National Grid's Energy Efficiency Programs: Benefits for Rhode Island's Economic Development and Environment

Prepared for

National Grid USA

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Executive Summary

This report examines National Grid's energy efficiency programs implemented 1990-2005 in Rhode Island. The impacts of these programs upon the state's electricity system, environment, and economy are summarized in Table 1 (page 2). These impacts were estimated using E^3AS (Energy, Economic, and Environmental Analysis System) software. E^3AS considers both the benefits and costs of energy alternatives. The Study Methodology section of this report (page 13) provides more detail as to the E^3AS software, and the underlying input-output model used to estimate economic development impacts.

The air emissions benefits estimated in this study are due to the decreased need for electricity generation. E^3AS computes these impacts based on the emission rates of power plants whose operation would be avoided. Specifically, the benefits reported are decreases in Carbon Dioxide (CO_2), Nitrogen Oxides (NO_x), Sulfur Dioxide (SO_2), and four other air emissions. National Grid's energy efficiency programs yield clear benefits in terms of improved air quality, making Rhode Island a more attractive place to live and work. In fact, the significant CO_2 emissions reductions (6,405 tons) associated with 1990-2005 energy efficiency programs are equivalent to almost half of Rhode Island's total annual CO_2 emissions.

Moreover, these impressive environmental benefits have been achieved while simultaneously reducing the state's overall cost of energy. Every dollar spent on energy efficiency during 1990-2005 has resulted in almost $1.85 in supply cost savings. These results are even more impressive when viewed in terms of spending by National Grid. The customers participating in efficiency programs have received substantial value in terms of reduced electricity bills, and they have directly contributed over 30% of the funds spent on efficiency. So every dollar spent by National Grid on energy efficiency during 1990-2005 has resulted in over $2.65 in estimated supply cost savings.

Respending of these energy cost savings has given rise to substantial employment and other economic development benefits for Rhode Island. For the 1990-2005 energy efficiency programs, the E^3AS model estimates that in-state employment has increased by 5,770 person-years (1 person-year = 1 full time job for 1 person for 1 year), with increased earnings of $169 million (2005$). The total state value-added from the programs (i.e. overall economic activity, including earnings, interest and profits) is estimated at $206 million (2005$).

The employment and other economic development benefits provided by efficiency programs are fairly small in the context of the overall Rhode Island economy. But even if they are not as dramatic as the air emissions benefits, these economic benefits are still quite significant. This report confirms that National Grid's 1990-2005 efficiency programs have been highly cost-effective. As a result, the state's economy is stronger and more efficient. And as was the case for the air quality benefits, the economic benefits from National Grid's efficiency programs are making Rhode Island a more attractive place to live and work.

This study also confirms that spending on efficiency produces far more in-state economic benefits than a comparable amount of spending on electricity supply. This is not surprising, given that fuel costs account for such a large share of overall spending on supply. Rhode Island is dependent upon imported fuels (notably natural gas for electric generation) that must be transported over long distances from other regions and other countries. Spending on imported fuels produces little employment or other in-state economic activity. By contrast, spending on efficiency programs includes a large component of labor and other goods and services that are sourced locally.

In addition, this report includes a discussion of the impacts of the energy efficiency programs on individual industries (page 6). Tables 2 and 3 (pages 8 and 9) provide comparisons of jobs for efficiency programs versus jobs related to expenditures on electricity supply. The overall conclusion is that the quality of employment associated with efficiency is not significantly different than that associated with supply. As such, most of the economic and employment benefits estimated in this study stem from the respending effect associated with these highly cost-effective energy efficiency programs.

This report builds upon a similar study performed in 2001 that examined National Grid's efficiency programs implemented 1990-2000 in Rhode Island.[1] The results of the current study are consistent with the results of this earlier study. The principle difference is that the benefits estimated for energy efficiency are now substantially larger. This is mainly due to the three factors:

- With five more years of program implementation, the current study is evaluating a significantly larger cumulative amount of efficiency.
- Compared with the assumptions in the 2001 study, natural gas prices have been, and are expected to remain, much higher. So efficiency has become an even more cost-effective alternative to supply.
- Other recent changes (including the restructuring of electricity markets) have also resulted in higher avoided supply costs. This effect is small relative to that of higher gas prices, but it has further enhanced the cost-effectiveness of efficiency.

[1] Narragansett Electric's Energy Efficiency Programs: Benefits for Rhode Island's Economic Development and Environment, prepared for Narragansett Electric Company, prepared by Ian Goodman, The Goodman Group, Ltd., August 14, 2001.

Introduction

For more than fifteen years, National Grid[2] has been implementing large scale energy efficiency programs for Rhode Island electricity consumers. This report examines how these programs have impacted the state's economy and environment.

The efficiency measures installed in a given year will continue to reduce electricity consumption until they wear out and are replaced. Some efficiency measures have lifetimes greater than 20 years, while others last only a few years. On average, the measures installed by National Grid in Rhode Island since 1990 have lifetimes exceeding 14 years.

Thus, in the year 2006, Rhode Island electricity consumption is lower due to the cumulative effect of more than a decade of efficiency programs. Absent ongoing efforts to increase efficiency, these savings will decline as currently installed measures reach the end of their useful lives. Alternatively, if Rhode Island continues to invest in new efficiency measures, the current level of savings can be maintained and increased.

For National Grid's Rhode Island efficiency programs implemented over the sixteen year period 1990-2005, Table 1 (page 2) summarizes the impacts upon the state's economic development and environment. The results in the "All Program Years" column are the impacts for *all* years during which the measures installed 1990-2005 save electricity. The results in the "Average Program Year" column are the impacts for *all* years during which the measures installed in a *single average year* 1990-2005 save electricity.[3]

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[2] This study includes the DSM (demand-side management) activities of Blackstone Valley Electric Company and Newport Electric Corporation prior to their purchase in 2000, and the DSM activities of Narragansett Electric Company, the name under which National Grid operated in Rhode Island until 2005.

[3] Stated another way, the results in the "Average Program Year Column" are calculated by dividing the results in the "All Program Years" column by 16 (the number of years during which programs have been implemented 1990-2005).

Table 1: Lifetime Impacts of Efficiency Programs Implemented 1990-2005

	All Program Years	Average Program Year
Electricity Savings		
Energy (GWh)	12,205	765
Demand (MW-year)	3,065	190
Value (Avoided Supply Cost 2005$ millions)	$983	$61
Avoided Emissions		
Carbon Dioxide: CO_2 (thousand tons)	6405	400
Nitrogen Oxides: NO_x (tons)	4460	280
Sulfur Dioxide: SO_2 (tons)	5360	335
Methane: CH_4 (tons)	160	10
Carbon Monoxide: CO (tons)	615	40
Total Suspended Particulate: TSP (tons)	695	45
Volatile Organic Compounds: VOC (tons)	80	5
Macro-economic indicators		
Employment (Person-Years)	5770	360
Earnings (2005$ millions)	$169	$11
Value-Added (2005$ millions)	$206	$13

Table 1 Notes:

1. All monetary results (value, earnings, and value-added) are reported in terms of real (year 2005 value) dollars. All other results are rounded to the nearest 5.
2. Energy: 1 GWh = 1,000 MWh = 1,000,000 kWh.
3. Energy and demand savings are reported at the power plant busbar and thus include the benefit of avoided transmission and distribution losses. Demand savings also include the benefit of avoided capacity reserve margin, and are reported in terms of reduction in annual summer peak.
4. Macro-economic indicators (employment, earnings, and value-added) are reported for the net effect of energy efficiency. As explained on page 7, these impacts are the sum of the following three components: (1) the *increase* in economic activity as a result of expenditures on efficiency programs, (2) the *decrease* in economic activity as a result of decreased expenditures on electricity supply, and (3) "*respending*", the *increase* in economic activity as consumers increase their spending for other goods and services (to the extent that efficiency programs reduce consumers' overall costs, these savings are available for other spending). Thus, the employment and earnings data in Table 1 is derived from the data for these three components (efficiency, supply, and respending) in Table 2 (page 8).
5. Employment: 1 person-year = 1 full time job for 1 person for 1 year.
6. Earnings: The compensation associated with this employment, as well as property income.
7. Value-added: The difference between the value of output (sales) and the cost of intermediate inputs (goods and services purchased from other businesses); stated another way, it represents the value that is added by the application of capital and labor in converting intermediate inputs to finished products. Summed across all industries, as it has been here, value-added is a measure of overall economic activity, which includes earnings (employee compensation), interest, and profits. It is equivalent to GDP (Gross Domestic Product) nationally.

Air Emissions Benefits

By reducing electricity consumption, efficiency programs reduce the need to operate existing power plants, as well as the need to build and operate new power plants. This will result in substantial air quality benefits. While the economic analysis model utilized does estimate reductions in air emissions associated with avoided electricity generation, it does not incorporate the economic benefits associated with these lower emissions (e.g., improvements in productivity and business competitiveness owing to lower costs for health care and pollution controls).

Absent efficiency programs, Rhode Island would suffer from reduced environmental quality and/or would have to undertake other costly measures to reduce emissions. Either way, electricity efficiency programs help to increase the efficiency of the overall economy and make the state a more attractive place to reside and operate businesses.

Typically, the three air emissions of greatest interest are NOx, SO_2, and CO_2, and that is true in this analysis as well. Certainly, the quantity of these three emissions exceed those of the other four reported above in Table 1.

The emissions reductions associated with electricity efficiency are most significant for CO_2. Over their lifetime, the efficiency measures installed 1990-2005 will avoid CO_2 emissions equivalent to almost half of Rhode Island's total annual CO_2 emissions, or more than all of Rhode Island's total annual CO_2 emissions specifically from either electric generation or transportation.[4]

Electricity efficiency programs have been a major ongoing activity in Rhode Island for more than fifteen years, and their cumulative contribution to reducing CO_2 emissions is quite impressive. Such programs have many benefits for the state, region, nation, and world. Moreover, it is clear that efficiency programs are a particularly effective and economical method of reducing carbon emissions.

By comparison, the effect of electricity efficiency programs upon NO_x emissions is substantial, but less so. Over their lifetime, the efficiency measures installed 1990-2005 avoid NO_x emissions equivalent to those of 325,000 automobiles used for one year (as compared to CO2, where the impact of DSM was equivalent to more than a million autos). But this difference is not surprising given that CO2 emissions are uncontrolled, while NO_x emissions from power

[4] The electricity grid and power plants throughout New England operate as part of an integrated system, with interconnections to neighboring states and Canada. Thus, it can not be assumed with certainty that electricity consumed in Rhode Island is generated within the state, or vice versa. But it is reasonable to assume that efficiency programs implemented in Rhode Island reduce the need for electricity generation within the state and elsewhere in New England, and that this in turn reduces the air emissions associated with supplying Rhode Island's electricity demand.

plants (especially new power plants) have been greatly reduced by a variety of technologies.[5]

For SO_2, the emissions reductions associated with DSM are quite sizable in the context of Rhode Island. Over their lifetime, the efficiency measures installed 1990-2005 avoid SO_2 emissions equivalent to more than Rhode Island's total annual SO_2 emissions. This large impact stems from two factors. First, to a far greater extent than for other emissions, electricity generation is the predominant source of SO_2. Second, the emissions reductions from DSM are being compared with actual Rhode Island SO_2 emissions which are now quite low. The existing power plants within the state are mostly gas-fired, and natural gas contains very little sulfur.

But when viewed in a wider context, the value of the SO_2 emissions reductions from Rhode Island DSM is not as significant. SO_2 emissions elsewhere in New England (and nationally) are substantially higher due to coal- and oil-fired generation, and these fuels contain more sulfur than natural gas.[6]

For other emissions, the impact of efficiency programs is less noticeable. For CH_4 (methane), CO, TSP, and VOC, the reductions associated with DSM are small relative to total emissions.

In summary, the emissions reduction benefits associated with electricity efficiency programs are quite significant overall, especially since they are attained at a negative cost. Unlike many other emissions control strategies, efficiency programs reduce, rather than increase, the costs of supplying electricity and other goods sold in the marketplace. For the programs implemented to date, these benefits have been most impressive for CO_2, significant for NO_x, and less so for other emissions.

For future efficiency programs, the emissions reduction benefits will be smaller (per kWh saved) than historically, since the generation avoided will be from new very clean plants, rather than existing facilities with much higher emissions rates.[7] Still, as long as New England continues to rely upon fossil fueled

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[5] To be conservative, the analysis in this study has assumed that the small amount of NO_x emissions from relatively new gas fired combined cycle plants are offset, rather than the more significant quantities associated with older, less-efficient plants.

[6] There is a national open market for the trading of SO_2 allowances. While this might provide a basis for quantifying the value of the SO_2 emissions reductions associated with DSM, this national value is quite low since it is dominated by the relatively low cost of mitigating coal-generated SO_2 emissions in other regions. Therefore, while it may be possible to quantify the SO_2 reduction benefit based on the national allowances market, this quantification would understate the value of SO_2 reduction in Rhode Island.

[7] Relative to older existing plants (mostly steam turbines fueled with oil, coal, and natural gas), new and recently added power plants have very low emissions owing to their high efficiency (combined cycle plants require less fuel per kWh produced), and their reliance on natural gas and advanced pollution control technology (lower emissions per Btu of fuel burned).

generation, efficiency programs will remain an effective way to reduce CO_2 emissions.[8]

Economic Development Benefits

In comparing the economic development impacts of energy alternatives, it is important to consider the overall costs of the alternatives. Notably, when efficiency programs lower consumers' energy costs (i.e., efficiency is less expensive than the avoided electricity supply costs), consumers have more money to spend upon other (non-energy related) activities. Spending on these other activities is typically more beneficial to the economy than spending on energy-related activities. In numerous previous studies, this respending of customer cost savings typically accounted for much of the total economic development benefit associated with efficiency programs.

Cost-effective energy efficiency reduces the cost of living and operating businesses and thus promotes economic development in Rhode Island. It increases the efficiency of the overall economy and makes the state a more attractive place for residents and businesses.

Consistent with numerous previous studies for Rhode Island and other jurisdictions, this analysis has also found that spending on efficiency produces more benefits than a comparable amount of total spending upon electricity supply. The simple explanation is that electricity supply includes a large fuel cost component, but spending upon fuels that are produced outside of the state contributes little to the local economy. For the non-fuel components of electricity supply costs (building and operating power plants and power lines), the overall benefits to the Rhode Island economy (per dollar of spending) are almost as large as those for efficiency programs.

The efficiency programs implemented 1990-2005 have benefited the Rhode Island economy. They are estimated to increase macro-economic indicators such as employment, earnings, and value-added. However, in contrast with emissions, the overall improvement is fairly small in the context of the overall state economy.

On the other hand, the economic benefits estimated in this study likely understate the total impacts of efficiency programs. As noted above, absent efficiency programs, Rhode Island would suffer from reduced environmental quality and/or would have to undertake other costly measures to reduce emissions.

[8] All fossil fuels contain carbon, and there is no currently widely implemented method to prevent this carbon from being released to the atmosphere when such fuels are combusted.

Also, from year 2000 onward, electricity supply costs have increased substantially, owing in large part to dramatically higher natural gas prices. As a result, electricity avoided costs have proven to be greater than was anticipated. And while the evolution of energy markets continues to be highly uncertain, it is now generally expected that gas prices and electricity avoided costs will remain above the levels experienced during the 1990s.

With today's much higher avoided costs, Rhode Island electricity consumers are reaping even larger than expected benefits in terms of electricity cost savings. Electricity efficiency is helping to shelter the state from the adverse impacts of increased fuel and other supply costs, and these enhanced benefits are expected to continue into the long term future.

The energy efficiency programs implemented 1990-2005 were highly cost-effective. On average, each kilowatthour of energy savings is estimated to avoid 8.2¢ in supply costs (for generation, transmission, and distribution); however, it has cost National Grid and its customers only 4.4¢ per kilowatthour to achieve these energy savings.[9] Thus, every dollar spent on energy efficiency is estimated to yield almost $1.85 in supply cost savings.

The costs for efficiency programs reported above consider both expenses paid by National Grid and those borne by the customers participating in the programs. Program participants have received substantial value in terms of reduced electricity bills, and they have directly contributed, on average, over 30% of the overall installation costs of their energy efficiency projects.[10] Considering only the utility's share of these expenses, it has cost National Grid just 3.1¢ per kilowatthour to achieve these energy savings. Thus, every dollar spent by the utility on energy efficiency during 1990-2005 has resulted in over $2.65 in estimated supply cost savings.

Impacts Upon Individual Industries and Types and Location of Employment

As reported above, the energy efficiency programs implemented 1990-2005 are estimated to have increased Rhode Island employment, earnings, and value-added. However, even if the overall impact is positive, it is relevant to explore whether certain industries have been advantaged or disadvantaged as a result, and what this might imply for types of employment.

[9] Costs are expressed in real (year 2005 value) dollars, levelized at the 1.88% real discount rate specified in National Grid's February 2006 avoided cost data.

[10] Customer willingness to contribute to the costs of their energy efficiency projects indicates that (a) customers are receiving the same (or greater) energy services than they would have received with the baseline technologies; (b) that they likely value the benefits associated with energy efficiency programs; and (c) that they realize significant additional net benefits in terms of improved comfort and amenities (e.g., new high quality appliances).

The economic development impacts estimated in this report are the sum of the following three components: (1) the *increase* in economic activity as a result of expenditures on efficiency programs;[11] (2) the *decrease* in economic activity as a result of decreased expenditures on electricity supply; and (3) *"respending,"* the *increase* in economic activity as consumers *increase* their spending for other goods and services (to the extent that efficiency programs reduce consumers' overall costs, these savings are available for other spending).

For Rhode Island electricity efficiency programs implemented 1990-2005, the employment associated with components (1) and (2) are roughly similar. In other words, the jobs gained by increased spending on efficiency are offset by the jobs lost owing to lower spending on supply. As shown in Table 2, energy efficiency gives rise to more than twice as much employment per dollar spent than does supply. Rhode Island efficiency programs have been highly cost-effective, such that a dollar of spending on efficiency avoids approximately two dollars of spending on supply.[12]

As it happens, a smaller amount of spending on more labor intensive efficiency yields a similar amount of overall employment as does a larger amount of spending on less labor intensive supply. However, since efficiency has cost less than avoided supply, there is still a net increase in overall employment, as a result of the respending of these cost savings [component (3) above].[13]

[11] Efficiency expenditures include direct utility costs and evaluation, plus customer contributions.

[12] As discussed on page 6, each dollar of efficiency spending avoids almost $1.85 in supply costs (computed in terms of real levelized costs at a real discount rate of 1.88%). When computed on the basis of real costs at a zero discount rate (not levelized), efficiency is even more cost-effective; each dollar of efficiency spending avoids $2.12 in supply costs. The economic benefits estimated in this study (for employment, earnings, and value-added) are based on real (year 2005 non-levelized) costs. This is appropriate for an analysis involving non-monetary indicators such as number of jobs.

[13] Specifically, the data (reported in Table 2) for direct jobs from efficiency (6070) – direct jobs from avoided supply (6200) + respending jobs (5900) = net jobs from efficiency (5770), as reported in Table 1 (page 2, employment for all program years). Likewise, the data reported in Table 2 for earnings (240-274+203) = net earnings from efficiency ($169 million), as shown in Table 1. Table 2 does not provide data for value-added, but the results for this indicator in Table 1 are based on the same type of computation as for jobs and earnings.

Table 2: Jobs and Earnings for Efficiency Programs and Avoided Supply

		Efficiency	Supply
Direct Expenditures (million $)		$464	$983
Direct Employment:	Jobs	6070	6200
	Earnings (million $)	$240	$274
	Earnings per job	$ 39,600	$ 44,200
	Jobs per million $ expended	13.1	6.3
	Earnings per million $ expended	$517,500	$278,800

Respending (million $) = Supply ($983) – Efficiency ($464)		$519
Respending Employment:	Jobs	5900
	Earnings (million $)	$203
	Earnings per job	$34,400
	Jobs per million $ expended	11.4
	Earnings per million $ expended	$391,000

Table 2 Notes:

1. All monetary results (expenditures and earnings) are reported in terms of real (year 2005 value) dollars.
2. Results for earnings per job and earning per million $ expended are rounded to the nearest $100. Results for number of jobs are rounded to the nearest 5.
3. Employment: 1 person-year = 1 full time job for 1 person for 1 year.
4. Earnings: The compensation associated with this employment, as well as property income.

The economic analysis software utilized in preparation of this report provides detailed estimates of which industries within the Rhode Island economy are affected by spending on (1) efficiency and (2) supply. For reasons that will be discussed below, the software does not provide such detailed estimates for (3) respending. Table 3 presents results reported in terms of jobs per million $ of expenditures, and as a proportion of total jobs.

Table 3: Jobs by Industry Grouping for Efficiency Programs and Avoided Supply

Industry Grouping	Jobs per million $ (year 2005 $) Efficiency	Supply
Construction	1.4	2.0
Manufacturing of Electrical and Non-Electrical Equipment & Machinery	3.5	0.3
Other Manufacturing	0.7	0.6
Transport, Utilities, Agriculture & Mining	0.4	0.7
Wholesale & Retail Trade	2.0	0.9
Business Services and Government	5.1	1.8
TOTAL	13.1	6.3

Industry Grouping	Proportion of total jobs Efficiency	Supply
Construction	10%	32%
Manufacturing of Electrical and Non-Electrical Equipment & Machinery	27%	5%
Other Manufacturing	5%	9%
Transport, Utilities, Agriculture & Mining	3%	11%
Wholesale & Retail Trade	15%	14%
Business Services and Government	39%	28%
TOTAL	100%	100%

The pattern of jobs from efficiency and avoided supply are roughly similar in many areas, but there are some notable differences. In interpreting the data, it is useful to remember that these are for employment in Rhode Island, and they take into account whether goods and services will be supplied in-state or outside. For there to be a large impact in the above data, it is necessary both for the activity to require substantial amounts of inputs from the industries in question, but also for the industries to be located in-state.

Rhode Island is situated within a very compact geographic area. The state's economy and labor force are closely linked with those of neighboring states (especially Massachusetts). Some of the economic activity related to Rhode Island efficiency programs and avoided supply will occur in neighboring states, and the study analysis has been structured to reflect this.

National Grid's operations in Rhode Island are part of a tightly integrated regional electricity system. Electricity consumed in state is not necessarily generated there; likewise, power plants in Rhode Island may be used to supply customers elsewhere. But for the purposes of this study, it has been assumed that all of the avoided supply would have been located in Rhode Island.

The data in Table 3 for proportion of total jobs should be viewed in the context that these results are calculated as a percentage of a total jobs and add to 100% (although may not appear to owing to rounding). Thus, if there is a large concentration of jobs in one category, this will help to reduce the percentage of the total assigned to other categories

Finally, as noted above, the total number of jobs from the efficiency programs implemented 1990-2005 and avoided supply are similar (prior to considering additional jobs from respending). Thus, it is possible to evaluate whether efficiency programs will result in a shift of employment from one industry to another by comparing the figures in Table 3 for proportion of total jobs. For example, relative to supply, efficiency has a much higher percentage of jobs associated with manufacturing of electrical and non-electrical equipment and machinery. This indicates potential job gains in this industry as a result of efficiency. Conversely, supply has a higher share of constructions jobs, indicating potential job losses.

Two factors help to explain why supply has much more construction than efficiency. First, avoided supply includes operation of power plants; in the economic analysis software underlying this report, maintenance work has been assigned to the construction sector (as opposed to utilities).[14]

Second, avoided supply includes building new power plants and T&D (transmission and distribution) facilities. T&D is especially construction intensive since it involves so much on-site work, as opposed to power plants and efficiency, where much of the cost is for manufactured equipment and business services (such as design and management).

However, some of the apparent differences between efficiency and supply in this regard may be overstated and a function of how expenditures were assigned to specific activities. In other words, some of what has been assigned to construction for supply may actually be business services (such as design and engineering), and some of what has been assigned to business services for efficiency may actually be construction.

As mentioned above, efficiency involves much more manufacturing than does supply, specifically for electrical and non-electrical equipment and machinery. This is not at all surprising. Basically, this is the equipment that uses electricity,

[14] The aggregate utility category in the input-output model is not representative of the very specific supply-side and demand-side activities modeled in the analysis software. Thus, supply and efficiency are modeled as if they were outsourced to entities that could provide the relevant goods and services (such as accounting and construction), even if in fact they would be performed in-house by utility personnel.

and that controls and regulates its use. Much of the cost of efficiency is for equipment that uses electricity more efficiently than it would be by baseline technology (such as high efficiency chillers) or for equipment that facilitates greater efficiency in electricity use by other equipment (such as energy management systems).

Relative to efficiency, supply involves more utilities. This relates to the large supply-side expenditures for natural gas to fuel power plants, which were assumed to give rise to activity in the companies responsible for delivering this fuel. Meanwhile, efficiency results in significantly more activity in business services than does supply. This reflects the heavy reliance of efficiency upon professional services (design, legal, and management), but may also represent some judgments made as to whether certain activities lay within the construction sector, or were outsourced to business services.

Having now considered in great detail how specific industries are affected by expenditures on efficiency and avoided supply, none of the differences between energy efficiency and avoided supply would appear to be of much concern in the context of the overall Rhode Island economy. It does not seem that the employment associated with efficiency is dramatically different from that associated with supply in terms of the types of industries and jobs affected, or the "quality" of those jobs. To the extent that supply-side activities give rise to high wage employment, efficiency would seem to be similar both in terms of the types of jobs and compensation levels.

Moreover, for both energy efficiency and avoided supply, most jobs relate to goods and services (notably construction, services, government, and trade) that are typically sourced either in-state or near-by. So there is relatively little uncertainty as to whether Rhode Island will benefit from these jobs.[15]

As noted earlier, Rhode Island electricity efficiency programs implemented 1990-2005 have been highly cost-effective, giving rise to substantial employment from respending of these energy cost savings. In contrast to the employment associated with efficiency and supply, it would be somewhat arbitrary to attempt to characterize the specific industries that will be affected by respending, especially since most of it is assumed to be by Commercial and Industrial (C&I) customers.[16]

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[15] By contrast, manufactured goods may be sourced nationally or even internationally. So it is meaningful that this study estimates that efficiency programs have significant impacts in terms of Rhode Island manufacturing. This indicates that the state has in recent years produced electrical and other equipment that is similar to that used in efficiency programs. Thus, businesses in the state could be suppliers of the specific equipment utilized in these programs.

[16] The C&I sector accounts for the majority of National Grid's total sales and efficiency spending. For simplicity, this study has assumed that respending (the net benefits of efficiency, i.e. reduced supply costs minus the cost of efficiency [including customer contributions]) will be allocated to customer groupings in proportion to the pattern of efficiency spending (including customer (continued on next page)

With residential customers, it is reasonable to assume that they will respend their electricity cost savings similarly to how they generally spend money: on a wide mix of consumer goods and services, with some assigned to savings. And because much of consumer spending goes to local businesses (such as restaurants), it produces a substantial amount of in-state jobs per dollar.

Relative to residential customers, it is much harder to know what effect electricity cost savings will have on C&I customers and where respending will be directed. Some may result in increased profits, and these profits will flow to business owners, who may be in-state or outside. Some may result in lower prices for what the C&I customers are producing, and the benefits of these lower prices will flow to both the in-state and other purchasers of these products.

Of course, if the C&I customers lower their prices, they might be able to sell more of whatever they are producing. And this could lead to increased production either in-state or outside to satisfy the increased demand. And the C&I customers might make investments to upgrade and expand their facilities (in-state and outside), to satisfy increased demand (possibly from lower prices) or in pursuit of other corporate goals.

The description above deals with for-profit businesses, and the C&I sector also includes government (public sector entities), and institutions (such as universities) and other non-profits. But in broad terms, the description above does capture the range of how any C&I customer might react to changes in electricity costs (e.g., government could react to lower costs by expanding services, reducing debt, or by reducing taxes).

In advance (or even after the fact), it is difficult to know how C&I customers react to changes in electricity costs. There are economic models that attempt to make such determinations, but they are considerably more expensive (and complicated) to use than the methodologies that have been employed in preparing this report. The economic analysis software utilized in this study calculates the economic developments impacts for respending by C&I customers based on multipliers for capital spending (new plant and equipment). The multipliers for such spending are intermediate between the results for various assumptions regarding the possible impacts of such respending, and as such appear reasonable (and likely conservative).

Stepping back from all these details, both economic theory and commonsense indicate that lowering the cost of living and operating businesses (without an offsetting loss of amenities) will encourage economic development. Rhode Island is operating in a regional, national, North American, and global economy.

contributions and evaluation). Thus, overall respending by residential customers is smaller than that of C&I customers.

DSM helps to make the state a more attractive place to live and work, and this will help to make the state more prosperous.

Study Methodology

The E^3AS Software

The economic development and air emissions impacts provided in this Report were estimated using the E^3AS (Energy, Economic, and Environmental Analysis System) software. E^3AS was developed by TGG (The Goodman Group, Ltd.) on behalf of the US EPA and is available to assist government agencies in evaluating the economic and environmental impacts of energy supply and efficiency programs. National Grid retained TGG to perform the E^3AS model analysis for this report.

The E^3AS software is designed to consider both the benefits and costs of energy alternatives. To estimate economic development impacts, the E^3AS software uses an input-output model. Input-output models generate regional economic impact estimates by first tracing the industries involved in a study region throughout successive rounds of supply linkages. At each step, they trace the portion of the inputs required from each industry which are supplied locally (within the regional economy being modeled).

For example, the impacts of Rhode Island lighting equipment purchases are not only based on the effects upon in-state lighting product manufacturers, but also include the effects on other in-state industries (e.g., fabricated metals) supplying in-state lighting manufacturers. Total impacts also include the effects of expenditures by households and governments as they spend the personal income and taxes derived from in-state businesses (in the example above, the businesses supplying lighting equipment and inputs to the lighting equipment suppliers).

The E^3AS software incorporates input-output multipliers for a wide variety of energy supply and efficiency technologies, e.g., employment generated per dollar spent on commercial lighting fixtures. The results in this report were developed using the Rhode Island-specific version of E^3AS, which contains multipliers estimated using the Rhode Island version of the IMPLAN input-output model. The IMPLAN model was developed at the US Forest Service and University of Minnesota and is now maintained by Minnesota IMPLAN Group.

In order to develop the input-output multipliers in E^3AS, the total expenditures upon each type of energy efficiency and supply technology had to be disaggregated into expenditures upon each of the 528 industries represented in the IMPLAN model.[17] The data used to perform this translation for each activity is called a bill of goods (BOG). The BOG data utilized in E^3AS were developed by TGG in an extensive research effort commencing in 1992.

For efficiency technologies, BOG data were principally derived from Massachusetts Electric[18] accounting records which incorporated all aspects of costs (program administration, overhead, labor, and consulting services, as well as materials and equipment). For electricity supply technologies, BOG data were largely based on (1) engineering studies performed by Oak Ridge National Laboratories for inclusion in the U.S. Department of Energy (DOE), Energy Economic Database, (2) utility accounting records, and (3) Electric Power Research Institute (EPRI) Technology Assessment Guide (TAG) data.

For energy efficiency and supply, the E^3AS model reports employment for each of 40 industry classifications. These classifications were developed by TGG as groupings of the 528 industries in the IMPLAN input-output model. To facilitate quick review by readers, in Table 3 above, results for the E^3AS model's 40 industries have been further aggregated into six classifications.

The air emissions impacts provided in this report are those avoided by efficiency programs owing to the decreased need for electricity generation.

Inputs to The E^3AS Software

In order to use the E^3AS software to produce results for this report, various input data were required for 1990-2005 Rhode Island efficiency programs and the electricity supply that will be avoided by these programs.

Efficiency Programs

Data on efficiency programs was provided by National Grid personnel, derived from previously prepared reports. The E^3AS software is designed to evaluate efficiency programs; it is not set up to consider load management programs such

[17] Even with this level of detail, it should be understood that the study analysis involves some degree of approximation. Notably, data (such as for the portion of goods and service supplied in-state and elsewhere) are based on the 528 industry categories, rather than each individual type of input that is utilized in efficiency and avoided supply. So it is possible that the study analysis will under- or overstate the job (and other) impacts for specific types of inputs for specific activities. But any such errors will tend to average out across the whole set of activities being analyzed.

[18] This is the name under which National Grid previously operated in that state.

as interuptibles.[19] Thus, the costs of load management programs were excluded from the data inputs to the E^3AS software.

The E^3AS software is designed to consider the expenditures associated with efficiency programs, regardless of who bears the costs. Thus, the input data utilized included both expenditures by utilities and customer contributions. On the other hand, costs associated with utility performance incentives were excluded from the input data.[20]

Finally, to facilitate a more precise modeling of efficiency technologies, the E^3AS software allows users to specify input data for a variety of technologies (e.g. commercial lighting, residential water heating). National Grid Staff and TGG collaborated to assign total efficiency expenditures into the E^3AS technology categories.

Avoided Electricity Supply

The E^3AS software does not incorporate a dispatch or system expansion model. Thus, the user must provide the E^3AS input data regarding how efficiency programs will reduce the need for electricity supply. As was the case for efficiency, the E^3AS software allows users to specify input data for a variety of supply expenditures (e.g. existing oil/gas steam plant non-fuel O&M, or new combined cycle with SCR capital cost).

The starting point for preparing E^3AS input data were the energy and capacity savings data reported by National Grid. These were adjusted to exclude the savings associated with load management. TGG then developed the following assumptions regarding avoided electricity supply based upon recent avoided cost studies.[21] The assumptions selected were intended to be reasonable, but somewhat conservative (i.e., they understate the benefits of efficiency programs).

The efficiency program energy and capacity savings provided by National Grid were grossed up by TGG to account for avoided line losses of 7% for energy and 11-12% for capacity. These loss factor assumptions were developed by TGG

[19] Efficiency programs are typically designed to provide customers with the same (or greater) energy services [e.g., motive power] than they would have received with the baseline technologies. By contrast, load management typically involves a reduction in energy services to the customer, and this loss of services can have economic impacts that are difficult to estimate. For example, an interruptible program for industrial customers could result in lost production. Thus, the E^3AS software was not designed to evaluate load management programs.

[20] From the perspective of economic impact modeling, such incentive payments could be considered as a transfer payment (from utility customers to shareholders), rather than a resource cost.

[21] Avoided Energy Supply Costs in New England, ICF Consulting, December 23, 2005 and August 21, 2003; Avoided Energy-Supply Costs For Demand-Side Management Screening in Massachusetts, Resource Insight and Synapse Energy Economics, July 7, 1999.

based upon avoided cost data and other information provided by National Grid. TGG then further grossed up capacity savings by 17-18% to account for avoided reserve margin.

The efficiency programs were estimated to avoid the operation of existing generating units from 1990 through 2001. These avoided units were assumed to be steam plants, with a heat rate averaging 11,000 Btu/kWh and a fuel mix shifting from 80% residual oil and 20% natural gas in 1990, to 50% oil/50% gas in 1998 and subsequent years.[22] Fuel cost and variable O&M were based upon US Department of Energy historical data for New England power plants and the 1999 avoided cost study assumptions.

Starting in 2002, efficiency programs were deemed to have avoided the construction and operation of new gas-fired combined cycle units equipped with SCR. Capital and operating cost (fuel, fixed and variable O&M) and heat rate were based upon the 2003 and 2005 avoided cost study assumptions; the E^3AS default data for these factors were overridden.

For existing units, the E^3AS software default values for emission rates (specified in pounds per MMBtu) were utilized. For new combined cycle plants, the E^3AS software default values were used for CO_2 (for which there is no currently widely implemented control technology). For all other emissions, the software default values were overridden and a zero emissions rate was assumed.[23]

Finally, efficiency programs were also assumed to reduce T&D (transmission and distribution) capital investments based upon the avoided cost values provided by National Grid.

Modeling Assumptions

1) Location of avoided supply
For the purposes of this study, it has been assumed that all of the avoided supply would have been located in Rhode Island.

This is a conservative assumption that will tend to substantially overstate the in-state economic impacts associated with supply. In reality, a large portion of avoided supply would likely have been located in neighboring states. As such,

[22] Data provided by the authors of the 1999 avoided cost study indicated that some of the avoidable supply from existing units was coal-fired. Nonetheless to be conservative, it was assumed that all of the avoided supply from existing units was oil and gas-fired (which have lower emissions than coal).
[23] Emissions rates for new plants continue to decline as technology improves and regulators require lower emissions. Also, for some emissions (notably NO_x), there are requirements for new plants to obtain pollution allowances and/or offsets. Nonetheless, the zero emission rates selected should be viewed as conservative.

this study has significantly understated the net benefits of efficiency, since many of the avoided supply jobs would have been elsewhere in New England, rather than in Rhode Island.

2) Regional interaction of energy efficiency programs.
Over the last two decades, Rhode Island has also benefited from the economic activity associated with efficiency programs implemented in other states (especially Massachusetts). More specifically, it can be assumed that Rhode Island residents and businesses have provided a significant portion of the labor and other inputs utilized in the efficiency programs conducted in nearby areas, and particularly in National Grid's Massachusetts service territory.

However, this study looks only at the efficiency programs previously implemented within Rhode Island. So the impacts estimated in this study understate the total economic and air quality benefits for the state from the overall regional (as well as national and international) spending on efficiency programs.[24] And to the extent that spending on efficiency continues in neighboring states (as well as nationally and internationally), Rhode Island will continue to share in the resulting ongoing economic and environmental benefits.

[24] To be fair, any expanded analysis that credited Rhode Island for economic activity gained supplying inputs to efficiency programs in other states should also consider activity lost if this avoids in-state power plants being used to supply electricity to other states. However, given the assumption in this study that all supply avoided by Rhode Island efficiency programs would be in-state, this study has effectively assumed that in-state generation is being used for in-state load. Thus, to the extent that efficiency programs in other states would reduce electricity generation, the assumptions in this study would indicate that these reductions (and any assumed reduction in economic activity) would take place outside Rhode Island. And such a scenario is plausible, given that Rhode Island is typically a net importer in terms of electricity supply (i.e., the state's share of regional consumption is larger than its share of regional generation).