Motor Vehicles	1,747	$137	$229
Insurance, Real Estate	1,036	$44	$242
Agriculture	951	$9	$29
Metal Durables	729	$69	$101
Transportation and Utilities	673	$40	$69
Food Processing	572	$27	$54
Primary Metals	529	$47	$68
Stone, Glass, and Clay	308	$20	$32
Coal Mining	218	$28	$48
Pulp and Paper	208	$14	$26
Other Mining	121	$7	$22
Refining	26	$3	$10
Oil/Gas Mining	(282)	($6)	($24)
Wholesale Trade	(610)	($30)	($45)
Natural Gas Utilities	(3,409)	($323)	($762)
Electric Utilities	(6,357)	($706)	($2,228)
Total	53,280	$950	$132

Notes: The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the alternative energy scenario. Jobs refer to the net jobs created or lost in each sector. Compensation refers to the net gain in wage and salary income by sector. GSP refers to the net gain or loss in Pennsylvania's Gross State Product created in each sector. All dollar values are in millions of 1993 dollars.

Table 13. Energy Efficiency Impacts in the Mid-Atlantic Region by Sector in 2010

Sectors	Jobs	Compensation	GSP
Services	87,032	$2,412	$3,459
Retail Trade	31,572	$696	$1,083
Government	25,607	$986	$1,021
Construction	15,512	$472	$893
Finance	8,360	$596	$847
Education	5,945	$212	$212
Other Manufacturing	5,595	$325	$615
Motor Vehicles	4,824	$459	$703
Insurance and Real Estate	2,931	$142	$810
Agriculture	2,302	$29	$71
Transportation, Communication, and Utilities	1,844	$122	$215
Metal Durables	1,719	$176	$276
Food Processing	1,200	$63	$140
Primary Metals	767	$67	$98
Stone, Glass, and Clay	629	$41	$66
Pulp and Paper	513	$34	$59
Other Mining	252	$16	$48
Coal Mining	218	$28	$48
Refining	38	$5	$16
Oil/Gas Mining	(1,020)	($42)	($84)
Wholesale Trade	(1,817)	($65)	($144)
Natural Gas Utilities	(9,483)	($1,026)	($2,519)
Electric Utilities	(20,220)	($2,254)	($7,319)
Total	164,319	$3,495	$613

Notes: The Mid-Atlantic region includes New York, New Jersey, and Pennsylvania. The numbers in parentheses reflect losses that are projected to occur in that sector as a result of the alternative energy scenario. Jobs refer to the net jobs created or lost in each sector. Compensation refers to the net gain in wage and salary income by sector. GSP refers to the net gain or loss in the states' combined Gross State Product created in each sector. All dollar values are in millions of 1993 dollars.

gressively 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 they 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 an energy supplier.[69]

Tables 10 through 13 show four big "winners" under the alternative energy scenario. These are the service sectors (41,299 jobs in New York, 17,559 in New Jersey, and 28,194 in Pennsylvania), retail trade (16,269 jobs in New York, 6,558 in New Jersey, and 8,745 in Pennsylvania), government (13,690 jobs in New York, 5,725 in New Jersey, and 6,193 in Pennsylvania), and construction (5,616 jobs in New York, 3,552 in New Jersey, and 6,344 in Pennsylvania). Retail trade and the service sectors are winners largely for two reasons. First, they benefit from the actual investments in energy efficiency programs and technologies made in the year 2010. Second, they benefit from the higher level of goods and services sold in each state as ratepayers and businesses respend their energy 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 respend their energy bill savings. Alternately, if the government were to use these revenues to cut other taxes, the additional jobs would be created as consumers spend their tax savings on a variety of goods and services.

The construction sector is a winner primarily because it is the industry that benefits most directly as special trade contractors and others are hired to install the new technologies and make the requisite efficiency upgrades. The construction sector alone pulls in about 9.4 percent of the net job increases in the year 2010. Using the construction industry as a benchmark for evaluation, it might be noted that about 1 out of 11 net job impacts in 2010 are from the efficiency investments made in that year. The remaining impacts are the result of respending the energy bill savings by ratepayers and businesses.

B. Electricity-Only Scenario

This section reviews the impacts of energy efficiency investments made only to reduce electricity use within the Mid-Atlantic region. In the high-efficiency scenario, electricity use in 2010 drops 33 percent relative to electricity use that year in the baseline scenario. The cumulative investment in energy efficiency measures during 1997 through 2010 is estimated

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69. The unemployment statistics for November 1996 (the most recent available) were downloaded from the U.S. Department of Labor Bulletin Board, at http://stats.bls. gov/cgi-bin on January 22, 1997.

at $27.1 billion while energy bill savings reach $78.8 billion in that same period of time. Table 14 summarizes the results for the same five-year periods as in the total efficiency scenario.

Perhaps the most interesting result is the drop in GSP for each of the states and the region as a whole for each year that is reviewed. This reflects the capital-intensive nature of the electric utility industry, which requires over $3.00 in total assets for each dollar of revenues generated by the utility. This is almost three times more than Fortune 500 companies, which, on average, require just over one dollar in assets for each dollar of revenue.[70] As the revenues of electric utilities decrease under an accelerated energy efficiency scenario, the amount of capital investment also decreases (i.e., fewer new power plants are built). This, in turn, lowers the overall value-added and GSP for the respective states and the region as a whole.

On the other hand, the wage and salary compensation share of GSP actually increases in all three periods evaluated here. This is for two reasons. First, new electric plants are displaced by more cost-effective efficiency investments that are also more labor intensive. Second, the respending of energy bill savings is used for consumer and business purchases that are also more labor intensive.

As a result of this change in the economic mix, net employment rises. We might note, for example, that while electricity efficiency investments account for about 40 percent of the total regional investment in energy efficiency (as shown in Table 1), by the year 2010, electricity efficiency improvements account for 63 percent of the net employment benefits. The latter is shown by comparing the results in Tables 9 and 14.

As might be expected, the traditional electric utilities sector would lose the most jobs, similar to the results from the total efficiency scenario noted earlier. The loss of jobs assumes a traditional economic structure for electric utilities in 2010. Thus, as fewer conventional power plants are needed as a result of efficiency gains, fewer traditional utility jobs are sustained. Once again, this points to an important opportunity for utilities: if utilities become more proactive in the area of energy efficiency services and other similar programs, they could take on new employees to carry out these new responsibilities. One might assume, therefore, that utilities could incorporate at least part of the jobs gained in the construction and service sectors.

It should also be remembered that these estimates are not job losses in the strict sense of the word. Rather, they reflect differences between a business-as-usual (baseline) projection of

70. See *Financial Statistics of Major U.S. Investor-Owned Electric Utilities 1994*, DOE/EIA-0437(97)/1, Energy Information Administration, U.S. Department of Energy, Washington, DC, 1995; and "A Review of This Year's Fortune 500," *Fortune*, April 18, 1994.

future employment and jobs made available from an accelerated energy efficiency scenario. In the aggregate, there is a significant positive gain in both employment and wage and salary compensation, and a drop in the unemployment rate.

Table 14. Impact of the Energy Efficiency Scenario — Electricity Only

Year	Change in Gross State Product (Million$)	Change in Wage and Salary Compensation (Million$)	Net Jobs Gain
New York			
2000	($264)	$86	6,600
2005	($387)	$461	26,200
2010	($547)	$909	49,300
New Jersey			
2000	($137)	$42	3,400
2005	($203)	$224	12,500
2010	($302)	$437	23,300
Pennsylvania			
2000	($191)	$7	3,500
2005	($313)	$159	14,600
2010	($478)	$340	28,000
Region Total			
2000	($592)	$135	13,500
2005	($903)	$844	53,300
2010	($1,327)	$1,686	100,600

Notes: Dollar figures are in millions of 1993 dollars while employment reflects the actual job total. The implied benefit-cost ratio across the 14-year period is 2.91. The calculations are based upon a working analysis by Economic Research Associates, July 1996. They assume a 33 percent reduction in electricity use over the year 2010 forecasted values and a displacement of conventional electric-generating resources by the use of energy efficiency technologies. Totals may not equal the sum of components (as shown) due to independent rounding.

C. Air Quality Impacts

One of the benefits of the high-efficiency scenario will be the impacts on pollutant emissions and air quality in the Mid-Atlantic Region. This positive impact is the direct result of the reduced burning of fossil fuels associated with improving the efficiency of energy consumption. The following analysis was undertaken to approximate carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxide (NO_x) emission savings associated with the efficiency scenario. It is not meant to represent a comprehensive analysis of the emission reductions but rather to identify the magnitude of emission savings available and provide a reasonable estimate. To accomplish this task the analysis incorporates average marginal emission coefficients (by fuel type) adapted for the region from a number of sources.[71]

As Table 15 shows, projected energy savings from implementation of the high-efficiency scenario, described earlier, suggest that carbon dioxide emissions would be reduced by about 161 million short tons in the region by the year 2010. Just over one third (36 percent) of these would be emissions from reduced electricity consumption. These savings represent a reduction of 24 percent over the baseline regional scenario for 2010. These same savings will reduce the total amount of carbon emissions necessary to meet national carbon stabilization goals by 12.6 percent.[72]

The high-efficiency scenario will also reduce emissions of sulfur dioxide by 176 thousand short tons and nitrogen oxides (NO_x) by 227 thousand short tons. Once again, electricity savings account for a significant percentage of the total savings, 83 percent of the SO_2 and 39 percent of the NO_x emissions. These savings also represent a significant reduction over baseline emissions for 2010. In addition to these emission savings, the high-efficiency scenario will contribute to significant reductions in other pollutants such as carbon monoxide, particulates, and other toxic substances.

71. Emission coefficients for the respective fuel types and end-use sectors are adapted from data provided by D. Oppenheimer, MSB Energy Associates, in October 1996, to reflect estimated 2010 technologies based on values contained in *America's Energy Choices, Technical Appendixes*, op. cit. The emission estimates are based on the use of fuel-specific coefficients that are multiplied by each of the major fuels consumed in each of the end-use sectors reviewed in this study. The emission coefficients are average coefficients, across all hours of the year, and do not differentiate by time of day or season.

72. According to the Climate Change Action Plan (CCAP) 1994, developed by the Clinton administration, the national goal is to stabilize carbon emissions at 1990 levels. For energy-related emissions this is 1,344 million metric tons (MMT). (See *Emission of Greenhouse Gases in the United States 1987-1994*, Energy Information Administration, U.S. Department of Energy, Washington, DC, 1995.) According to the *Annual Energy Outlook 1996*, op cit., carbon emissions in 2010 are projected to be 1,660 MMT. To meet the 1990 CCAP stabilization goals carbon emissions will need to be reduced by 316 MMT. Converting the 161 million short tons of carbon dioxide emission savings (from the high-efficiency scenario) to carbon equivalent equals 40 MMT. These savings, then, represent 12.6 percent of the total needed (40 / 316 = 12.6 percent).

Table 15. Avoided Air Emissions in 2010 (In Thousand Short Tons)

	SO_2	NO_x	CO_2
Total Savings			
New York	74	99	69,119
New Jersey	36	47	33,001
Pennsylvania	66	81	58,636
Region	176	227	160,756
Electricity Only Savings			
New York	62	38	24,485
New Jersey	31	19	12,219
Pennsylvania	53	33	21,216
Region	146	89	57,920

Note: Emission reductions are derived from energy saving in the residential, commercial, industrial, and transportation sectors from implementation of the high-efficiency scenario.

VII. POLICY REVIEW AND RECOMMENDATIONS

The Mid-Atlantic region has already made significant progress in improving energy efficiency. From 1973 to 1983, energy use in the residential and commercial sectors declined 11 percent, despite increases in the number of homes, commercial building floor area, and GSP during this period.[73] More recently energy use has grown only modestly — an average of 1.3 percent per year.

New York State has been particularly active in promoting energy efficiency, including being among the national leaders in developing and running utility demand-side management (DSM) programs, developing and adopting statewide building energy codes and appliance efficiency standards, and establishing a research and development authority to promote the development and demonstration of energy efficiency and renewable energy technologies in the state.

New Jersey has also taken significant initiatives to promote energy efficiency, including developing some of the nation's earliest utility DSM programs in 1983 in order to help make up for generating capacity lost as a result of the accident at Three Mile Island. These utility programs gradually withered but then were revived following the Board of Public Utilities 1991 decision to provide utilities with a profit incentive for successful implementation of DSM programs.

In Pennsylvania, activities to promote energy savings have been limited but have included such steps as adoption in 1980 of a statewide building energy code and an early 1990s PUC order encouraging utilities to increase their DSM activities. Unfortunately, due to court challenges, this order has never really been implemented.

However, despite all that has been done in the region, as shown in Section III, the potential for additional cost-effective energy savings is very large. This section explores how to capture much of this potential by reviewing existing policies and programs that support energy efficiency improvements in the Mid-Atlantic region, and then recommending new and expanded initiatives in six policy areas that would lead to greater adoption of cost-effective energy-saving measures.

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73. *State Energy Data Report 1993,* op. cit.

A. UTILITY ENERGY EFFICIENCY PROGRAMS

Recent and Current Situations

Utility energy efficiency programs have played a role in all three Mid-Atlantic states, with the level of effort periodically rising and falling in reaction to a variety of factors. Expenditures and savings by utility for recent years are summarized in Table 16. As noted above, significant utility energy efficiency programs began in 1983 when General Public Utilities (the parent company of Jersey Central, Metropolitan Edison [Pennsylvania], and Pennsylvania Electric Company), offered a series of programs to help reduce power demand and energy bills following the accident at Three Mile Island. These programs were gradually scaled back until only limited activities remained.

In the late 1980s, New York utilities began to offer substantial energy efficiency programs, driven by a series of decisions by the Public Service Commission that first asked utilities to experiment with DSM programs and then ultimately asked utilities to try to meet the State Energy Plan goal of DSM savings totaling 8 percent of electricity use and 10 percent of peak demand by 2000. In 1992-93, the peak years for New York DSM programs, New York utilities spent nearly $300 million annually and achieved incremental energy savings of approximately 1,300 GWh each year. In 1994-96, many utilities significantly scaled back their energy efficiency efforts (see Table 16), driven by concerns about utility industry restructuring as well as financial difficulties at two of the state's largest utilities. As a result, statewide utility efficiency spending dropped to $106 million in 1995 and probably lower in 1996 (final spending figures are not yet available). Thus, over the 1993-1996 period, DSM spending in New York has declined by approximately two-thirds. The one partial exception has been Consolidated Edison, which in 1996 maintained a DSM budget of approximately $60 million, approximately two-thirds of the statewide total. Overall, New York utilities were estimating that their energy efficiency programs were saving 4,239 GWh in 1995, including measures installed throughout the 1988-1995 period.[74] This amounts to about 3.2 percent of 1995 electricity use in the state and is substantially above the national average as of 1994 of approximately 1.8 percent savings.[75]

In New Jersey, in 1991 the Board of Public Utilities (BPU) decided that utility DSM efforts should be expanded, and it implemented new rules designed to improve the financial impact of DSM programs on utility profits including providing utilities with a small portion of the net benefits actually achieved with DSM programs and recovery of the contribution to fixed costs

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74. *Final Environmental Impact Statement on Competition in the Electric Utility Industry*, New York Department of Public Service, Albany, NY, 1996.

75. *U.S. Electric Utility Demand-Side Management 1994*, Energy Information Administration, U.S. Dept. of Energy, Washington, DC, 1995.

Table 16. Historical DSM Program Costs and Savings.

Utility	DSM Expenditures (1000 $)			DSM Savings (GWh)		
	1993	1994	1995	1993	1994	1995
New Jersey:						
Atlantic Electric	10,397	10,397	7,546	65	65	59
Jersey Central P&L	13,685	29,325	29,325	106	118	160
Public Service E&G	50,200	42,775	60,674	57	144	428
Subtotal	74,282	82,497	97,545	228	327	647
New York:						
Central Hudson E&G	5,011	3,331	4,300	97	119	156
Consolidated Edison	125,073	99,358	57,500	498	1624	1878
Long Island Lighting	33,441	19,827	11,800	580	698	761
NY State E&G	47,690	14,369	11,900	695	537	593
Niagara Mohawk	42,105	41,429	8,100	737	962	1197
Orange & Rockland	22,077	13,432	6,900	167	194	234
Power Authority of NY	10,315	6,825	10,400	81	138	196
Rochester G&E	10,087	8,498	6,000	183	204	238
Subtotal	295,799	207,069	116,900	3,038	4,476	5,253
Pennsylvania:						
Metropolitan Edison	4,461	4,155	4,410	81	82	86
Penn. Electric	3,376	4,270	4,496	75	41	11
Penn. P&L	13,050	13,301	12,531	29	25	26
PECO Energy	10,606	9,582	9,379	60	68	68
Subtotal	31,493	31,308	30,816	245	216	191
Regional total	401,574	320,874	245,261	3,511	5,019	6,091

Notes:

* DSM savings generally include savings in the current year attributable to programs operated in previous years. For a few utilities, this line may only include savings from current year programs.

* For New York utilities except NYPA, 1995 figures are from year-end compilations; for other states and NYPA, 1995 figures were estimated by utilities in the spring of 1995.

Source: *U.S. Electric Utility Demand-Side Management*, DOE/EIA-0589(94), Energy Information Administration, U.S. Department of Energy, Washington, DC, 1994. New York data for 1995 from *Summary of New York State DSM Costs and Impacts*, NY Public Service Commission, 1997.

that utilities would have collected had the energy been sold instead of saved. As a result, utility combined budgets for DSM increased from approximately $40 million in 1991[76] to over $80 million in 1994. In 1995-1996, some New Jersey utilities reduced or attempted to reduce DSM expenditures as part of cost-cutting efforts to prepare for utility industry restructuring. An exception was Public Service Electric & Gas, which entered into a partnership with major consumer and environmental groups in the state and has been expanding the number of DSM programs it offers. In March 1996, the BPU rejected Jersey Central's plan to eliminate rebates from its DSM programs, and in November 1996, Atlantic Electric agreed to work with consumer and environmental groups on additions to its DSM portfolio. In total, in 1995 New Jersey utilities saved approximately 600 GWh of electricity, approximately 0.9 percent of electricity sales in that year and half the average among U.S. states.

Pennsylvania also took some steps in the early 1990s to augment utility energy efficiency programs, although these steps were not successful in expanding programs or achieving substantial energy savings. In 1993, the PUC issued an order that allowed utilities to recover their direct DSM costs and a portion of the revenues lost from saving rather than selling energy, and provided utilities with a small profit incentive (a small share of the net benefits achieved by their programs) for successful implementation of DSM programs. However, a consortium of large industrial customers along with the state's Office of Consumer Advocate challenged the rule in the courts, and after a lengthy process, in February 1996 the state Supreme Court reaffirmed direct DSM cost recovery and the profit incentive, but remanded lost revenue recovery to the PUC. Throughout this long court proceeding, Pennsylvania DSM programs have largely remained at early 1990's levels — a combined total of about $30 million per year for all utilities, primarily to fund information programs and programs providing energy efficiency services to low-income households.[77] Total DSM savings in Pennsylvania are the lowest of the Mid-Atlantic states — on the order of 200 GWh in 1995, just 0.2 percent of statewide electricity use.

In all three Mid-Atlantic states, restructuring of the electric industry is receiving a great deal of attention. Restructuring legislation was adopted in Pennsylvania in November 1996. In July 1996 the PUC issued a report outlining how they would like to see restructuring proceed. The Governor then made passage of restructuring a high priority for 1996. Intensive negotiations over the legislation took place in the fall of 1996, resulting in agreement among the PUC, electric utilities, state government agencies, and large industrial customers. Under the legislation, retail customer choice would be phased in over the 1999-2001 period. To address large investments made by utilities in power plants that are no longer economically sound, the state will guarantee new utility bonds to refinance the debt on these plants, lowering interest

76. *New Jersey Energy Master Plan, Phase I Report*, New Jersey Board of Public Utilities, Newark, NJ, 1995.

77. A. Barak, Pennsylvania Energy Project, personal communication, October 1996.

rates. The bill did nothing to fund energy efficiency programs but does include energy efficiency as one of a permitted list of services to included in a "universal service charge" to fund services for low-income customers.[78] This lack of energy efficiency programs for residential and small commercial/industrial customers is a major shortcoming, and if not rectified, will continue to make Pennsylvania place last in DSM programs in the Mid-Atlantic region. Rules implementing the new legislation are now being developed.

In New York, in May 1996 the Public Service Commission (PSC) issued a decision that calls for all retail customers to be able to choose their electricity supplier by early 1998. The decision also made a commitment to continue energy efficiency and other "environmental and public policy" programs (e.g., research and development, environmental, and low-income programs) at approximately current levels. Details will be worked out through further proceedings in 1996-97 and restructuring legislation that is likely to be considered by the legislature in 1997.[79]

In New Jersey, the BPU staff, utilities, and other interested parties have been working actively to develop a restructuring proposal, and a "strawman proposal for discussion purposes" was released in August 1996. After extensive discussions among interested parties, the BPU issued a draft decision in January 1997 as part of its Energy Master Plan Phase 2 effort. This decision calls for gradually phasing in customer choice over a 2.5-year period and includes a surcharge on electric bills to fund social protection programs (e.g., a moratorium during the winter months on shutting customers off for non-payment) and energy efficiency programs. The draft plan refers some issues to the legislature for legislative action.[80]

Recommendations

In this climate, it is clear that the future of utility energy efficiency programs is tied to decisions on how to restructure the utility industry, and that critical decisions will be made in 1997 that will affect utility energy efficiency programs for many years to come. In the context of these discussions, we make three recommendations:

1. Establish a "systems benefits charge" to fund energy efficiency and other public benefit programs (e.g., research and development — R&D — and low-income

78. B. Fernandez, "Pennsylvania Officials Devise Bill to Dismantle Electric Monopolies," *Philadelphia Inquirer*, Nov. 4, 1996; A. Barak, Pennsylvania Energy Project, personal communication, January 1997.

79. D. Wooley and A. Gupta, "Memorandum re: NY PSC Decision — Electric Industry Restructuring," Energy Project, Pace University School of Law, White Plains, NY, May 21, 1996.

80. *Restructuring the Electric Power Industry in New Jersey, Proposed Findings and Recommendations*, Docket EX94120585Y, New Jersey Board of Public Utilities, Trenton, NJ, January 16, 1997.

energy services) at historic levels in New York and New Jersey. Expand the limited program in Pennsylvania to include energy efficiency programs and R&D.

2. In regulating prices for distribution services (which will remain regulated monopolies), decouple transmission company profits from the level of sales.

3. For distribution companies, require periodic preparation of simplified, integrated resource plans that identify a least-cost mix of distribution upgrades, energy efficiency investments, and other resource procurements.

Each of these recommendations are discussed in the sections below.

Adopt a Systems Benefits Charge

A systems benefit charge is part of the New York PSC and New Jersey BPU decisions. There is even a truncated version of such a mechanism in the Pennsylvania universal service charge for low-income energy services. As the NewYork PSC decision notes, energy efficiency and other public benefit programs are needed "in the interest of lowering consumer bills, mitigating pollution and promoting economic development." While a private competitive market can be expected to provide some of these services, a systems benefit charge is needed "for public policy initiatives that are not expected to be adequately addressed by competitive markets."[81]

Efficiency investments are unlikely to be adequately addressed by competitive markets because of a number of barriers in these markets — barriers that public benefit programs can address. Among these barriers are:

- "Third-party decision makers" such as landlords and builders who purchase energy consuming equipment but have little incentive to purchase efficient equipment because tenants and home buyers pay the energy bills

- "Panic purchases" that occur when critical equipment such as a refrigerator or water heater fails and there is no time to conduct research on product efficiency or to backorder a more efficient model that is not readily available.

- Poorly informed consumers who lack the information to make informed decisions regarding product efficiency and who often lack the time to obtain this information.

81. Wooley and Gupta, op cit.

- High transaction costs in the private energy services industry, which make it difficult to serve small customers profitably.

Due to problems such as these, market-based efficiency investments have been very limited in Great Britain and Norway, the first two countries to restructure their electric industries.[82]

While the New York decision embraces the idea of a systems benefit charge, it only includes "current" funding levels, which for energy efficiency programs appears to mean the $106 million spent in 1995, after two years of utility budget cutting that reduced DSM spending by more than 60 percent . The New York plan calls for revisiting the use of a systems benefit charge "after retail competition has commenced to determine whether the level of these programs is sufficient and whether the continued use of a systems benefit charge is required." Similarly, the New Jersey plan calls for funding current programs during a transition period to full competition and possibly for longer. Based on the opportunities for cost-effective electricity-saving investments discussed in Section III, which called for annual investments of $786 million in New York, $442 million in New Jersey, and $707 million in Pennsylvania, we recommend that systems benefit charge funding for energy efficiency programs be set at approximately one-third of these levels, assuming an average 2:1 match between private and public benefit funds. Thus, the ideal public benefit energy efficiency fund would be approximately $260 million in New York, $150 million in New Jersey, and $240 million in Pennsylvania. These levels are broadly in line with the peak (1993) spending levels in New York and are a moderate increase above peak spending levels in New Jersey. In Pennsylvania, since utility energy efficiency programs are currently very limited, a systems benefit charge should be set at least at the historic level of DSM programs in the other Mid-Atlantic states (approximately $0.002 per kWh). Such action could perhaps be taken as part of future utility commission proceedings on how to regulate distribution companies following restructuring.

However, while establishing an appropriate funding level is important, what is equally critical is that these funds be spent in ways that complement efficiency investments in the private market and that maximize energy savings. Towards these ends, priority uses for systems benefit charge funds should include:

- "Market transformation" programs that seek to permanently change markets so that efficient goods and services become normal practice by identifying the barriers inhibiting specific energy-efficient goods and services, and through a multi-pronged

82. S. Nadel, *The Impact of Energy Sector Restructuring on Energy Consumptin and the Environment: International Experiences*, American Council for an Energy-Efficient Economy, Washington, DC, 1996.

approach work in the market to overcome these barriers.[83] Such programs can result in very large energy savings (because ultimately participation levels approach 100 percent) at very modest cost per unit of energy saved.[84, 85]

- "Lost opportunity" programs that seek to influence equipment purchase decisions that are happening in the market (e.g., for new construction or to replace failed equipment) so that energy savings can be purchased for the incremental cost of efficient equipment relative to standard-efficiency equipment. If standard-efficiency equipment is purchased, the opportunity to save energy is lost for the many years that will elapse before the equipment or building is again replaced. These programs can be important components in larger market transformation initiatives.

- Programs for low-income households, which seek to lower energy bills for those least able to pay their bills and also those least likely to be attractive to private-market efficiency service providers.

- Energy service-industry programs to help the private energy-services industry to serve new markets (e.g., expand beyond their traditional focus on large institutional and commercial customers), thereby possibly reducing the need for publicly funded energy efficiency programs in the future. These programs should be modeled after market transformation programs in that they should identify and try to overcome the barriers standing between the energy-services industry and promising markets.

- Financing programs so that homeowners and small businesses can borrow money for energy-saving improvements at reduced interest rates. Capital can be provided by banks and other financiers; public benefit funds should be used to buy-down interest rates and to fund marketing and technical assistance efforts.

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83. In the Mid-Atlantic area, several utilities have begun work on market transformation national programs that are trying to transform the residential and commercial air conditioning markets to higher levels of efficiency. Also, Public Service Electric and Gas is developing a program to transform air conditioner installation practices so that units are properly installed and do not needlessly waste energy due to improper maintenance.

84. For example, a review of four different largely successful market transformation efforts found that program costs in all cases are less than $0.01/kWh saved in the long-run. S. Nadel, *Providing Utility Energy Efficiency Services in an Era of Tight Budgets: Maximizing Long-Term Energy Savings While Minimizing Utility Costs*, American Council for an Energy-Efficient Economy, Washington, DC, 1996.

85. A new organization, the Northeast Energy Efficiency Partnership (NEEP), has recently been formed to foster the development of market transformation programs in the Mid-Atlantic and New England regions (NEEP, 3 Dana Court, Lexington, MA, 617-860-9177).

Several Mid-Atlantic utilities have been active in these areas. The New York Power Authority has spearheaded the development and operation of a market transformation program to increase the efficiency of small refrigerators used in apartments. The Long Island Lighting Company helped develop a somewhat similar program for larger refrigerators, although in recent years the company has been much less active. Public Service Electric & Gas (PSE&G) is just beginning a market transformation program to improve installation practices for residential air conditioners. In the new construction field, Consolidated Edison has a very effective program, the Commercial and Industrial New Construction Design Assistance Program, for improving the efficiency of new commercial buildings. PSE&G is now redesigning their Energy-Efficient Home Program to be more effective. Other notable lost-opportunity programs include efforts by Jersey Central to improve the efficiency of new residential and commercial air conditioners, PSE&G's similar program for residential air conditioners, Con Edison's programs for residential refrigerators and air conditioners, and commercial lighting, and PSE&G's new program that promotes premium-efficiency electric motors. Among programs for low-income households, PSE&G's newly developed E-Team program appears to be well designed and likely to be successful. PSE&G has also been a leader in fostering the private energy-services industry through their "standard offer" program.[86]

To ensure that the public interest is served, any administrative mechanism employed for public benefit programs should be independent from market competitors and should include the following features:

- **Open and integrated planning** that invites input regarding goals, objectives, and alternative approaches from all affected sectors and stakeholders.

- **Competitive selection of program implementors and programs** on the basis of best ideas and experience, as judged by evaluation panels that include experts external to any organization involved in program planning and administration.

- **Extensive use of pilot programs** to try out new and innovative program concepts.

- **Timely and efficient delivery of program services** that includes streamlined contracting, low administrative overhead, and timely delivery of services.

- **Program review and evaluation:** Administering organizations should invite periodic evaluation of their projects and overall program performance by outside experts who provide multiple perspectives. As the competitive market evolves, the review process

86. A. Gupta, Natural Resources Defense Council, New York, NY, and S. Coakley, Northeast Energy Efficiency Partnerships, Lexington, MA, personal communications, January 1997.

will help to ensure that existing programs are discontinued if market forces adequately address their markets and that new public benefit program gaps are covered if they develop.

Decouple Distribution Company Profits from Sales

In all three states, utility commissions are proposing to largely deregulate the generation side of the utility business, but local distribution services will remain regulated monopolies because it does not make sense to construct competing sets of electric wires to each individual customer. Under this scheme, utility commissions will still regulate the price of local distribution services. In all three states there is discussion of using "price cap" regulation, in which maximum prices are set by the commission based primarily on traditional cost of service regulatory principles and then distribution companies have the flexibility to develop a set of tariffs, provided each is below the price cap. The advantage of this system is it gives distribution companies increased flexibility to develop creative pricing schemes and it encourages management efficiency because cost reductions below the traditional cost of service largely accrue to shareholders (although under most price cap schemes, a portion of these cost reductions also benefit ratepayers). The disadvantage of straight price cap regulation is that it also encourages distribution companies to increase sales because increased sales increase revenues, and while some of these additional revenues are needed to cover the costs of serving additional load, much of these additional revenues are pure profit.[87] Likewise, pure price cap regulation discourages energy efficiency investments because these investments reduce sales and profits.

To remedy this situation, price cap regulation needs to be modified so that, at the end of the year, actual sales levels and forecasted sales levels used to develop the price cap are compared, and, if actual sales are greater than forecasted sales, the fixed cost portion of these excess sales are refunded to customers. Conversely, if actual sales are less than forecast, the fixed cost portion of below forecast sales are charged to customers. Such a system is included in a recent settlement agreement in Oregon between PacifiCorp and intervenors.[88] Similar approaches have been proposed in New York in a proceeding involving Niagara Mohawk Power Corp.[89]

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87. A portion of the additional revenues are profit because the price cap includes the marginal cost of serving each increment of load (which for distribution services are very low), as well as fixed costs (which for distribution services are relatively high) divided by expected sales. However, for each increment of sales beyond the forecasted sales level, the fixed cost portion of the price cap is pure profit.

88. "Oregon Alternative Regulation Settlement Proposal," Joint Parties, filing to Oregon Public Utilities Commission, Portland, OR, October 1996,

89. P. Centollela, "Testimony of Paul Centollela in Case 94-E-0098 — Proceeding on Motion of the Commission as to Rates, Charges, Rules and Regulations of Niagara Mohawk Power Corporation," NYPSC, Albany, NY, 1996.

Adopt Distributed Utility Planning for Distribution Companies

In the age of vertically integrated monopoly utilities, integrated resource planning (IRP) was a planning technique in which a wide array of possible investments for meeting future load growth were examined and an optimum mix selected that minimized cost while providing good levels of reliability. In recent years, IRP has been extensively used by utilities to determine optimum new investments in generation, transmission, distribution, and DSM resources. With the restructuring of the utility industry, distribution companies will be primarily concerned with only distribution investments. In addition, distribution companies may be the electricity supplier of last resort for customers who do not choose an alternative supplier. For these generation services, distribution companies will contract for power purchases from generation companies.

However, in some cases, energy efficiency investments can be a lower cost alternative than investments in new distribution lines because efficiency induced load reductions can postpone the need to reinforce the distribution system in areas where growing loads threaten to make existing distribution capacity inadequate. For example, Con Ed and Rochester Gas & Electric have both targeted some of their energy efficiency programs in this manner. Similarly, energy efficiency investments that reduce loads can be an alternative to increased power purchases made by distribution companies to serve customers who elect not to choose alternative power providers.

Back when utilities provided generation, transmission, and distribution services, IRPs were large and complex undertakings. With planning limited to distribution upgrades and power purchases, planning processes can be significantly simplified. For example, instead of screening a wide array of potential generation resources, prices in the futures market can be used. Instead of planning for 20 year time horizons typical for generation, much shorter (5 to 10-year) time horizons used for distribution and power purchase planning can be used. In these ways, a distributed utility planning requirement can serve a useful purpose — optimization of investments — without becoming a major burden. The New Jersey BPU plan includes a proposal to modify existing regulations to provide for a biannual filing by each electric utility of a "comprehensive resource analysis" that determines the appropriate level of energy efficiency and renewable energy programs. It is unclear whether these analyses will examine the opportunity for using these resources for deferring distribution investments.

B. Building Codes

Current Situation

Building energy codes are an effective and widely used strategy for ensuring that new buildings are relatively efficient. The Energy Policy Act of 1992 (EPAct) requires state building energy codes to meet or exceed the ASHRAE[90] 90.1 model standard for new commercial buildings. EPAct also requires states to consider meeting or exceeding the CABO[91] Model Energy Code (MEC) for new residential buildings (but states can choose whether or not to adopt the CABO code or its equivalent).

At this time, only New York is basically in compliance with the EPAct directives. New York has developed its own residential and commercial building energy codes, codes that were most recently updated in 1991, and these codes have been determined by the U.S. Department of Energy to be on average equivalent to ASHRAE 90.1 and the CABO MEC. However, for many building types, the New York code is less stringent than these model codes.

In New Jersey, the Department of Community Affairs is now considering whether to adopt the 1996 BOCA[92] National Building Code, a code that incorporates both the ASHRAE 90.1 and CABO MEC codes. While New Jersey has already adopted ASHRAE 90.1, adoption of the latest BOCA code would bring New Jersey's residential energy code up-to-date. In early 1997 the Department of Community Affairs (DCA) is expected to propose adopting the BOCA code, but to delete the MEC provisions. A coalition of utilities, environmental, and consumer groups is urging the DCA to reassess this decision and keep the MEC in the adopted code. A final decision is not expected until spring 1997. Deleting the MEC from the BOCA code would leave the New Jersey energy code at levels set by ASHRAE in 1980.

In Pennsylvania, there is a statewide building energy code but it is based on the out-dated 1980 version of the ASHRAE code. The Pennsylvania House of Representatives devoted a large amount of time in 1996 to developing a statewide building code, including an updated energy code. As a result, the Pennsylvania House adopted the 1995 BOCA code in June 1996. The Pennsylvania Senate had inadequate time to consider this bill in 1996. Action on the bill is expected to resume in 1997.

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90. ASHRAE stands for the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.

91. CABO stands for the Council of American Building Officials.

92. BOCA stands for the Building Officials and Code Administrators International, Inc.

Recommendations

Adopt BOCA Model Code

The New Jersey Department of Community Affairs and the Pennsylvania legislature should adopt the 1996 BOCA code without modifying the energy provisions. By this action they will adopt the most up-to-date national model codes, codes that are now in force in more than a 20 states and working well.[93] The benefits of code adoption are substantial. For example, an analysis by Pacific Northwest National Laboratory on adopting the 1996 BOCA code in New Jersey found that meeting the 1996 BOCA code reduces annual energy costs by $17-$454 per home (varying as a function of home type, size, and fuel), and that these annual energy cost savings are significantly greater than the $8-$85 annual increase in mortgage payments needed to pay for the additional cost of the more efficient home. Meeting the BOCA code does increase the amount of downpayment to purchase a home by $14-$25 for a "starter" condominium to $217-$330 for a large single-family home, but annual energy cost savings pay off this additional downpayment within one to five years.[94] Very large additional benefits will occur in Pennsylvania from adoption of the commercial building efficiency provisions referenced in the BOCA code.

New York State should also consider adopting the BOCA code. New York now has an energy code that it developed itself, but with the dismantling of the New York State Energy Office little support is available to help designers and code officials implement the code. Adoption of national model codes, such as BOCA 1996, would allow a wealth of technical support materials to be used in New York. Also, BOCA 1996 would result in energy savings relative to the current New York code as the BOCA code has significantly stronger window efficiency and other requirements for gas- and oil-heated homes (which account for the vast majority of new construction). According to a recent analysis by Pacific Northwest National Laboratory, for non-electric homes, energy use is 26 percent higher under the New York Code than more current model codes.

The aggregate benefits of adopting the BOCA code can be approximated using the new construction estimates made in Section III, the Pacific Northwest National Laboratory estimates of residential code costs and savings for New Jersey and New York, and recent

93. "Bi-Monthly Status of State Energy Codes,"Building Codes Assistance Project, Washington, DC, November 1, 1996.

94. R.G. Lucas, *Cost Effectiveness of the 1993 Model Energy Code in New Jersey (Draft)*, Pacific Northwest National Laboratory, Richland, WA, Aug. 1995.

ACEEE estimates of commercial code costs and savings for Illinois,[95] Overall, by 2010, adoption of the 1996 BOCA code will provide cumulative net benefits of approximately $380 million in New Jersey, $1 billion in Pennsylvania, and $410 million in New York over the 1998-2010 period (see Table 17). Savings are much larger in Pennsylvania because unlike the other states it has not adopted a new commercial energy code in recent years.

Opposition to the BOCA code is only for residential buildings and comes from some home builders who object to any regulation that increases the cost of housing. However, energy efficiency investments are investments that pay for themselves through lower energy bills. Many of the major players in the secondary mortgage recognize this and allow larger mortgages for homes that meet the CABO code.[96] Also, homebuilder opposition to the CABO code appears to be based on non-optimized estimates of the cost of meeting the code. Through proper design it is possible to meet the code for only a modest cost increment — the Pacific Northwest National Laboratory study mentioned above estimates that meeting the 1995 BOCA energy requirements adds only $121-$223 to the cost of a starter/attached home, and $1,028-$1,564 to a large single-family detached home, significantly less than non-optimized estimates made by some builders, which have ranged as high as a $4,500 incremental cost per home.[97]

Periodically Update Codes

Adoption of current model codes will be a significant step for New Jersey and Pennsylvania and a modest improvement for New York. But current model codes do not include many of the cost-effective efficiency measures for new buildings shown in the analysis of new building prototypes in Appendix B. National model codes are periodically updated to incorporate additional cost-effective efficiency measures that have been demonstrated to work in a wide range of buildings.

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95. L. Smith and S. Nadel, *Energy Efficiency Codes and Standards for Illinois*, American Council for an Energy-Efficient Economy, Washington, DC, 1994. Most of the commercial code savings are not climate dependent and thus the Illinois estimates are roughly applicable to New Jersey and Pennsylvania. Furthermore, the climate in New Jersey and Pennsylvania (average winter temperature of 37-45°F) is broadly similar to the central Illinois location (Springfield, average winter temperature of 41°F) used in the analysis.

96. For example, the Federal National Mortgage Association ("Fannie Mae") and the Federal Home Loan Mortgage Corp. ("Freddie Mac"), two of the largest players in the U.S. secondary mortgage market, allow a maximum debt to income ratio of 30 percent on homes meeting CABO, 2 percent higher than that maximum ratio for non-CABO homes (*Energy Efficiency Financing; A Lender's guide for Taking Advantage of this Emerging Market*, Alliance to Save Energy, Washington, DC, 1996).

97. Reasons for the relatively modest costs include use of foam sheathing plus corner bracing instead of wood exterior sheathing, saving energy without increasing costs, and use of relatively new inexpensive "hardcoat" low-emissivity window coatings.

Table 17. Energy and Financial Savings from Adopting BOCA 1996 Building Code

	New Jersey	New York	Pennsylvania	Region
Energy Savings in 2010				
Electricity (GWh)	147	0	1,064	1,211
Fossil fuels (billion Btu)	12,890	13,236	17,894	44,021
Total (billion Btu)	14,447	13,236	29,176	56,858
Financial Savings (1993 $, millions)				
In 2010	$55	$58	$143	$256
Cumulative 1998-2010 (undiscounted)	$384	$409	$998	$1,791

Source: last table in Appendix B.

For example, the current ASHRAE 90.1 code was developed during the 1980s and finalized in 1989. Since 1992, ASHRAE has been working on a new version of 90.1. The first draft of this new version was released for public comment in early 1996; the second draft is expected in mid-1997. The new version is projected to reduce energy use by more than 17 percent relative to the existing 90.1, using only measures with a benefit-cost ratio of approximately 1.7 or more.[98] The CABO MEC is also periodically revised. In addition, a consortium of ten states has formed the Multi-State Working Group to adapt and improve upon the ASHRAE and CABO codes to make them easier to use and to update them more frequently.[99] As new versions of these model codes are developed, all three Mid-Atlantic states should adopt the latest versions when they revise their codes. Also, all three states should join the Multi-State Working Group.

Improve Code Implementation and Enforcement

Code adoption at the state level is just one step towards increasing the energy efficiency of new buildings. Building codes are implemented and enforced at the local level in each of the states. Energy code compliance is critical for achieving the potential benefits, and compliance levels are less than ideal in many states. For example, a recent review of studies on code compliance found that, on average, significant energy savings are lost due to the fact that many buildings are not fully in compliance with existing codes.[100] Designers and builders need

98. Projected savings from ASHRAE, "Position Papers on Cross Cutting Issues Related to 90.1R Public Review," Pacific Northwest National Laboratory, Richland, WA. The benefit-cost ratio of at least 1.7 was derived by ACEEE based on the economic analysis technique and assumptions used by ASHRAE to develop the new code.

99. This effort is being coordinated by the Southface Energy Institute, Boone, NC, 704-265-4888.

100. L. Smith and S. Nadel, *Energy Code Compliance*, American Council for an Energy-Efficient Economy, Washington, DC, 1995.

to be trained on how to comply with new building codes, taking advantage of the flexibility provided in codes to meet the code requirements in the least-cost manner. Local code officials need training as well as adequate financial and technical resources for enforcing the codes. In order to make the new codes a success, state agencies (e.g., Department of Community Affairs or Board of Public Utilities in New Jersey, Department of Labor and Industry in Pennsylvania, and either Department of State or NYSERDA in New York) and possibly distribution utilities should sponsor education, training, and compliance programs. Such programs can and should be coordinated with new construction programs (funded with systems benefit charge monies) that encourage builders and designers to exceed code requirements. Federal grants may also be available to help fund code implementation activities.[101] For example, New Jersey has received two code implementation grants, one in 1995 for supporting implementation of ASHRAE 90.1 and one in 1996 for promoting and supporting the adoption of a new cost-effective residential code.

C. Additional Measures in Support of Building Energy Efficiency

Current Situation

All three Mid-Atlantic states have abolished their independent state energy offices as part of budget-cutting efforts. However, many of the traditional energy office functions remain in other agencies — the New York Energy Research and Development Authority, the New Jersey Board of Public Utilities, and the Pennsylvania Departments of Environmental Protection and Commerce. These programs are funded by the Federal State Energy Conservation Program, which provides grants to the states for energy conservation and other activities. While previously many states had provided some state funds to their state energy offices, this no longer happens in the Mid-Atlantic region.

Recommendations

While funds are limited for new initiatives, there are several things states may be able to do by carefully using the funds they have, and supplementing these with new funds they may be able to raise in federal grants, from private investments, or from a systems benefit charge. All of these initiatives should be relatively modest in cost. Specific initiatives we recommend are:

1. Implement home energy rating systems and energy-efficient mortgage programs;

2. Adopt equipment efficiency standards; and

101. Through the U.S. Department of Energy, Office of Codes and Standards, 202-586-9446.

3. Improve the energy efficiency of state-owned buildings.

Each of these initiatives are briefly summarized in the paragraphs below.

Implement Home Energy Rating Systems and Energy-Efficient Mortgages

Home energy rating systems (HERS) rate the efficiency of new and existing homes on a simple, easy-to-understand scale, such as one through five stars. Home-buyers can look at each home's rating and use this information as a factor in selecting a home to buy. A national-model HERS program has been developed by the HERS Council. Under this program, homes that meet the CABO model energy code receive a four-star rating and are eligible for a 2 percent higher debt-to-income ratio offered by many players in the secondary mortgage market (so-called "Energy Efficient Mortgages" — EEMs). Homes that do not earn a four-star rating can be eligible for a special Energy Improvement Mortgage in which money to upgrade the home's energy efficiency is added to the mortgage, allowing energy-saving improvements to be made immediately after closing.[102] Such HERS/EEM programs have been in operation for several years in 11 states. For example, the Virginia Home Energy Rating Organization (VHERO) program has been in operation since 1992 on a pilot basis. In 1995 the program was offered statewide and performed 7345 ratings. Based on an evaluation of the pilot program, energy and bill savings exceeded 30 percent, although the sample size in this evaluation was very small and this savings level may not be sustainable in a larger program.[103] Pennsylvania, New Jersey, and New York are all seriously considering joining the national HERO program. We encourage all three states to take this step.

HERS/EEM programs are primarily aimed at encouraging upgrades to the existing housing stock. Earning a four-star rating on a new home is very easy — in states with a CABO MEC building code, all new homes qualify for four stars. In order to encourage higher efficiency levels, particularly in new construction, several states and the U.S. Environmental Protection Agency (EPA) offer special technical assistance and promotion programs for homes that significantly exceed code requirements. For example, in New York, the NYSTAR program promotes the construction of homes that exceed code requirements by 25 percent, using builder training, home purchaser promotions, and other initiatives. Similarly, the EPA Energy Star Homes program awards a special Energy Star rating to new homes that qualify for a HERS Council rating of five stars, meaning they use at least 30 percent less energy than a home that complies with the CABO MEC. EPA provides special technical assistance to help

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102. Farhar and Eckert, *Energy-Efficient Mortgages and Home Energy Rating Systems: A Report on the Nation's Progress*, National Renewable Energy Laboratory, Golden, CO, 1993; Luboff, "How Energy Mortgages Work," *Home Energy*, May/June 1995, p. 27.

103. Farhar, Collins and Walsh, *Linking Home Energy Rating Systems with Energy Efficiency Financing: National and State Programs*, NREL/TP-460-21322, National Renewable Energy Laboratory, Golden, CO, 1996.

builders figure out the easiest way to receive an Energy Star rating. EPA is also conducting a nationwide promotion program on the benefits of Energy Star Homes and is working with Fannie Mae and several banks on special Energy Star mortgage packages that use the home's energy-saving features to justify mortgage terms banks are usually hesitant to provide.[104]

All three Mid-Atlantic states should adopt HERS/EEM programs, with appropriate components for existing and new homes. Such a program is mentioned as an initiative in the 1994 New York State Energy Plan.[105] Federal grants now help fund HERS/EEM programs in seven states. Additional states may be eligible for such grants in the future. In addition, New Jersey and Pennsylvania should consider a complementary promotion program for new five-star homes, perhaps working in conjunction with EPA. New York should likewise consider closer cooperation between NYSTAR and the EPA Energy Star program.

Adopt Equipment Efficiency Standards

Equipment standards provide minimum efficiency thresholds all products must meet in order to be sold. Standards are generally set to remove inefficient products from the market and leave consumers and businesses to choose from a wide variety of medium- and high-efficiency products. In the 1980s, efficiency standards were set by several states, including New York, on a variety of home appliances. These state standards in turn led to the enactment of federal appliance efficiency standards in 1987. A similar pattern occurred with regards to fluorescent ballasts, electric motors, and the most common types of commercial lamps and HVAC equipment where states, including New York, began setting standards, leading to enactment of federal standards.

However, there are still a number of mass-produced products for which a substantial amount of energy can be saved by establishing minimum efficiency standards. For these products, high-efficiency levels are very cost effective to consumers, but due to a variety of market barriers, low efficiency products still dominate the market. Among these products are dry-type distribution transformers (used in many commercial buildings) and packaged commercial refrigeration equipment (e.g., vending machines, ice makers, and water coolers). These and other opportunities for state efficiency standards are discussed in detail elsewhere.[106] New

104. Bretz, Bloomfield, Rooney and Kollar, "Marketing Energy-Efficient Residential Construction Nationwide: EPA's Energy Star Homes Program," in *Proceedings 1996 ACEEE Summer Study on Energy Efficiency in Buildings*, pp. 2.13-2.24, American Council for an Energy-Efficient Economy, Washington, DC, 1996.

105. *New York State Energy Plan, Vol. 1: Summary Report*, Energy Planning Board, New York State Energy Office, Albany, NY, 1994.

106. Nadel and Suozzo, *The Need and Opportunities for State Action on Equipment Efficiency Standards*, American Council for an Energy-Efficient Economy, Washington, DC, 1996; Nadel, *Minimum Efficiency Standards: Options for Federal and State Action*, American Council for an Energy-Efficient Economy, Washington, DC, 1994.

York, New Jersey, and Pennsylvania should consider setting state efficiency standards on these products. Such a step would provide direct in-state benefits as well as lay the groundwork for new national standards.

Improve the Efficiency of State-Owned Buildings

In each of the three states, one of the largest owners and operators of buildings are the states themselves. While each state has made some progress in improving the energy efficiency of their buildings, much more can be done. Improving the efficiency of state buildings demonstrates opportunities for efficiency improvement to the private sector and reduces the operating cost of state facilities, ultimately savings taxpayers money.

In New Jersey, several years ago an Energy Conservation Bond Program was enacted that provided $50 million for financing energy audits and renovations at state facilities. The funds have now been all spent or committed.[107]

In New York, there have been a number of programs to encourage energy-saving investments in state buildings by private energy service companies.

Building on these past efforts, all three states should undertake new initiatives to improve the efficiency of state buildings, including such steps as identifying and removing institutional barriers to the use of private energy service companies to finance and implement energy-saving improvements in state facilities and enacting life-cycle cost regulations for the purchase of new equipment and the design of new buildings.

The three states should also consider establishing a revolving loan fund to finance energy-saving improvements in state and municipal facilities. A highly successful program of this type, the LoanStar program, is operating in Texas and to date has achieved measured energy cost savings of more than $19.9 million in public buildings and schools. A key feature of this program is that it devotes extensive attention to properly commissioning energy-saving measures (making sure they operate correctly) and to monitoring actual energy savings, both to catch problems that may develop and to make a compelling case that the program is providing a substantial return on the state's investment. Funding for the Texas program comes from oil overcharge funds but programs in the Mid-Atlantic states could just as well be funded through state bonds.[108]

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107. *New Jersey Energy Master Plan, Phase I Report*, New Jersey Board of Public Utilities, Newark, NJ, 1995.

108. J. Haberl et al., *Measuring Energy-Savings Retrofits: Experiences from the Texas LoanStar Program*, Oak Ridge National Laboratory, Oak Ridge, TN, 1995; "LoanSTAR Program Saves Texas Taxpayers Millions in Energy Bills," *TEES Engineering Issues*, Texas A&M Univ.,Texas Engineering Experiment Station, College Station, TX, 1995.

In addition, states should look for opportunities to use their large purchasing power to help improve the availability and lower the cost of efficient products and services in-state. A consortium of state officials, the Procurement Collaborative, has recently been formed for this purpose. New York State is among the leaders of this effort; New Jersey and Pennsylvania should become involved as well.[109]

D. Industrial Energy Efficiency

As can be seen from the preceding analysis, significant cost-justified energy efficiency potential clearly remains within the industrial sector. However, energy savings alone have not proven sufficient to motivate industry to action. Fortunately, many energy efficiency opportunities will have additional benefits in the areas of productivity, product quality, and environmental compliance. An integrated strategy is needed to capture this potential, focusing on a broad range of benefits and looking at the manufacturing system, rather than focusing exclusively on its components.

The industrial energy efficiency strategy should address all aspects of the opportunity implementation process: opportunity identification, technical and design assistance, financing, operation improvements, and promoting advanced technologies. Government and utility programs can help to reduce the cost and hassle of identifying efficiency improvements (e.g., through surveys and technical and purchasing assistance) and the cost of installing efficiency measures (e.g., through rebates, loans, and creative private market financing). While large companies can benefit from these programs, they are critical for many smaller companies that lack the financial and human resources available in many larger companies to implement these energy efficiency and process improvement projects.

Current State and Regional Activities

New York State has been a national leader in the industrial energy efficiency program area. In the past, the New York State Energy Office (NYSEO) conducted comprehensive industrial energy efficiency programs with the above-mentioned characteristics for small and medium-sized industries. NYSEO's Flexible Technical Assistance Program (FlexTech) provided audit, design assistance, procurement, and implementation services. The Energy Investment Loan Program provided financing with interest rate subsidies to commercial lenders for their customers' energy efficiency projects, and the Construction Services and Professional Training Programs provided training, technical assistance, and educational materials to all levels of industrial staff from engineers to operators. Also, utilities in New York have conducted

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109. "Energy Efficient Procurement Collaborative Inc." (brochure), Energy Efficient Procurement Collaborative Inc., c/o New York State Energy Research and Development Authority, Albany, NY, 1996.

industrial DSM programs complementing the state's activities. These combined programs have achieved impressive results, especially in encouraging industrial facilities to make process-related improvements.[110]

In recent years, funding for some of these programs and activities has declined in spite of the continued presence of many cost-effective opportunities. For example, with the elimination of NYSEO, FlexTech was transferred to the New York State Energy Research and Development Authority (NYSERDA) where it continues at a 1996 level of 94 projects per year, with little if any marketing. FlexTech's current annual funding is about $1.2 million, with three full-time equivalent staff. The average project cost-share with other partners is about fifty-fifty, with the goal for coming years to leverage funds even more. FlexTech is achieving a 63 percent implementation rate (with an additional 19 percent indicating future plans to implement). At this level of implementation, the program is achieving 8 million Btus and $5 in annual savings, and $17 in capital investment, for each program dollar.[111]

Unfortunately, the majority of the financial assistance services of the NYSEO program were not continued because of limited funding. NYSERDA estimates that, with marketing, the demand for FlexTech would be eight to ten times the current level. NYSERDA also indicates that the need for financing assistance is perhaps greater now than when FlexTech was available from NYSEO because many businesses have implemented the quick payback measures, such as lighting, and the remaining (but very large) energy savings opportunities, such as process improvements, are more capital intensive.[112]

NYSERDA offers several other programs that encourage industrial energy efficiency. It has actively promoted and supported DOE's Motor Challenge and the joint DOE/EPA Climate Wise program to New York businesses. NYSERDA has active research and demonstration efforts in energy efficiency and pollution prevention, with 35 projects active at any one time and average annual funding of about $4 million.[113] NYSERDA offers, in cooperation with the State Department of Environmental Conservation and the Environmental Business Association of New York State, pollution prevention (referred to in industry as P2) assistance to the state's industries, and holds an annual P2 conference that attracts about 300 representatives from the state's industries.[114] The funding for some of these programs has also declined.

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110. R.N. Elliott and A. Weidenbaum, "Financing of Industrial Energy Efficiency Through State Energy Offices," *Proceedings of the 16th Industrial Energy Technology Conference*, Houston, TX, April 13-14, 1994.

111. B. Platt, NYSERDA, personal communication, Albany, NY, 1997.

112. B. Henderson, NYSERDA, personal communication, Albany, NY, 1996.

113. P. Douglas, NYSERDA, personal communication, Albany, NY, 1997.

114. A. Ferranti, NYSERDA, personal communication, Albany, NY, 1996.

The state of New Jersey has no current industrial energy efficiency program activities. Three of the electric utilities (Public Service Electric and Gas [PSE&G], Jersey Central Power and Light, and Atlantic Electric) offer energy efficiency programs and incentives targeted at industrial customers. In addition to existing programs, a DSM collaborative with PSE&G has recently begun focusing on electric motor systems opportunities in manufacturing. The state does have a pollution prevention program as part of the state facilities planning law requiring a pollution prevention plan for all industrial facilities. As part of this program, the Division of Environmental Protection funds a center at the New Jersey Institute of Technology that provided technical assistance to 68 firms in 1996.[115]

Since the closing of the Pennsylvania state energy office in 1995, the industrial energy efficiency (referred to by the state as E2) activities have been transferred to the Pennsylvania Department of Environmental Protection (PADEP). The energy efficiency activities are undertaken as part of the pollution prevention program that was expanded significantly in July 1996. PADEP offers assistance to industry in complying with state and federal environmental regulations, including integrated P2/E2 assessments and teleconference training. The program held a state P2/E2 conference in October 1996, which was attended by 385 representatives from industry, government, utilities, and the consulting community. At the conference the Governor presented awards for environmental excellence to industry leaders. To encourage responsible environmental behavior, the program is now establishing an environmental leadership program.[116]

The additional initiatives needed to realize the energy efficiency opportunities in the region fall into five broad categories (as listed above): opportunity identification, technical and design assistance, financing, operation improvements, and promotion of advanced technologies. A number of expanded, redirected, and new programs should be undertaken at the regional and state levels in these areas.

Opportunity Identification

Identification of energy efficiency opportunities is the first step in the process. NYSERDA's FlexTech represents a model program that should be strengthened and expanded. New Jersey and Pennsylvania should also establish programs based upon the FlexTech design. These could be housed within state agencies but it would be preferable to establish a statewide nonprofit center to provide these services. Initial operating funding for the industrial assessment initiative should be between $500,000 and $1,000,000 annually for each center. This funding level would allow hiring several experienced staff engineers, as well as

115. J. Herbert, Department of Environmental Protection, personal communication, Trenton, NJ, 1996.

116. G. Kagel, Pennsylvania Department of Environmental Protection, personal communication, Harrisburg, PA, 1996.

establishing consulting relationships with technical experts. Funding should be expanded as the demand for the center's services grow. As noted above, an increased demand has been seen in New York State with FlexTech, which could benefit from increased funding.

The Industrial Assessment Centers (IACs) (formally know as the Energy Analysis and Diagnostic Centers) are an existing resource of technical assistance that could be augmented with funds from either state revenues or a utility systems benefit change. There are two IACs located in the region (based at the Rutgers University in New Jersey and Hofstra University in New York) as well as three additional IACs (University of Massachusetts, Old Dominion University, and West Virginia University) located in near-by states and serving parts of the region.[117] This successful program, which receives its core funding from the U.S. Department of Energy (DOE), provides low-cost audits to small and medium-sized firms. Nationally, 30 IACs each conduct 30 assessments annually. Assessments identify energy savings opportunities that can be pursued by other key players, such as gas and electric utilities, or by the industries themselves. The overall IAC program achieves an average of 10 percent implemented energy savings with the average overall measures at a facility having a simple payback of less than two years. In addition, the program trains engineers in industrial energy efficiency techniques and these individuals often seek employment as energy managers in local industries.[118] The five IACs mentioned above cover most of the Mid-Atlantic region, though the number of assessments they can offer represents a small fraction of the need of eligible firms.

Several opportunities exist to expand and enhance the IACs in the region. NYSERDA and Hofstra University have tried to establish a motor system training program as part of the New York IAC but so far have failed to secure funding from DOE.[119] The three states could follow the example of Texas, which is now using "oil overcharge funds" to expand the activities of the IAC at Texas A&M in support of the new Texas Industrial LoanStar program. In addition, the IAC at Texas A&M University College Station has created an affiliate relationship with Texas A&M University in Prairie View to expand the coverage in the state.[120] Based upon the precedent in Texas, the Mid-Atlantic utilities and states could expand the activities of the five IACs in order to increase their services to small and medium-sized manufacturers, who

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117. *Energy Analysis and Diagnostic Center Program Description*, U.S. Department of Energy, Washington, DC, 1994.

118. M.G. Woodruff et al., *Analysis of Energy efficiency Investment Decisions by Small and Medium-Sized Manufacturers*, Pacific Northwest National Laboratory, Richland, WA, 1996.

119. B. Henderson, NYSERDA, personal communication, Albany, NY, 1996.

120. J. Eggebrecht, Texas A&M University, personal communication, College Station, TX, 1996.

have been shown to benefit the most from this type of assistance.[121] In addition, new state-supported IACs could be established at other universities or community colleges, either as affiliates of existing IACs or as new, independent centers. By expanding the level of activity at existing IACs as well as the number of IACs, a larger fraction of the eligible firms could be served. Increasing the number of centers would also allow closer relationships to develop between the IACs and the firms in their immediate area.

Technical and Design Assistance

Industries' lack of access to specialized expertise and energy efficiency services can be barriers to implementing efficiency opportunities.[122] The NYSERDA FlexTech program provides one example of the kind of resource available in the region although, as mentioned previously, this program should be given additional resources. Other centers sponsored by the states, utilities, and industry could be developed, increasing the scope and availability of expertise to assist industry with energy efficiency and productivity enhancements.

Since the development of this expertise is costly, it would be reasonable for state agencies and utilities in the region to pool their resources. A regional effort along these lines has been established in the southeastern United States, and could be copied in the Mid-Atlantic region. The North Carolina Alternative Energy Corporation has established an Industrial Electrotechnology Laboratory (IEL), which now operates in South Carolina and Virginia as well as North Carolina. The IEL provides technical training, assistance, and testing services to industrial users in areas such as electric motor systems, product heating and drying, and low-emission coatings. The IEL allows industrial customers to develop and evaluate process technology changes in a near-production environment without disrupting the manufacturing operation.[123]

Electric motor systems offer one of the most attractive opportunities for energy efficiency improvements but the expertise necessary to support motor programs is in limited supply. A state or regional motor systems program could address this problem. An example of a successful program is the Electric League of Washington State (a collation of electric utilities), which has retained a motor expert to coordinate motor programs among its members. This

121. M. Hopkins and T. Jones, *Getting in Gear: How Energy Efficiency Can Help Smaller Manufacturers Compete in the Global Marketplace*, Alliance to Save Energy, Washington, DC, 1995.

122. H. Geller and R.N. Elliott, *Industrial Energy Efficiency: Trends, Savings Potential, and Policy Options*, American Council for an Energy-Efficient Economy, Washington, DC, 1994; *Efficient Electric Motor Systems for Industry*, U.S. Department of Energy, Washington, DC, 1993.

123. R. Koger, Alternative Energy Corporation, personal communication, Raleigh, NC, 1994.

effort is expanding to the entire Pacific Northwest region under the new Northwest Energy Efficiency Alliance.[124]

The Energy Center of Wisconsin also offers two motor system model programs: Responsible Power Management (RPM) and Performance Optimization Service (POS), which promote energy-efficient equipment and improved optimization of motor-driven systems. RPM offers a consistent motor-driven equipment incentive program for all the state's electric utilities, coupled with technical support. The POS program, which uses the systems approach to identify, assess, and optimize the performance of industrial motor systems, offers comprehensive technical training and support to end-users and motor system design engineers.

Programs similar to the Washington and Wisconsin initiatives to improve motor system efficiency should be considered at the state or regional level in the Mid-Atlantic region. Some initial discussions on creating a northeast regional utility motor initiative, led by the Northeast Energy Efficiency Partnership, Inc., are now taking place.[125] It is important that utilities in the region be encouraged to support and participate in this initiative and that other groups coordinate their efforts as well.

Financing

Some industrial customers, particularly many small to medium-sized companies, lack the capital to finance energy-saving improvements. Creation of a financing program would alleviate this problem. Such a program could be specifically for industry, in the model of the NYSEO Energy Investment Loan Program; be part of the utility system benefit charge discussed in the utility section; or operated in conjunction with loan programs for other sectors, as with the Texas LoanStar program. Based on the New York experience, we suggest a state total industrial loan pool of approximately $190 million for Pennsylvania, $125 million for New York, and $85 million for New Jersey.[126] Such a program could use private capital with interest-rate reductions for small and medium-sized companies, financed with system-benefit charge monies, or state funds could be issued at interest rates somewhat below market rates.

124. R. Zbedski, Electric League of Washington State, personal communication, Bellevue, WA, 1996.

125. F. Gordon, Pacific Energy Associates, personal communication, Portland, OR, 1996.

126. These levels are based on subsidizing the financing of an additional 3 percent of industrial capital investment in each state (as reported by the Census [1993]) for an average five 5-year term. The cost of the subsidy is 29 percent of the dollar value of the realized capital investments, as was achieved in the NYSEO program (Elliott and Weidenbaum, op. cit.).

Operation Improvements

Once energy efficiency measures and process improvements are installed, individual plant staff must learn how to operate this equipment correctly. FlexTech is unique in that it provides customized training as part of its energy services program.[127] As the Energy Center of Wisconsin's POS program has discovered, an important aspect of process optimization frequently involves changes to the operating procedures. These can frequently be more important than the equipment changes.[128] On-the-job training services in the Mid-Atlantic region will help insure that industrial equipment is operated and maintained properly and that the energy savings potential of efficiency improvements is realized. Funding for these efforts are included in the recommended budgets for the industrial assistance center initiative discussed above.

Efficient operation requires properly trained engineers and technicians who are aware of the benefits of energy efficiency to the success for the company. Companies such as Dow and 3M have achieved impressive bottom-line benefits when they "empowered" their staffs to look for efficiency opportunities.[129] One opportunity to create trained and aware engineers is through the IACs in the region. In addition to providing immediate benefits to companies, the IACs are creating a pool of engineers with energy efficiency expertise for companies to draw upon. Technicians are as important to the efficient operation of industrial process as are engineers. The region's community college systems should be encouraged and funded to incorporate energy efficiency into the engineering technology curriculum, as has occurred with programs in North Carolina and Wisconsin.

Promoting Advanced Technologies

In addition to promoting currently available energy efficiency measures, the states and utilities in the region should encourage technological innovation in the industrial sector. This can lower energy intensity as well as create new opportunities for economic growth. Technological innovation is also critical for industrial competitiveness and environmental protection over the long run.

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127. Elliott and Weidenbaum, op. cit.

128. A. Prestill, Energy Center of Wisconsin, personal communication, Madison, WI, 1996.

129. K. Nelson "Creating an Empowered Conservation Culture," *Proceeding of the Workshop on Partnerships for Industrial Productivity through Energy Efficiency*, American Council for an Energy-Efficient Economy, Washington, DC, 1993; S. Schultz, "3M's Motor Challenge Showcase Demonstration Project," *Proceedings of the Eighteenth Industrial Energy Technology Conference*, Houston, TX, April 17-18, 1996.

NYSERDA has an active state program supporting research and demonstration into industrial energy efficiency and pollution prevention technologies. NYSERDA's industrial research program funding is currently about $4 million annually. This represents about a quarter of the Authority's annual research budget. In recent years, the program has averaged about 35 active programs. NYSERDA documents annual benefits from industrial sector projects undertaken after 1990 of $8 million in 1995 and $9.4 million in 1996. These energy savings represent only a portion of the true benefits since benefits estimates are unavailable for a fraction of the projects. NYSERDA is attempting to make a more accurate projection and forecasts program benefits of more than $15 million for 1997.[130] New Jersey and Pennsylvania should consider similar programs.

Another opportunity is the National Industrial Competitiveness through Energy, Environment, and Economics (NICE^3) program, which can be viewed as a model effort in this area. NICE^3, a joint program of DOE and the Environmental Protection Agency, provides matching grants to state government and industry partnerships that demonstrate innovative energy efficiency and waste reducing technologies. Four projects have been funded in the region (one each in New York and Pennsylvania, and two in New Jersey) during the program's history from 1991 through the current (1996) funding year. Many of these projects have successfully demonstrated new techniques for reducing energy use, cutting emissions, and saving businesses money. States and utilities in the region should provide additional resources for NICE^3 or similar projects.

Conclusion

The structure of New York State's efforts in industrial assistance, financing, and research represent good models for programs in Pennsylvania and New Jersey. The good efforts in New York also need additional resources. Moreover, all the states would benefit from a technology center similar to North Carolina Alternative Energy Corporation's IEL, which would provide comprehensive assistance to industry on energy efficiency and the accompanying benefits of reduced production costs, improved product quality, and lower environmental emissions. This center might be part of a multi-sector center or could be specifically targeted at the industrial sector alone. Because of the costs associated with establishing this type of center and retaining expert staff, regional joint efforts should be seriously considered. By coordinating efforts, the region can plot a more productive and secure future for its industrial sector with broad benefits from industrial process improvements and modernization, as have already been realized in New York.

130. P. Douglas, NYSERDA, personal communication, Albany, NY, 1997.

E. Transportation

Our policy recommendations for saving energy in the transportation sector focus on improving the fuel economy of light duty vehicles (cars and light trucks), which are the largest energy users in that sector. Three types of policy options are available to states for improving the energy efficiency of cars and light trucks. First, states in the region should enact vehicle purchase price incentives ("feebates") linked to efficiency. Second, the region should procure vehicles that are the most efficient in each vehicle class and coordinate efforts for similar efficient vehicle procurement efforts by municipalities and private fleet purchasers in the state. Finally, the region should provide concerted political support for stronger federal policies to advance vehicle efficiency.

Historically, most improvements in vehicle efficiency have come from improved technology in vehicles of all classes rather than market shifts among type of vehicles. This situation will also be the case for future efficiency improvements, especially if they are policy-driven. Under current market conditions, consumer and manufacturer interest in higher fuel economy is low. States can create an incentive for higher efficiency by establishing feebates: lower taxes or rebates on vehicles that are more efficient than average, financed by higher taxes or fees on less efficient vehicles. The result would be a revenue-neutral rearrangement of vehicle tax schedules. For example, a sales tax rate on vehicle purchases, which might now take the form of a fixed *ad valorem* tax rate (say, 6 percent) could be converted to a sliding-scale tax ranging from 0 to 12 percent of a vehicle's sales price. Currently, the ability of states to establish such programs is a matter of controversy, since the state of Maryland enacted a "guzzler/sipper" tax/credit plan in 1992 that was subsequently blocked by the threat of a federal preemption challenge. The Maryland program involved some technical labeling provisions which may have been preempted, but the state's Attorney General issued an opinion that the overall approach of instituting a state incentive for higher vehicle efficiency is not preempted. Further federal clarification is needed and we recommend that states seek such guidance from the U.S. Department of Transportation (DOT) and Environmental Protection Agency (EPA) in the course of developing incentive programs.

States can also lead the way to more efficient vehicles by establishing procurement policies for state fleets to buy the most efficient vehicles in a given class. States can also multiply the effects of its own procurement by playing a coordinating role for similar procurement efforts by county and municipal fleets along with voluntary efforts by private fleets. A similar strategy is now being pursued for alternative fuel vehicles. However, the scope of such efforts is limited by alternative fuel infrastructure needs. An effort to purchase efficient gasoline vehicles could have a much broader scope and is likely to deliver greater fuel conservation and emissions reduction benefits in a more timely fashion.

An efficient vehicle procurement strategy can be designed with two stages. One stage would be directed toward bulk purchases of current production vehicles that are "best-in-class" in terms of fuel efficiency. The second stage could be directed to advanced, next-generation vehicles having substantially higher efficiencies, should they become available.

"Best-in-class" procurement guidelines are something that states can do now as a way to demonstrate leadership for higher vehicle efficiency as well as obtain fuel savings in the course of state vehicle operations. The states should also encourage and help organize municipal governments within their jurisdictions to similarly pursue efficient vehicle procurement guidelines. Table D-1 in Appendix D lists the status of government-owned fleet vehicles in New York, New Jersey, and Pennsylvania; state and local government owned automobiles numbered an estimated 156,000 in 1992. Most federal vehicles will be subject to alternative fuel use requirements, as specified by the Energy Policy Act of 1992. Some state and local government fleet vehicles will also be expected to use alternative fuels. However, most state and local government fleets can select more efficient than average conventional vehicles to obtain additional energy savings and environmental benefits. EPA's "Best-in-Class" analysis of recent cars shows that the most efficient vehicles have an average fuel economy 8 percent greater than the overall average.[131] Assuming 12,000 miles of annual driving, such an improvement in the region's state and local automobile fleets would save 6.6 million gallons of gasoline per year, valued at $4.9 million (based on a recent average wholesale gasoline price of $0.74 per gallon). The corresponding emissions reductions associated with the reduced gasoline consumption would be 160,000 pounds of volatile organic compounds (hydrocarbon vapors) and 99,000 tons of CO_2-equivalent greenhouse gases. Even larger savings and emissions reductions could be obtained if such state and local government led efforts spread to private fleets and individual car purchasers.

As part of a nationwide initiative, state fleets could also participate in a potential advanced efficiency vehicle procurement program to aid in creation of an initial market for ultra-efficient vehicles. This approach would be tied to a nationwide effort to provide a "Golden Carrot" program, a "Green Machine Challenge," for inducing automakers to put ultra-efficient vehicles into production.[132] Such a proposal is being explored as a way to accelerate the commercialization of promising advanced technologies for vehicle efficiency, for example, as a market pull complement to the advanced efficient vehicle technology research and development efforts being pursued by U.S. automakers through the Partnership for a New Generation of Vehicles. Although the organizational framework for a Green Machine Challenge does not yet exist, ACEEE will be working with other groups to establish

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131. J.D. Murrell, K.H. Hellman, and RM. Heavenrich. *Light-Duty Automotive Technology and Fuel Economy Trends Through 1993.* Report EPA/AA/T.G./93-01, U.S. Environmental Protection Agency, Office of Mobile Sources, Ann Arbor, MI, 1993.

132. J. DeCicco and A. deLaski, *The Green Machine Challenge: A Concept for Promoting Ultra-Efficient Vehicles*, American Council for an Energy-Efficient Economy, Washington, DC, 1995.

a program in 1997; interested state officials should contact us for more information about how to get involved in developing and implementing this type of market creation mechanism for efficient vehicles.

Vehicle efficiency improvement is just one — albeit the largest — of the opportunities for improving energy efficiency in state and regional transportation systems. Particularly in cities and in corridors connecting the region's many centers of economic activity, policies for reducing vehicle-miles traveled and providing better transit, intercity rail, and intermodal services are also important. While analyzing the potential role for such broader transport efficiency measures is beyond the scope of this study, these approaches can make an additional contribution to reducing energy and environmental costs in the region.

Finally, it is important to note that cars and light trucks are produced for a national — if not international — market, of which any one state holds only a small share. Federal policy is crucial in determining the types of vehicles that automakers bring to market in terms of public concerns, such as safety, emissions, and efficiency. All states will benefit from a nationwide improvement in car and light truck efficiency and, while the leverage of any one state is limited, all states are responsible for helping set the direction of the larger market. States should, therefore, play an active role in pressing for the full range of federal policies to induce greater vehicle efficiency, including stronger fuel economy standards, feebates linked to higher efficiency (in which state feebates can complement a more widespread and substantial federal program), and a nationwide Green Machine Challenge. New federal action on vehicle efficiency is long overdue, since no meaningful steps have been taken on this issue since the oil crisis years of the 1970s. One valuable step state legislatures could take would be to enact resolutions calling on their Congressional delegations and the federal government to enact stronger national policies to encourage nationwide improvements in vehicle efficiency.

F. Form a Sustainable Energy Development Agency in New Jersey and Pennsylvania

Our final policy recommendation is for New Jersey and Pennsylvania to establish a Sustainable Energy Development Agency. New York already has a highly effective agency, the New York State Energy Research and Development Authority (NYSERDA), which can serve as a model for the other states (other potential models include sustainable energy development agencies in California, Florida, Iowa, North Carolina, and Wisconsin). These agencies support technology research and development, demonstrations, field monitoring, and (in some cases) education, training, and other implementation activities.[133] They can also be powerful tools for economic development.

For example, NYSERDA's research and development (R&D) program encourages economic development by promoting energy efficiency and New York State-manufactured energy and environmental products through five program areas — Applications, Buildings, Energy Resources, Transportation, and Environmental Research. NYSERDA's R&D projects develop new technologies, create and retain jobs, reduce energy imports (which promotes economic development by allowing more discretionary money to be spent in-state), and mitigate environmental effects of energy production and use. NYSERDA has more than 300 projects aimed at helping the state's businesses and municipalities, of which 185 are developing new products.[134] One of these projects improved turbine efficiency, which saves New York up to $12 million per year in energy costs and could save $108 million a year nationwide. Another example of NYSERDA's contribution to the state's economic development is its support for the development of an energy-efficient window-insulation system that can be operated automatically using a photovoltaic power source. Over a few years time, this product helped a New York company grow from two people to 200 people, with $12 million in annual sales.[135]

Funding for state energy development agencies has typically come through utility contributions or small utility surcharges. With the utility industry restructuring, a systems benefit charge is the most likely funding source, judging from the negotiations to fund the agencies in California, New York, and Wisconsin. The cost of an agency like NYSERDA is relatively limited. NYSERDA, which is the largest state agency of its type in the country, covers its approximately $14 million annual research budget with an electric bill surcharge of only $0.0001 per kWh and a natural gas surcharge of only $0.001 per therm of natural gas.

A Sustainable Energy Development Agency in New Jersey and Pennsylvania could provide a number of functions in working with manufactures and consumers in their state, including: (1) applied R&D and demonstrations of advanced energy efficiency and renewable energy technologies; (2) technology and market assessments; and (3) support for technology transfer and commercialization. These agencies can also help the state's utilities and state agencies in the design and evaluation of energy efficiency and renewable energy programs, and possibly assist with training or technical assistance concerning building code implementation or

133. For more information on these state energy RD&D agencies, see J. Harris et al., "Energy Efficiency Research, Development and Demonstration: New Roles for U.S. States," *Energy Policy*, pp. 1205-1216, December 1993,

134. *1995-96 Annual Report*, New York State Energy Research and Development Authority, Albany, NY, 1996.

135. *Top 75 NYSERDA R&D Program Achievements*, New York State Energy Research and Development Authority, Albany, NY, 1996.

improving industrial energy efficiency. In summary, a Sustainable Energy Development Agency could be of great value in helping the Mid-Atlantic region achieve the economic and environmental benefits outlined in this report.

VII. CONCLUSION

Based on the analysis of the high-efficiency scenarios, it is clear that accelerated energy efficiency improvements can help ensure that citizens and businesses in the Mid-Atlantic region obtain energy-related services at the lowest possible overall cost. Total region-wide expenditures for energy services (including energy efficiency expenditures) in 2010 are projected to be about 20 percent lower in the high-efficiency scenario relative to the baseline projections.

Moreover, accelerated energy efficiency investments would provide significant macroeconomic and environmental benefits. For example, we estimate a net increase of 164,300 jobs in the Mid-Atlantic region by 2010 as a result of pursuing the high-efficiency scenario. Those jobs are equivalent to the employment supported directly and indirectly by about 1,095 small manufacturing plants throughout the region. This would represent a reduction in the region-wide unemployment rate of about 1.1 percent in 2010.

On the environmental side, we estimate that the energy savings projected in this analysis will reduce carbon dioxide emissions by 161 million short tons by the year 2010 (24 percent reduction projected). The high-efficiency scenario will also reduce emissions of sulfur dioxide by 176 thousand short tons and nitrogen oxides by 227 thousand short tons.[136] In this way, energy efficiency will help utilities and the individual states meet their Clean Air Act requirements and national carbon stabilization goals defined in the Climate Change Action Plan.[137]

Hence, energy efficiency investments are more than mere cost-cutting measures. They yield both positive environmental benefits and net employment gains. Given the additional net employment and income that would be generated, energy efficiency investments should be viewed as an important economic development strategy for the Mid-Atlantic region.[138]

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136. The emission estimates are based on the use of fuel-specific coefficients, which are multiplied by each of the major fuels consumed in each of the end-use sectors reviewed in this study.

137. As an example, in an analysis for a large Indiana electric utility, ACEEE found that an optimum DSM scenario can reduce SO_2 emissions by 18.6 percent of the total required due to the 1990 Clean Air Act Amendments. See S. Nadel et al., *Using DSM to Help Meet Clean Air Act Targets: A Case Study of PSI Energy*, American Council for an Energy-Efficient Economy, Washington, DC, 1994.

138. A recent report evaluating the Clinton Administration's *Climate Change Action Plan* reached a similar conclusion, noting that the plan could lead to as many as 260,000 more jobs for the United States in the year 2010. See S. Laitner, *The Climate Change Action Plan as an Economic Development Strategy for the United States*, American Council for an Energy-Efficient Economy, Washington, DC, 1994.

One important aspect of the high-efficiency scenario is that "it takes money to make money." In order to achieve the level of economic benefits illustrated in Table 9, policies must be adopted and effectively implemented to encourage a $65.6 billion investment in the period 1997-2010. Averaged out over the 14-year period, this implies an average annual investment of $4.7 billion - about 7 percent of the region's current energy bill.

While the investment is modest in comparison with the anticipated energy expenditures in the initial years, needed capital will exceed energy bill savings because the efficiency investments will take an average of 3-5 years to pay for themselves. In fact, the cross-over point where annual savings exceed annual investment will not occur until about the year 2000, assuming that large-scale investments begin in 1997. Moreover, there are a number of behavioral and institutional barriers inhibiting energy efficiency investments from approaching this scale in the Mid-Atlantic region.

Overcoming these barriers and redirecting financial investments away from conventional energy resources and towards energy efficiency measures will not occur without concerted action by policy makers in each of the three states, along with critical support from the federal government.

If the Mid-Atlantic region wishes to capture the full economic benefits of the high-efficiency scenario, we suggest that a number of policies be adopted, including:

*** Strong policies to make sure that energy efficiency services play a major role in a restructured utility industry, including establishment of a systems benefit charge to fund energy efficiency, low-income, and other public benefit programs, and structuring remaining regulatory authority over distribution utilities so that these utilities have incentives to pursue cost-effective investments in energy efficiency;

*** State-of-the-art building energy codes plus training and support for the effective implementation of residential and commercial building codes;

*** Additional policies to improve the efficiency of the buildings sector, such as home energy rating and energy-efficient mortgage programs and equipment efficiency standards;

*** Expanded technical and financial support to accelerate energy and process efficiency improvements in the industrial sector;

*** Policies that improve the fuel economy of cars and light trucks, such as variable state taxes on new vehicles based on fuel economy and purchase of 'best in class" vehicles for state fleets; and

*** Creation of Sustainable Energy Development Agencies in New Jersey and Pennsylvania that would complement the New York State Energy Research and Development Authority and fund R&D, demonstration, economic development, and promotion activities in support of energy efficiency and renewable energy implementation.

These initiatives, along with other actions that can be taken to increase energy efficiency and economic productivity, can help to ensure a healthier economy and a cleaner environment in New York, New Jersey, and Pennsylvania in the coming decades.

APPENDIX A

I. ECONOMIC PROFILE OF THE MID-ATLANTIC REGION

A. Population and Income

The combined population of New York, New Jersey, and Pennsylvania rose slightly from 37.2 million people in 1970 to 38.1 million people in 1994. This represents a relatively small increase of 2.5 percent in just over 20 years (i.e., -0.4 percent decrease in New York, 2.1 percent increase in Pennsylvania, and 10.2 percent increase in New Jersey). By comparison, the U.S. population rose by 28 percent in that same period (1970-1994). A smaller population growth might generally be taken as an indication of a smaller level of growth in energy use. As we will see, this turns out to be the case for a variety of reasons.

As Table A-1 indicates, approximately 20 percent of the regional population lives in rural areas. This ranges from a low of 10.6 percent in New Jersey to a high of 31.1 percent in Pennsylvania. The regional average however, is slightly lower than the U.S. average of just under 25 percent.

Table A-1. Selected 1994 Economic and Demographic Data

Category	US	Region	New York	New Jersey	Pennsylvania
Population (000s)	260,341	38,125	18,169	7,904	12,052
Rural Population (1990 percent of total)	24.8%	19.5%	15.7%	10.6%	31.1%
Population Density (per square mile)	73.6	383	384.7	1,065.4	268.9
Persons Per Household	2.64	2.64	2.64	2.72	2.57
Per Capita Personal Income (current $)	$21,809	$25,260	$25,999	$28,038	$22,324

Source: The population data contained in this table is based on calculations from 1990 census data found in various tables in the *Statistical Abstract of the United States 1995*. The Per Capita Personal Income data reflects values found in the *Survey of Current Business*, August 1995.

When the total populations are viewed in terms of density per square mile, the region's average density of just more than 383 persons per square mile is more than five times greater than that of the United States as a whole. Individually, New York's density is approximately the same as the regional average, Pennsylvania is lower than the regional average but 3.7 times the national average, and New Jersey's population density (second only to Washington, DC) is more than 14 times the U.S. average.

The average number of persons per household however, is the same for the United States and the region. In spite of these similarities in household size, the more densely populated nature of the region – especially states like New Jersey with over 1,000 persons per square mile – suggests that the region may consume less energy for its transportation uses than does the United States as a whole. Indeed, the per capita transportation energy consumption in the region is only 76 percent of that for the nation as a whole.

In 1980, the region's average per capita personal income of $10,738 was approximately 8 percent above the average per capita income in the United States.[139] By 1994, the region's per capita income increased to almost 16 percent more than the U.S. average. This increase is the result of slower population growth and sustainable growth in personal income (the two factors used to estimate per capita personal income) for each of the states in the region.

In an overall comparison with other states, New Jersey ranked second in per capita income in 1994, followed by New York at third, and Pennsylvania ranked 17th.[140] Higher income usually suggests that a state (or region) consumes more energy per capita than the national average. As it turns out, this is not true in the Mid-Atlantic region. In fact, as we see later in this appendix (see Table A-4), when all end-use sectors are considered, the state of New York consumed approximately one-third less energy per capita than the U.S. as a whole, and almost 21 percent less than the weighted average for the region. Similarly, New Jersey consumed more than 5 percent less than the U.S. average and Pennsylvania more than 6 percent less.

B. Employment

The regional economy supported a combined total of just over 20 million jobs in 1994.[141] Measured on a per capita basis, the regional employment level was 94 percent of the national average, with the region's businesses providing 0.53 jobs per resident compared with a U.S. total of 0.56 jobs per resident. Individually, the states were fairly consistent, all providing less jobs per capita than the U.S. average. New Jersey provided the highest level of employment at 0.54 jobs per capita, Pennsylvania provided 0.53, and New York provided 0.52.

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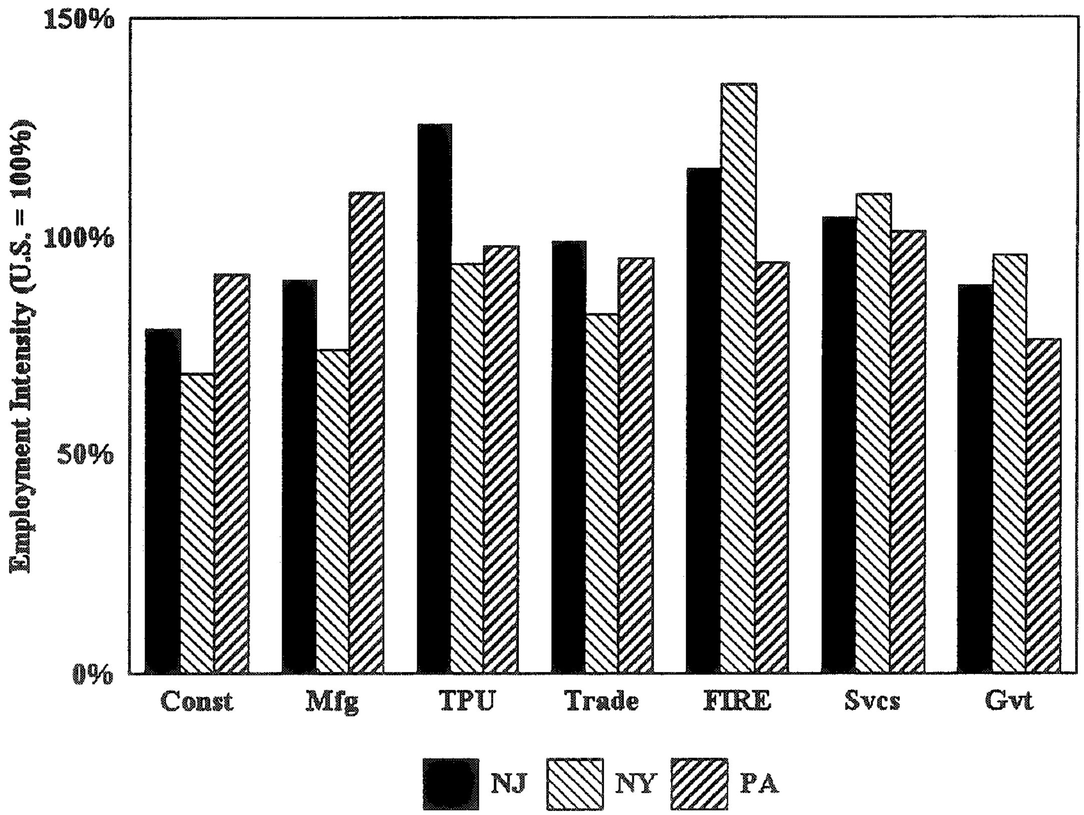
139. This value is based on the sum of a population-based weighting for each of the states.

140. See the *U.S. Statistical Abstract 1995*, op. cit., table 713.

141. The employment data that follows are provided by the Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC, 1995. The data include wage and salaried employees as well as proprietors, self-employed, farm workers, unpaid family workers, private household workers, and members of the Armed Forces.

Figure A-1 illustrates the employment intensities (i.e., a measure of the number of persons employed) in selected economic sectors within the region and the individual states. The figure

Figure A-1. 1994 Sectoral Employment Intensities



Notes: The economic sectors noted include: (1) construction (referenced as "Const") — businesses/contractors involved in general building, heavy construction, special trades and other construction activities; (2) businesses involved in wholesale and retail trade ("trade"); (3) manufacturing ("Mfg") — businesses producing nondurable goods such as food products, textile products, chemicals, etc., and durable goods such as lumber and wood products, glass products, machinery, motor vehicles, etc.; (4) finance, insurance, and real estate ("FIRE") — businesses involved in banking, investment services, insurance and real estate; (5) transportation and public utilities ("TPU") — businesses involved in rail, air and bus transportation, trucking and warehousing, pipelines, communications, and electric, gas and sanitary services among others; (6) services ("Svcs") — businesses providing any number of services including: business, auto repair, recreational, household, health, legal, education, etc.; and (7) government ("Gvt") — federal, state and local government including civilian and military enterprises. For more details on the specific type of business, products, or services within each of the respective sectors refer to the *Standard Industrial Classification Manual*, Office of Management and Budget, Washington, DC, 1987. Sectoral employment intensities are calculated from data published by the Bureau of Economic Analysis.

indexes the region's combined per capita employment in each sector to that of the United States as a whole.

Sectors having an employment intensity greater than 100 percent are those which provide more jobs per capita compared to the same sectors within the United States. Similarly, those sectors with an employment intensity less than 100 percent provide fewer jobs per capita compared to those same sectors for the nation as a whole.

As shown in Figure A- 1, the region has a strong and relatively diverse economic base. Three of the seven employment sectors analyzed have an employment intensity that is greater than that of the nation as a whole. The combined finance, insurance, and real estate industries (FIRE) however, have the highest intensity — 120 percent of the nation as a whole. New York's FIRE industry employment leads the region at almost 135 percent of the U.S. level. This is followed by New Jersey at 116 percent and Pennsylvania, significantly lower at 94 percent.

Other industries with high employment intensities in the respective states include services, transportation and public utilities (TPU), and manufacturing. Services are strong in each of the states, ranging from 110 percent of the national level in New York, to 104 percent in New Jersey, and 101 percent in Pennsylvania. Transportation and public utilities have the highest employment intensity in New Jersey (125 percent of the U.S. level) but are below the U.S. level in each of the other states. In Pennsylvania, manufacturing is the strongest industry with an intensity of 110 percent of U.S. levels, yet it too is below U.S. levels in the other states.

The remainder of the economic sectors reviewed - construction, government, and trade - all have employment intensities significantly lower (regionally and in each of the individual states) compared with the United States as a whole. Stated differently, although only three of the seven industries noted in Figure A-1 have regional employment intensities equal to, or greater than the U.S. as a whole, the combined number of employees in the more energy-intensive industries is slightly higher than for the U.S. average.

According to the U.S. Department of Energy, just six industries account for 84 percent of total energy use in the manufacturing sector. These include: food processing, chemicals, petroleum refining, pulp and paper, primary metals, and stone, glass and clay products.[142] The region's employment intensity in these six industries is approximately 102 percent of the U.S. average. Normally, this suggests a level of industrial use in the region approximately equal to that for the country as a whole.

142. See "Manufacturing Energy Consumption Survey Preliminary Estimates 1991," *Monthly Energy Review*, Energy Information Administration, U.S. Department of Energy, Washington, DC, September 1993, pages 1-4.

Pennsylvania has an employment intensity of 141 percent of the national level in the six industries and has industrial energy consumption almost twice as high as either of the other states in the region (see Table A-3 for more detail). Pennsylvania's industrial consumption is the fifth highest in the U.S. New Jersey however, which also has a high employment intensity in these industries (139 percent) ranks fifteenth in industrial energy use nationwide. New York has a significantly lower employment intensity in these industries (61 percent) and also has a lower industrial energy use, although greater (eleventh in the U.S.) than New Jersey's. Thus, efficiency measures and programs addressed to industry in general and these six industries in particular will be very important in Pennsylvania and New Jersey.

C. Energy Intensity Indicators

A comparison of data on energy use per dollar of Gross State Product (GSP)[143] offers additional insights about the role of energy as part of the Mid-Atlantic economy. Table A-2 contains relevant data for the United States, the region, and each of the individual states.

As Table A-2 illustrates, the region's residents and businesses spent the equivalent of 6.8 percent of the region's combined GSP on energy.[144] This ratio of energy expenditures to GSP compares to the U.S. ratio of 7.9 percent. The state of Pennsylvania, however, spent the equivalent of 8.1 percent of its GSP on energy. This ratio is slightly more than the U.S. as a whole and considerably more than the other two states in the region. This is due in part to the high energy use in the industrial sector and the relatively large energy consumption in the state overall - almost as high as New York — combined with a considerably lower GSP than either of the other states. New York and New Jersey each spent lower percentages of their GSP on energy expenditures, 5.9, and 7.2 percent, respectively.

Likewise, the level of energy intensity for the region as a whole (measured as the number of Btus[145] consumed per dollar of GSP) is also significantly lower - about 28 percent lower than the U.S. level. In other words, every dollar of valued-added products generated in the region requires less energy and a lower level of spending for energy than the U.S. average.

143. This refers to the total value of goods and services at market prices produced by the state's economy in a given year. It includes the total purchases of goods and services by private consumers and government, gross private domestic capital investment, and net foreign trade.

144. This includes total expenditures for coal, natural gas, petroleum and electricity in the residential, commercial, industrial, and transportation sectors.

145. Btus, or British Thermal Units, refers to the energy or heat value per unit quantity of fuel. One Btu is the quantity of heat needed to raise the temperature of 1 pound of water by 1 degree Fahrenheit at or near 39.2 degrees Fahrenheit; or roughly equivalent to the amount of heat given off by one wooden kitchen match.

Contrary to this lower level of energy intensity for the region as a whole, we once again see that the state of Pennsylvania, with the second highest energy expenditures and second highest Btu consumption in the region, has the highest energy intensity in the region. In other words, Pennsylvania lags behind its Mid-Atlantic neighbors in overall energy efficiency. Still, this level of intensity is only 97 percent of the national average. In fact, all of the states in the region are below the national average, ranging from 12,976 Btus per dollar of GSP in Pennsylvania to 10,613 in New Jersey (79 percent of national average), to a low of 7,233 in New York (54 percent of national average).

Although the measure of energy used to produce economic output is not a direct indicator of energy efficiency (i.e., industries can be efficient users of energy but still consume large amounts of energy relative to other economic activities), it is interesting to note that each of the Mid-Atlantic states uses less energy per dollar of output than the national average. The three-state Mid-Atlantic region as a whole accounts for approximately 16.3 percent of the nation's combined GSP and utilizes only 11.7 percent of the total energy consumed nationwide.

Table A-2. 1993 Energy Consumption Per Dollar of GSP

	GSP (Billion $)	Energy Expenditures (Billion $)	Energy Expenditures As % of GSP	Energy Consumption (Trillion Btu)	Btus Per Dollar GSP
United States	$6,271	$493.3	7.9%	83,958	13,388
Region	$1,022	$69.8	6.8%	9,790	9,574
New York	$512	$30.4	5.9%	3,702	7,233
New Jersey	$228	$16.4	7.2%	2,422	10,613
Pennsylvania	$283	$23.0	8.1%	3,666	12,976

Source: The data in this table are adapted from the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) economic data, the Energy Information Administration's (EIA) *State Energy Price and Expenditure Report 1993*, and the *State Energy Data Report 1993*. The GSP data have been updated from 1992 figures using published information on personal income for 1993. All dollar values used in this table reflect current year totals.

II. Regional Energy Use Patterns

A. An Overview

Overall, total energy consumption in the region decreased approximately 5.2 percent between 1970 and 1993. The decreases ranged from 9.7 percent in Pennsylvania to 13.1 percent in New York. Contrary to this trend of decreasing energy consumption in the region, New Jersey actually increased its total energy consumption by more than 20 percent during this 23-year period (consistent with the large increase in GSP and population).

As Table A-3 indicates, a large portion of this decrease in energy consumption (for the region as a whole and for New York) occurred by 1980. Since 1980 energy consumption in the residential, commercial, and transportation sectors generally increased in each of the states. The one exception is New York's transportation sector, which decreased energy consumption by 12.6 percent in this period.

Energy consumption in the industrial sector (in all of the states) decreased substantially between 1970 and 1993 reflecting primarily a decline in the number of manufacturing establishments. The industrial sectors in both New York and Pennsylvania registered the largest decreases in energy consumption — almost 37 percent. New Jersey's industrial sector decreased consumption by just over 6 percent. Table A-3 shows that the decline in energy consumption in the industrial sector (31.4 percent as a region between 1970-1993) more than offset the increases in the other sectors, and is largely responsible for the total decrease in energy use in the region. This impact on the region's total consumption is not surprising when we consider that the industrial sector has consistently accounted for between 28 and 39 percent of the region's energy consumption for the years noted.

When viewed on a per capita basis we see that total energy consumption in the region decreased 7.2 percent during this same period. Consumption dropped from a high of 277 million Btus (MBtu) per capita in 1970 to a low of 238 MBtus in 1985, and then increased to 257 MBtu in 1993. New York had the lowest per capita consumption in 1970 (234 MBtus), decreasing to 190 MBtus in 1985, and rising again by 1993 to 204 MBtus. New York also had the largest decrease in per capita consumption (12.7 percent) during this period.

On the other end, Pennsylvania had the highest per capita consumption (344 MBtus) in 1970. Consumption decreased to 281 MBtus in 1985 and then increased again to 305 MBtus in 1993, for a total decrease of 11.4 percent. In spite of a brief decline in per capita consumption in New Jersey in 1980, overall, per capita consumption (consistent with the increase in total energy consumption) increased 10.5 percent from 279 MBtus in 1970 to 308 MBtus in 1993.

Consistent with this decline in total and per capita energy consumption (in New York, New

Jersey, and for the region as a whole) during the same period, each of the states (including Pennsylvania) consumed less energy per capita in 1993 than did the nation as a whole. New York consumed 37 percent less, New Jersey 5 percent less, and Pennsylvania 6 percent less.

As Table A-4 indicates, the region consumed 257.8 MBtu per person in 1993 compared to the U.S. total of 325.7 MBtu. If we were to translate this energy into an equivalent amount of gasoline, it turns out that the region requires 2,061 gallons of gasoline equivalent per capita per year compared with a nationwide requirement of 2,604 gallons. Even with the declines noted above, the region's commercial sector (as a whole) consumed more energy per capita than the U.S. average.

Taking the major end-use sectors one at a time, the residential sector requires slightly less energy per capita in New York and New Jersey, 55.8 MBtu and 62 MBtus, respectively. This compares with the national average of 66.3 MBtus and Pennsylvania's 72.8 MBtus. This may signify greater implementation of energy efficiency measures in both New York and New Jersey (as a result of high energy prices) and/or a greater percentage of multifamily housing.

Commercial sector energy use in the region (and in each of the states) is slightly higher than the national average at 108 percent of the U.S. consumption. This is the result of both higher heating requirements than the country as a whole, the use of air conditioning in most commercial buildings and the large number of commercial buildings, especially in New York and New Jersey. New Jersey's commercial sector has the highest per capita consumption in the region, using 64.9 MBtus. This compares with 57.8 MBtus in New York and 45.7 MBtus in Pennsylvania.

Unlike the commercial sector, per capita energy consumption in the industrial sector (72.2 MBtus) is only 60 percent of the U.S. average per capita energy use. It is interesting to note however, that while industrial energy use per capita (for the region as a whole) is 40 percent lower than the national average, manufacturing employment is only 10 percent lower than the national average.

Consistent with New York's low per capita energy consumption in the residential sector, per capita energy consumption in its industrial sector (40.9 MBtus) is also the lowest in the region and approximately one-third of the national level (119.3 MBtus). New Jersey's industrial sector has a per capita consumption more than twice (82.7 MBtus) that of New York but still well below the national level. Similarly, Pennsylvania's per capita consumption in the industrial sector is the highest in the region (112.5 MBtus), but still only 94 percent of the national average.

Similar to the lower energy consumption in the residential and industrial sectors (compared with the U.S. average), the region's transportation sector (as a whole) is also lower, at 76 percent of the U.S. average. This appears to be due primarily to significantly greater popu-

Table A-3. Regional Energy Consumption 1970-1993
(In trillion Btu)

Sector	1970	1975	1980	1985	1990	1993	Annual Percent Change 1970-80	Annual Percent Change 1980-93
RESIDENTIAL								
Region	2,370.7	2,346.4	2,286.2	2,176.7	2,217.5	2,399.7	-0.36%	0.37%
New York	1,052.9	1,030.3	942.3	918.5	949.4	1,013.2	-1.10%	0.56%
New Jersey	487.0	487.8	476.9	465.7	470.8	510.2	-0.21%	0.52%
Pennsylvania	830.8	828.3	867.0	792.5	797.3	876.3	0.43%	0.08%
COMMERCIAL								
Region	1,645.3	1,598.7	1,722.4	1,767.8	2,001.4	2,087.8	0.46%	1.49%
New York	939.5	874.9	896.8	926.4	1,013.9	1,050.1	-0.46%	1.22%
New Jersey	327.1	322.9	385.1	382.3	469.5	487.6	1.65%	1.83%
Pennsylvania	378.7	400.9	440.5	459.1	518.0	550.1	1.52%	1.72%
INDUSTRIAL								
Region	4,000.4	3,379.8	3,351.4	2,506.5	2,622.2	2,745.1	-1.75%	-1.52%
New York	1,174.1	933.6	915.5	699.8	698.7	741.6	-2.46%	-1.61%
New Jersey	692.7	582.0	657.4	507.8	523.9	650.2	-0.52%	-0.08%
Pennsylvania	2,133.6	1,864.2	1,778.5	1,298.9	1,399.6	1,353.3	-1.80%	-2.08%
TRANSPORTATION								
Region	2,304.6	2,339.1	2,410.5	2,398.7	2,562.0	2,556.8	0.45%	0.45%
New York	1,093.7	1,050.2	1,026.5	842.4	922.8	896.8	-0.63%	-1.03%
New Jersey	493.1	519.5	566.3	794.9	796.3	773.8	1.39%	2.43%
Pennsylvania	717.8	769.4	817.7	761.4	842.9	886.2	1.31%	0.62%
TOTAL								
Region	10,321.0	9,664.0	9,770.5	8,849.7	9,403.1	9,789.4	-0.55%	0.01%
New York	4,260.2	3,889.0	3,781.1	3,387.1	3,584.8	3,701.7	-1.19%	-0.16%
New Jersey	1,999.9	1,912.2	2,085.7	2,150.7	2,260.5	2,421.8	0.42%	1.16%
Pennsylvania	4060.9	3862.8	3903.7	3311.9	3557.8	3665.9	-0.39%	-0.48%
PER CAPITA (MBtus)								
Region	277	258	266	238	250	257	-0.43%	-0.24%
New York	234	215	215	190	199	204	-0.81%	-0.42%
New Jersey	279	260	283	284	292	308	0.15%	0.65%
Pennsylvania	344	323	329	281	299	305	-0.45%	-0.59%
POPULATION (000s)								
Region	37,213	37,394	36,787	37,129	37,604	38,042	-0.12%	0.26%
New York	18,241	18,074	17,558	17,792	17,991	18,153	-0.38%	0.26%
New Jersey	7,171	7,359	7,365	7,566	7,730	7,859	0.27%	0.50%
Pennsylvania	11,801	11,961	11,864	11,771	11,883	12,030	0.05%	0.11%

Source: The information in this table reflects primary rather than end-use energy consumption. The data are derived from data in the *State Energy Data Report 1993* and the *Statistical Abstract of the United States 1995*.

Table A-4. A Comparison of 1993 Per Capita Energy Consumption (In Million Btus)

	Residential	Commercial	Industrial	Transportation	Total
United States	66.3	51.3	119.3	88.8	325.7
Region	62.5	55.5	72.2	67.2	257.3
New York	55.8	57.8	40.9	49.4	203.9
New Jersey	62.0	64.9	82.7	98.5	308.2
Pennsylvania	72.8	45.7	112.5	73.7	304.7
Region as Percent of United States	94%	108%	60%	76%	79%

Source: The information in this table is derived from data in the *State Energy Data Report 1993*, and the *Statistical Abstract of the United States 1995*. Regional estimates are based on the sum of a population-based weighting for each of the states.

lation densities in the region (as noted earlier) and the use of mass transit. Nevertheless, New Jersey's per capita consumption of 98.5 MBtus is actually greater than the national level of 88.8 MBtus. Both New York and Pennsylvania have per capita consumption levels well below New Jersey's and the national level, 49.4 MBtus and 73.7 MBtus, respectively.

B. Energy Expenditures

In 1993 the Mid-Atlantic region as a whole used about 21 percent less energy per capita than did the United States as a whole. As Table A-5 shows, the average energy price in each of the states was higher in the region compared to the U.S. Electricity prices in New York were the second highest in the nation. Although not as high, New Jersey and Pennsylvania both had electricity prices far above the national average.

Similarly, prices for natural gas, coal, and motor gasoline were also above the national averages within each of the states (with the exception of petroleum in New Jersey). These higher prices probably contribute to the lower energy consumption in the region relative to national averages. As a result of these generally higher prices and lower consumption levels, the region's per capita energy bill in 1993 was $1,834, approximately 0.4 percent lower than the national average of $1,914.

Per capita GSP in the region was 10.5 percent higher than the national average. The end result is that families and businesses in the region spent approximately 13 percent less of the

Table A-5. 1993 Regional Energy Prices
(In Dollars per Million Btu)

	Coal	Natural Gas	Motor Gasoline	Petroleum	Electricity	Average
New York	$1.56	$6.00	$9.30	7.15	$31.43	$11.05
New Jersey	$1.75	$5.07	$9.09	6.44	$29.31	$8.87
Pennsylvania	$1.50	$5.33	$9.27	7.63	$23.26	$8.63
United States	$1.43	$4.16	$9.07	7.09	$20.38	$8.42

Notes: Data derived from the *State Energy Price and Expenditure Report 1993*. Average price refers to all fuels for all end-use sectors (i.e., residential, commercial, industrial, and transportation).

region's GSP for energy than did the average U.S. resident or business.[146] The region's total energy expenditure was $69.8 billion in 1993. This is 12.7 percent larger than the region's combined collection of state income and sales taxes in 1993.[147]

Table A-6 provides a breakdown of total energy expenditures by fuel type and end-use sector. The expenditures are divided between coal, natural gas, petroleum, and electricity. [148]The data indicate that the residents and businesses in each of the states in the region spent between 82 and 83 percent of their total energy expenditures on petroleum and electricity.

The transportation sector was the largest energy user in dollar terms in both New Jersey and Pennsylvania. These expenditures, primarily for petroleum, accounted for almost one-third of each state's 1993 total energy expenditures, $5.3 billion and $7.2 billion, respectively. The residential sector was the largest energy user in New York however, spending more than $9.9 billion. More than half of these residential expenditures were for electricity. This is in part due to the large residential sector and high electricity prices noted earlier.

146. The state's total energy expenditures for 1993 are based on the *State Energy Price and Expenditure Report 1993*, op. cit. The population and income data are taken from the *Survey of Current Business*, August 1995 and the *Statistical Abstract of the United States 1995*, op.cit.

147. According to the published data, the three-state region collected a combined $60.9 billion in state income and sales taxes in 1993. See *Statistical Abstract of the United States 1995*, Table 492, op. cit.

148. Utility expenditures for coal, natural gas, and petroleum, along with other costs of providing electricity, are included in the electricity column.

Following transportation in New Jersey and Pennsylvania, the residential sectors in each state accounted for between 27 and 30 percent of total energy expenditures, respectively. In New York, the commercial sector was the second largest energy user in dollar terms, accounting for $8.7 billion or approximately 29 percent of the state's total energy expenditures.

The commercial sector had the third largest energy expenditures in New Jersey, accounting for just over 23 percent of total expenditures. This was followed by industrial expenditures which totaled almost $2.9 billion or 17.5 percent.

Industrial sector energy expenditures were the third highest energy expenditures in Pennsylvania (22.3 percent) followed by commercial sector expenditures of $3.8 billion (16.7 percent). Transportation expenditures were the third highest expenditure in New York (26.4 percent) followed by industrial sector expenditures (12.2 percent).

Table A-6. 1993 Regional End-Use Expenditures by Sector and Fuel (in Millions of Current Dollars)

Sector	Coal	Natural Gas	Petroleum	Electricity	Total
RESIDENTIAL					
Region	$54.0	$6,338.3	$3,083.1	$11,729.1	$21,204.5
New York	$9.5	$3,131.4	$1,536.0	$5,256.1	$9,933.0
New Jersey	$0.3	$1,367.0	$553.4	$2,514.0	$4,434.7
Pennsylvania	$44.2	$1,839.9	$993.7	$3,959.0	$6,836.8
COMMERCIAL					
Region	$24.9	$2,871.3	$1,323.3	$12,130.1	$16,349.6
New York	$4.6	$1,359.8	$864.4	$6,495.0	$8,723.8
New Jersey	$0.1	$722.1	$227.1	$2,842.2	$3,791.5
Pennsylvania	$20.2	$789.4	$231.8	$2,792.9	$3,834.3
INDUSTRIAL					
Region	$762.2	$2,386.8	$2,751.1	$5,805.5	$11,705.6
New York	$129.2	$829.3	$732.9	$2,012.0	$3,703.4
New Jersey	$8.3	$668.6	$1,042.9	$1,149.8	$2,869.6
Pennsylvania	$624.7	$888.9	$975.3	$2,643.7	$5,132.6
TRANSPORTATION					
Region	$0.0	$0.0	$20,249.7	$250.0	$20,499.7
New York	$0.0	$0.0	$7,809.5	$198.1	$8,007.6
New Jersey	$0.0	$0.0	$5,294.3	$17.8	$5,312.1
Pennsylvania	$0.0	$0.0	$7,145.9	$34.1	$7,180.0
TOTAL EXPENDITURES					
Region	$841.1	$11,596.4	$27,407.2	$29,914.7	$69,759.4
New York	$143.3	$5,320.5	$10,942.8	$13,961.2	$30,367.8
New Jersey	$8.7	$2,757.7	$7,117.7	$6,523.8	$16,407.9
Pennsylvania	$689.1	$3,518.2	$9,346.7	$9,429.7	$22,983.7

Source: This information is based on data contained in the Energy Information Administration's *State Energy Price and Expenditure Report 1993*. Based on this EIA reporting format agricultural uses are included in the industrial class together with mining, construction and manufacturing. Government uses are included with the commercial uses, together with trade and service industries.

APPENDIX B

Residential and non residential building prototypes were developed using the DOE-2.1E building energy simulation computer program. The DOE-2.1E prototypes were used to evaluate energy savings estimates for a number of energy efficiency measures. The following measures could not be evaluated using DOE-2: steam distribution package; furnace fan/thermostat adjustment; duct sealing; and duct insulation. Energy savings for these measures are extrapolated from measured data. Building prototypes were developed using data from the Gas Research Institute (GRI 1991), Lawrence Berkeley Laboratory, Orange and Rockland (OR 1995), and NYSERDA (1989, 1994). Eight non residential and four residential building prototypes were developed.

<u>Non Residential</u>

1. Existing Medium Office
2. New Medium Office
3. Existing Medium Retail
4. New Medium Retail
5. Existing School
6. New School
7. Existing Warehouse
8. New Warehouse

<u>Residential</u>

1. Existing Multifamily Apartment (Gas Boiler/RAC)
2. Existing Multifamily Apartment (Elec. Heat/RAC)
3. New Multifamily Townhouse (Heat Pump)
4. New Multifamily Townhouse (Gas Furn./CAC)
5. Existing Single Family Detached (Gas Furn./CAC)
6. New Single Family Detached (Gas Furn./CAC)

Section B-1 provides a brief description of each building prototype. Section B-2 provides a description of each energy efficiency measure. At the end of this appendix are a set of tables that provide for each building prototype percentage gas and electric energy savings, total specific gas and electric use (kWh/sf, KBtu/sf), energy efficiency measure costs per unit, units per square foot of floor area, marginal cost of saved energy (CSE, $/MMBtu), average CSE, and estimated measure life.

Also attached is a table summarizing the analysis of potential efficiency improvements for appliances and an analysis of energy and financial savings fro adopting the BOCA 1996 building code in the three states.

B-1. DOE-2.1E BUILDING PROTOTYPES

Existing Medium Office

The existing medium office prototype is a three-story building with 60,000 square feet of conditioned floor area. The base case has no insulation in the walls and an average of R-2.6 insulation in the roof. Peak lighting intensity is 2.0 W/sf and the peak equipment intensity is

1.2 W/sf. Windows are metal frame single-pane with a U-value of 1.11 Btu/hr-ft^2-F and a shading coefficient of 0.83. The window-to-wall area ratio is 0.25, floor to ceiling height is 10 ft, and floors are medium weight (70 lb/cf). Peak occupancy level is 275 sf/person. The HVAC system is a reheat fan system serving two zones per floor (perimeter and core) with a 70 hp fan supply fan and a 23 hp return fan. Chilled water is provided by two 75 ton hermetic reciprocating chillers (3.82 COP, 150 tons total). Heat rejection is accomplished with two induced-draft cooling towers with a total capacity of 190 tons. Space heating is provided by two 75 percent efficient hot water boilers with a total capacity of 3,500 kBtu/hr. Occupancy, lighting, miscellaneous equipment, and service hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a).

New Medium Office

The new medium office prototype is a three-story building with 60,000 square feet of conditioned floor area. The base case has metal-frame walls with nominal R-11 (R-5.5) insulation and R-19 insulation in the ceiling. Peak lighting intensity is 1.76 W/sf and the peak equipment intensity is 1.2 W/sf. Windows are metal frame double-pane with a U-value of 0.57 Btu/hr-ft^2-F and a shading coefficient of 0.72. The window-to-wall area ratio is 0.25, floor to ceiling height is 10 ft, and floors are medium weight (70 lb/cf). Peak occupancy level is 275 sf/person. The HVAC system is a variable air volume (VAV) system serving two zones per floor (perimeter and core) with a 55 hp fan supply fan and a 18 hp return fan. Chilled water is provided by two 65 ton hermetic centrifugal chillers (4.23 COP, 130 tons total). Heat rejection is accomplished with two induced-draft cooling towers with a total capacity of 165 tons. Space heating is provided by two 80 percent efficient hot water boilers with a total capacity of 3,875 kBtu/hr. Occupancy, lighting, miscellaneous equipment, and service hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a).

Existing Medium Retail

The existing retail prototype is a one story building with 10,000 square feet of conditioned floor area. The base case has R-1 insulation in the walls and R-11 insulation in the roof. Peak lighting intensity is 2.1 W/sf and peak equipment intensity is 0.25 W/sf. The windows are metal frame single-pane with a U-value of 1.11 Btu/hr-ft^2-F and a shading coefficient of 0.83. Window-to-wall area ratio is 0.17, floor to ceiling height is 15 ft, floor weight is medium (60 lb/cf). Peak occupancy level is 300 sf/person. The HVAC system consists of two (2) packaged single-zone (PSZ) systems with total cooling capacity of 25 tons and total gas furnace heating capacity of 480 kBtu/hr. The PSZ system serving the northeast zone has a 2.4 hp fan and the PSZ system serving the southwest zone has a 3.0 hp fan. Occupancy, lighting, miscellaneous equipment, and service hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a).

New Medium Retail

The new retail prototype is a one story building with 10,000 square feet of conditioned floor area. The base case has metal-frame walls with nominal R-11 (R-5.5) insulation and R-19 insulation in the ceiling. Peak lighting intensity is 1.76 W/sf and peak equipment intensity is 0.25 W/sf. The windows are metal frame double-pane with a U-value of 0.57 Btu/hr-ft^2-F and a shading coefficient of 0.72. Window-to-wall area ratio is 0.17, floor to ceiling height is 15 ft, floor weight is medium (60 lb/cf). Peak occupancy level is 300 sf/person. The HVAC system consists of two (2) packaged single-zone (PSZ) systems with total cooling capacity of 20 ton and total gas furnace heating capacity of 390 kBtu/hr. The PSZ system serving the northeast zone has a 1.9 hp fan and the PSZ system serving the southwest zone has a 2.4 hp fan. Occupancy, lighting, miscellaneous equipment, and service hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a).

Existing School

The existing school prototype is a two story building with 240,000 square feet of conditioned floor area. The base case has no insulation in the walls and R-3.3 insulation in the roof. Peak lighting intensity is 2.4 W/sf in the classrooms, library, kitchen, and dining areas, 0.65 W/sf in the gym, and 0.8 W/sf in the auditorium. Peak electric equipment intensity is 0.05 W/sf in the classrooms, 0.025 W/sf in the library and auditorium, 0.02 W/sf in the gym, 0.04 W/sf in the dining room and 5 W/sf in the kitchen. Peak gas equipment intensity is 148 Btu/hr-sf in the kitchen. The windows are metal frame single-pane with a U-value of 1.11 Btu/hr-ft^2-F and a shading coefficient of 0.83. The overall window-to-wall area ratio is 0.13. The window-to-wall ratio is 0.2 in classrooms, 0.4 in the dining and library rooms, and no windows in the auditorium, gym, and kitchen. The floor to ceiling height is 10 ft in all rooms except the gym and auditorium that have 32 ft ceiling height. Floor weight is medium (60 lb/cf). Average peak occupancy level is 86.5 sf/person. All zones are served by packaged air conditioning and heating systems. Heat is provided by two 75 percent efficient hot water boilers with total capacity of 11,054 kBtu/hr. Total cooling capacity is 861 tons and the average EER is 8.1. Occupancy, lighting, miscellaneous equipment, and service hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a).

New School

The new school prototype is a two story building with 240,000 square feet of conditioned floor area. The base case has metal-frame walls with nominal R-11 (R-5.5) insulation and R-19 insulation in the ceiling. Peak lighting intensity is 2.1 W/sf in the classrooms, library, kitchen, and dining areas, 0.65 W/sf in the gym, and 0.8 W/sf in the auditorium. Peak electric equipment intensity is 0.05 W/sf in the classrooms, 0.025 W/sf in the library and auditorium, 0.02 W/sf in the gym, 0.04 W/sf in the dining room and 5 W/sf in the kitchen. Peak gas equipment intensity is 148 Btu/hr-sf in the kitchen. The windows are metal frame double-pane with a U-value of 0.57 Btu/hr-ft^2-F and a shading coefficient of 0.71. The overall window-to-wall area ratio is 0.13. The window-to-wall ratio is 0.2 in classrooms, 0.4 in the dining and library rooms, and no windows in the auditorium, gym, and kitchen. The floor to ceiling height is 10 ft in all rooms except the gym and auditorium that have 32 ft ceiling height. Floor weight is medium (60 lb/cf). Average peak occupancy level is 86.5 sf/person. All zones are served by packaged air conditioning and heating systems. Heat is provided by two 80 percent efficient hot water boilers with total capacity of 9,934 kBtu/hr. Total cooling capacity is 832 tons and the average EER is 8.5. Occupancy, lighting, miscellaneous equipment, and service hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a).

Existing Warehouse

The existing warehouse prototype is a one story building with 25,000 total square feet of conditioned floor area (22,875 warehouse and 2,125 office). The base case has no insulation in the walls and R-5.3 insulation in the roof. Peak lighting intensity is 1.59 W/sf in the warehouse area and 1.76 W/sf in the office area. Peak equipment intensity is 0.10 W/sf in the warehouse area and 0.75 W/sf in the office area. The windows are metal frame single-pane with a U-value of 1.11 Btu/hr-ft^2-F and a shading coefficient of 0.83. There are no windows in the warehouse and the window-to-wall area ratio in the office is 0.26. Floor to ceiling height is 25 ft in the warehouse and 10 ft in the office, floor weight is medium (60 lb/cf). Peak occupancy is 15,000 sf/person in the warehouse and 275 sf/person in the office. The HVAC system consists of two (2) packaged single-zone (PSZ) systems one for the warehouse and one for the office. The warehouse PSZ has 50 tons cooling capacity and 1100 kBtu/hr gas furnace. The office PSZ has 7.5 ton cooling capacity and a 140 kBtu/hr gas furnace. Base cooling EER is 8.1 and furnace efficiency is 75%. Occupancy, lighting, miscellaneous equipment, and service hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a).

New Warehouse

The new warehouse prototype is a one story building with 25,000 total square feet of conditioned floor area (22,875 warehouse and 2,125 office). The base case has metal-frame walls with nominal R-11 (R-5.5) insulation and R-11 insulation in the ceiling. Peak lighting intensity is 1.59 W/sf in the warehouse area and 1.76 W/sf in the office area. Peak equipment intensity is 0.10 W/sf in the warehouse area and 0.75 W/sf in the office area. The windows are metal frame double-pane with a U-value of 0.57 Btu/hr-ft^2-F and a shading coefficient of 0.71. There are no windows in the warehouse and the window-to-wall area ratio in the office is 0.26. Floor to ceiling height is 25 ft in the warehouse and 10 ft in the office, floor weight is medium (60 lb/cf). Peak occupancy is 15,000 sf/person in the warehouse and 275 sf/person in the office. The HVAC system consists of two (2) packaged single-zone (PSZ) systems one for the warehouse and one for the office. The warehouse PSZ has 37 tons cooling capacity and 800 kBtu/hr gas furnace. The office PSZ has 5.5 ton cooling capacity and a 100 kBtu/hr gas furnace. The base air conditioning EER is 8.5 and furnace efficiency is 80%. Occupancy, lighting, miscellaneous equipment, and service hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a).

Existing Multifamily Apartment (Gas Boiler/RAC)

The existing multifamily apartment prototype is a three-story building with eighteen apartments. Each apartment is 900 sf with a total of 18,216 square feet of conditioned floor area. Construction is masonry veneer over wood frame. The base case has no insulation in the walls and ceiling. Peak lighting intensity is 0.9 W/sf and the peak internal loads are 2 Btu/hr-ft^2. Windows are metal frame single pane having a U-value of 1.09 Btu/hr-ft^2-F and a shading coefficient of 0.95. The window-to-wall area ratio is 0.20, floor to ceiling height is 8 ft. Peak occupancy level is 2 persons per unit. Infiltration is 0.7 ACH. Heating is provided by steam radiators in each unit and a 60 percent efficient central steam boiler with total capacity of 1,000 kBtu/hr. Each unit has a 2 ton 8 EER room air conditioner (RAC). Occupancy, lighting, miscellaneous equipment, and domestic hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a). Heating setpoint is 68 F and setback is 64 F from 10 PM to 6 AM (at night) and 10 AM to 4 PM (during the day). Cooling setpoint is 76 F and setforward is 84 F from 9 AM to 5 PM.

Existing Multifamily Apartment (Electric Heat/RAC)

Same as above, but base case has R-12 ceiling insulation, and each unit has electric baseboard heat rather than steam radiators.

New Multifamily Townhouse (Gas Furnace/CAC)

The new multifamily townhouse apartment prototype has ten two-story units and each unit is 1200 sf. Construction is wood frame. The base case has R-13 wall insulation, R-19 floor insulation, and R-30 ceiling insulation. Peak lighting intensity is 0.9 W/sf and the peak internal loads are 2 Btu/hr-ft^2. Windows are metal frame double pane having a U-value of 0.57 Btu/hr-ft^2-F and a shading coefficient of 0.88. The window-to-wall area ratio is 0.14, floor to ceiling height is 8 ft. Peak occupancy level is 2 persons per unit. Infiltration is 0.6 ACH. Each unit has a separate central air conditioner and heating system. The heating system is a heat pump with heating capacity of 60 kBtu/hr and electric resistance supplemental heating capacity of 120 kBtu/hr capacity. Heating is provided by a gas forced-air furnace with heating capacity of 60 kBtu/hr and an annual fuel utilization efficiency (AFUE) rating of 78 percent. Cooling is provided by a 3.5 ton central air conditioner with a 10 seasonal energy efficiency ratio (SEER). Occupancy, lighting, miscellaneous equipment, and domestic hot water schedules and minimum outdoor air ventilation requirements are taken from ASHRAE (ASHRAE 1989, ASHRAE 1989a). Heating setpoint is 68 F and setback is 64 F from 10 PM to 6 AM (at night) and 10 AM to 4 PM (during the day). Cooling setpoint is 76 F and setforward is 84 F from 9 AM to 5 PM.

New Multifamily Townhouse (Heat Pump)

Same as above, except each unit has a separate heat pump system for cooling and heating. The heating system is a heat pump with heating capacity of 46 kBtu/hr and electric resistance supplemental heating capacity of 60 kBtu/hr capacity. The base heat pump has a heating season performance factor (HSPF) of 6.8. In air conditioning mode the heat pump has 3.5 tons of cooling capacity with a 10 SEER.

Existing Single Family Detached (Gas Furnace/CAC)

The existing single family detached prototype is a two-story building with 1,600 square feet of conditioned floor area. Construction is wood frame with a basement. The base case has R-3 insulation in the walls and R-13 ceiling insulation in the roof. Peak lighting intensity is 0.9 W/sf and the peak internal loads are 1.15 Btu/hr-ft^2. Windows are wood frame with storms having a U-value of 0.57 Btu/hr-ft^2-F and a shading coefficient of 0.88. The window-to-wall area ratio is 0.18, floor to ceiling height is 8 ft. Peak occupancy level is 3 persons. Infiltration is 0.7 ACH. Heating is provided by a gas forced-air furnace with heating capacity of 120 kBtu/hr and an AFUE rating of 75 percent. Cooling is provided by a 5 ton central air conditioner with an 8.1 SEER. Heating setpoint is 70 F and setback is 64 F from 10 PM to 6 AM (at night) and 10 AM to 4 PM (during the day). Cooling setpoint is 76 F and setforward is 84 F from 9 AM to 5 PM.

New Single Family Detached (Gas Furnace/CAC)

The new single family detached prototype is a two-story building with 1,600 square feet of conditioned floor area. Construction is wood frame with a basement. The base case has R-13 wall insulation, R-11 floor insulation, and R-30 ceiling insulation. Peak lighting intensity is 0.9 W/sf and the peak internal loads are 2 Btu/hr-ft^2. Windows are vinyl frame double pane with a U-value of 0.57 Btu/hr-ft^2-F and a shading coefficient of 0.88. The window-to-wall area ratio is 0.18, floor to ceiling height is 8 ft. Peak occupancy level is 2 persons per unit. Infiltration is 0.6 ACH. Heating is provided by a gas forced-air furnace with heating capacity of 120 kBtu/hr and an AFUE rating of 82 percent. Cooling is provided by a 5 ton central air conditioner with a 10 SEER. Heating setpoint is 70 F and setback is 64 F from 10 PM to 6

AM (at night) and 10 AM to 4 PM (during the day). Cooling setpoint is 76 F and setforward is 84 F from 9 AM to 5 PM.

B-2. MEASURE DESCRIPTION

Efficient Office Equipment

Measure Description. The energy efficient office equipment measure consists of replacing inefficient computers, video display terminals (VDTs), and printers with high-efficiency products. EPA's Energy Star program in cooperation with major electronic manufacturers is hastening the evolution towards more energy efficient electronic office equipment. At this time all personal computer manufacturers (such as Apple, IBM, Compaq, Dell, Micron, Hewlett Packard) sell EPA certified Energy Star products. These products include portable laptops that plug into desktop "docking" systems, VDTs, desktop computers and printers that have a low-energy "sleep" mode (when inactive for a predetermined period of time). When the market is saturated (in 2-4 years), these innovative products will reduce office equipment energy use by approximately 63% compared to average components used today.

Base Case Equipment Power Density Levels. Baseline prototypical office equipment power density levels (1.2 W/sf) for new and existing buildings are based on *America's Energy Choices* (UCS 1992). The tables provide base case office equipment power density levels for each building prototype and vintage.

Incremental Cost. Incremental cost for efficient office equipment is assumed negligible due to EPA's cooperative Energy Star program and the general trend towards more energy efficient office technologies (E-Source 1990).

Efficient Lighting

Measure Description. The energy efficient lighting measure consists of replacing the standard fluorescent fixtures, lamps, and ballasts with high efficiency components. The high efficiency components are typically fixtures with specular reflectors, tri-phosphor T-8 lamps (32 W), and electronic ballasts. Incandescent lighting fixtures are replaced with IR halogen lamps or compact fluorescent lamps where appropriate. Efficient lighting power density (W/sf) is based on America's Energy Choices (UCS 1992).

Base Case Lighting Levels. Baseline prototypical lighting levels (W/sf) for new and existing buildings are based on America's Energy Choices (UCS 1992). The tables provide base case lighting levels for each building prototype and vintage.

Incremental Cost. The average incremental cost for efficient lighting is $37 per fixture for existing construction and $29 per fixture for new construction (XEN 1992).

Wall, Ceiling/Roof Insulation

Measure Description. Installing fiberglass or cellulose insulation material in floor, wall or roof cavities will reduce heat transfer across these surfaces. The type of building construction limits insulation possibilities. Choice of insulation material will vary depending on the wall or roof construction type. Wall construction types include, but are not limited to, mass walls, metal frame walls, wood frame walls, curtain walls, precast concrete panels, and tilt-duct concrete panels. Nominal R-values are used as the performance factor for insulation levels. For each commercial building prototype, the assumed overall wall or ceiling R-value are given followed by the nominal R-value for cavities (given in parentheses). The overall R-values include the thermal resistances of construction layers (gypsum, air gaps, framing, sheathing, concrete, roofing, etc.).

Base Case Insulation Levels. Assumed prototypical insulation levels for existing buildings are based on survey data. The tables provide base case insulation levels for each building prototype and vintage.

Wall Insulation in Metal Frame Walls. Insulation installed in metal frame walls will have an effective R-value that is about 50% less than the nominal R-value of the insulation (CEC 1992). This is due to the high thermal conductance of metal framing relative to wood framing. In our analysis we conservatively assumed metal frame walls exist in all new non residential construction.

Incremental Cost. Insulation costs are greater for retrofit installations where blown-in insulation is typically the only option. Assumed costs for insulation are shown in Table B-1 (XEN 1992).

Windows

Measure Description. The important energy performance parameters for windows are U-value, shading coefficient, visible light transmission and air leakage. The window U-value will vary as a function of the number of panes, gap thickness, gap fill (air or inert gas), presence of low-emissivity (low-e) coatings, and frame type. The shading coefficient and visible transmission will vary as a function of glass type and low-e coatings. Air leakage will depend on the type of frame and window design (casement vs. slider).

Base Case Windows. For non residential prototypes, base case windows are assumed to be single-pane with metal frames. For residential prototypes, base case windows are assumed to be single-pane wood windows with storm windows. U-values and shading coefficients for each prototype are given in the tables.

Double Pane, No Thermal Break (NTB). Replacing single pane with double pane windows reduces the U-value and heat transfer by 40%. This also reduces the shading coefficient, solar heat gain and the cooling load.

Double Pane, Thermal Break (TB). A metal window frame acts like a short circuit to heat transfer. Adding a thermal break to the metal frame will reduce the overall U-value by about 20%.

Double Pane Low-e, NTB and TB. Adding a low-e coating will improve the U-value by about 15%. The low-e coating will also provide a better shading coefficient than standard double pane glass while maintaining good visible light transmission. High performance low-e coatings cost more but provide much more flexibility and savings potential. Window manufacturers have different techniques of adding the low-e coating. Some manufacturers use low-e coated thin film plastic suspended between the double panes, some use "soft" low-e sputter coatings added to the inside of the outside lite, some use "hard" low-e pyrolytic coatings that can be added to either the inside or outside lite. Adding a thermal break provides even more savings at a slightly higher cost

Incremental Costs and Window Performance Characteristics. The U-values, shading coefficients and costs for all window types evaluated in the study are shown in Table B-2 along with assumed costs per square foot. The U-values and shading coefficients were calculated using the WINDOW 4.0 computer program (LBL 1992). Costs are based on Eley 1990 and the XENERGY Measure Cost Study (XEN 1992). Retrofit costs include labor which is roughly equal to the cost of the window, effectively doubling the retrofit cost compared to new construction.

Efficient HVAC Retrofit

Measure Description. The efficient HVAC retrofit consists of the following three measures.

1. Variable speed drive (VSD) fan control; VSD fan control provides a method to vary the amount of constant temperature air delivered to the space. Other less efficient methods to create a variable air volume (VAV) system involve the use of fan inlet (vortex) dampers or discharge damper control. Terminal sections may be single duct variable volume units with or without reheat, controlled by space thermostats. VAV systems

Table B-1. Insulation Costs.

Type of Insulation	Retrofit Cost $/sf	New Cost $/sf
Wall Insulation		
R-8 (R-4 for metal frame)	0.91	0.23
R-11 (R-5.5 for metal frame)	1.00	0.25
R-19 (R-9.5 metal frame)	1.25	0.35
Ceiling Insulation		
R-4	0.21	0.19
R-8	0.25	0.23
R-11	0.27	0.25
R-19	0.37	0.35
R-30	0.48	0.46

Table B-2. Window Costs and Performance Data.

Window Description	U-value Btu/hr-sf	Shading Coefficien t	Retrofit Cost $/sf	New Cost $/sf
Base Case; single pane, metal frame	1.000	0.850	-	-
Double pane, no thermal break	0.570	0.710	9.424.71	
Double pane, thermal break	0.425	0.500	13.32	6.66
Double pane Low-e, no thermal break	0.453	0.287	14.30	7.15
Double pane, Low-e, thermal break (residential)	0.304	0.650	18.20	9.10
Double pane, Low-e, thermal break (commercial)	0.304	0.330	18.20	9.10

reduce energy use by reducing the volume of air handled by the entire system as a function of the air required to meet the needs of the warmest or coolest zone. When the space demands peak cooling the fan operates at full speed (and/or VAV dampers are fully opened). When less cooling is required the fan operates at low speed and the primary air flow to the space is reduced to the minimum flow rate. When in space heating mode, the supply air flow is held at the minimum flow rate reducing the heating energy use. There are many VAV system variations, such as VAV with reheat, VAV dual duct, VAV dual fan/dual duct, VAV with fan-powered boxes, etc. All of these are multiple zone systems. It is not generally practical nor desirable to use VAV for a single zone building such as a supermarket or warehouse. These types of buildings typically have constant-volume variable-temperature packaged single zone HVAC systems.

2. High efficiency fans; Overall fan efficiency is the multiplicative product of the fan motor and fan blade efficiencies. This study assumes that overall fan efficiency can be improved from 55 percent to 70 percent.

3. High efficiency chiller; This study assumes the high efficiency chiller is 6.3 COP (0.56 kW/ton). California's Title 24 Energy Efficiency Standards (CEC 1992) and the ASHRAE Standard 90.1-1989 (ASHRAE 1989) require minimum chiller efficiency of 0.75 kW/ton for non-ozone depleting refrigerants. Efficiency of 0.55 kW/ton represents the best available efficiency for hermetic centrifugal chillers using non-ozone depleting refrigerants. Higher efficiency is achieved by increasing condenser and evaporator area.

Base Case Air Handling System. VAV retrofit is only considered for existing large buildings having multi-zone systems. We assume that VAV systems are standard for new buildings having multiple zone systems. For this study only the existing medium office prototype was considered for the VAV retrofit measure.

Incremental Cost. Incremental cost for VSD fan control is 125 $/hp (XEN 1992) and involve adding an electronic variable-speed controller to the fan motor. Incremental cost for the high efficiency fan motor is 8 $/hp (XEN 1992). Incremental cost for the high efficiency hermetic centrifugal chiller is assumed to be $56/ton based on 245 $/ton for the high efficiency hermetic centrifugal chiller and 189 $/ton for the 4.7 COP (0.75 kW/ton) chiller. Costs for existing and new construction are assumed to be the same since the existing cost is for replace-on-burnout (ROB).

High-Efficiency Furnace/Condensing Furnace

Measure Description. High-efficiency gas furnaces have AFUEs of about 82% or higher. Condensing gas furnaces have AFUEs of greater than 90%. As efficiencies are increased, vaporized by-products of combustion may condense in the heat exchanger and vent system, forming an acidic liquid. Furnaces with moderate efficiencies (78 to 82%) do not produce any condensate. Furnaces with intermediate efficiencies (82% to 89%) may form condensate and have high flue gas temperatures which require costly, corrosion-resistant metals for the venting system. Consequently, furnaces in the latter efficiency range are being phased out by most manufacturers. If the efficiency is raised to 90% or higher, although condensate is formed, the flue gas temperatures are low enough that low-cost corrosion-resistant plastic materials can be used for venting. Efficiencies above 90% can be achieved with a number of technologies, pulse combustion and condenser being among the design approaches.

High-efficiency gas furnaces can be installed in new construction or can be retrofitted to existing commercial structures which have other heating systems. In most cases, a condensate drain must be added and a new or modified venting system must be installed.

Incremental Cost. Incremental cost for the high-efficiency furnace (75 to 82% AFUE) is 1.60 $/kBtuh. For residential and commercial applications the incremental cost of the condensing furnace is 4.54 $/kBtuh for new houses and 6.13 $/kBtuh for existing houses (XEN 1992). Most commercial manufacturers of packaged systems do not currently offer a condensing furnace option due to end user "first cost" price sensitivity. However, the technology is available in sizes up to 225 kBtuh and could be offered as an option for packaged units up to 15 tons.

High Efficiency Boiler

Measure Description. Standard atmospheric boilers, in both fire-tube and water-tube designs, have combustion efficiencies of about 75%. Forced draft boilers with electronic ignition have higher full load combustion efficiencies of ~80%. At part load, they perform more efficiently due to reduced stack losses during off-cycles and better fuel/air ratios. Modular design allows for higher part-load efficiency since short cycling is eliminated.

Incremental Cost. High efficiency boiler cost is 14 $/kBtuh. The incremental cost is 3 $/kBtuh (XEN 1992) based on comparison to base case atmospheric boiler cost of 11 $/kBtuh ($14 - $11 = $3).

Condensing Boiler

Measure Description. Condensing boilers are the most efficient boilers available with combustion efficiencies of ~90%. Modular design allows for higher part-load efficiency since short cycling is eliminated. The pulse combustion technology is described below.

1. The boiler burns only a small amount of gas (0.8 cf) per cycle. A small amount of outdoor air is drawn into the combustion chamber and the mixture is ignited by a spark

only on the initial cycle. Each subsequent air-gas mixture is ignited by residual heat from the previous cycle.

2. Pressure resulting from the combustion process forces hot gases down the heat exchanger tubes inside the boiler. Heat is then transferred to the surrounding boiler water.

3. As the hot gasses are cooled below the dew point, water vapor in the flue gases condenses, releasing the latent heat of vaporization. The condensate is removed by a drain at the boiler's base and the low-temperature exhaust is safely vented outside through plastic pipe.

Incremental Cost. Condensing boiler cost is 17 $/kBtuh. The incremental cost of 3 $/kBtuh (XEN 1992) is based on comparison to high efficiency boiler cost of 14 $/kBtuh ($17 - $14 = $3).

Duct Sealing Plus Duct Insulation

Measure Description. Recent studies indicate that duct leakage and conduction losses in forced-air distribution systems are among the biggest energy consumers in typical residential buildings (Modera 1993). Duct leakage and conduction losses can add 20-30% to heating and cooling energy use. Houses with basement foundations typically have losses of about 20% and houses with crawl space foundations have losses of about 30%. Research shows that duct leakage and conduction through poorly insulated ducts account for about an equal 50-50 share of the losses. Duct sealing involves the use of a duct pressurization system that is used to detect the leaks. Leaks are then sealed using mastic. This measure cannot be simulated using DOE-2.1E. Savings are therefore, based on measured data. Savings estimates used for duct insulation are based on insulating with R-8 foil skrim cracked (FSC) insulation[1]

Incremental Cost. Incremental costs per square foot of floor area, average losses, savings, post-installation losses are shown in Table B-3.

Reduce Infiltration

Measure Description. Natural infiltration is caused by temperature and wind induced pressure differences between the building shell and outdoors. Cracks and crevices in the building shell allow outdoor air to infiltrate the building based on indoor-outdoor pressure differences. Weatherstipping doors and windows and caulking cracks and crevices in the

[1] FSC R-8 insulation costs about 2.13 $/ft installed, 0.76 $/ft for the insulation and 1.37 $/ft for installation (Modera 1993).

building shell will reduce infiltration. This study assumes that infiltration can be reduced from 0.7 to 0.4 air changes per hour (ACH) in existing construction and 0.6 to 0.4 ACH for new construction.

Table B-3. Duct Sealing Plus Insulation: Costs and Savings Data.

Description	Loss %	Savings %	Post Installation Loss %	Cost $/sf
Basement Foundation				
Single Family New Construction				
Duct Sealing + R-8 Insulation	20	10	10	0.23
Multi-Family New Construction				
Duct Sealing + R-8 Insulation	20	10	10	0.23
Single Family Existing Construction				
Duct Sealing + R-8 Insulation	20	9	11	0.38
Crawl Space Foundation				
Single Family New Construction				
Duct Sealing + R-8 Insulation	30	21	9	0.23
Multi-Family New Construction				
Duct Sealing + R-8 Insulation	30	21	9	0.23
Single Family Existing Construction				
Duct Sealing + R-8 Insulation	30	18	12	0.38

Incremental Cost. The cost to reduce infiltration for existing construction is 0.46 $/sf and the cost for new construction is 0.24 $/sf (XEN 1992). It is easier to reduce infiltration in new construction than in existing construction and the costs reflect this fact.

High Efficiency 3.5 COP Air-Cooled Package Air Conditioner

Measure Description. Over 50% of current commercial air conditioning capacity is provided by packaged units with air handler, compressor, and compressor mounted in a metal box (Houghton et al. 1992). These units are typically roof-mounted to save interior space and have capacities ranging from 1 to 100 tons (5-20 tons are typical). Packaged units are attractive to builders and developers, especially those that build on speculation, because of their low first cost (often less than 500 $/ton). This emphasis fosters inefficiency. For example, packaged units monitored by PG&E in San Ramon had an overall efficiency of 1.75 COP (6 EER). California's Title 24 standards set minimum efficiency of 8.9 EER at 95F (1.34 kW/ton). Actual operating efficiencies can be even less, due to such factors as thin uninsulated cases which can leak substantial amounts of hot rooftop air; constricted high velocity, high-pressure duct work, and undersized, low-performance heat exchangers.

Much higher efficiencies are obtainable at reasonable cost through better design, materials, and controls, but have not yet been realized due to emphasis on first cost. To address this problem, a collaboration of energy groups and utilities known as the Consortium for Energy Efficiency (CEE) is implementing a program similar to the Super Efficient Refrigerator Program ("Golden Carrot") for residential refrigerators. CEE's plan will offer a coordinated rebate designed to create a market for high-efficiency packaged equipment, eventually making efficient equipment the norm. Efficiency goals of the program are a 3.5 COP (12 to 12.5 EER, 1 kW/ton at 95 F). Initial production is anticipated in 1995 (Nadel 1993).

Incremental Cost. The incremental cost for a high efficiency 3.5 COP air-cooled packaged air conditioner is expected to be 250 $/ton more than a 2.5 COP unit (Nadel 1993).

High Efficiency Central Air Conditioner

Measure Description. The 1992 Energy Policy Act (1992 EPACT) established minimum appliance efficiency standards for residential central air conditioners (CACs) with capacity less than 65,000 Btuh. The EPACT requires a minimum 10 Seasonal Energy Efficiency Ratio (SEER). High efficiency CACs with SEER of 12 are available at a reasonable cost from most suppliers. Very high efficiency CACs with variable speed drive (VSD) compressors have SEERs of 16.9. VSD CACs have better part-load performance than constant speed CACs, but their peak efficiency is not as good as high efficiency CACs. Typical CACs are split systems with an outdoor section housing the compressor and condenser and an indoor section housing the evaporator. The indoor and outdoor (split) systems are connected by a pair of refrigerant lines and control wiring. High efficiency CACs can be installed in new construction or retrofit into existing construction.

Incremental Cost. The cost for a 3 to 5 ton high efficiency SEER 12 CAC is 161 $/ton more than a SEER 10 unit (XEN 1994). The incremental cost for a 3 to 5 ton SEER 16.9 VSD CAC is 608 $/ton more than a constant speed SEER 10 unit (XEN 1992). Our analysis showed that for new construction, the constant speed SEER 12 unit was more cost-effective than the VSD CAC SEER 16.9 unit.

High Efficiency Room Air Conditioner

Measure Description. The 1990 national appliance efficiency standards for residential room air conditioners (RAC) require minimum EER of 8.6. High efficiency RACs with EER of 11 are available at a reasonable cost from most manufacturers. RACs are housed in a single assembly that will fit into a standard window opening. RACs run on 115 volt or 230/208 volt power. High efficiency RACs can be installed in new construction or retrofit into existing construction.

Incremental Cost. The cost for a 2-ton EER 11 RAC is 115 $/ton more than an EER 8.9 unit (XEN 1994).

High Efficiency Room Heat Pump (RHP)

Measure Description. High efficiency RHPs with 10 EER and 2 COP are available at a reasonable cost from most manufacturers. RHPs are housed in a single assembly that will fit into a standard window opening. RHPs run on 115 volt or 230/208 volt power. High efficiency RHPs can be installed in new construction or retrofit into existing construction.

Incremental Cost. The cost for a 2-ton 10 EER, 2 COP RHP is 468 $/ton more than a standard 10 EER room air conditioner (RAC) (XEN 1994).

High Efficiency Central Heat Pump (CHP)

Measure Description. The 1992 Energy Policy Act (1992 EPACT) established minimum appliance efficiency standards for residential heat pumps with capacity less than 65,000 Btuh. The EPACT requires a minimum 10 Seasonal Energy Efficiency Ratio (SEER) and a minimum 6.8 Heating Seasonal Performance Factor (HSPF). High efficiency CHPs with 12 SEER and 8 HSPF are available at a reasonable cost from most manufacturers. High efficiency CHPs can be installed in new construction or retrofit into existing construction.

Incremental Cost. The cost for a high efficiency 12 SEER and 8 HSPF CHP rated at 3 to 5 tons is 234 $/ton more than a standard CHP rated at 10 SEER and 6.8 HSPF (XEN 1994).

Cooling Tower 80 F Setpoint

Measure Description. Thefficient cooling tower package consists of resetting the tower sump water setpoint temperature from 85 F to 80 F (5 F approach in Harrisburg, PA). This measure trades tower fan energy for an improvement in chiller performance due to lower average condenser water temperatures. This measure might already be in practice at certain facilities. Applicability might also be limited with certain chillers that surge when condenser water temperatures drop below 80 F.

Incremental Cost. The cost for the efficient cooling tower package is assumed to be zero since all that is required is resetting the tower water sump thermostat to achieve a temperature of 80 F.

Furnace Fan and Thermostat Adjustment

Measure Description. This measure is applicable to forced air heating systems in single family residences. Several studies have found that furnace thermostats are often set too high and thus useful heat in the furnace plenum is wasted and not moved to the living space (Proctor 1987). In addition, the anticipator on thermostats is often improperly set, which leads to overshooting the desired setpoint on each furnace cycle. Proper adjustment of these controls as well as basic furnace maintenance can produce energy savings of approximately 8 percent according to several Colorado field studies (Proctor 1987). These savings cannot be simulated using DOE-2.1E. As stated above, savings are assumed to be 8% of space heating energy (Proctor 1987).

Incremental Cost. The installed cost for the furnace fan/thermostat adjustment measure is $150 per home (Proctor 1984).

Steam Distribution Package

Measure Description. This measure is applicable to single pipe steam (SPS) distribution systems in multi-family buildings. This measure cannot be simulated using DOE-2.1E. Savings are therefore, based on measured data. Savings are assumed to 20% of space heating energy use. The package consists of three measures (Peterson 1985).

1. Main Line Air Vents (MLAVs); MLAVs allow more even flow of steam down the main distribution pipes at the expense of flow up into the radiators close to the boiler. Radiators farther from the boiler receive steam more quickly and close radiators receive steam more slowly. These are large thermostatic steam traps installed on the main distribution lines in the basement after the last riser and before the dry return drops into the wet return. The

valve is open until heated by steam, at which point it quickly closes preventing steam from escaping. MLAV's cost about $90 each ($125 to $200 installed).

2. Thermostatic Steam Valves (TRVs); Normally there will always be some temperature variation between apartments. To compensate for this, the building can be divided into a number of different zones, each with some degree of separate thermostatic control. TRVs respond to temperature changes near the radiator. They are filled with fluid which expands and closes the air vent if the temperature goes above the setpoint. When the TRV is closed no air can be released and thus no steam can enter the radiator. TRVs cost about $45 each ($80 to $95 installed).

3. Pipe insulation; Insulating steam distribution pipes in the boiler room and/or basement area will allow more useful heat from the boiler to reach the radiators. Insulation costs about $3.20 per linear foot of pipe (XEN 1992).

Incremental Cost. The installed cost for the steam distribution package is $150 per apartment (Katrakis 1993).

White Surface Roof

Measure Description. Light or white colored exterior surfaces will reduce solar absorption and increase emittance thereby reducing cooling loads. This measure is most appropriate to roof applications. In addition to reducing cooling loads, a white surface roof should last longer than a dark roof since reducing absorbed solar radiation will prolong the integrity of the roof membrane. The extended life of white roof surfaces is not accounted for in this study.

Incremental Cost. In new construction a white surface roof is primarily a design measure, and therefore, cost is negligible. For existing construction, the cost is also assumed to be negligible since the roof color can be selected at time of replacement. If an existing roof were painted white as a retrofit measure the cost would be 0.50 $/sf (XEN 1992). The high cost of painting an existing roof surface white before it needs to be resurfaced (due to leaks and/or failure) is prohibitive.

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Existing Medium Office - Percentage Savings and Unit Costs By Efficiency Measure.

Description	Electric Savings %	Gas Savings %	Primary Savings %	Total Electric *kWh/sf*	Total Gas *kBtu/sf*	Energy Efficiency Measure Cost *$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	Marginal CSE $/MMBtu	Average CSE $/MMBtu	Estimated Measure Life
Base Existing (R-2.6 roof, R-1 wall)	n/a	n/a	n/a	18.48	62.03	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Eff. Office Equip. (1.2 W/sf to 0.45 W/	13.85	-4.32	9.62	15.92	64.71	0.00	I	0.01	workstation	0.00	0.00	5
White Surface (ABS = 0.7 to 0.3)	16.20	-2.25	11.90	15.49	63.42	0.00	I	0.333 333	roof area	0.00	0.00	20
Efficient Lighting (2 W/sf to 0.83 W/sf)	37.05	-10.07	26.08	11.63	68.27	37.00	I	0.013 514	fixtures	4.05	2.20	15
Eff. HVAC (Eff. Fans, VSD, COP=6.3	56.62	9.51	45.66	8.02	56.12	139.03	I	0.002 500	chiller tons	2.01	2.12	20
Condensing Boiler (75% to 90%)	56.62	24.34	49.11	8.02	46.93	4.54	I	0.058 500	boiler kBtu	8.71	2.58	20
R-18.1 roof (add R-11)	58.08	34.05	52.49	7.75	40.90	0.37	F	0.333 333	roof area	4.11	2.68	30
Window, TB-Low-e (SC=0.29, u=0.3	61.26	45.94	57.70	7.16	33.53	18.20	F	0.070 850	window area	27.90	4.96	30
Cooling Tower 80F Setpoint (5F Appro	61.53	45.94	57.90	7.11	33.53	0.00	F	0.003 167	tower tons	0.00	4.94	30

New Medium Office - Percentage Savings and Unit Costs By Efficiency Measure.

Description	Electric Savings %	Gas Savings %	Primary Savings %	Total Electric *kWh/sf*	Total Gas *kBtu/sf*	Energy Efficiency Measure Cost *$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	Marginal CSE $/MMBtu	Average CSE $/MMBtu	Estimated Measure Life
Base New (R-19 roof. R-5.5 wall)	n/a	n/a	n/a	13.32	31.61	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Eff. Office Equip. (1.2 W/sf to 0.45 W/	0.17	-0.14	0.12	11.04	35.90	0.00	I	0.01	workstation	0.00	0.00	5
White Surface (ABS = 0.7 to 0.3)	0.18	-0.15	0.12	10.99	36.26	0.00	I	0.333 333	roof area	0.00	0.00	20
Efficient Lighting (1.76 W/sf to 0.7 W/s	0.41	-0.39	0.27	7.85	43.87	37.00	I	0.013 514	fixtures	5.65	3.17	15
Eff. HVAC (Eff. Fans, Herm. Cent. C	0.49	-0.39	0.33	6.85	43.88	59.53	I	0.002 167	chiller tons	3.50	3.23	20
Condensing Boiler (80% to 90%)	0.49	-0.24	0.36	6.85	39.10	4.54	I	0.058 333	boiler kBtu	16.68	4.23	20
R-30 roof, R-9.5 wall (R-19)	0.49	-0.11	0.39	6.73	34.96	0.06	I	0.333 333	roof area	1.11	3.99	30
Window, TB-Low-e (SC=0.29, u=0.3	0.52	0.09	0.45	6.34	28.92	18.20	I	0.070 850	window area	37.05	8.31	30
Cooling Tower 80F Setpoint (5F Appro	0.53	0.09	0.45	6.28	28.92	0.00	I	0.002 750	tower tons	0.00	8.25	20

Note:

1. Percentage savings are with respect to the stock and new base buildings.
2. Cost code: I = Incremental cost, F = Full cost.

Existing Retail - Percentage Savings and Unit Costs By Efficiency Measure.

Description	Electric Savings %	Gas Savings %	Primary Savings %	Total Electric *kWh/sf*	Total Gas *kBtu/sf*	Energy Efficiency Measure Cost *$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	Marginal CSE $/MMBtu	Average CSE $/MMBtu	Estimated Measure Life
Base Existing (R-11 roof, R-1 wall)	n/a	n/a	n/a	12.25	38.96	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	2.60	-4.36	1.04	11.93	40.66	0.00	I	1.000 000	roof area	0.00	0.00	5
Efficient Lighting (2.1 to 0.93 W/sf)	47.65	-32.18	29.83	6.41	51.50	37.00	I	0.006 061	fixtures	0.37	0.36	15
Condensing Furnace (75% to 90%)	47.65	-14.11	33.86	6.41	44.46	4.54	I	0.039 000	furnace kBtu	1.69	0.52	20
R-30 roof (add R-19)	48.53	-3.07	37.01	6.31	40.16	0.37	F	1.000 000	roof area	3.43	0.77	30
Eff. HVAC (COP=2.37 to 3.5)	51.80	0.77	40.41	5.91	38.66	250.00	I	0.002 500	A/C tons	8.84	1.45	15
Window, TB-Low-e (u=0.29, SC=0.3	55.81	10.23	45.63	5.41	34.97	18.20	F	0.099 080	window area	10.08	2.43	30

New Retail - Percentage Savings and Unit Costs By Efficiency Measure.

Description	Electric Savings %	Gas Savings %	Primary Savings %	Total Electric *kWh/sf*	Total Gas *kBtu/sf*	Energy Efficiency Measure Cost *$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	Marginal CSE $/MMBtu	Average CSE $/MMBtu	Estimated Measure Life
Base New (R-19 roof, R-5.5 wall)	n/a	n/a	n/a	10.45	20.83	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	1.59	-4.32	0.69	10.28	21.73	0.00	I	1.000 000	roof area	0.00	0.00	5
Efficient Lighting (1.76 to 0.93 W/sf)	33.08	-31.28	23.25	6.99	27.35	29.00	I	0.007 194	# fixtures	0.57	0.55	15
R-30 roof, R-9.5 wall (R-19)	33.59	-10.83	26.81	6.94	23.08	0.11	I	1.500 972	oof+wall are	1.69	0.70	30
Window, TB-Low-e (u=0.29, SC=0.3	37.24	-4.97	30.79	6.56	21.86	4.39	I	0.099 080	window area	4.08	1.14	30
Condensing Furnace (80% to 90%)	37.24	4.67	32.26	6.56	19.86	4.54	I	0.039 000	furnace kBtu	5.93	1.36	20
Eff. HVAC (COP=2.5 to 3.5)	40.89	4.37	35.31	6.18	19.92	250.00	I	0.002 000	A/C tons	10.07	2.11	15

Note:

1. Percentage savings are with respect to the stock and new base buildings.
2. Cost code: I = Incremental cost, F = Full cost.

Existing School - Percentage Savings and Unit Costs By Efficiency Measure.

	Electric Savings	Gas Savings	Primary Savings	Total Electric	Total Gas	Energy Efficiency Measure Cost				Marginal CSE	Average CSE	Estimated Measure
Description	%	%	%	*kWh/sf*	*kBtu/sf*	*$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	$/MMBtu	$/MMBtu	Life
Base Existing (R-3.3 roof, R-1 wall)	n/a	n/a	n/a	9.60	75.26	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	3.67	-6.09	-0.38	9.25	79.84	0.00	I	0.551 250	roof area	0.00	0.00	5
R-22.3 roof (add R-19)	7.22	6.27	6.83	8.91	70.54	0.37	F	0.551 250	roof area	0.80	0.84	30
Condensing Boiler (75% to 90%)	7.22	19.72	12.40	8.91	60.42	3.00	I	0.046 058	boiler kBtu	0.92	0.87	20
Efficient Lighting (2.04 to 1.07 W/sf)	24.66	14.87	20.60	7.23	64.07	37.00	I	0.014 925	fixtures	3.11	1.76	15
Eff. HVAC (COP=2.37 to 3.5)	27.78	19.42	24.31	6.93	60.65	250.00	I	0.003 589	chiller tons	11.14	3.20	15
Window, TB-Low-e (u=0.29, SC=0.3	29.55	22.08	26.46	6.76	58.64	18.20	F	0.049 526	window area	11.83	3.90	30

New School - Percentage Savings and Unit Costs By Efficiency Measure.

	Electric Savings	Gas Savings	Primary Savings	Total Electric	Total Gas	Energy Efficiency Measure Cost				Marginal CSE	Average CSE	Estimated Measure
Description	%	%	%	*kWh/sf*	*kBtu/sf*	*$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	$/MMBtu	$/MMBtu	Life
Base New (R-19 roof, R-5.5 wall)	n/a	n/a	n/a	8.52	57.81	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	0.89	-1.35	0.04	8.44	58.59	0.00	I	0.551 250	roof area	0.00	0.00	5
R-30 roof, R-9.5 wall (R-19)	1.64	3.77	2.45	8.38	55.63	0.11	I	0.875 741	oof+wall are	1.30	1.27	30
Condensing Boiler (80% to 90%)	1.64	12.50	5.77	8.38	50.58	3.00	I	0.041 392	boiler kBtu	1.65	1.49	20
Efficient Lighting (1.81 to 1.03 W/sf)	18.39	6.91	14.03	6.95	53.82	29.00	I	0.013 123	# fixtures	2.54	2.11	15
Window, TB-Low-e (u=0.29, SC=0.3	19.69	8.87	15.58	6.84	52.68	4.39	I	0.049 526	window area	4.70	2.37	30
Eff. HVAC (COP=2.5 to 3.5)	23.04	8.87	17.65	6.56	52.68	250.00	I	0.003 468	chiller tons	23.01	4.79	15

Note:

1. Percentage savings are with respect to the stock and new base buildings.
2. Cost code: I = Incremental cost, F = Full cost.

Existing Warehouse - Percentage Savings and Unit Costs By Efficiency Measure.

Description	Electric Savings	Gas Savings	Primary Savings	Total Electric	Total Gas	Energy Efficiency Measure Cost				Marginal CSE	Average CSE	Estimated Measure
	%	%	%	*kWh/sf*	*kBtu/sf*	*$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	$/MMBtu	$/MMBtu	Life
Base Existing (R-5.3 roof, R-1.0 wall)	n/a	n/a	n/a	6.03	52.81	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	6.18	-5.01	1.24	5.66	55.46	0.00	I	1.000 000	roof area	0.00	0.00	5
Condensing Furnace (75% to 90%)	6.18	12.77	9.09	5.66	46.07	4.54	I	0.036 000	furnace kBtu	1.17	1.01	20
Efficient Lighting (1.6 W/sf to 0.82 W/s	36.87	6.82	23.59	3.81	49.21	37.00	I	0.011 111	fixtures	1.99	1.61	15
R-24.3 roof (add R-19)	43.50	15.22	31.00	3.41	44.78	0.37	F	1.000 000	roof area	2.81	1.90	20
Window, TB-Low-e (u=0.29, SC=0.3	43.21	16.04	31.21	3.43	44.34	18.20	F	0.012 333	window area	47.19	2.19	30
Eff. HVAC (COP=2.37 to 3.5)	43.25	16.45	31.41	3.42	44.12	250.00	I	0.002 300	A/C tons	193.23	3.46	15

New Warehouse - Percentage Savings and Unit Costs By Efficiency Measure.

Description	Electric Savings	Gas Savings	Primary Savings	Total Electric	Total Gas	Energy Efficiency Measure Cost				Marginal CSE	Average CSE	Estimated Measure
	%	%	%	*kWh/sf*	*kBtu/sf*	*$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	$/MMBtu	$/MMBtu	Life
Base New (R-19 roof, R-5.5 wall)	n/a	n/a	n/a	5.12	39.57	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	1.41	-2.30	-0.12	5.05	40.48	0.00	I	1.000 000	roof area	0.00	0.00	5
Efficient Lighting (1.6 W/sf to 0.82 W/s	36.07	-10.70	16.84	3.28	43.80	29.00	I	0.007 194	# fixtures	1.07	1.08	15
Condensing Furnace (80% to 90%)	36.07	1.44	21.84	3.28	39.00	4.54	I	0.036 000	furnace kBtu	2.29	1.35	20
R-30 roof, R-9.5 wall (R-19)	38.27	6.65	25.27	3.16	36.94	0.11	I	1.629 583	oof+wall are	3.52	1.65	20
Window, TB-Low-e (u=0.29, SC=0.3	38.96	6.49	25.61	3.13	37.00	4.39	I	0.012 333	window area	8.45	1.74	30
Eff. HVAC (COP=2.5 to 3.5)	39.39	6.49	25.86	3.11	37.00	250.00	I	0.001 700	A/C tons	145.69	3.15	15

Note:

1. Percentage savings are with respect to the stock and new base buildings.
2. Cost code: I = Incremental cost, F = Full cost.

Existing Residential - Percentage Savings and Unit Costs By Efficiency Measure.

	Electric Savings	Gas Savings	Primary Savings	Total Electric	Total Gas	Energy Efficiency Measure Cost				Marginal CSE	Average CSE	Estimated Measure
Description	%	%	%	kWh/sf	kBtu/sf	$/unit	Cost Code	unit/sf-floor	unit	$/MMBtu	$/MMBtu	Life
Base (R-13 roof, R-3 wall, R-1 floor)	n/a	n/a	n/a	5.13	82.44	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	1.43	1.06	1.21	5.05	81.56	0.00	I	0.500 000	roof area	0.00	0.00	20
R-38 roof, R-13 wall, R-19 floor	4.77	28.18	18.64	4.88	59.21	0.63	F	1.000 000	floor area	1.73	1.62	20
Condensing Furnace (75% to 92%)	4.77	38.91	24.99	4.88	50.36	6.13	I	0.075 000	furnace kBtu	3.49	2.10	20
Infiltration Reduction (0.7 to 0.4 ACH)	5.26	44.09	28.26	4.86	46.09	0.46	F	1.000 000	floor area	8.46	2.83	15
Ducts, Sealing + R-8 Insulation	7.79	48.67	32.00	4.73	42.32	0.50	F	1.000 000	floor area	8.05	3.44	15
Efficient Central A/C (8.1 to 12 SEER)	15.73	49.39	35.67	4.32	41.72	161.00	I	0.003 125	A/C tons	8.26	3.94	15
Furnace Fan/Thermostat Adjustment	15.84	50.64	36.46	4.32	40.69	0.09	F	1.000 000	floor area	10.05	4.07	10
Window, Low-e/argon (u=0.31, SC=0	19.19	54.21	39.94	4.14	37.75	8.78	F	0.211 806	window area	19.59	5.42	30

New Residential - Percentage Savings and Unit Costs By Efficiency Measure.

	Electric Savings	Gas Savings	Primary Savings	Total Electric	Total Gas	Energy Efficiency Measure Cost				Marginal CSE	Average CSE	Estimated Measure
Description	%	%	%	kWh/sf	kBtu/sf	$/unit	Cost Code	unit/sf-floor	unit	$/MMBtu	$/MMBtu	Life
Base (R-30 roof, R-13 wall, R-11 floor)	n/a	n/a	n/a	4.82	53.50	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	0.38	-0.23	0.07	4.80	53.63	0.00	I	0.500 000	roof area	0.00	0.00	20
Ducts, Sealing + R-8 Insulation	3.77	8.21	5.99	4.63	49.11	0.30	F	1.000 000	floor area	4.02	3.98	15
Infiltration Reduction (0.6 to 0.4 ACH)	3.43	16.39	9.92	4.65	44.73	0.24	F	1.000 000	floor area	4.79	4.30	15
R-38 roof, R-19 wall, R-19 floor	3.43	20.57	12.01	4.65	42.50	0.21	I	1.000 000	floor area	4.85	4.39	30
Condensing Furnace (82% to 92%)	3.43	28.83	16.15	4.65	38.08	4.54	I	0.075 000	furnace kBtu	5.18	4.60	20
Window, Low-e/argon (u=0.31, SC=0	7.59	34.40	21.02	4.45	35.09	4.39	I	0.211 806	window area	9.12	5.64	30
Furnace Fan/Thermostat Adjustment	7.30	35.98	21.67	4.46	34.25	0.09	F	1.000 000	floor area	15.93	5.95	10
Efficient Central A/C (10 to 12 SEER)	12.12	35.98	24.07	4.23	34.25	161.00	I	0.003 125	A/C tons	16.42	7.00	15

Note:

1. Percentage savings are with respect to the stock and new base buildings.
2. Cost code: I = Incremental cost, F = Full cost.

New Townhouse Gas Heat - Percentage Savings and Unit Costs By Efficiency Measure.

Description	Electric Savings %	Gas Savings %	Primary Savings %	Total Electric *kWh/sf*	Total Gas *kBtu/sf*	Energy Efficiency Measure Cost *$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	Marginal CSE $/MMBtu	Average CSE $/MMBtu	Estimated Measure Life
Base New (R-30 roof, R-13 wall)	n/a	n/a	n/a	4.37	40.44	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	1.01	-0.56	0.29	4.33	40.67	0.00	I	0.500 000	roof area	0.00	0.00	20
Roof Insulation (R-30 to R-38)	1.11	2.07	1.55	4.32	39.60	0.10	F	0.500 000	roof area	2.29	1.85	30
Condensing Furnace (78% to 92%)	1.11	18.06	8.83	4.32	33.14	6.12	I	0.050 000	furnace kBtu	3.18	2.95	20
Ducts, Sealing + R-8 Insulation	4.37	24.88	13.71	4.18	30.38	0.23	F	1.000 000	floor area	4.45	3.48	15
Window, Low-e + argon (u=0.31, SC	9.11	31.05	19.10	3.97	27.89	4.39	I	0.105 440	window area	4.93	3.89	30
Infiltration Reduction (0.6 to 0.4 ACH)	9.05	36.09	21.36	3.98	25.85	0.24	F	1.000 000	floor area	13.98	4.96	10
High Efficiency CAC (10 to 12 SEER)	13.51	36.09	23.79	3.78	25.85	161.00	I	0.002 778	A/C tons	17.38	6.23	15

New Townhouse Heat Pump - Percentage Savings and Unit Costs By Efficiency Measure.

Description	Electric Savings %	Gas Savings %	Primary Savings %	Total Electric *kWh/sf*	Total Gas *kBtu/sf*	Energy Efficiency Measure Cost *$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	Marginal CSE $/MMBtu	Average CSE $/MMBtu	Estimated Measure Life
Base New (R-30 roof, R-13 wall)	n/a	n/a	n/a	7.14	0.00	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	0.17	n/a	0.17	7.13	0.00	0.00	I	0.500 000	roof area	0.00	0.00	20
Ducts, Sealing + R-8 Insulation	5.31	n/a	5.31	6.76	0.00	0.23	I	1.000 000	floor area	4.74	4.59	15
Roof Insulation (R-30 to R-38)	5.97	n/a	5.97	6.72	0.00	0.10	I	0.500 000	roof area	4.90	4.62	30
Infiltration Reduction (0.6 to 0.4 ACH)	9.99	n/a	9.99	6.43	0.00	0.24	F	1.000 000	floor area	8.87	6.33	10
Window, Low-e + argon (u=0.31, SC	16.07	n/a	16.07	6.00	0.00	4.39	I	0.105 440	window area	4.91	5.79	30
High Eff. HP (8 HSPF, 12 SEER)	21.83	n/a	21.83	5.58	0.00	234.00	I	0.002 778	A/C tons	11.94	7.42	15

Note:

1. Percentage savings are with respect to the stock and new base buildings.
2. Cost code: I = Incremental cost, F = Full cost.

Existing Multi-Family (Steam Heat/RAC)- Percentage Savings and Unit Costs By Efficiency Measure.

	Electric Savings	Gas Savings	Primary Savings	Total Electric	Total Gas	Energy Efficiency Measure Cost				Marginal CSE	Average CSE	Estimated Measure
Description	%	%	%	*kWh/sf*	*kBtu/sf*	*$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	$/MMBtu	$/MMBtu	Life
Base Existing (R-19 roof, R-1 wall)	n/a	n/a	n/a	5.26	78.23	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	1.93	-1.29	0.08	5.16	79.23	0.00	I	0.333 333	roof area	0.00	0.00	20
High Efficiency RAC (8 to 11 EER)	6.96	14.60	11.34	4.89	66.80	115.00	I	0.000 123	A/C tons	0.08	0.08	15
Roof Insulation (R-12 to R-30)	8.56	24.20	17.53	4.81	59.30	0.04	F	1.000 000	floor area	0.22	0.13	30
Steam Dist. Pkg. (vents, pipe insul., t-sta	16.96	33.53	26.46	4.37	52.00	0.17	F	1.000 000	floor area	1.15	0.47	15
Efficient Boiler (60% to 82%)	16.96	45.46	33.31	4.37	42.66	4.00	I	0.061 728	boiler kBtu	1.78	0.74	20
Window, Low-e + argon (u=0.323, SC	16.38	51.78	36.68	4.40	37.72	8.78	F	0.112 444	window area	10.94	1.68	30
Infiltration Reduction (0.7 to 0.4 ACH)	13.34	54.70	37.06	4.56	35.43	0.46	F	1.000 000	floor area	103.84	2.73	10

Existing Multi-Family (Elec. Heat/RAC) - Percentage Savings and Unit Costs By Efficiency Measure.

	Electric Savings	Gas Savings	Primary Savings	Total Electric	Total Gas	Energy Efficiency Measure Cost				Marginal CSE	Average CSE	Estimated Measure
Description	%	%	%	*kWh/sf*	*kBtu/sf*	*$/unit*	*Cost Code*	*unit/sf-floor*	*unit*	$/MMBtu	$/MMBtu	Life
Base Elec. Heat (R-12 roof, R-1 wall)	n/a	n/a	n/a	12.51	0.00	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Surface (ABS = 0.7 to 0.3)	-0.04	n/a	-0.04	12.51	0.00	0.00	I	0.333 333	roof area	0.00	0.00	20
Room Heat Pump (2.0 COP, 10 EER)	24.55	n/a	24.55	9.44	0.00	468.00	I	0.000 123	A/C tons	0.14	0.14	15
Roof Insulation (R-30 to R-38)	26.36	n/a	26.36	9.21	0.00	0.10	F	0.333 333	roof area	0.68	0.18	30
Window, Low-e+argon (u=0.323, SC=	34.86	n/a	34.86	8.15	0.00	8.78	F	0.074 074	window area	2.82	0.82	30
Infiltration Reduction (0.6 to 0.4 ACH)	37.89	n/a	37.89	7.77	0.00	0.46	F	1.000 000	floor area	12.89	1.79	10

Note:

1. Percentage savings are with respect to the stock and new base buildings.
2. Cost code: I = Incremental cost, F = Full cost.

Potential Efficiency Improvements for Appliances

Appliance	Fuel	Measure	Base Use (per unit, per year)	Savings (per unit, per year)	Incremental Cost (per unit)	Measure Life (years)	CSE	CSE $/MMBtu Primary	% Implemented By 2010	Footnote
Electric			(kWh)	(kWh)			(/kWh)			
Water heater	elec	Low-cost package	2,617	523	$46	10	$0.01	$1.03	100%	1
Water heater	elec	EF .94 tank	2,094	134	$25	10	$0.02	$2.19	100%	2
Water heater	elec	Low water use dishwasher	2,339	82	$20	13	$0.03	$2.35	58%	3
Water heater	elec	Horizontal-axis clothes washer	2,339	371	$125	14	$0.03	$3.08	50%	4
Water heater	elec	Heat pump water heater	1,507	806	$495	15	$0.06	$5.35	50%	5
Refrigerator	elec	1993 standard	1,186	482	$0	19	$0.00	$0.00	89%	
Refrigerator	elec	SERP-like refrigerator	704	211	$75	19	$0.03	$2.66	53%	10
Refrigerator	elec	Advanced refrigerator	493	243	$110	19	$0.04	$3.39	21%	11
Freezer	elec	Advanced freezer	526	176	$75	21	$0.03	$3.00	48%	12
Clothes dryer	elec	High spin-speed clothes washer	521	208	$50	14	$0.02	$2.20	50%	13
Lighting	elec	Energy-saver lamps	844	76	$3	2	$0.02	$1.92	100%	15
Lighting	elec	Compact fluorescent lamps	768	332	$90	8	$0.04	$3.80	100%	16
Gas										
			(therms)	(therms)			(/therm)			
Water heater	gas	Low-cost package	218	44	$46	10	$0.14	$1.37	100%	6
Water heater	gas	EF .63 tank	174	22	$25	10	$0.15	$1.46	100%	7
Water heater	gas	Low water use dishwasher	190	7	$20	13	$0.32	$3.20	58%	8
Water heater	gas	Horizontal-axis clothes washer	190	30	$125	14	$0.42	$4.18	50%	9
Clothes dryer	gas	High spin-speed clothes washer	33	12	$50	14	$0.42	$4.21	50%	14

Notes:

* Base use is for new units -- existing units will generally be less efficient.
* 5% real discount rate assumed.
* Measure lives are published estimates by DOE from appliance efficiency standard dockets.

1 Base use from EIA 1993, adjusted for recent improvements in water heater efficiency. Savings and costs from Alliance to Save Energy et al. 1992.

2 Savings assume typical new water heater has an EF of .88 (from DOE 1993). Cost based on discussions with utilities in the northwest.

3 14% of hot water use due to dishwashers (Bancroft et al. 1991). Costs and savings estimated by Nadel et al. 1993 for 25% reduction in dishwasher hot water use.

4 26% of hot water use due to clothes washers (Bancroft et al. 1991). Savings of 61% from Nadel et al. 1993. This reference estimates the incremental cost of horizontal-axis washers at $175 but some of this cost includes the high spin speed option discussed below. For this analysis we allocate the $175 cost between these two measures.

5 Savings based on increasing EF from 0.88 to 1.89. Costs are incremental and include $395 for the heat pump (E-Tech published price estimate) and $100 for installation (DOE 1993).

6 See measure 1.

7 See measure 2.

8 See measure 3.

9 See measure 4.

10 Base use from DOE 1989. Savings of 30% based on SERP unit. Incremental cost based on Nadel et al. 1993 plus discussions with industry experts.

11 EPA 1993 discusses five different options for reducing refrigerator energy use down to approximately 250 kWh/year. Average incremental manufacturer cost of these options, relative to the previous measure, was estimated to be $73. To this we add 50% to account for markups between the manufacturer and the consumer.

12 Baseline, costs and savings from DOE 1989.

13 Baseline and savings from Nadel et al. 1993. Costs are discussed above under measure 4.

14 See measure 13.

15 Base use from EIA 1993. 90% of lamps assumed to be incandescent (Geller et al. 1986). Analysis based on 10% energy savings, an incremental cost of $0.10/lamp, and 30 lamps/house. Average lamp life estimated from Geller et al. 1986.

16 Analysis based on 75% energy savings in 6 heavily used lamps which operate an average of 3 hours/day. Analysis assumes 67 Watt lamps are displaced. A lamp life of 9000 hours and a lamp cost of $15 are assumed. These estimates are consistent with experience in utility DSM programs.

References:
DOE 1989 -- Refrigerator TSD
DOE 1993 -- Water heater TSD
EPA 1993 -- Multiple Pathways report
Bancroft et al. 1991 -- RMI Water heating Technology Atlas
Nadel et al. 1993 -- Emerging Technologies report
EIA 1993 -- RECS Energy Consumption and Expenditures
Geller et al. 1986 -- Residential Conservation Power Plant Study -- Phase I.

Energy and Financial Savings from Adopting the BOCA 1996 Building Code

	FOR NJ AND PENNSYLVANIA:			FOR NEW YORK:		
	Incremental	Annual Savings		Increment	Annual Savings	
	Cost	kWh	Therms	Cost	kWh	Therms
Residential single-family	1296	2771	269	1071	0	223
Residential multi-family	172	325	35	172	0	35
Commercial office	0.46	1	1	NA		
Gas heating		3.72	0.012		NA	NA
Electric heating		6.25	0		NA	NA
Commercial retail	0.87	1	1	NA		
Gas heating		2.02	0.023		NA	NA
Electric heating		3.61	0		NA	NA
Allocation of space heat by fuel:						
Residential		10%	90%		10%	90%
Commercial		19%	81%		19%	81%
Avg. rates:						
Residential		0.1	0.66		0.13	0.79
Commercial		0.09	0.56		0.11	0.6

		Savings in 2010		
	New units per year	Elec. (GWh)	Fuels (10^9 Btu)	Dollars (million)
Residential single-family				
New Jersey	39,200	141	12,355	53
Pennsylvania	53,900	194	16,989	72
New York	45,200	0	11,770	52
Residential multi-family				
New Jersey	13,200	6	535	2
Pennsylvania	12,400	5	503	2
New York	35,800	0	1,466	6
Commercial — offices				
New Jersey	5,637,870	0	0	0
Pennsylvania	9,534,610	521	124	44
New York	16,940,300	N/A	N/A	N/A
Commercial — retail				
New Jersey	5,637,870	0	0	0
Pennsylvania	11,406,050	344	279	24
New York	15,608,940	N/A	N/A	N/A

Notes:

* Assumes new codes effective in 1998.
* Residential costs and savings for NJ and PA from Lucas, "Cost Effectiveness of the 1993 Model Energy Code in New Jersey, Pacific NW Lab, Richland, WA.
* Residential savings in NY single-family homes based on 26% of natural gas use, where 26% is taken from L.A. Klevgard, Z.T. Taylor, & R.G. Lucas, "Comparison of Current State Residential Energy Codes with the 1992 Model Energy Code for One- & Two-Family Dwellings," PNL-10121, prep'd for DOE contract DE-AC06-76LO 1830, Pacific Northwest National Laboratory, Richland, WA, 1994; natural gas use from analysis summarized in Section 3 and Appendix B. Multi-family savings from NJ analysis cited above. Costs are prorated based on NJ analysis.
* Commercial costs and savings for NJ and PA from Smith and Nadel, "Energy Efficiency Codes and Standards for Illinois," ACEEE, Washington, DC. NY's current code is on average a little less stringent than the ASHRAE model code but sufficient data are not readily available to estimate the savings.
* New units per year based on analysis in section 3 and actual construction during early 1990's.
* Financial savings assume incremental costs financed with 30 year mortgage at 5% real interest & that energy prices are constant in real terms throughout the period.

APPENDIX C
ESTIMATION OF INDUSTRIAL SECTOR CONSERVATION POTENTIAL

DESCRIPTION OF MODEL

ACEEE has developed a methodology for the estimation of base case energy consumption in the industrial sector at the state level and the potential for cost-effective energy-efficiency improvements.[1] This analysis requires three steps: (1) project a baseline consumption for the industry groups in each state and then aggregate to the region; (2) estimate the economically viable savings potential from efficiency measures for each industry group in the region; and (3) estimate the investment necessary to achieve and maintain that savings.

The method uses national and state data for energy use and employment to project baseline energy consumption. Sector energy growth is projected based upon energy and employment growth projections. The energy efficiency potential was estimated using conservation supply curves derived from the Long-Term Industrial Energy Forecasting (LIEF) model.[2] Most conservation supply curves have been developed by combining various characteristic measures for a particular market. Such an approach is impractical for the industrial sector because of the complexity and site-specific nature of many efficiency measures. The LIEF curves were developed from a historical analysis of sectoral energy intensities and prices over the 1958-1985 period. The model segregates industries into 18 categories that have similar energy use characteristics based on their historical energy use data, and treats electricity and all other fuels use separately.

This appendix describes in detail the various aspects of the methodology and assumptions made, and reports the data used to perform the analysis. For purposes of illustration, the data for the state of New Jersey are used.

Data Sources

The U.S. Department of Commerce, Bureau of the Census (Census) and U.S. DOE Energy Information Administration (EIA) classify the industrial sector as those industries with

1. This analysis methodology was developed for a previous study by S. Laitner et al., *Energy Efficiency and Economic Development in the Midwest*, American Council for an Energy-Efficient Economy, Washington, DC, 1995.

2. Ross et al., op. cit.

Standard Industrial Classification (SIC) codes 01 through 39. These SIC codes include agriculture, forestry, fisheries, mining, construction and manufacturing (Preston, 1994).[3]

Excellent disaggregated data are available at the national level for the manufacturing sector (the manufacturing sector is normally defined as industries with SIC codes 20 through 39) from the EIA's Manufacturing Energy Consumption Survey (MECS). MECS has been conducted every three years with 1991 the most recent.[4] MECS includes data on energy consumption by fuel type for all two-digit manufacturing SIC codes, as well as data for several of the most energy intensive four-digit manufacturing codes.

Similar data are not readily available for the other industry sectors. A Congressional Office of Technology Assessment study[5] derived estimates of 1985 consumption for these non-manufacturing sectors from the National Energy Accounts Data Base. The data upon which these estimates are based are no longer collected, so more recent estimates are not available.

Only limited data are available on industrial energy consumption at the state level. The EIA's State Energy Data System estimates industrial energy consumption by state and reports the estimates annually in the State Energy Data Report (SEDR).[6] These estimates report consumption by fuel type at the aggregated industry level, but are not desegregated by industry group. Though data are not available for individual states, MECS reports data for U.S. Census regions. Consumption data for some industry groups at the regional level are not available or are withheld to avoid disclosing data for individual establishments. The missing data reduces the value of MECS to regional energy planning.

The SEDR and MECS feature two different types of surveys conducted by EIA. The surveys used to produce the SEDR are targeted at suppliers and marketers of specific fuels, while those used in the MECS collect consumption data directly from end-use consumers. Differences in methodology result in important differences in the results. One area of difference is irregularities in the definition of "industry." While the standard definition of the industry sector includes SIC 01 through 39, the supply survey does not "map" directly these SIC

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3. J.L. Preston, "Comparability of Supply- and Consumption-Derived Estimates of Manufacturing Energy Consumption," *Monthly Energy Review*, Energy Information Administration, U.S. Department of Energy, Washington, DC, 1994.

4. *Manufacturing Energy Consumption Survey: Consumption of Energy 1991*, Energy Information Administration, U.S. Department of Energy, Washington, DC, 1994.

5. *Industrial Energy Efficiency*, Office of Technology Assessment, Congress of the United States, Washington, DC, 1993.

6. *State Energy Data Report 1992*, Energy Information Administration, U.S. Department of Energy, Washington, DC, 1994.

codes. For example, SEDR documentation indicates that ". . . data on agricultural use of natural gas are collected and reported in the commercial sector rather than the industrial sector, (b)ecause agricultural use of natural gas cannot be identified separately . . . " [7].

The U.S. Department of Commerce, Bureau of Economic Analysis (BEA) estimates employment at the two-digit SIC level for states along with projections of employment growth through 2040.[8] In addition, Census conducts an Annual Survey of Manufactures (ASM) that reports value of shipments, value added, capital expenditures, and employment by state at the three-digit level.[9]

Estimation of Baseline Energy Consumption

Using all the data sources previously mentioned, this study develops a methodology to estimate disaggregated state industrial energy consumption based on energy intensity per employee, derived from estimates of 1991 national energy consumption and employment data. The state consumption estimate involves the following steps: 1) developing estimates of 1991 national energy consumption by industry, 2) identifying projections of national energy and employment growth by industry, 3) apportioning state industrial energy consumption using employment and energy intensity measurements, and 4) projecting future energy use by industry in the state using weighted industry growth projections.

1991 National Industrial Base Case Energy Consumption Estimates

The 1991 MECS [10] is used as the source for estimating energy consumption in the manufacturing sector for electricity and for all other fuels. Since many industrial firms switch among fuels other than electricity and most thermal efficiency measures considered in this study are fuel blind, no attempt was made to disaggregate by fuel type.

Since 1985 is the most recent year for which non-manufacturing data are available, these estimates are used as the starting point for estimating 1991 energy consumption in non-manufacturing sectors. It is assumed that the difference between the 1991 MECS estimate of manufacturing energy consumption and the SEDR estimate of total national industrial energy

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7. Preston, op. cit.

8. Bureau of Economic Analysis, *Regional Employment Database*, U.S. Dept. of Commerce, Washington, DC, 1994.

9. Bureau of the Census, *1991 Annual Survey of Manufacturers: Geographic Area Statistics,* U.S. Dept. of Commerce, Washington, DC, 1993.

10. *Manufacturing Energy Consumption Survey: Consumption of Energy 1991*, op.cit.

Table C-1
Factors Used In Extrapolation of 1985 Energy Consumption to 1991 for Non-Manufacturing Sectors

Industry Group	Employment (Thousands)		Employment Change	1985 Consumption Fractions		Employment Weighting Factors	
	1985	1991		Elec.	Fuel	Elec.	Fuel
Agriculture	4,616	4,551	99%	24.2 %	6.1%	27.2%	7.4%
Mining	1,376	984					
Coal Mining	198	139	70%	12.1 %	3.3%	9.7%	2.9%
Metal Mining	53	59	112%	11.9 %	2.2%	15.1%	3.1%
Oil and Gas	1,008	670	66%	29.9 %	56.7%	22.6%	46.5%
Non-Metal Mining	117	116	98%	8.4%	7.3%	9.5%	8.8%
Construction	6,425	6,681	104%	13.4 %	24.3%	15.9%	31.3%

Sources: see text

consumption is the consumption of the non-manufacturing sector. As noted in the previous section, this simplifying assumption is less than ideal but does provide a means to estimate otherwise unavailable data. A two-step extrapolation scheme is used to apportion this consumption to the six non-manufacturing groups used in this study. First, the fraction of 1985 non-manufacturing energy consumption for agriculture, mining and construction is calculated for both electricity and other fuels (Table C-1). Next the change in employment for each group from 1985 to 1991 is calculated from BEA data.[11] The employment changes are then used to weight the consumption distribution in order to apportion the non-manufacturing consumption of the 1991 industrial consumption estimate (Table C-2).

11. *Regional Employment Database*, op. cit.

Table C-2
Estimates of 1991 National Industrial Energy Consumption

Industry Group	SIC	1991 Employ. (1,000s)	1991 Consumption Electricity (Mill. kWh)	1991 Consumption Fuel (TBtu)	Energy Employment Ratio Electric. (kWh/empl.)	Energy Employment Ratio Fuel (MBtus/empl.)
Agriculture	1,2,7-9	4,551	68,696	497	15,096	109
Mining		983	143,491	4,103	145,943	4,174
Coal Mining	12	139	24,388	193	175,703	1,390
Metal Mining	10	59	38,166	206	646,874	3,491
Oil and Gas	13	670	57,044	3,113	85,204	4,650
Non-Metal Mining	14	116	23,894	592	206,158	5,105
Construction	15-17	6,681	40,111	2,092	6,004	313
Food	20	1,683	49,536	784	29,440	466
Paper	26	691	58,896	2,271	85,245	3,287
Chemicals	28	1,093	129,093	2,636	118,109	2,411
Petro. Refining	29	158	30,782	2,865	195,070	18,156
Rubber & Plastics	30	865	33,908	121	39,205	140
Stone, Glass, Clay	32	615	30,814	789	50,104	1,283
Primary Metals	33	725	146,276	1,793	201,677	2,472
Metals Fab. Ind.		7,892	136,340	702	17,276	89
Fab. Metal Prod.	34	1,370	29,772	203	21,739	149
Ind. Machinery	35	2,046	29,484	134	14,413	66
Elect. Equipment	36	1,607	29,996	94	18,667	58
Transport Equip.	37	1,896	34,721	215	18,312	113
Instruments	38	974	12,367	56	12,701	57
Other Mfg.		5,336	79,057	712	14,817	133
Tobacco	21	50	1,002	21	20,202	415
Textiles	22	678	29,532	172	43,564	254
Apparel	23	1,049	5,645	25	5,382	24
Wood Prod.	24	802	17,878	362	22,292	451
Furniture	25	500	4,915	50	9,830	100
Printing	27	1,678	15,629	55	9,312	33
Leather	31	130	795	9	6,130	72
Miscellaneous	39	449	3,661	19	8,146	41
National Total		31,272	947,000	19,365	30,283	619

Sources: see text

The ratio of estimated 1991 energy consumption for electricity and other fuels to 1991 employment estimates is then calculated for each industry considered. These ratios are used as the basis for apportioning SEDR[12] estimates of state energy consumption to the different industrial groups (Table C-2).[13] It would be preferable to base the apportioning on an indication other than employment, such as value of shipments or value added, but such data are not uniformly available at the state level for all industry groups. Using value of shipments for the manufacturing sector from ASM data[14] combined with employment-based apportioning for other sectors does not yield significantly different distributions of consumption among the industry groups than did using employment for all sectors. This data deficit represents a void begging to be filled.

Energy and Employment Growth

In order to estimate energy savings in the future it is necessary to project the growth in energy consumption for a "base case" (i.e., in the absence of efficiency improvements). EIA estimates industrial energy consumption growth at the national level by both fuel type and industry group.[15] These projections take into account changes in fuel mix, efficiency improvements due to modernization and changes in products, and changes in the size of the industry group. Electricity consumption is projected to grow 1.7 percent per year from 1990 to 2010. During the same period the principal fossil fuels, natural gas, coal and petroleum, are projected to grow 1.2, 0.1 and 1.3 percent per year respectively. Growth in total energy consumption varies significantly between industry groups (Table C-3) with energy intensive industries like primary metals, paper and petroleum refining growing at 0.9 percent per year and metal durables growing at 2.1 percent per year.

The growth of different industries varies between states. To make projections of energy growth rates at the state level, it is necessary to weight the national energy growth rates to account for the projected change in the size of the industries at the state level. This weighting is accomplished by multiplying the national energy growth rate by the ratio of rate of employment growth at the state level to the national level. The BEA projections for national employment growth are reported in Table C-3.[16]

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12. *State Energy Data Report 1992*, op.cit.

13. *Regional Employment Database*, op. cit.

14. *1991 Annual Survey of Manufacturers: Geographic Area Statistics*, op. cit.

15. *Annual Energy Outlook 1994*, Energy Information Administration, U.S. Dept. of Energy, Washington, DC, 1994.

16. *Regional Employment Database*, op. cit.

Estimation of State Energy Consumption Baseline

The 1991 base-year state industrial energy consumption is estimated by apportioning the SEDR state industrial totals to the industry groups by multiplying the national energy to employment rations by employment at the state level. The annual consumption baseline for the example of New Jersey (Table C-4 and Table C-5) is reported for twelve groupings of industries though actual calculations are made at the two-digit level (except for agriculture and construction that are aggregated). Based on the 1991 consumption estimates, annual electricity and other fuel consumption is estimated for each year from 1995 through 2010.

Estimation of the Savings Potential from Efficiency Improvements

The cumulative energy savings is calculated using conservation supply curves developed from the Long Term Energy Forecasting (LIEF) Model[17] and estimates of the average price for electricity and other fuels for each industry grouping. Calculations are made and results are then aggregated into the twelve groups shown in the New Jersey example (Table C-4 and Table C-5).

Table C-3
Estimates of National Energy and Employment Growth Rates

Industry Group	SIC	Annual Growth Rate	
		Energy	Employ.
Agriculture	1,2,7-9	1.9%	0.1%
Mining		1.9%	-0.3%
Coal Mining	12	1.9%	-0.4%
Metal Mining	10	1.9%	0.1%
Oil and Gas	13	1.9%	-0.4%
Non-Metal Mining	14	1.9%	0.4%
Construction	15-17	1.9%	0.4%
Food	20	0.9%	-0.2%
Paper	26	0.9%	0.0%
Chemicals	28	0.9%	0.0%
Petroleum Refining	29	0.9%	-0.3%
Rubber & Plastics	30	1.9%	0.6%
Stone, Glass, Clay	32	1.9%	0.1%
Primary Metals	33	1.9%	-0.3%
Metals Fab. Ind.		2.1%	0.0%
Fab. Metal Prod.	34	2.1%	-0.2%
Ind. Machinery	35	2.1%	-0.2%
Elec. Equipment	36	2.1%	-0.1%
Transport Equip.	37	2.1%	0.3%
Instruments	38	2.1%	0.3%
Other Mfg.		1.9%	0.2%
Tobacco	21	1.9%	-0.5%
Textiles	22	1.9%	-0.1%
Apparel	23	1.9%	-0.2%
Wood Prod.	24	1.9%	0.6%
Furniture	25	1.9%	0.5%
Printing	27	1.9%	0.7%
Leather	31	1.9%	-0.9%
Miscellaneous	39	1.9%	-0.3%
Weighted Average		1.5%	

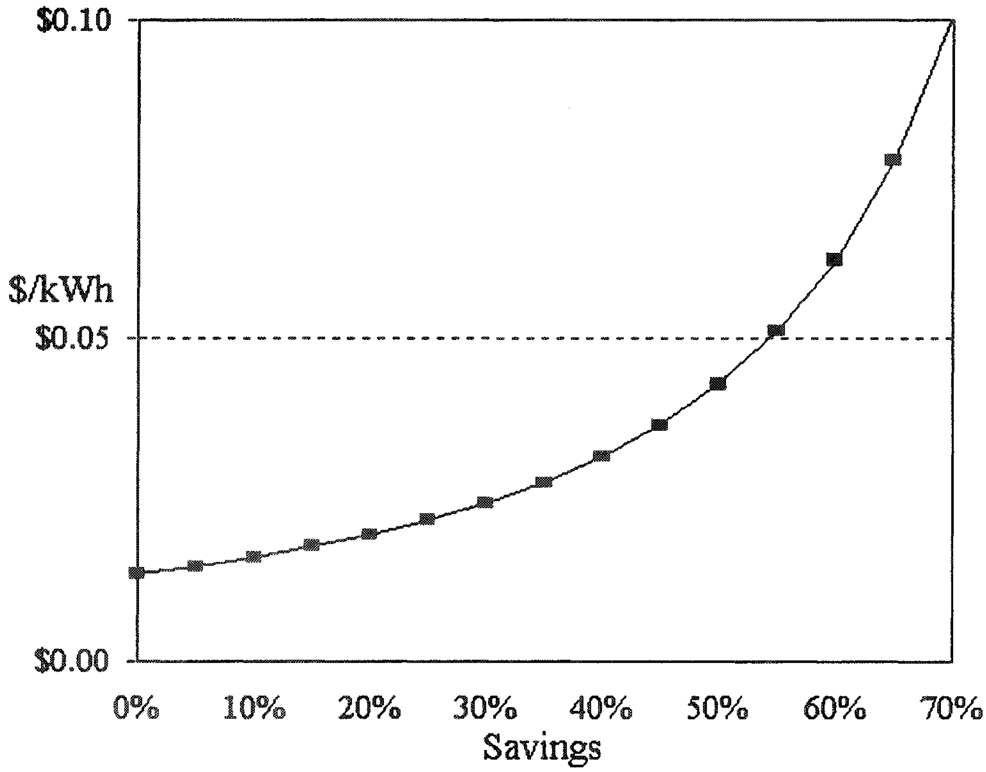
Source: Energy EIA, 1994a and Employment BEA, 1994

The LIEF curves were developed from a historical analysis of 1958-1985 sectoral energy intensities and prices. Most

17. Ross et al., op. cit

conservation supply curves have been developed by combining various characteristic measures for a particular market. Such an approach is impractical for the industrial sector because of the complexity and site-specific nature of many measures. The LIEF model segregates industries into 18 categories that have similar energy use characteristics based on their historical energy use data, and treats electricity and all other fuels use separately.[18] (An example of an electricity conservation supply curve appears in Figure C-1.)

FIGURE C-1. Electricity Conservation Supply Curve for General Manufacturing Derived from LIEF Model



18. Ross et al., op. cit

Table C-4
Base Case Fuel Consumption in New Jersey (TBtu)

Industry	1991	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agriculture	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mining	8	9	9	9	9	9	9	10	10	10	10	10	11	11	11	11	11
Construction	29	31	31	32	33	33	34	35	35	36	37	37	38	39	39	40	41
Food	11	11	11	11	12	12	12	12	12	12	12	12	12	13	13	13	13
Paper	43	44	45	45	45	46	46	47	47	47	48	48	49	49	50	50	50
Chemicals	151	156	158	159	160	162	163	165	166	168	169	171	172	174	175	177	179
Petroleum Refining	83	86	87	88	89	89	90	91	92	93	93	94	95	96	97	98	99
Rubber & Plastics	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Stone, Glass, Clay	13	14	15	15	15	15	16	16	16	17	17	17	18	18	18	19	19
Primary Metals	20	21	22	22	23	23	23	24	24	25	25	26	26	27	27	28	28
Metals Fab. Ind.	8	8	8	9	9	9	9	9	10	10	10	10	10	11	11	11	11
Other Mfg.	5	5	5	6	6	6	6	6	6	6	6	6	7	7	7	7	7
State Total	373	391	395	400	404	409	413	418	423	428	433	438	443	448	453	458	464

Table C-5
Base Case Electricity Consumption in New Jersey (Mill. kWh)

Industry	1991	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agriculture	203	220	224	228	233	237	242	247	252	256	261	267	272	277	282	288	294
Mining	257	277	282	287	293	299	304	310	316	322	328	335	341	347	354	361	368
Construction	507	546	557	567	578	589	600	611	623	635	647	659	671	684	697	710	723
Food	633	656	662	668	674	680	686	692	698	705	711	717	724	730	737	744	750
Paper	1,019	1056	1066	1075	1085	1095	1104	1114	1124	1134	1144	1155	1165	1175	1186	1197	1207
Chemicals	6,815	7063	7127	7191	7255	7320	7386	7453	7519	7587	7655	7724	7793	7863	7934	8005	8077
Petroleum Refining	826	856	864	871	879	887	895	903	911	919	927	935	944	952	961	969	978
Rubber & Plastics	586	632	644	656	668	681	694	707	720	734	747	761	776	790	805	821	836
Stone, Glass, Clay	477	514	524	534	544	554	565	575	586	597	608	620	631	643	655	668	680
Primary Metals	1,486	1601	1631	1662	1694	1726	1758	1792	1825	1860	1895	1931	1968	2005	2043	2081	2121
Metals Fab. Ind.	1,440	1565	1598	1631	1665	1700	1736	1772	1809	1847	1886	1925	1965	2007	2049	2091	2135
Other Mfg.	781	842	858	875	891	908	925	943	961	979	998	1017	1036	1056	1076	1096	1117
State Total	15,031	15,828	16,035	16,245	16,459	16,675	16,895	17,118	17,345	17,575	17,808	18,045	18,286	18,531	18,779	19,031	19,287

The LIEF model uses electricity and fuel prices to estimate the economically acceptable energy efficiency potential. Since there is significant variation in fuel prices among the states, as is evident from Table 10 in the body of the report, we preformed separate analyses for each state. The fuel price for each industry in each state was calculated using the average state industrial fuel prices[19] and the national average fuel mix[20] to develop a consumption-weighted fuel price. The weighted average industrial electricity price in the state is used for all industries.[21] This assumption is made to simplify analysis and does not account for the variation in electricity prices among different size customers or the impact of measures on demand charges.

Table C-6 presents the consumption-weighted, average energy prices for 11 industry groupings. These values were calculated from the average fuel prices for the state (see Table 10 in the main body of the report) and the national average fuel mix for each industry grouping as reported in MECS.[22] A weighted price for fuels is calculated for each industry by taking average industrial price in the state for residual and distillate oil, LPG, natural gas, and coal (as discussed in the main body of the report) and weighting the prices by the fuel mix for each industry (Table C-7).[23] The price for waste fuels is assumed to be zero for purposes of this analysis. The weighted price of fuels varies among industry groups, with industries such as wood products, furniture, pulp and paper and petroleum refining having relatively low prices because a significant portion of their thermal energy comes from manufacturing by-products and wastes (Table C-8).

The maximum economic savings potential is assumed to be the point on the conservation supply curve at which the marginal cost of energy saved equal the current fuel or electricity price. In the case of electricity, the calculated average price of industrial electricity in each state is used. For other fuels, the estimated average price (as discussed above) for a particular industry group is used. The efficiency curves reflect the different savings potential based upon price and industry.

As an example, if a food processing plant pays $0.07 per kilowatt-hour (kWh) for electricity, the efficiency potential is 63 percent of current consumption. For a primary metals manufacturing plant, the savings potential is only 22 percent at $4.00 per million Btu. The difference is a function of the way each industry typically uses energy, the steps already undertaken by that industry to save energy, and energy prices paid by each industry.

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19. *State Energy Price and Expenditure Report 1992*, op. cit.

20. *1991 Manufacturing Energy Consumption Survey*, op. cit.

21. *State Energy Price and Expenditure Report 1991*, Energy Information Administration, U.S. Department of Energy, Washington, DC, 1993.

22. *1991 Manufacturing Energy Consumption Survey*, op. cit.

23. *Manufacturing Energy Consumption Survey: Consumption of Energy 1991*, op.cit.; and *Industrial Energy Efficiency*, op. cit.

TABLE C-6. CONSUMPTION-WEIGHTED 1993 AVERAGE FUEL PRICES BY INDUSTRY ($/MBTU)			
Industry	New Jersey	New York	Pennsylvania
Agriculture	$6.79	$6.61	$6.43
Mining	$3.43	$4.05	$3.71
Construction	$4.09	$5.01	$4.34
Food	$2.88	$3.86	$3.00
Pulp & Paper	$1.23	$1.61	$1.28
Chemicals	$2.49	$3.43	$2.59
Petroleum Refining	$1.38	$1.77	$1.39
Rubber and Plastics	$3.42	$4.55	$3.52
Primary Metals	$1.97	$2.59	$2.06
Metal Fabrication	$3.29	$4.44	$3.40
Other Manufacturing	$2.58	$3.38	$2.68

Notes: The fuel prices in this table are reported are dollars per million Btu ($/MBtu) and were calculated by combining the 1993 average industrial energy prices for fuels reported in the EIA, *1993 State Energy Price and Expenditure Report*, op. cit., and the national average industrial fuel mix as reported the EIA, *1991 Manufacturing Energy Consumption survey*, op. cit.

Efficiency investments in the high efficiency scenario are estimated by multiplying the estimated energy savings in each year by the average capital cost. The investment is calculated for each industry grouping since the average fuel price varies by industry due to differences in fuel mix. Because the average measure life is assumed to be 10 years, the capital expenditures made in the first years must be repeated beginning in 2007 in order to maintain the savings realized in those prior years.

Table C-7
Fuel Consumption Fractions by Industry Group

SIC	Petroleum			Nat. Gas	Coal	Coke	Other
	Resid	Dist	LPG				
Ag.	0%	30%	40%	30%	1%	0%	0%
12	0%	91%	0%	1%	8%	0%	0%
10	0%	28%	1%	25%	45%	0%	0%
13	0%	11%	0%	75%	0%	0%	12%
14	0%	21%	1%	46%	32%	0%	0%
Const.	0%	35%	3%	63%	0%	0%	0%
20	3%	2%	1%	65%	19%	0%	0%
21	4%	1%	0%	20%	74%	0%	0%
22	7%	4%	1%	63%	17%	0%	8%
23	0%	3%	2%	75%	8%	0%	4%
24	1%	4%	1%	11%	1%	0%	83%
25	2%	2%	2%	37%	7%	0%	50%
26	7%	0%	0%	24%	13%	0%	55%
27	1%	3%	1%	89%	0%	0%	7%
28	2%	0%	0%	63%	9%	0%	25%
29	3%	1%	2%	29%	0%	0%	65%
30	6%	2%	2%	79%	5%	0%	4%
31	15%	14%	2%	56%	0%	0%	11%
32	1%	2%	0%	48%	37%	1%	10%
33	2%	1%	0%	38%	3%	31%	25%
34	2%	3%	2%	86%	3%	0%	0%
35	2%	3%	2%	81%	8%	0%	4%
36	4%	3%	2%	84%	0%	0%	0%
37	5%	3%	1%	62%	15%	0%	13%
38	4%	3%	2%	84%	0%	0%	0%

Regarding implementation rate, it is assumed that 80 percent of the maximum savings potential shown in Table C-9 is achievable by the year 2010. But it is assumed that energy efficiency measures are implemented gradually. In particular, the annual savings, beginning in 1997, was estimated to be 5.7 percent of the maximum potential. In other words, it is assumed that the efficiency measures are implemented linearly over the 14-year period. The annual savings potential for each industry is applied to base-case consumption for each year to yield an annual energy savings estimate that is added to the previous year's savings to yield a cumulative energy savings estimate for each year.

Costs of Conservation

The investment needed to achieved a particular level of energy savings is based on the assumptions of an average ten-year technology life and a five percent real discount rate. In reality, the life of the measures will vary depending upon the measure and the point in the economic cycle of the specific plant at which the measure is applied. Ten years is the median life for many of the industrial measures and is used as a simplifying assumption. Efficiency investments in the high efficiency scenario are estimated by multiplying the estimated energy savings in each year by the average capital cost for measures. It is assumed that the average cost of measures will remain constant. The investment is calculated for each industry grouping since the average fuel price varies by industry due to differences in fuel mix.

Table C-8
Weighted Average
Non-Electrical Fuel Prices for New Jersey Industries

SIC	Fossil ($/MBtu)
Ag.	6.32
Mines	3.74
Const.	4.33
20	2.89
21	2.08
22	2.99
23	3.19
24	0.71
25	1.75
26	1.24
27	3.46
28	2.49
29	1.34
30	3.39
31	3.22
32	2.50
33	1.99
34	3.46
35	3.41
36	3.35
37	2.84
38	3.35
39	3.35

TABLE C-9. COST-EFFECTIVE SAVINGS POTENTIAL BY INDUSTRY BASED ON ENERGY PRICE

Industry	Electricity Savings ($/kWh)			Fuel Savings ($/MBtu)		
	$0.05	$0.07	$0.09	$2.00	$4.00	$6.00
Agriculture	48%	57%	63%	20%	43%	54%
Mining	48%	57%	63%	20%	47%	59%
Construction	48%	57%	63%	20%	43%	54%
Food	54%	63%	68%	20%	39%	48%
Pulp & Paper	29%	35%	39%	15%	26%	32%
Chemicals	29%	35%	39%	15%	26%	32%
Petroleum Refining	29%	35%	39%	20%	43%	54%
Rubber and Plastics	66%	75%	81%	20%	47%	59%
Primary Metals	27%	34%	39%	10%	22%	28%
Metal Fabrication	66%	75%	81%	20%	47%	59%
Other Manufacturing	54%	63%	68%	20%	39%	48%

Notes: This table shows the energy savings potential in percent based upon the price of energy paid by the respective industry. The electricity prices are shown as dollars per kilowatt-hour ($/kWh), while fuel prices are dollars per million Btu ($/MBtu). The savings refer to the percent reduction from baseline consumption estimates. The estimates shown here are taken from the Long-Term Industrial Forecast (LIEF) model described in the text.

APPENDIX D
FURTHER DETAILS OF TRANSPORTATION SECTOR ANALYSIS

This appendix provides further details on assumptions and calculation procedures used to analyze potential transportation sector energy savings in the Mid-Atlantic region. The first topic covered is how we developed VMT forecasts for the region, which underpin the light vehicle energy use calculations. Because the VMT forecasts obtained for each state were not uniform in nature, each was subject to specific modifications apart from those applied uniformly as described in the main text. The other sections of this appendix presents the cost curve used to estimate the costs of vehicle efficiency improvement assumed for our analysis and a tabulation of government-owned fleet vehicles in the region.

State-Specific VMT Forecasting

New Jersey: The state does not produce long-range VMT forecasts. We estimated statewide future year VMT by combining forecasts produced by the three metropolitan planning organizations (MPO) in the state.[1, 2, 3] Together, these MPOs represent every county in the state. Historical and forecast VMT for New Jersey, as well as New York and Pennsylvania are shown in Figure 6. As the graph shows, VMT in New Jersey is expected to grow more slowly in the future, 0.78 percent/year for 1990 to 2010, than it did between 1970 and 1990, when it averaged 1.97 percent/year. The VMT growth rate for future years would bring it more in line with forecast population growth. While population grew at 0.27 percent/year during the 1970s, VMT grew at 2.34 percent/year. The states' forecasts estimate that from 2000 to 2010 population will grow at 0.96 percent/year and VMT will grow at 0.84 percent/year. From 2000 to 2010 there is forecast to be a slight decline in VMT per capita, dropping 0.12 percent/year. VMT growth relative to Gross State Product (GSP) has shown even sharper declines. While VMT/GSP rose 1.0 percent/year in the 1970s, it shows declines in the following three decades, dropping 2.14 percent/year in the 1980s, 0.73 percent/year in the 1990s and 1.03 percent/year from 2000 to 2010. While these trends indicate a reverse

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1. Muller, N. (North Jersey Transportation Planning Authority, Newark, N.J.). 1995. Personal communication to Hugh Morris. November 27.

2. Roggenburk, R. (Delaware Valley Regional Planning Commission, Philadelphia, Penn.). 1995. Personal communication to Hugh Morris. November 27.

3. SJTPO. 1994. *South Jersey 2015 Regional Transportation Plan*. Vineland, NJ.: South Jersey Transportation Planning Organization.

from historical VMT growth patterns, Pisarski[4] identified several demographic trends that support declining travel growth rates. Such demographic shifts are accounted for in the modeling process used by New Jersey's MPOs. The state transportation plan,[5] while not providing specific travel forecasts, does list actions to support a reduction in travel demand. The plan advocates improved transit, more park and ride lots, congestion pricing, priority for high-occupancy vehicles, tax incentives and changes to building codes to support land use changes, and an increase in the gas tax from 2.5 cents/gal in 1995 to 9.0 cents/gal in 2000. While more thorough examination of the New Jersey VMT forecast is beyond the scope of this study, we believe the forecast is likely to be low, based on the lack of empirical evidence that growth in travel demand can be so dramatically slowed.

New York: The state does produce a long-range VMT forecast for air quality analysis purposes.[6] This forecast shows a slowing in the growth of VMT, though not as dramatic as New Jersey. While VMT growth was low between 1970 and 1980, 1.24 percent/year, it peaked in the next decade at 3.25 percent/year and is expected to slow to 1.99 percent/year by 2010. The modeling procedure used by the state for this long-range forecast followed EPA guidelines for air quality analysis. This method calls for an extrapolation of past trends, relying on historical characteristics rather than taking into account future demographic impacts as the New Jersey forecasting process does.[7] Growth of VMT per capita trends downward as well. While the growth was 1.6 percent/year in the 1970s and reached 3.0 percent/year in the 1980s, the state's forecast indicates a drop back to 1.6 percent/year by 2010. State VMT in relation to economic output shows stronger growth in the future, with VMT/GSP growing at 0.69 percent/year between 1970 and 1990 and 1.02 percent/year from 1990 to 2010. Reduction in VMT growth are supported by the state long-range transportation plan[8] that advocates increasing intercity rail transport, a desire to cut solo commute trips in half by 2005 and increase rush hour transit use by 20 percent. While the plan provides no details to achieve such gains, it does mention that congestion pricing may become necessary. The New York VMT projection appears to be reasonably consistent with historical trends.

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4. Pisarski, A. 1990. *Travel Demand in the 1990s: A Look at Demographic Changes that will Affect Highway Transportation in this Decade*. Washington, D.C.: Highway Users Federation.

5. NJDOT. 1995. *Transportation Choices 2020: Statewide Long-Range Transportation Plan*. Trenton, N.J.: New Jersey Department of Transportation.

6. NYDOT. 1995. *County Level DVMT Forecasts for SIP Development*. Long Island City, NY.: Urban Planning Section, Planning Division, New York State Department of Transportation.

7. Escarpeta, D. (Region 2 Division of Air Resources, New York State Department of Environmental Conservation, Long Island City, N.Y.). 1995. Personal communication to Hugh Morris. November 28.

8. NYDOT. 1996. *The Next Generation: Transportation Choices for the 21st Century*. Albany, NY: State of New York, Department of Transportation.

Pennsylvania: The state only produces a short-term VMT forecast to 1996.[9] Thus, long-range forecasts were collected from five MPOs representing the major urban areas of Philadelphia, Pittsburgh, and Harrisburg, as well as surrounding counties[10, 11, 12, 13, 14]). We calculated that these MPOs represent 65 percent of the state's population and 60 percent of the state's VMT in 1990. The available forecast VMT estimates were combined and expanded to a statewide estimate based on the above mentioned statewide 1990 and 1996 VMT data. The expansion factor was found to change over time. The VMT of the sampled areas represents a declining portion of the state VMT, dropping from 60 percent in 1990 to 59 percent in 1996, a trend we continue, reaching 57 percent in 2010. Though the MPO VMT forecasts were daily, they were for average summer weekday and thus could not be expanded by a factor of 365 to obtain annual volumes. The MPOs contacted could not provide an appropriate conversion factor. Thus, since both annual and daily estimates were available for 1990, a ratio was calculated that implied that the weekday summer estimates represented a higher than annual average daily traffic volume. This ratio, 1.12 to 365, was applied to daily forecasts of future-year VMT to obtain annual estimates.

The composite VMT forecast we developed for Pennsylvania shows a modest decrease in VMT growth rates, dropping from 2.09 percent/year between 1970 and 1990 to 1.45 percent/year between 1990 and 2010. VMT per capita shows a declining trend, falling from 1.81 percent/year in the 1980s to 0.76 percent/year by 2010. VMT per GSP grew modestly from 1970 to 1990 at 0.59 percent/year and is forecast to decline by 0.11 percent/year from 1990 to 2010. The modeling process used by the MPOs we contacted was similar to that used by the New Jersey MPOs and thus would have captured some of the demographic impacts

9. Baker, M. (Pennsylvania Department of Environmental Resources, Harrisburg, Penn.). 1995. Personal communication to Hugh Morris. November 8.

10. PennDER. 1994. *Proposed SIP Revision for Meeting the Reasonable Further Progress Requirement Under the Clean Air Act in the Philadelphia Severe Nonattainment Area*. Harrisburg, Penn.: Bureau of Air Quality Control, Pennsylvania Department of Environmental Resources.

11. PennDOT. 1993a. *Pittsburgh-Beaver Valley Area Request for Redesignation as Attainment for Ozone*. Harrisburg, Penn.: Air Quality Program Support to Pennsylvania Department of Transportation.

12. PennDOT. 1993b. *Reading Area Request for Redesignation as Attainment for Ozone*. Harrisburg, Penn.: Air Quality Program Support to Pennsylvania Department of Transportation.

13. PennDOT. 1994a. *Air Quality Conformity Analysis Report for the Harrisburg Ozone Nonattainment Area*. Harrisburg, Penn.: Secretary's Air Quality Task Force. Pennsylvania Department of Transportation.

14. PennDOT. 1994b. *Air Quality Conformity Analysis Report for the Lancaster Ozone Nonattainment Area*. Harrisburg, Penn.: Secretary's Air Quality Task Force, Pennsylvania Department of Transportation.

discussed above. The state transportation plan[15] advocates VMT reduction and land use initiatives to increase non-auto access, but does not provide details. The plan does consider development of a stable transportation funding source which could include a mileage-based fee. Although the drop-off in VMT growth projected for Pennsylvania is not as striking as for New Jersey, it is probably likely that the Pennsylvania forecast is on the low side, since it doesn't reflect historical trends.

Cost of Vehicle Efficiency Improvement

As noted in the main text, we adopted the DeCicco and Ross[16] results to guide our estimates of the potential for and cost of improving car and light truck fuel economy. The costs of vehicle efficiency improvement are estimated at the retail (as opposed to manufacturing) cost level. Initial investments in improved technologies would be made by the auto industry and their suppliers in response to initiatives to foster efficiency improvement. However, we assumed that these costs are fully passed on to new car buyers, including markups proportional to those embodied in the base price of vehicles. DeCicco and Ross provided cost estimates for a set of roughly 20 technology options. When ranked according to cost-effectiveness (e.g., increasing cost of conserved energy), the resulting curve of incremental vehicle cost versus incremental efficiency improvement is closely matched by a quadratic function, as shown in Figure D-1. We used this quadratic fit to the technology cost estimates in order to interpolate cost for the phased-in, 1.5 mpg/year improvements assumed for our analysis.

Government Fleet Vehicles in the Region

Table D-1 lists the numbers of government-owned fleet vehicles in the Mid-Atlantic region, based on Federal Highway Administration statistics for 1992. The top portion of the table breaks out federal versus state and local vehicles by major class. Of relevance to this study are state and local government automobiles. These vehicles total 156,000 for the three states, and could be the focus of For context, the lower portion of Table D-1 lists total vehicle registrations in the New Jersey, New York, and Pennsylvania and shows the government-owned fraction, which accounts for roughly 1% of the total. Although the fraction is small, these fleets could form an important core of efforts to foster best-in-class efficient vehicle purchasing and strategic procurement of advanced vehicles, as discussed in the main text.

15. PennDOT. 1994c. *Interim Transportation Policy Plan.* Harrisburg, Penn.: Pennsylvania Department of Transportation.

16. DeCicco, J.M., and M. Ross. 1993. An Updated Assessment of the Near-Term Potential for Improving Automotive Fuel Economy. Washington, DC: American Council for an Energy-Efficient Economy. November.

Figure D-1. Incremental Retail Costs for Improving New Car Fuel Economy Based on DeCicco and Ross (1993), at 3 Levels of Technical Certainty

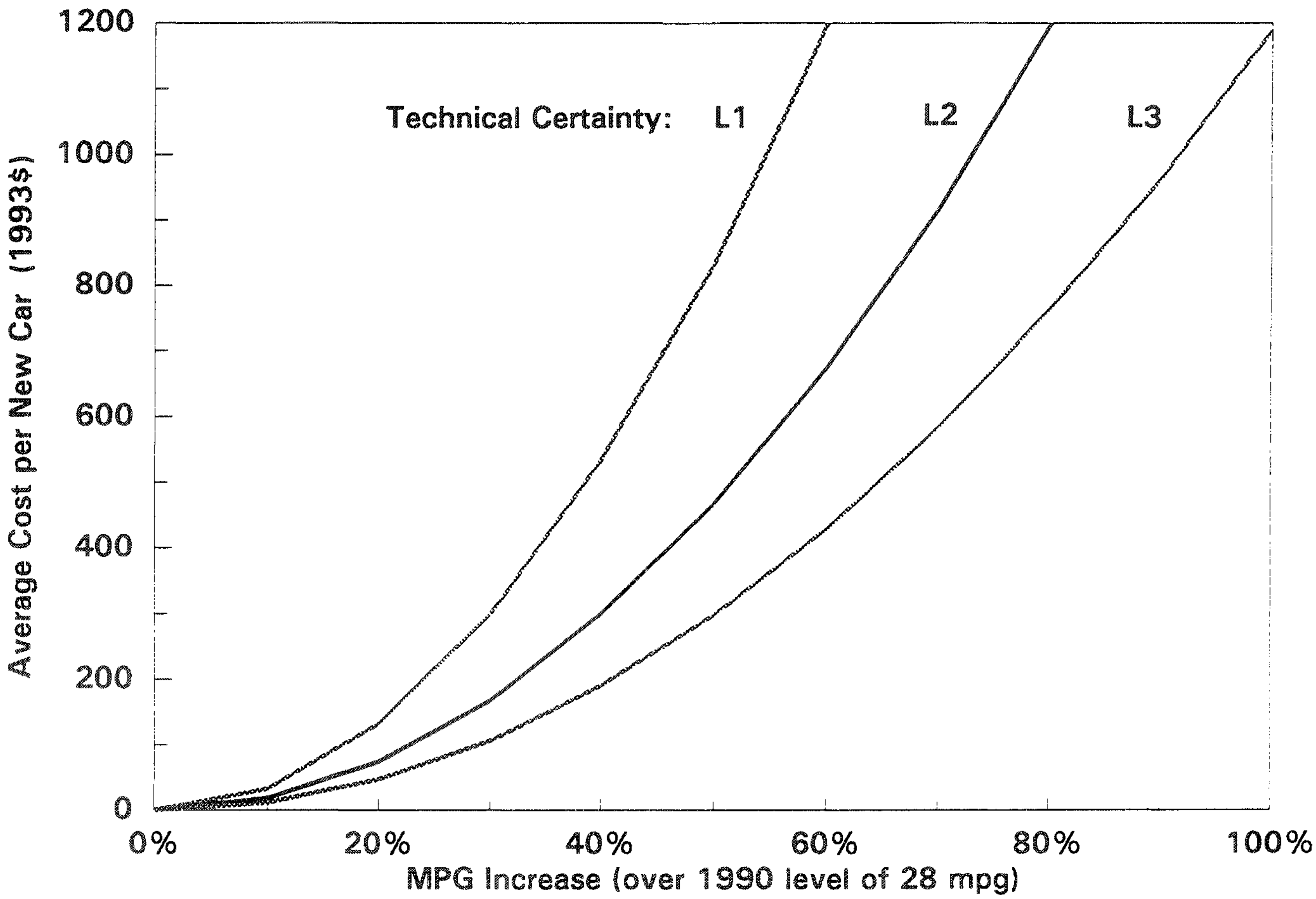

Table D-1. Government Fleet Vehicles in Three-State Region, 1992

	New Jersey	New York	Pennsylvania	Total
Federal				
Auto	2,092	7,948	4,785	14,825
Bus	53	203	113	369
Truck	8,211	14,536	10,128	32,875
Motorcycle	0	11	4	15
Subtotal	10,356	22,698	15,030	48,084
State & Local				
Auto	57,352	63,888	35,022	156,262
Bus	3,000	20,470	6,712	30,182
Truck	76,420	67,229	44,196	187,845
Motorcycle	982	1,160	964	3,106
Subtotal	137,754	152,747	86,894	377,395
Gov't Fleet Total				
Auto	59,444	71,836	39,807	171,087
Bus	3,053	20,673	6,825	30,551
Truck	84,631	81,765	54,324	220,720
Motorcycle	982	1,171	968	3,121
Total	148,110	175,445	101,924	425,479

	New Jersey	New York	Pennsylvania	Total
Registered Total				
Auto	5,135,703	8,467,220	6,534,865	20,137,788
Bus	18,185	39,667	31,708	89,560
Truck	437,466	1,272,667	1,612,658	3,322,791
Motorcycle	No data available.			
Total	5,591,354	9,779,554	8,179,231	23,550,139
Gov't Fleet % Total				
Auto	1%	1%	1%	1%
Bus	17%	52%	22%	34%
Truck	19%	6%	3%	7%
Motorcycle	No data available.			
Total	3%	2%	1%	2%

Notes:

All data from FHWA Highway Statistics 1992, tables MV-1 and MV-7.
Does not include military vehicles and diplomatic vehicles.