Power To Spare

A Plan for Increasing New England's Competitiveness Through Energy Efficiency

July 1987

New England Energy Policy Council

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Acknowledgments

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New England Energy Policy Council

Who We Are

The Council is a group of public interest organizations and state agencies from all six New England states that have joined together to ensure that the region's growing electrical service needs will be met at the lowest monetary and environmental cost.

Why We Joined Together

The production and distribution of electricity in New England has an enormous impact on the region's economy, competitiveness and quality of life. New England's electricity system also now stands at an historic crossroads. Robust economic and population growth suggests steadily increasing demand for electrical services. But attempting to meet this demand by building ever-larger baseload power plants has proven an unwise and uneconomic strategy: since the mid-1970s, New England has poured hundreds of millions of dollars into the construction of cancelled plants. And the completed plants have caused significant rate increases and a drain on precious capital resources. We have joined together to ensure that the region avoids repeating these costly mistakes.

Our Goals

Ultimately, developing the most cost-effective and environmentally sound strategy to supply our electrical needs will require several approaches:

- A substantial portion of the growth of our future electrical needs can be met by increasing the efficiency of electrical use and not by new supply.
- The answer to our energy needs must include a regionwide analysis and solution, since our electricity is already planned, generated, transmitted and funded on a regional basis.
- The regional energy strategy must minimize financial and social costs to the region.
- The regional strategy must be developed through open public debate and discussion.

Council Members

Action, Inc. (MA)
Campaign for Ratepayers' Rights (NH)
Center for Ecological Technology (MA)
Coalition for Consumer Justice (RI)
Connecticut Citizens Action Group
Connecticut Division of Consumer Counsel
Conservation Law Foundation of New England
Energy Conservation Coalition (Washington, D.C.)
Energy Federation, Inc. (MA)
Fundamental Action to Conserve Energy, Inc. (MA)
League of Conservation Voters
Maine Audubon Society
Maine People's Alliance
Massachusetts Audubon Society
Massachusetts Fair Share
Massachusetts PIRG
National Consumer Law Center
Natural Resources Council of Maine
Natural Resources Defense Council
New England Community Action Association
New Hampshire Office of Consumer Advocate
New Hampshire People's Alliance
Rhode Island PIRG
Union of Concerned Scientists
Vermont Natural Resources Council
Vermont PIRG

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Executive Summary

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A Plan for Increasing New England's Competitiveness through Energy Efficiency

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New England Energy Policy Council, July 1987

Recently, there has been much public debate and discussion about how to meet New England's electricity needs. The region's electrical utilities, predicting electric demand growth of 2% annually or more, have warned of imminent power shortages if new power plants are not built. And the New England Governors' Conference recently called for long-term power planning to ensure that the region taps the cheapest power sources first — whether that source is increased electrical efficiency or new power plants.

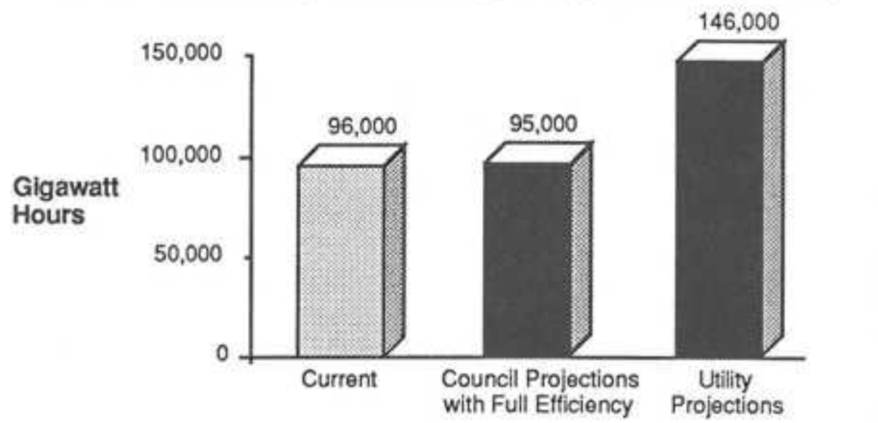
The choice of options has profound economic and environmental implications for New England. Building more multi-billion dollar power plants would be both expensive and risky. New generating facilities face uncertain construction and fuel costs as well as unpredictable electric demand. New power plants would also damage the quality of New England's air, water and landscape.

The New England Energy Policy Council (composed of the leading environmental and consumer organizations in the region concerned with regional electricity supply) recently undertook a collaborative research effort to determine whether New England could meet a substantial portion of its power needs by dramatically increasing the efficiency with which energy is used rather than by producing more of it.

The resulting analysis demonstrates that New England could meet between 35% and 57% of its total electricity requirements in the next two decades through the efficiency improvements studied in the Council's report. Moreover, the analysis shows that New England's power needs could be met in this fashion while maintaining or increasing the rate of economic growth projected by the utilities.

The Council's analysis looked at the potential for increasing electrical efficiency in New England by utilizing proven, commercially available technologies which provide the same quality of service (e.g., light, refrigeration, and electric motor drive), but use substantially less energy than existing equipment. The resulting savings in electricity can be seen as a new source of energy — a source which costs less than any alternative supply. ❑

Full Efficiency vs. Utility Projections (2005)



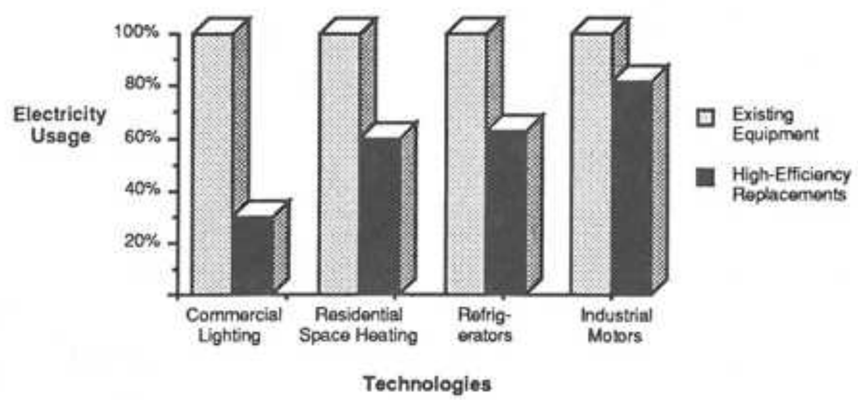
Source: New England Utilities; New England Energy Policy Council.

Energy Efficiency at Work

Overall Savings

Three electric utilities in the nation — Tampa Electric, Public Service Electric & Gas Co. (NJ), and the Sacramento Municipal Utility District — have undertaken efficiency improvement programs which they predict will reduce by 50% the growth in their customers' demand for electricity in the next ten years. A recent report of independent consultants to the Boston Edison Company concluded that if the utility implemented cost-effective efficiency improvements, it could "eliminate all load growth through the end of this century."

Savings from Efficient Technologies



Electricity use of existing equipment vs. commercially available high-efficiency replacements.

Source: Lawrence Berkeley Laboratory; ACEEE; Manufacturers (efficiency gains). New England utilities (existing use).

Energy Efficient Products

Examples of these technologies include:

Lighting: Electric use from lighting in office buildings, schools and stores can be reduced as much as 80% by installing a package of energy-saving measures such as high-efficiency compact fluorescent lights, reflectors, high-frequency ballasts, use of natural lighting, and automated control systems to target lighting needs.

Electric Heat Reductions: Simply adding extra insulation and plugging air leaks in electrically heated homes can result in 40% lower electric use for the same comfort level.

High-Efficiency Motor Technology: About a fifth of all electricity produced in New England is consumed by industrial motors. At a minimum, 18% of this energy could be saved by the use of high-efficiency motors and the use of electronic controls which more finely tune motor outputs to match production demand.

High-Efficiency Ventilation and Cooling Equipment: Innovations in space cooling and ventilation equipment, combined with lower heat produced by high-efficiency lighting, can reduce electric consumption for cooling and ventilation in New England by 50-60%.

Replacing existing inefficient equipment with these technologies is like shutting the windows in a drafty house: energy that previously leaked away is retained and used, with the same effect as if a "new" source of energy had been added.

The performance characteristics and savings of these and other commercially available products were obtained from leading electrical efficiency experts such as the federally sponsored energy research facility, Lawrence Berkeley Laboratory. The Council then analyzed what would happen if these technologies were installed in all appropriate situations or locations utilizing electricity in New England. In addition to analyzing the impact of current commercially available technologies, the Council also separately analyzed the impact of using more advanced technologies which leading energy experts predict will become commercially available within the study period. Data on current and future uses of electricity was taken from the region's electrical utilities. ❑

Lighting Savings in Rhode Island

The University of Rhode Island, with the help of the New England Electric System, recently reduced electricity use for lighting by 78% on large portions of its Kingston, RI campus. These reductions were achieved by replacing low-efficiency with high-efficiency lights, and reduction of unnecessarily high lighting levels. As a result, the campus saved $200,000 per year on its electricity bill — substantially more than the cost of obtaining the reductions.

Building Efficiency in Massachusetts

Through the use of better insulation and high-efficiency cooling and heating equipment, the 900,000 square foot Massachusetts State Transportation Building in Boston uses approximately 40% less electricity than a comparably sized conventional office building. Annual electricity savings exceed $1 million.

Results of Analysis

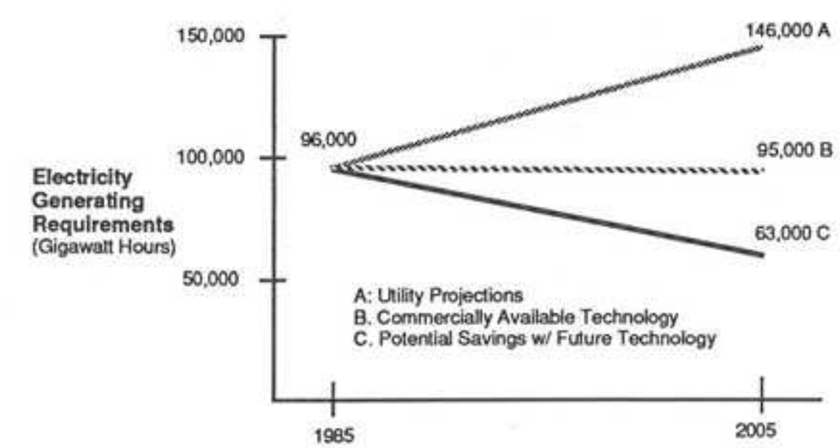
The results show that, at full efficiency, New England would require 35% to 57% less electricity in the year 2005 than current utility projections, with the same level of economic activity and personal comfort. The amount of "peak" generating capacity required to service year 2005 demand would be reduced by an even greater percentage.

Put another way, at full efficiency, New England could be using less electricity and generating capacity than it is using today even with the same level and pace of economic growth predicted by the region's utilities.

In addition, the Council's analysis shows that, in most cases, power supplied through installation of high-efficiency equipment costs between one quarter and one half the price of power supplied from new power plants. The study also notes that, dollar for dollar, investments in electrical efficiency equipment are less risky, cause fewer environmental problems, and create far more jobs than capital-intensive power plant construction.

It is important to stress that the Council's analysis looks at what could happen if all cost-effective electrical efficiency improvements were fully implemented. The Council's analysis does not attempt to predict what level of efficiency will in fact be realized. That will depend on how vigorously New England's decisionmakers pursue electrical efficiency. Nevertheless, it is striking to note that if only half of the Council's lower estimate of efficiency potential were realized, New England's total electric demand would be approximately 17% lower than predicted by the region's utilities — enough difference to eliminate the need for several coal or nuclear plants. ❑

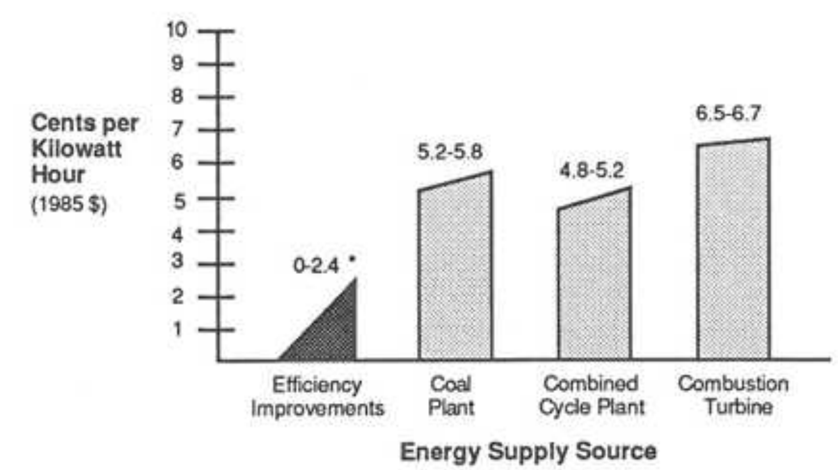
Energy Savings Potential



New England Electricity Generation Requirements 1985-2005: Utility Projections vs. Increased Use of Efficient Technologies.

Source: New England Utilities; New England Energy Policy Council.

Electricity Production Costs



Comparison of costs of energy from efficiency programs vs. new plants.

Source: Energy Systems Research Group; California Energy Commission; New England Energy Policy Council.

*With the exception of motors, commercial ventilation, clothes dryers, and home air conditioners. (3.4-4.7 ¢ per kilowatt hour)

Successful Load Management

California utilities have implemented a program that enables them to obtain shared load reductions from large customers during "peak" hours without interruption of the customers' businesses. The available reductions have already reached 60 megawatts of capacity — an amount equivalent to several New England peak generating plants.

Obstacles to Efficiency

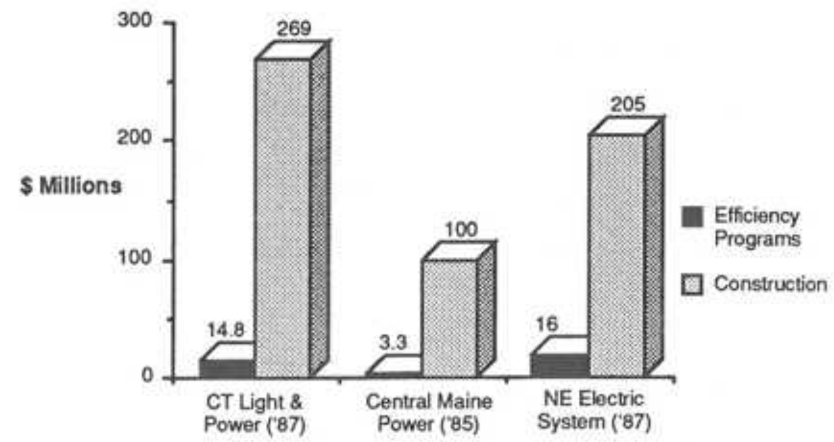
However, as noted, these efficiency improvements will not happen by themselves. Serious obstacles exist to their implementation. For example,

Lack of Information: Many of these technologies are relatively new and markets for them are not well developed; consequently, information about them has not been widely disseminated to consumers and utilities;

Lack of Resources or Incentives: Many electric users, especially small businesses and homeowners, do not have the capital or incentives to purchase new equipment because they often do not receive all of the economic benefits of the resulting electrical savings;

Lack of Utility Action: Even the region's most active utilities are still spending on end-use efficiency only a small fraction of the amount they are spending on building power plants and transmission lines. ❑

The Efficiency Spending Gap



Expenditures in $ millions of three major New England utilities on construction and electrical efficiency improvements.

Sources: Northeast Utilities; Central Maine Power; NEES; Moody's 1986 Public Utility Manual; Investor Responsibility Research Center.

Action Plan

To overcome these obstacles and make our region as electrically efficient as it can be, the New England Energy Policy Council proposes in this report a detailed 12-point electrical efficiency action plan for New England. These actions include:

Short Term Actions

- the region's utilities should immediately undertake a substantial investment program to design and fund efficiency improvements in homes, businesses and industry;
- utilities must fund technologies and programs that reduce New England's maximum or "peak" electrical demand, to delay the need for new generating capacity;
- states must adopt regulatory and rate policies to ensure that utility planning gives top priority to economically sound efficiency investments;

Long Term Actions

- develop a New England Energy Laboratory to develop information on performance and savings of efficiency technology;
- require utilities to undertake integrated "least-cost" planning;
- stimulate a marketplace for efficiency improvement technology;
- increase the energy efficiency levels required by state building codes;
- create a freer market in regional electricity services; and
- plan New England's electricity needs on a regional basis, in a long-term and publicly accountable fashion.

Summary

In summary, the analysis shows that, if New England succeeds in tapping even a fraction of the cost-effective efficiency gains identified in the report, there will indeed be substantial "power to spare" — power that is cheap, creates jobs, and does not pollute. But to achieve that goal, New England regulators, utilities and the public must join together to pursue the Council's recommended policies immediately, before the region engages in another costly, risky, and ultimately unnecessary round of power plant construction. ❑

Power To Spare

A Plan for Increasing New England's Competitiveness Through Energy Efficiency

New England Energy Policy Council

July 1987

The purpose of this report is to explore the dramatic role that increased efficiency in the use of electricity can play in meeting New England's future energy needs.

I. Purpose of this Report

The New England Energy Policy Council consists of the leading consumer and environmental organizations in the region, and state consumer advocates. The Council was formed in Fall 1986 out of a concern for the way in which New England's electricity needs will be met in the coming decades. The purpose of this report is to explore the dramatic role that increased efficiency in the use of electricity can play in meeting those needs. This report also examines how increased electrical efficiency can enhance New England's competitiveness and economic vitality.

Finally, this report sets forth a 12-point program for tapping all cost-effective electrical efficiency potential. ❑

II. Background

Recently, there has been much public debate and discussion about New England's growing electricity needs and how best to meet them. In June 1985, the New England Governors' Conference, Inc. (NEGC) undertook an extensive study of the issue. In December 1986, the NEGC issued its *Final Report*.[1] That report reviewed a projection by the region's electrical utility companies that New England's demand for electricity will most likely grow by approximately 2.2% annually until the year 2000. The report also reviewed the utilities' suggestion that additional electrical generating facilities and power purchases, as well as increased electrical efficiency, may be needed to meet or reduce this increased demand. The Governors' report called for the initiation of long-term "least cost" planning to ensure that New England can economically meet its electric needs.[2]

In developing a long-term regional plan, however, it is apparent that a strategy relying primarily upon expansion of New England's production of electricity from new generating facilities — or committing to significant new power purchases — poses large risks to the region's economy and environment.

The Consequences of New Power Plants

On the economic side, such a power expansion program would be very costly and risky. New England already spends over $7 billion a year for electricity, reflecting utility rates which are 25% higher than the national average.[3] Another round of accelerated power plant construction in New England would consume additional billions of dollars for more long lead time projects. Uncertain demand growth, unpredictable fuel prices, and volatile interest rates and construction costs create a less than favorable prospect for such a traditional path. The last such round of plant construction — in the early to mid-1970's — contributed substantially to the doubling of regional electric rates between 1974 and 1985, and resulted in the expenditure of hundreds of millions of dollars for plants that were ultimately abandoned due to slower-than-expected demand growth and lack of financial feasibility.[4]

Building more power plants will also take a tremendous toll on New England's environment. New England's coal-and oil-fired plants already emit over half a million tons per year of sulfur dioxide and nitrogen oxides, the major causes of acid rain,[5] while New England's nuclear plants produce 200-250 metric tons/year of high level radioactive waste.[6] Trash-burning and wood-fired plants emit toxic compounds such as dioxin and acid gases.[7] In addition, lacing the region with new power plants and transmission lines would dramatically lower the quality of our already threatened landscape.

This economic and environmental damage cannot be avoided simply through expanded power purchases from Canada. Even ignoring environmental damage to that nation, Canadian power purchase agreements entail costly long-term, capital-intensive commitments and many have been tied to the price of fossil fuels, which can escalate unpredictably.

Increased electrical efficiency is still not seen by most companies as a major supply resource equivalent to new generating capacity.

Building costly and environmentally intrusive high-voltage transmission lines through New England is also a necessary component of an expanded power purchase strategy. Finally, stepped-up power purchases increase New England's dependence on foreign imports and ensure a steady flow of capital out of the region, just as building more power plants would increase our dependence on coal and foreign uranium and oil.

The Potential for Efficiency

The adverse economic and environmental risks of increased production of electricity has led the region's decision-makers increasingly to examine the potential for more efficient use of our existing electricity supply. As will be shown below, increasing New England's electrical efficiency would:

- Be substantially cheaper than building or buying an equivalent power supply;
- Be less risky than investment in equivalent generating capacity, because it can be tailored by increments to changing demand and does not require decade-long capital-intensive construction projects;
- Decrease adverse environmental impacts;
- Create more permanent jobs for New England than would transient bursts of capital-intensive plant construction.

These virtues of increased electrical efficiency led the New England Governors' Conference in its December 1986 *Final Report* to call for "an immediate acceleration in the planning and implementation" of investments in efficiency.[8]

Yet seven months later, the Governors' call has not been visibly heeded. Although some of the region's utilities have made some outstanding individual program efforts in the past few years, increased electrical efficiency is still not seen by most companies as a major supply resource equivalent to new generating capacity.[9] In addition, New England's utility commissions have not put forth a clear set of policies and incentives designed to achieve the maximum cost-effective electrical efficiency improvements.

This report attempts to take the Governors' call seriously. It represents the first comprehensive effort to assess on a region-wide and uniform basis the economic and technical potential for increased electrical efficiency. The report also sets forth several very specific short-and long-term policies and actions which must be taken by utilities and public officials in order to realize this potential. ❑

III. New England Electric Use: Current and Future

New Englanders currently consume a little under 100 billion kilowatt hours (kwh) per year and about 18,000 megawatts (MW) at peak load — roughly the output of eighteen large coal or nuclear plants.[10]

The New England Governors' Conference Power Planning Committee recently reviewed projections by the region's utilities that electricity consumption is likely to grow by 2.2% annually through the year 2000, and that New England's peak demand is likely to increase by 27% to about 23,500 megawatts (MW) — the energy equivalent of five new large coal or nuclear plants.[11]

There are several reasons to doubt that this electricity growth will in fact occur even if the efficiency improvements suggested in this report are not implemented: New England's utilities have historically overestimated demand by a substantial margin.[12] However, the New England Energy Policy Council agrees that, for planning purposes, it is appropriate to assume that New Englanders will continue to demand substantially more light, heat, cooling, and motor drive in the coming decades. The question then becomes: how much can increased electrical efficiency contribute to meeting this projected increased demand?

To answer that question, it is necessary first to look at how New England uses electricity currently, and how that use is expected to change in the near future. A numerical description of these uses and trends is contained in Appendix 3 to this report. In brief, that description shows that:

- Most of New England's electricity is used by industries and commercial facilities (offices, stores, hospitals, schools) — which comprise only 10% of all customers;
- New England's electricity is used mostly for a few basic tasks including, most prominently, lighting (23%), industrial motors (21%), and space conditioning (19%).
- New construction — particularly new office and retail buildings — accounts for much of the expected increase in demand over the next decades.

These trends suggest that some of the greatest potential for electrical efficiency improvements exists in commercial and industrial facilities, and particularly in lighting, motor drive, and space conditioning. The description also suggests that increasing the electrical efficiency of new construction is an important key to an energy efficient future. ❑

Electrical efficiency improvements should not be confused with chilly homes and idle industrial capacity.

How New England Uses Electricity

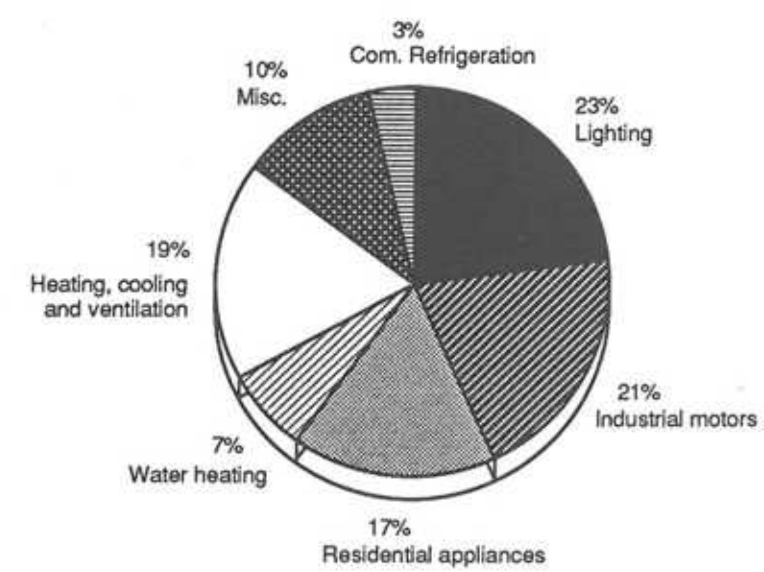


Figure 1: Percentage of annual average consumption by end use.

Source: New England utilities; Electric Power Research Institute; New England Energy Policy Council.

IV. Opportunities for Electric Use Efficiency

As used in this report, electrical efficiency improvements (sometimes also called "demand side management" measures) include:

1. Measures which allow electricity customers to receive the same amount and quality of light, heat, refrigeration, or mechanical output with less electricity input than before the measure was undertaken (traditionally, such measures have been labelled "conservation"); and

2. Measures which shift an electricity customer's use of electricity away from certain hours of the day (typically early evenings in winter and mid-afternoons in summer) when New England's power plants are experiencing maximum, or so-called "peak," demand from other customers. Traditionally labelled "load management," these measures are important because (1) by reducing present "peak" demand, they reduce the total amount of time New England's utilities must run their most expensive "peak" generating facilities; and (2) by reducing future "peak" demand growth, these measures can ultimately reduce the total amount of new generating capacity which New England's utilities must have on line to both meet that "peak" demand and serve as "reserve" in case of plant malfunction or planned maintenance.

Electrical efficiency improvements should not be confused with chilly homes and idle industrial capacity. Added hardship is not and should not be the answer to our energy needs.

New efficient technologies allow the same level of electrical service to be provided with dramatically less electricity input and generating capacity.

Economic growth, convenience and comfort can be achieved simultaneously with efficiency.

Electrical efficiency improvements today are based on an explosion of developments in high technology, advanced materials, and simple good design that allow *the same level of electrical service to be provided with dramatically less electricity input and generating capacity.* These developments include:

- New lighting equipment that saves 70–80% of existing lighting electricity consumption (a high percentage of the region's total)
- High-efficiency industrial motors and computerized motor controls that can save approximately 20% of electricity used by New England industry
- Insulation techniques which reduce annual residential electric space heating requirements by at least 40%
- Computer controls that allow large industrial and commercial customers to collectively reduce their peak demand on a spot basis with no impact on sensitive production processes
- High-efficiency air conditioners and other home appliances which consume 20–50% less electricity than their inefficient counterparts.

These developments are not futuristic dreams, but rather reliable "off the shelf" technology which can be purchased today.

Savings from Efficient Technologies

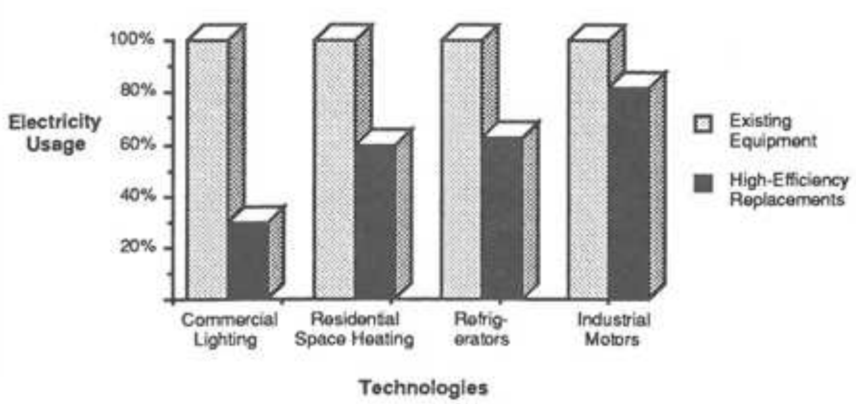


Figure 2: Electricity use of existing equipment vs. commercially available high-efficiency replacements.

Source: Lawrence Berkeley Laboratory; ACEEE; Manufacturers (efficiency gains). New England utilities (existing use).

Item: The University of Rhode Island, with the help of the New England Electric System, recently reduced its electricity use for lighting by 78% on large portions of its Kingston, RI campus. This reduction was accomplished by replacement of existing incandescent and mercury vapor lights with efficient fluorescent and high-pressure sodium lights. It did not even include many measures such as electronic ballasts which could have reduced consumption even more. These replacements paid for themselves in saved electricity in less than one year.[13] Lighting savings of greater than 75% in commercial buildings have been routinely demonstrated.[14]

Item: Through the use of more efficient compressors, and better design and insulation, the most efficient mass-marketed refrigerators use roughly 40% less electricity than the average New England stock.[15]

Item: By using sophisticated computer-based system controls, electrical utilities in California are able to obtain load reductions from large industrial and commercial customers on short notice during periods of peak demand. These controls provide the utility with an effective additional capacity of 60 MW, the equivalent of a small power plant. A recent consultants' report to the Boston Edison Company estimated that as much as 8% of the Company's current peak demand could be saved through such controls.[16]

Item: Through the use of better insulation, double-paned glass, a heat recovery system, monitoring of building mechanical functions, and a limited menu of high-efficiency lighting measures, the 900,000 square foot Massachusetts State Transportation Building in Boston uses approximately 40% less electricity than a comparably sized conventional office building. Electricity savings exceed $1 million annually.[17]

The Council's analysis does not attempt to predict what level of efficiency will in fact be realized. That will depend on how vigorously New England's decision-makers pursue electrical efficiency.

Moreover, the power and potential of these technologies is increasing rapidly while their cost is coming down, just like the computer technology which has made many of these devices possible.

In essence, these new efficiency and load management approaches can be considered collectively as a new kind of "power plant." They can be "built" to meet a specific peak capacity or electricity need, and in fact they "produce" power more reliably (thus avoiding the need for costly "reserve" capacity) than conventional power plants.

As will be shown below, the problem is not the availability of the "efficiency improvement power plant," but the creation of policies to ensure that it gets built before the region embarks on more costly, environmentally intrusive and perhaps unneeded electricity generating plants.

V. Total Electrical Efficiency Potential in New England

The estimates of New England's efficiency potential contained in this report are fully documented and described in Appendix 1. The following is a brief outline of the method and results of these estimates.

A. Method

To determine how much electrical efficiency could contribute to meeting New England's energy needs in an economic fashion, the Council's first step was to identify the most efficient commercially available devices and practices applicable to each specific category of electrical use — lights, refrigeration, motors, etc. This "commercially available savings" inventory was developed from information supplied and reviewed by the Lawrence Berkeley Laboratory (the federal government's principal energy efficiency research institute), the American Council for an Energy Efficient Economy (an independent research organization), and other energy experts. In addition, the Council compiled a "potential savings" inventory of energy-efficient technologies which are not all currently commercially available, but which leading energy experts believe are likely to become available during the study period.

The next step was to identify from the "commercially available savings" inventory those technologies and practices which, based on their current or expected market cost, could produce a kilowatt hour of increased efficiency for less than or equal to the utility's cost of producing a kilowatt hour of electricity from new and existing generating plants.

Finally, the Council applied these technologies and practices to each category of electrical use projected by the region's utilities for the year 2005 to determine what percentage of average consumption and peak demand for those uses could be saved through increased efficiency.

It is important to stress that the Council's analysis looks at what could happen if all cost-effective electrical efficiency improvements were fully implemented. The Council's analysis does not attempt to predict what level of implementation will be in fact realized. The Council felt it was important to identify this "technical potential" rather than attempting to predict in advance how vigorously that potential would be pursued, because the question of how quickly resources are devoted to implementation is precisely the issue before regional decision makers today. It is equally important to note, however, that there are many conservative assumptions built into the Council's estimates. (These conservatisms are more fully explained in Appendix 1):

- The Council's "commercially available savings" estimate does not take into account significant improvements in efficiency technology occurring during the study period. *Only technologies on the market as of Spring 1987 are included.* Electricity efficiency technology is progressing rapidly and such

If all cost-effective efficiency improvements were fully implemented, New England could be using 35% to 57% less electricity in the year 2005 than the utilities currently predict, even with robust economic growth.

progress during the forecast period is likely to continue, particularly as markets for such products expand;

- The Council's "commercially available savings" estimate does not take into account future reductions in the cost of the technologies utilized; as markets and hence production increase, the cost of efficiency measures is likely to drop;
- The Council's "commercially available savings" estimate excludes potential energy and peak demand reductions possible with cost-effective fuel-switching (e. g., installing gas hot water heaters in place of electric hot water heaters where natural gas service exists) and with well-documented potential improvements in transmission and distribution efficiency;
- Both "commercially available savings" and "potential savings" estimates generally excluded efficiency measures that might be economically competitive if included in buildings being built today but not economic if retrofitted into existing buildings. Yet, as noted above, a substantial percentage of New England's projected load growth results from new buildings; and
- The Council's "commercially available savings" estimate assumes relatively high efficiencies for existing industrial equipment (despite the almost complete absence of data to support such high-efficiency assumptions), and does not consider some possible substantial improvements in industrial drive train and industrial process efficiency.

B. Results

As shown in Appendix 1, and summarized in figure 3 the results of the Council's analysis are striking. They show that, *if all cost-effective efficiency improvements were fully implemented, New England could be using 35% to 57% less electricity in the year 2005 than the utilities currently predict, even with robust economic growth.*

The study results (Appendix 1, Table E) also reveal that the amount of "peak" generating capacity required to service year 2005 demand would, at full efficiency, be less than capacity required today, *even in the absence of additional load management measures targeted at reducing peak demand.* Such measures, discussed in Appendix 2, would reduce peak demand by an even greater amount.

Just as importantly, as figure 4 shows, *power supplied through installation of high-efficiency equipment generally costs on average between one quarter and one half the price of power supplied from new power plants.* That is, the efficiency "power plant" is substantially less expensive than the output of a conventional generating facility.

While these conclusions may appear surprising at first glance, they are in line with the conclusions of many utilities and independent studies elsewhere in the nation:

- At least three electric utilities in the nation — Tampa Electric, Public Service Electric & Gas Co. (N. J.), and Sacramento (Ca.) Municipal Utility District — expect utility-sponsored electrical efficiency improvements to reduce their load growth within the next decade by approximately 50%. A fourth utility, Florida Power & Light, anticipates savings of approximately 40%[18].
- A recent independent analysis commissioned by the Boston Edison Company found that sufficient cost-effective electrical efficiency improvements were available to allow the utility to "eliminate all load growth through the end of this century." The analysis demonstrated that, in the commercial lighting sector alone, efficiency improvements could save approximately 71%–85% of present electrical consumption at a fraction of the cost of new power generation.[19]
- A 1987 study conducted by the federally sponsored Lawrence Berkeley Laboratory analyzed potential electricity efficiency improvements in 70% of residential uses in Michigan and found savings of 61% of total sector usage technically achievable by the year 2005.[20]
- In 1983, the Pacific Northwest's utilities deferred all new large central generating facilities indefinitely, relying in large part upon a system-wide analysis showing approximately 5150 MW of efficiency gains achievable over the next twenty years, at an average cost of 1. 8 cents per kilowatt hour.[21]

Obviously, however, even if only a fraction of the Council's estimate of efficiency potential were achieved by the region's utilities, the implications for New England's economy and environment are enormous. ❑

Power supplied through installation of high-efficiency equipment generally costs from one quarter to one half the price of power supplied from new power plants.

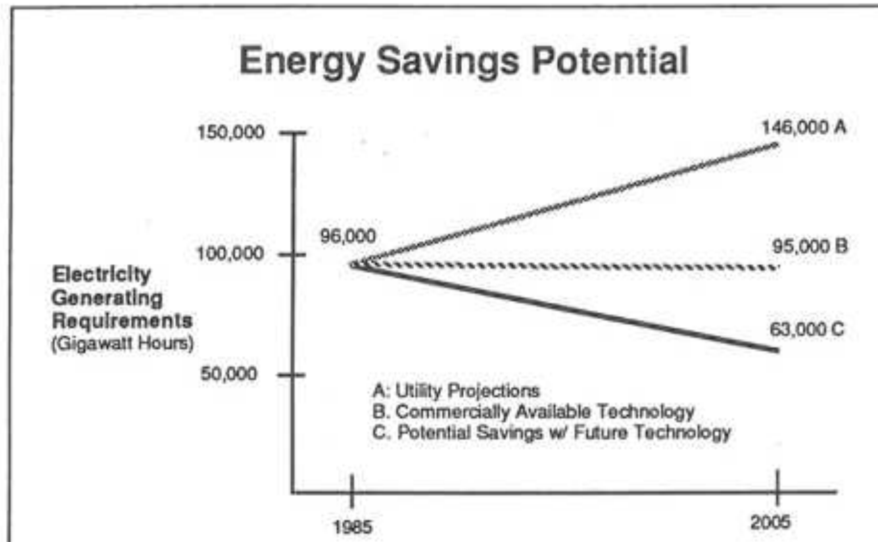


Figure 3: New England Electricity Generation Requirements 1985-2005: Utility Projections vs. Increased Use of Efficient Technologies.

Source: New England Utilities; New England Energy Policy Council.

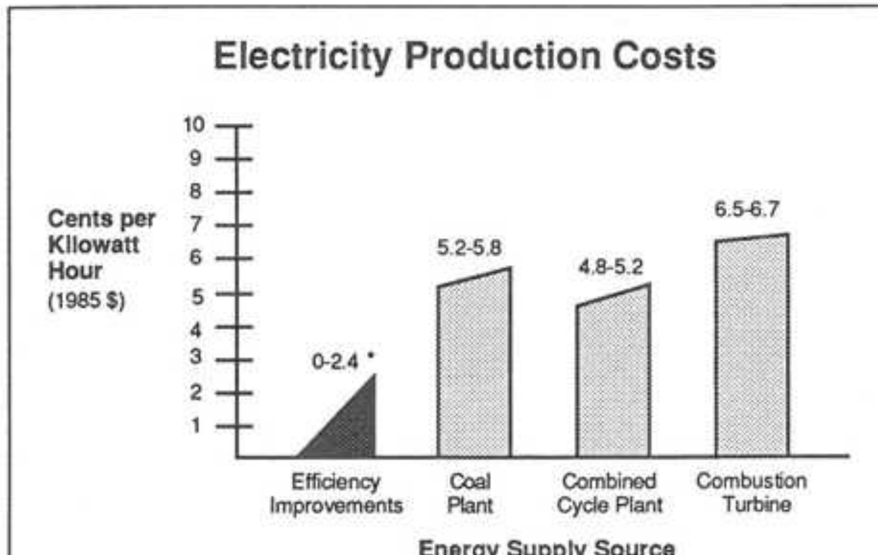


Figure 4: Comparison of costs of energy from efficiency programs vs. new plants.

Source: Energy Systems Research Group; California Energy Commission; New England Energy Policy Council.

*With the exception of motors, commercial ventilation, clothes dryers, and home air conditioners. (3.4-4.7 ¢ per kilowatt hour)

Lacking the time, staff or resources to fully investigate the market for electrical efficiency options, electricity customers have left many cost-effective opportunities untapped.

VI. Obstacles to Increasing Electrical Efficiency

As noted, this report estimates the technical potential for electrical efficiency improvements in New England. It does not tell us what will happen, but what could happen if all cost-effective efficiency gains were tapped.

In fact, if "business as usual" prevails, little of the identified potential will be realized. Despite the New England Governors' Conference's call for accelerated efficiency investment, New England's utilities currently project that only 1,066 MW of load will be saved through efficiency improvements by the year 2,000, less than 5% of the otherwise prevailing peak demand.[22]

Although this assumption may be unduly pessimistic, it is fair to ask: If the identified efficiency improvements are so cost-effective, why aren't individual electrical customers currently making such investments on a scale sufficient to eliminate New England's electric growth?Just as importantly, why are the region's utilities not sponsoring all of the available potential improvements?

Recent research and common sense suggest several reasons. These reasons fall into four broad categories:

- *Lack of information.* Consumers in all sectors and the utilities themselves lack information about the availability, cost and reliability of many efficiency measures, many of which are very new to the market; consumers and utilities also lack information about the efficiency of existing electrical uses, thus making it hard to evaluate the potential gains;
- *Lack of direct benefits or control.* Consumers are often unable to capture the full economic benefits of efficiency measures, either because they occupy rental property (in which case efficiency improvements may accrue to the landlord) or because they pay only the average cost of electricity, not the cost of producing electricity from new, more expensive plants;
- *Lack of financing.* Consumers require much shorter paybacks than do the utilities for electricity-saving investments, and consequently will not spend their limited capital on such improvements;
- *Lack of strong utility action.* While many utility managers recognize the value of investments in electrical efficiency, utilities have traditionally spent no more than a small fraction of their resources on tapping efficiency gains.

A. Lack of Information

For the most part, electrical efficiency improvement technologies of the kind described in this report are relatively new. A combination of post-1973 increases in energy costs and developments in electronics and advanced materials have only recently made them possible and desirable, leading to a rapid and dizzying explosion in the market.[23]

Consequently, as with any new product (personal computers in the mid-1970's come to mind), even sophisticated business consumers lack all the necessary information about product reliability, availability and compatibility with their business needs. Recent analyses commissioned by Northeast Utilities and the Boston Edison Company concluded that many business customers "evinced a certain bewilderment at the array of choices now being touted by vendors and the trade press" and express concern about the reliability of efficiency technologies and their purveyors.[24] To take a simple example, few nonspecialists in New England have even heard of such straightforward energy efficiency technologies as compact fluorescent light bulbs, even though such bulbs are mass-produced in Europe and have received mass distribution in some United States utility territories.

Even where high-efficiency product information is readily available, prospective purchasers such as commercial landlords are skeptical of claims that high-efficiency fixtures will not degrade the quality of a particular office environment.[25] Nor does there exist a uniform industry-wide quality certification mechanism for efficiency technologies. Lacking the time, staff or resources to fully investigate the market for electrical efficiency options — especially where electricity costs are but a fraction of the business and household budget — electricity customers have left many cost-effective opportunities untapped.

Another information gap hobbling efficiency gains is the region's lack of knowledge about existing efficiencies. It is not surprising, for example, to find recently that a large industrial electricity user — a Maine paper mill — had never measured the embedded efficiencies of its existing motors, even though motors accounted for virtually all of its electric demand.[26] Without such crucial "baseline" information, it is difficult for utilities and customers to clearly perceive the true gains that would result from installing electrical efficiency technologies, or to target programs to areas of greatest potential.

The obstacles suggest that the one player with the requisite resources and incentives — the utilities themselves — should be purchasing all cost-effective efficiency improvements.

B. Lack of Direct Benefits and Control

Even where adequate information is available, incentives to adopt efficiency technology are often split between the potentially benefitting parties. The simplest version of this problem appears in leased commercial and residential buildings, where landlords have little incentive to reduce electrical consumption if tenants are entirely responsible for electric bills, and tenants are reluctant to make large capital improvements in leased space. In a variation of this theme, commercial leases often include a fixed pass-through of electrical costs calculated by square foot; reductions of this fixed fee involve time-consuming and complicated lease negotiations.[27] Not surprisingly, utility-sponsored efficiency improvement programs that require customer contributions have often made little headway in leased buildings.[28]

Another kind of split incentive is inherent between a single utility customer, and the utility, representing all utility customers. Generally speaking, a utility customer pays only the cost of electricity from the utility's existing mix of plants (the "average cost"). But utility customers as a whole benefit from any efficiency investment that provides energy or capacity at less than the higher cost of a new power plant ("marginal cost"). Accordingly, many efficiency purchases that are cost-effective from the utility's standpoint are foregone by individual utility customers who do not bear the full brunt of their decision.

Put another way, an individual's calculation to forego electricity efficiency investments, while perhaps rational for that individual, is disastrous for New England as a whole because it contributes to the need for expensive and risky new power plants.

C. Lack of Financing

Most utility customers do not have an unlimited pool of money to invest in electrical efficiency improvements. Moreover, in all but a few businesses, electricity is a minor component of overall costs. Consequently, very few businesses believe that they can justify spending money on electrical efficiency improvements that do not pay for themselves in less than two to three years, especially in a volatile business and regulatory climate.[29] For homeowners, particularly the poor, paybacks must be almost immediate.

By contrast, the utilities, with larger pools of capital and regulated rates of return, operate in an environment which permits significantly longer paybacks, particularly for long-term capacity investments. Consequently, many efficiency investments are foregone by individual capital-constrained customers even though they are attractive to the utility and its customers as whole as a means of staving off the need for costly new power plants. As noted below, this suggests that utility funding of efficiency improvements — or buying a surrogate "power plant" at the point of end use — is attractive, producing benefits for both parties to the agreement.

D. Lack of Strong Utility Action

Each of the above three obstacles (informational constraints, split incentives, capital constraints) suggests that the one player with the requisite resources and incentives — the utilities themselves — should be purchasing all cost-effective efficiency improvements. And in fact, many of New England's utilities have begun to do so.

Programs in hot water heater load reduction, rebates for selected energy efficient equipment, and "shared savings" have resulted in national recognition for such companies as the New England Electric System, Central Maine Power Company, and Northeast Utilities. Many of New England's utility commissions and state energy planning agencies have given strong support and encouragement to these efforts.

Despite these laudable innovations, however, the evidence suggests that efficiency improvements are not even close to receiving their full consideration as a competitive supply resource in utility planning.

First, as mentioned previously, New England's utilities are currently

The financial priorities of New England's utilities are still devoted almost entirely to new power production rather than efficiency.

planning for electrical efficiency improvements yielding less than a 5% reduction of otherwise prevailing year 2000 electrical demand. This is well below the potential described in this report, and in the estimates of other utilities and national studies cited.

Second, it is clear that the financial priorities of New England's utilities are still devoted almost entirely to new power production rather than efficiency. In recent years, for example, the three New England utilities recognized as regional leaders in efficiency improvements — Central Maine Power, New England Electric System, and Connecticut Light and Power — *had conservation and load management budgets which represented a small fraction of the amount they spent on construction of generating and transmission facilities.*[30]

This resource imbalance continues. For example, over the next two decades, Northeast Utilities, New England's largest utility, plans to spend thirty times more on power purchases than on demand side management even though the utility concedes that its planned efficiency measures are twenty times cheaper than equivalent power purchases.[31] While traditional power supply options no doubt have a place in the region's future energy mix, the need for greater balance is manifest.

Third, most of the utility-sponsored efficiency programs in place in New England are very limited in scope or only at a pilot stage.

For example,

The Efficiency Spending Gap

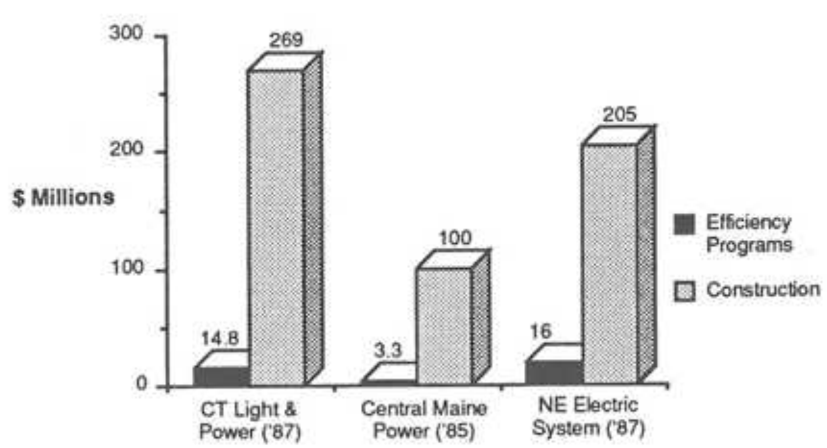


Figure 5: Expenditures in $ millions of three major New England utilities on construction and electrical efficiency improvements.

Sources: Northeast Utilities; Central Maine Power; NEES; Moody's 1986 Public Utility Manual; Investor Responsibility Research Center.

- The bulk of these programs consist of providing efficiency information, "energy audits," and very limited hardware investments such as hot water heater wraps and weatherstripping.
- Barely half of the region's major utilities have even pilot programs to help customers purchase high-efficiency equipment, and these programs are almost exclusively confined to limited categories of hardware rather than to all cost-effective equipment.
- Likewise, only three of the region's twelve major utilities have programs addressing electrical efficiency in new construction (and none of those programs actually provide direct subsidies to builders or homeowners for more efficient construction techniques).
- Finally, no utility in the region has fully implemented the type of comprehensive energy retrofit program described in Section VII below which is designed to elicit and fund all cost-effective efficiency improvements in the residential, commercial and industrial sectors.[32]

In short, despite many excellent "first generation" programs in place throughout the region, the region's utilities have not developed advanced programs designed to address all end uses, utilizing all cost-effective measures.

While such a program may seem quite ambitious, the nation already has several examples of electrical efficiency programs that have achieved very broad implementation:

- The Hood River (Oregon) Conservation Project, sponsored by the Pacific Power & Light Company and the Bonneville Power Administration, succeeded in modifying 95% of all electrically heated homes with increased insulation and other weatherization measures; nearly all of these retrofits entailed major construction work.[33]
- An air conditioner rebate program in Austin, Texas has achieved a new-house penetration rate of 90 per cent.[34]
- Arkansas Power & Light Company has placed half of its irrigation customers and 40% of its residential customers on load management switches.[35]

Other examples of similarly successful electric efficiency programs are discussed in Appendix 2 to this report.

In sum, the limits to realization of the efficiency gains identified in this report are not technical, but institutional. Money and managerial attention, if marshalled properly, can ensure that New England becomes as proficient at supplying electrical efficiency as it has traditionally been at generating power. ❑

The obstacles to full electrical efficiency run deep. So must the policies designed to eliminate those obstacles.

VII. An Action Plan for New England

As suggested above, the obstacles to full electrical efficiency run deep. So must the policies designed to eliminate those obstacles. Attacking informational gaps, clarifying proper economic signals, and mobilizing utility capital are not easy tasks. Accomplishing them will require utility and governmental action, coordinated on a regional basis.

Because the task is so large, but the need is so pressing, the New England Energy Policy Council believes that a phased approach to implementing electrical efficiency is desirable.

The Council's policy recommendations, set forth below and in detail in Appendix 2, entail both short-and long-term actions. The short-term actions, which could be implemented within the coming year, are designed to capitalize on the utilities' existing capital resources, incentives, and marketing infrastructure to "prime the pump" for efficiency investments. The longer-term actions, which could be implemented over the next five years, focus on developing a market environment, information base, and regional planning context to ensure that New England achieves the most electrical efficiency possible in the decades to come.

A. Short-Term Actions: Pump-Priming By The Utilities

Much has been written about the desirability of allowing electrical efficiency technology simply to compete on its own strengths in the open market place with electricity itself, rather than having utilities plan for increased efficiency investments on behalf of their customers. Many utilities have argued, with some justification, that their expertise is in producing and distributing kilowatt hours, and that it is a tall order to expect them to reorient their business toward delivering electrical services (that is, light, heat, motor drive) with the fewest possible kilowatt hours. Better, some say, to leave it all to the "free market."

However, as we have seen, numerous obstacles stand in the way of a completely free and efficient market for electricity savings: lack of readily accessible information; the inability of customers to reap the full value of their efficiency investments; and the shorter paybacks required by end-use customers. As a result, large energy efficiency potential is going untapped and in some cases lost forever (new residential and commercial construction, for example).

The region's utilities have the capital and the obvious incentive to achieve very large efficiency gains in their customers' use of electrical services over the next several years. By taking a far more active role in efficiency improvements than is presently the case, the utilities can buy valuable time for the region, nurture markets for efficiency technology, and defer the need for new generating capacity until a fuller transition to market-based efficiency can take place.

Several specific actions should be taken within the next year to ensure that the region's utilities play this role:

New England's energy policymakers should require utilities to adopt a program to design and fund all cost-effective efficiency measures at the user end.

1. Comprehensive End-Use Efficiency Design.

As noted previously, New England utilities' traditional focus on simply providing audits and limited rebates for specific hardware measures will be of limited effectiveness. Most customers lack the knowledge, interest, or real incentive to pursue these savings.

Therefore, *New England's energy policymakers should require utilities to adopt a program to design and fund all cost-effective efficiency measures at the user end.* Each utility would employ "design teams" that would go into businesses and residences to determine the full package of measures which beats the utility's marginal cost of supplying power over a period comparable to the life of the measures. The utility would be required to draw from up-to-date measures whose cost and performance had been certified by a special engineering division or affiliate of the company; ultimately, this task could be assumed by a regional entity (see recommendation 7 below). The utility would then be required to install the measures and fund them.

In a study commissioned by the Boston Edison Company, Putnam, Hayes & Bartlett analyzed a number of options, and recommended such a program to the utility (see Appendix 4). Such a program could initially focus on the utility's largest commercial and industrial customers. Boston Edison has recently responded by beginning to develop such a program, offering to pay all the costs of efficiency designs and up to half the cost of their implementation.

2. Customized Rebates

For those customers not readily reached by the comprehensive design program, utilities should be required to provide funding to reimburse customers for their purchase of efficiency measures. Rebates would be made per kw or kwh of demonstrated savings, with the maximum rebate amount equivalent to the present value of the savings.

Item: Pacific Gas & Electric Company reports that in one year alone its customized rebate program elicited new savings of 350 million kwh — enough to supply over 50,000 New England homes.[36]

3. Targeted Mass Retrofits

While in general it is preferable to install efficiency measures as part of a comprehensive site analysis, many measures (e. g. low flow showerheads, compact fluorescent light bulbs, residential weatherization) are so cost-effective and easy to install that utilities should be required to distribute or install them for nominal cost on a mass basis.

4. Programs to Increase the Efficiency of New Construction

As noted above, a large portion of growth in electricity sales and peak demand over the next 15 years can be accounted for by sales to new buildings and facilities. *New England's energy decisionmakers should require utilities to help implement full efficiency in new construction,* including:

- *Hook-up fees and incentives.* Utilities should pay developers or home purchasers an incentive for incorporating high-efficiency design into new construction, and, conversely, assess the developer or owner a fee for inefficient design that reflects the increased cost which the utility incurs to service that unnecessary demand;

- *Efficiency design assistance.* Utilities should make available to developers at nominal cost expertise on high-efficiency building design and fixtures.

Item: The Bonneville Power Administration has instituted a project in which developers are paid the added design and construction costs of making new commercial buildings at least 30% more electrically efficient than required by a model regional building code.[37]

5. Load Management Initiatives

Approximately 10% of New England's total electrical generating capacity is needed simply to meet dramatic leaps in demand during a few afternoon hours on a handful of days of the year (typically in January and August).[38] Rather than building expensive new capacity to meet these infrequent demand "spikes," *New England regulators should require utilities to develop programs which will enable and encourage customers to scale back their electrical demand during these few crucial hours,* including:

To avoid any possible energy shortfalls in the next two years, the Council's load management proposals should be adopted immediately.

- Rate structures which discourage electrical use during peak demand hours, including rates which reward customers for curtailing consumption upon notice by the utility;

- Utility funding of load management measures such as equipment that allows office buildings to chill water at night for cooling use during peak summer days, and direct utility control of end-uses such as hot water heating;

Item: A report recently prepared for the Washington Electric Cooperative (VT) found that the utility could shave its peak load by over 20% through the installation of refrigerator, water heater, lighting, electric space heating and school lighting and heating load management measures.[39]

- The formation of large commercial and industrial customers into "load shedding cooperatives" which can collectively reduce their peak electric demand, while sharing such reductions among each cooperative member in an economically optimal fashion.

If the region's utilities are correct in their recent claims that New England's current capacity will soon be insufficient to meet peak load, it is all the more imperative that these measures be adopted immediately.

6. Regulatory Treatment of Efficiency Investments

The region's utility commissions should implement generic approaches to further encourage the region's utilities to undertake efficiency investments. These include:

- Allowing utilities to place capital investments in end-use efficiency into the rate base as if they were investments in an equivalent generating plant;

- Establishing minimum efficiency investment targets for each utility, such as the funding of all measures which, on a life-cycle basis, cost less than equivalent generating capacity.

- Adjusting a utility's allowable rate of return to reflect its degree of progress in developing a truly least-cost energy supply plan.

B. Longer-Term Actions: Improving Planning And The Market

To get the maximum cost-effective electrical efficiency improvements in place, utilities and consumers must develop the requisite information, and experience the requisite incentives, to undertake these improvements. Creating the proper balance of planning and a correct market environment for efficiency will take more than simply utility action, including:

7. Development of a New England Energy Laboratory

As noted above, much of customers' — and utilities' — slow pace in adopting efficiency measures stems from lack of information about the availability of various technologies, concerns about their reliability, and an incomplete understanding of the efficiency of existing end-uses, particularly in New England industry.

To rectify this gap, the New England states should establish and fund a New England Energy Laboratory. With a full-time staff advised by experts from the utilities, the electrical manufacturing industry, universities, and independent research institutes, the New England Energy Laboratory would:

- Test and certify the reliability and savings yield of available electrical efficiency improvement technology, and make the results available to both the public and the utilities for use in planning comprehensive efficiency designs (item 1 above);

- Undertake studies of existing electrical efficiency in various end-use sectors in New England; and

- Work with New England universities to develop research and development programs for electricity improvement technology and curricula for the training of electrical engineers specializing in end-use energy efficiency.

8. Integrated Least-Cost Planning

The New England Governors' Conference in their December 1986 *Final Report* called for utility planning to ensure that the region's utilities tap the cheapest supply sources — including efficiency improvements — first. To implement this idea, the New England Energy Policy Council rec-

Many of the Council's proposals can be adopted quickly without significant change to the utility or regulatory structure.

ommends that all utilities should be required to prepare, for periodic regulatory review, integrated least-cost electrical service plans which identify the costs, risks, and environmental impacts of various options available to meet projected need.

9. Auctions for Efficiency Improvements

To encourage the ultimate development of a truly competitive market for electrical efficiency, the region's utilities should develop an auction process. As in the current system for buying power from independent power producers in Maine and Massachusetts, each utility would be required to determine a supply decrement and develop a request to solicit bids to fill this decrement with efficiency measures. Ultimately, the auction could be expanded to include bids for power supply as well as for efficiency improvements, thus forcing small power and utility-built plants to compete directly against efficiency measures.

10. More Energy-Efficient Building Codes

As noted above, increasing the electrical efficiency of new construction is a regional imperative. While incentives and hook-up fees may encourage such efficiency, New England would benefit greatly from establishing a legal "floor" for the efficiency of new construction in building codes. Despite some recent revisions, no state building code in New England fully captures cost-effective efficiency levels. A regionwide model code should be prepared for adoption by each state.

C. Longer-Term Actions: Regional Least-Cost Efficiency Markets And Coordination

New England's electricity generation and distribution system is more tightly integrated than perhaps anywhere else in the nation: essentially, all power in the region is dispatched interchangeably, as if by a single utility. Consequently, when cost-effective efficiency investments go untapped in one utility's territory, the customers of other utilities suffer through a higher-cost regional power mix and the necessity of maintaining an additional, higher regional "reserve margin."[40]

Just as the region's policy makers should implement policies to ensure that market distortions do not prevent adoption of cost-effective efficiency improvements within individual utility territories, so also policies should be implemented to ensure that the New England region as a whole does not miss out on cost-effective improvements. These policies include:

11. Creating a Free Market in Regional Electricity Services

To ensure that the region as a whole taps maximum efficiency opportunity, several remedies must be applied to existing regional market distortions:

- The region's utilities must eliminate disincentives to efficiency contained in the New England Power Pool (NEPOOL) contract;
- The region's utilities should work toward wholesale price contracts which more closely reflect the market value of power;
- In evaluating the cost-effectiveness of efficiency investment, the region's utilities should take into account the market value of "capacity" saved by efficiency improvements which can be sold to other utilities in the region.
- Mechanisms should be established to allow New England's utilities to jointly fund efficiency initiatives and share in the savings, just as is currently the case with new power plants.

12. Regional Power Planning Coordination

A mechanism must be created that allows the New England region to obtain better control over its long-term electricity future. There must be a regional forum to conduct ongoing, publicly accountable power planning.

These proposals do not exhaust the policy options that would help realize the efficiency potential described in this report. They are an important start, however, and many of them can be adopted quickly without significant change to the utility or regulatory structure. ❑

Improving electrical efficiency would enhance our competitiveness and economic stability, accelerate job creation, and improve environmental quality.

VIII. Regional Benefits of Maximizing Electrical Efficiency

Meeting New England's future electrical service needs through increased efficiency rather than through another round of new plant construction is a strategy with enormous benefits for the region. Such an approach would enhance our competitiveness and economic stability, accelerate job creation, and improve environmental quality.

A. Enhanced Competitiveness and Economic Stability

New England uses approximately 40% more electricity per capita than Japan, and 20% more per capita than West Germany.[41] Increasing our electrical efficiency has obvious implications for our international competitiveness.

From a domestic standpoint, meeting New England's electricity needs through efficiency improvements could reduce long-run utility expenditures for new power supply, and hence electricity costs, by a substantial amount in the coming decades. For a region which already suffers some of the highest electric rates in the nation, this is not an insignificant factor in its future attractiveness to business and industry.

A light industrial manufacturer deciding whether to locate a production facility in New England or the Midwest or South, for example, currently faces *electric rates in New England which are substantially higher than in those other locations.*[42] *This differential would widen greatly if New England were to embark on a new round of costly plant construction.* The last such construction binge in New England helped contribute to the doubling of the region's average rates between 1974 and 1985, and left substantial capital wasted on plants that were abandoned due to collapse in demand growth.[43] The huge rate volatility which attends large construction programs harms the competitiveness of existing New England business and will discourage new electrically intensive businesses from locating in the region.

By contrast, an efficiency improvement strategy would lower costs and increase the predictability and stability of rates in New England. Unlike conventional power plants, efficiency improvements need not be purchased in huge, indivisible "chunks," but can rather be purchased in kilowatt increments. This means that the region need not commit itself to enormous, long lead time capital investments subject to radical swings in demand, interest rates, construction costs, regulatory requirements, and other factors that inflate costs and may ultimately lead to plant abandonment.

Put another way, efficiency investments would allow New England to manage and control power demand rather than passively responding to it, where there is a risk and high probability of guessing wrong. When tens of billions of ratepayer dollars are at stake, this is the kind of control which is vital to the health of New England's economy.[44]

B. Job Creation

In addition to ensuring lower rates and rate stability, an aggressive efficiency improvement program could, according to a recent federal study, be expected to result in *up to four times as many stable, high-quality jobs in New England as would an alternative strategy of massive plant construction.*[45] As the study explains:

> The literature generally concludes that expenditures on conservation generate more regional employment opportunities than expenditures of the same size on power plant construction and operation. There are several contributing reasons for this. First, conservation programs tend to be more labor-intensive than construction programs. Second, conservation programs are less dependent on imports from other regions than is the construction of power plants.[46]

In addition to these direct job impacts, the efficiency improvement strategy also increases jobs by freeing up for investment and expenditure the precious capital resources that would otherwise be spent on less economically productive construction projects.[47] In other words, *dollars saved on plant construction can be retained in the region to stimulate growth.*

Jobs associated with efficiency improvements have several other advantages over those associated with plant construction:[48]

- The incremental and flexible

This report sets forth a path for New England's electricity future — one which is less costly, less risky, and less environmentally intrusive than the alternatives.

nature of efficiency improvement investments allows for close matching of programs and employment cycles;

- Efficiency improvements do not demand rare labor skills requiring extended training, and thus a larger fraction of jobs can be captured by local labor;
- Efficiency improvement projects are geographically dispersed and decentralized, thus avoiding the socially disruptive "boom town" phenomenon associated with large construction projects.

Policy makers should also note that there is a very particular economic advantage which a program of electrical efficiency improvements would offer New England: the potential reinvigoration and enhancement of the region's electrical equipment and high-technology sector. While major New England electrical manufacturers such as General Electric suffer from downturns in turbine and transformer orders, a major push for efficiency such as is suggested in this report would create enormous demand for other electrical products such as high-efficiency lighting equipment, motors, heating equipment, etc. Similarly, accelerated electrical efficiency investment (much of the best of which involves the use of computer-aided controls) could benefit New England's high-technology computer and electronics industry, providing an important buffer against any future downturn in the regional economy.

In short, there is abundant evidence that the program of efficiency improvements described in this report would put the region's labor, as well as capital, resources to their most productive use.

C. Environmental Benefits

New England's quality of life — as well as its ever-growing tourism industry — demands that our natural resources not be sacrificed unnecessarily. As noted above in Section II., virtually every form of electricity generation — oil, coal, wood, nuclear, hydroelectric, wind — requires some trade-off of our air, water, or scenic resources. Efficiency improvements entail no such sacrifices.[49]

New Englanders will resist the siting of major new generating and transmission facilities until it can be demonstrated that all cost-effective efficiency opportunities have been exhausted. Accordingly, the measures and policy initiatives discussed in this report could spare the region a new wave of acrimony and polarization that would no doubt result from the pursuit of less environmentally benign energy options. From an environmental standpoint, then, aggressive efficiency improvements are the only energy source about which it can be truly said: New England has everything to gain, and nothing to lose. ❑

IX. Conclusion

This report sets forth one path for New England's electricity future — one which the New England Energy Policy Council believes is less costly, less risky, and less environmentally intrusive than any other alternative.

An extraordinary convergence of events has focussed our region's attention on the key issues in our electricity future. Now is the time to act on the efficiency strategy laid out in this report. If we do so, there is every reason to be optimistic about the future competitiveness and quality of life of New England. ❑

Footnotes

1. New England Governors' Conference Inc., *A Plan for Meeting New England's Electricity Needs:* Final Report of the New England Governors' Conference, Inc.'s Assessment of New England's Electricity Situation (December 1986) ["Governors' Report"].
2. *Governors' Report, id.* note 1 at 55.
3. Electric Council of New England, *Electric Utility Industry in New England: Statistical Bulletin 1985* (1986) at 1, 13 ["ECNE Bulletin"]. In 1985, the average New England electricity customer paid 8.24 cents per kilowatt hour, or over 25% more than the national average. Edison Electric Institute, *Statistical Yearbook of the Electric Utility Industry* (1986) at 74 ["*EEI Statistical Year Book*"]. Only four states in the nation — Alaska, New Jersey, New York and Hawaii — had higher average rates than New England as a whole. *Id.* Connecticut boasted the second highest average rate in the country, after Hawaii. *Id.*
4. *ECNE Bulletin, id.* note 3 at p. 16. Cancelled baseload plants include Pilgrim 2 (Massachusetts), Montague 1 and 2 (Massachusetts), Charlestown 1 and 2 (Rhode Island), Seabrook 2 (New Hampshire), and Richmond 1 and 2 (Maine).
5. Office of Technology Assessment, *Acid Rain and Transported Air Pollutants: Implications for Public Policy* at 150-51 (June 1984).
6. The U.S. Department of Energy estimates that every 800 – 1000 MW commercial nuclear reactor utilizes 110 – 115 metric tons of nuclear fuel annually, a third of which is removed annually. Energy Information Administration, Department of Energy, *Commercial Nuclear Power: Prospects for the U.S. and the World,* Publication No. 0438 (1985). Currently, New England has approximately 5500 MW of installed nuclear generating capacity. NEPOOL, 1986 Annual Report at 5. A conservative calculation thus suggests annual waste of 200 –250 metric tons.
7. California Air Resources Board, *Air Pollution Control at Resource Recovery Facilities* at 74;215 (May 24, 1984).
8. *Governors' Report, id.* note 1 at 10; see also *id.* at 45-46.
9. See text of this report at Section VI.D.
10. Annual 1986 kilowatt consumption figure is from New England Power Pool, 1986 *Annual Report* at 6. Annual peak figure is taken from projected 1987 August peak in New England Power Pool, *NEPOOL Forecast Report of Capacity, Energy, Loads and Transmission 1987 – 2002* (April 1, 1987) at 1.
11. *Governors' Report, id.* note 1 at 18, based on 1986 NEPOOL figures.
12. The region's utilities have historically predicted far more electric load growth than has actually occurred. In the late 1970's, for example, the New England Power Pool (a consortium of most of the region's electric utilities) predicted that New England would experience a peak demand of 21,502 MW in 1985. NEPOOL, *Report of the NEPOOL Load Forecasting Task Force on the NEPOOL Model-Based Forecast of New England Electric Energy and Peak Load 1979 – 1989* (March 1, 1979). Actual consumption in that year was only 17,401 MW. ECNE Bulletin, *id.* note 3 at 11. Thus, the utilities overestimated demand by 23%.
13. See NEES Energy, Inc., *Lighting Study: University of Rhode Island* (July 1986). While this project did result in the reduction of some lighting levels, these reductions were reported to have met with the approval of the university community. See note 16 below at VI-4.
14. For example, a recent lighting retrofit by the State of Connecticut, utilizing electronic ballasts and high-efficiency fixtures, saved 77% of lighting power, with the measures paying for themselves in under two and half years. Energy User News, May 27, 1985 at p. 1, 7.
15. The Whirlpool ET17HK1M uses approximately 744 kwh/yr of electricity. Howard Geller, *et al., Acid Rain and Electricity Conservation* (Draft) at p. 3-40, note 17 (American Council for an Energy Efficient Economy, Washington, D.C. April, 1987). By contrast, New England's utilities estimate that the average residential refrigerator in the region consumes 1203 kwh/yr. See Table D–2 of Appendix 1 to this report.
16. Putnam, Hayes & Bartlett, Boston Edison Review Panel: *Final Report,* "Supporting Documents on Conservation and Load Management" at VI-21-23 (March 1987) ["BECO Report"]. The report estimated that Boston Edison Company could save as much as

200 MW through such controls. *Id.* at VI-22. Boston Edison's current peak load is approximately 2500 MW.

17. Commonwealth of Massachusetts, Executive Office of Administration and Finance, *Managing Massachusetts Government: Progress to Date,* Chapter 1, "Energy Conservation," at p. 10; Personal Communication with John Wetherell, Chief Engineer, State Transportation Building.
18. Investor Responsibility Research Center, *Generating Energy Alternatives: Demand-Side Management and Renewable Energy at America's Electric Utilities* (Washington, D.C. 1987) at 12.
19. Boston Edison Review Panel, *Final Report* (March 1987), Vol. I at S-8, 28.
20. Florentine Krause, personal communication (Lawrence Berkeley Laboratory, Berkeley, CA 1987).
21. Northwest Power Planning Council, *Northwest Conservation and Electric Power Plan* (1986) at 5-12.
22. *Governors' Report, id.* note 1 at p. 19.
23. A recent study performed for the United States Department of Energy by the Battelle Pacific Northwest Laboratory noted that "[o]f the ten energy-saving technologies selected for detailed analysis, several are new enough and radically different enough from existing technologies that their commercial availability is probably not reflected in the [existing DOE] models ... ." R.J. Moe, *et al., The Electric Energy Savings from New Technologies* (January 1986) (Prepared for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830) at p. 2.1. See also *id.* at 10.2-10.3 (High frequency ballast technology, while known to be more efficient since the 1950's, did not achieve economic feasibility until energy price increases in the early 1970's and the refinement of certain electronic switching devices by the auto industry).
24. *BECo Report,* note 16 at VI-10-11; Temple, Barker & Sloane, *Mid-Program Market Analysis of the Western Massachusetts Electric Company's Performance Contracting Pilot Program* (March, 1987).
25. *BECo Report, id.* note 16 at VI-11.
26. Testimony of Orrin Merrill (paper mill's chief conservation engineer), April 19, 1987, at page 33, *In re Great Northern Nekoosa Corporation Application for Permit for the Proposed Big "A" Hydroelectric Project,* Maine Land Use Regulation Commission Docket No. HP-0005.
27. *BECo Report, id.* note 16 at VI-11.
28. Pre-filed Testimony of Frederick R. Locke, Western Massachusetts Electric Company, Mass. DPU 86-280 (1986), Appendix 3 at p. 6. (Describing finding of third party energy service companies that leased buildings have "little or no potential" for energy savings contracts).
29. *BECo Report, id.* note 16 at VI-11; California Public Utilities Commission, *1984 Energy Conservation Program Summary* (1985) at 6; R. Stobaugh & D. Yergin, *Energy Future* 195-96 (1981). In the Big "A" proceeding, referred to in note 26 above, it was revealed that Great Northern Paper Company had failed to invest in a motor replacement program which its own engineers estimated could save the Company over $2 million annually, with an average payback of 3 months. Exhibit 924, *id.* note 26. The Company simply did not place high priority on expediting the project. Testimony of Orrin Merrill, *id.* note 26, April 19, 1985 at page 70.
30. In 1987, Connecticut Light and Power estimated construction spending for electricity production and distribution facilities at approximately $269 million. See Connecticut Light and Power, Form 10-K (Dec. 1986) at p. 14. For the same year, conservation and load management expenditures were projected at $14.7 million. See Connecticut Light and Power *Energy Alliance Annual Report* (April 1987), p. VI-33, exhibit R. The New England Electric System projects that it will spend $205 million on construction in 1987, NEES 1986 Annual Report at 19, while spending $8.5 million on efficiency improvements, NEES News Release, 1/28/87. In 1985, Central Maine Power spent $3.3 million on conservation and load management. Investor Responsibility Research Center, *Generating Energy Alternatives,* n. 18 at 75. In the same year, CMP spent $100 million on construction, including accrued interest on construction (AFUDC). Central Maine Power Co., *Annual Report* (1986) at p. 23.
31. In its response to Data Request AG-JPC-3, Western Massachusetts Electric Company, Mass. DPU 86-280, Northeast Utilities noted that between 1987 and 2010, it planned to spend an average of $334,071,000 per year to purchase an average of 469 MW of capacity per year from Qualifying Facilities, a rough (undiscounted) average of $712/kw. During the same period, the Company projects, it will spend an average of $10,110,000 per year on conservation and load management, yielding an average of 269 MW of capacity — for a rough (undiscounted) average of $38/kw.
32. The Boston Edison Company's newly announced "Design Plus" program, however, will begin to explore this concept for the utility's largest commercial and industrial customers. *Boston Globe,* Business Section, p. 2, (June 10, 1987).
33. R. Cavanagh & E. Hirst, "The Nation's Conservation Capital" (Draft)(Natural Resources Defense Council, San Francisco, California)(June 2, 1987) at p. 4-5.
34. Rocky Mountain Institute, "Advanced Electricity-Savings Technologies and the South Texas Project," *Report to the City of Austin Electric Utility Department* (December 31, 1986) at p. 94.
35. *Id.* at p. 118.
36. Pacific Gas Electric Company, *A Report on 1985 Energy Management and Conservation Activities* at p. 7. The current average annual electric use by a home with electric space heat is about 6,726 kwh. New England Electric System, Supplement 3A to *Long-Range Forecast for the Ten Year Period 1987 – 1996* (Vol. 3) at p. 34.
37. Bonneville Power Administration, "The Energy Edge Project: 'A Design Challenge That Pays': Project Description" (October 1986).
38. For example, about 10% of Boston Edison's and Central Maine Power's capacity is needed for 2% of the year. See Boston Edison Company, *Long-Range Forecast of Electric Power Needs and Requirements,* (January 17, 1986), Vol I at p. K-13; Central Maine Power Co., *Conservation and Load Management Update* (April 1987) at Figure 1.
39. Energy Solutions, Inc. (Barre, VT), *Energy Efficiency Supply Options for Washington Electric Cooperative,* Volume I at p. 3 (November 1986).
40. The addition of new large power plants to meet regional demand increases the regional reserve requirement necessary to hedge the risk of the new plant's outrage. For example, New England's newest baseload unit, Millstone III, was responsible for an increase in regional reserve margin of between 2 and 4% — or the equivalent of an additional small coal plant. See Ex. CLF-WTS-12 at 3; Ex. CLF-WTS-35 at 5-9, Western Massachusetts Electric Company, Mass. DPU 85-270.
41. New England in 1986 utilized 101 billion kwh, with a population of 12.66 million. NEPOOL 1986 Annual Report at 6; New England Governor's Conference. In the same year, Japan consumed 677 billion kwh with a population of 121 million, and West Germany consumed 404 billion kwh with a population of 61 million. International Energy Agency, "Quarterly Energy Balances of OECD Countries: Fourth Quarter 1986 and Earlier" (Draft) (1986).
42. *EEI Statistical Yearbook,* note 3 at 74.
43. See note 4.
44. Much of the nation's heavy industry has already learned this lesson. Current trends in the petrochemical, automotive, tire and paper industries reveal a pattern of reduced expenditure on fixed capital and enhanced expenditure on work-flow improvements and increasing the efficiency of existing capital stock. See *New York Times,* D1 (4/20/87).
45. Compare Bonneville Power Administration, *U.S. Dep't. of Energy, Employment Effects of Electric Energy Conservation* at A-3 and A-11 (April 1984) (report prepared by Charles River Associates under Contract No. DE-AC79-83BP39210).
46. *Id.* at 2.
47. *Id.* at 5, A-9, A-10.
48. *Id.* at 6-7.
49. Although concerns have recently surfaced around the impact of increased building insulation on indoor air quality, there is reason to believe that properly designed ventilation and other measures can reduce if not eliminate these impacts. See Ralph Cavanagh, et al., *Comments of the Natural Resources Defense Council on the Bonneville Power Administration's Draft Environmental Impact Statement on New Energy-Efficient Homes Programs: Assessing Indoor Air Quality Options* (May 18, 1987).

Appendix 1

Potential for Electrical Efficiency in New England

Overview

The purpose of this study was to determine the range of potential for improving electrical efficiency in New England by the year 2005. To determine this range, the study simulates the impact on electrical consumption of two alternative events or "cases".

In the first case, the study looks at what would happen if all inefficient electricity-using equipment in homes, offices and factories in New England were replaced by the year 2005 with the most energy-efficient equipment that is commercially available today. In the second case, the study looks at what would happen if existing inefficient equipment were replaced with the most efficient substitutes likely to become commercially available during the period 1987-2005.

To determine what is the most efficient currently commercially available equipment, and how much electricity is saved by such equipment, the study relies primarily on information provided by the Lawrence Berkeley Laboratory ("LBL") (Berkeley, Ca.), a federally sponsored energy research facility, and the American Council for an Energy Efficient Economy ("ACEEE") (Washington, D.C.), an independent research institute which has published numerous studies of electrical savings potential around the nation. In addition to providing this information, these two organizations reviewed the study's "commercially available" savings case for accuracy. To determine what high-efficiency equipment is projected to become commercially available during the study period, the study relied on information provided by LBL, ACEEE, the federally sponsored Battelle Pacific Northwest Laboratory, and other sources cited.

In compiling the "commercially available" efficiency case, the study utilized only those technologies and equipment which save electricity at a cost which is less than that of supplying equivalent electricity from a new power plant coming on line in 1995, estimated conservatively at 4.8 - 6.7 cents per kilowatt hour in 1985 dollars. (ESRG 1987; CEC 1985).

To determine how New England currently uses electricity, and is expected to use it in the year 2005, the study relies almost exclusively on data from the New England utilities themselves, supplemented where necessary with cited national and regional analyses (see discussion below).

The tables presented in this appendix are summary tables for New England.

Scope of Analysis

This study is the first detailed analysis ever undertaken of New England's electrical efficiency potential by specific categories of electrical use. The study utilizes the best available data on current and projected use of electricity in New England, and the impact high-efficiency technology could have on that use.

It is important to note, however, that the study's alternate projections of electricity generation requirements are estimates. No one, including the region's utilities, can predict with mathematical certainty how much electrical service (light, heat, refrigeration) will be demanded in the year 2005 with and without efficiency improvements. Indeed, to a large extent, the utilities do not even have a precise accounting of how electricity is currently used in the region. (For example, no utility in New England has ever done a detailed empirical study of how its customers currently use electricity in all sectors, and how efficient that use is).

Using the most precise available utility and industry data, the study indicates a reliable approximate range of potential efficiency improvements, indicating that there is a vast untapped potential sufficient to warrant a reorientation of public policy to help capture that potential. These estimates, however, should not be confused with a definitive accounting: as the programs suggested in the Council's plan are implemented and more becomes known about the region's electrical use, that accounting is likely to change in some of its numerical details.

It is also important to note that this study is not a "forecast" or prediction of what will happen by the year 2005, in the way that the region's utilities traditionally attempt to "forecast" electrical demand for future years. Instead, the study estimates what electrical demand in New England could be like in the year 2005 if 100% of all cost-effective electrical efficiency improvements were made. The study does not attempt to predict how many of those efficiency improvements will in fact be made: that is an issue for the region's regulators, utilities, and the public to decide. The object of the study was to point out the size of the potential to be realized, not to guess how completely the region would grasp that potential if the Council's 12-point action plan were adopted. Nonetheless, as noted below, the 100% implementation assumption of the study is balanced by a number of conservative assumptions (spelled out below) used in estimating the total efficiency potential.

Methodology

As noted, this study compares estimated New England electric use in the year 2005 at full efficiency with estimated New England electric use assuming only the levels of efficiency currently predicted by the region's utility companies.

The first step in this process was to determine how New England currently uses electricity, and the level of electric service which New Englanders are likely to demand in the year 2005 assuming only those efficiency improvements for which the utilities have already planned. A summary of New England's 1985 demand for electricity by specific "end use" (e.g. lights, motors, cooling, etc.) is set forth in Table A. An estimate of New England's future demand for electricity, as predicted by the utilities (with and without any post-1985 efficiency improvements), is contained in Table B.

In each New England state except Vermont, these estimates were developed from data published by the state's dominant electrical utility or utilities, supplemented by studies from the Electric Power Research Institute and other cited regional or national sources where end use detail was absent. These data were then scaled up to correspond to total reported sales for each state, in order to account for minor utility service territories. In the case of Vermont, the Department of Public Service's proposed Twenty Year Electric Plan was the source of demand forecast and end use consumption data.

The second step in the study was to determine how much of New England's electrical consumption in each end use could be reduced in the year 2005 by applying two sets of energy-savings technologies: those which are currently commercially available, and those which are expected to become commercially available within the study period. A list of the currently "commercially available" technologies utilized in the study, and the efficiency improvements they yield, is contained in Table C-1, and further described below. A list of the future commercially available technologies, and the savings they are predicted to yield, is set forth in Table C-2.

To calculate the potential impact of these high-efficiency technologies on regional electricity consumption, the study first applied an "efficiency factor" to each end use reported in each state in 1985. This efficiency factor is simply the amount of electricity consumed by a high-efficiency technology (e.g. motor, light, or air conditioner) expressed as a percentage of the electricity consumed by the low-efficiency technology which it is assumed to replace. Put another way, the efficiency factor is the reciprocal of the "savings" for that end use identified in Table C-1 and C-2. (For example, a high-efficiency motor which, according to Table C-1, consumes 18% less electricity than its low-efficiency counterpart has an efficiency factor of .82). The result of applying these efficiency factors to each end use in 1985 is to produce an estimate of reduced electricity consumption for that end use had high-efficiency technologies been fully utilized. Total end use savings within each sector (residential, commercial and industrial) were than added together and compared with that sector's actual 1985 consumption to produce an aggregate efficiency factor for the entire sector in that state.

To illustrate how this process worked, Tables D-1 - D-4 display how the sectoral efficiency factors and efficiency savings for 1985 for "commercially available" technology would have looked had they been calculated directly for New England as a whole. (Instead, for greater accuracy, this study calculated those efficiency factors and resultant savings for each state separately and then totalled the results to a regional figure). In addition to illustrating the methodology of this study, Tables D-1 - D-4 also indicate which electrical end uses in New England contain the largest relative and absolute efficiency improvement potential.

The next step in the study was to apply the sectoral efficiency factors generated for each state to that state's year 2005 sector-specific end use demand as projected by the utilities (assuming no post-1985 efficiency improvements took place). The resulting estimates — New England electric consumption in the year 2005 with all cost-effective efficiency improvements in place — are displayed in Tables D-5 and D-6.

Finally, these "full efficiency" estimates were then translated into commensurate regional electricity generation requirements for the year 2005 (accounting for utility-estimated transmission and distribution losses), and compared with the utilities' current projections of year 2005 generation requirements. These comparisons are displayed in Table B. They are the "bottom line" estimates of efficiency improvement potential cited in the text of the report.

An additional step in the study was to determine how full implementation of the estimated year 2005 efficiency improvements would affect year 2005 peak load. To estimate peak impacts, the present study utilized an empirical analysis of the relationship between energy use and peak demand for specific electrical end uses in New England (ESRG 1980). These end use correlations were renormalized to the region's actual 1985 peak/energy relationship and then applied to the reduced energy demand resulting from the study's commercially available technology case (C-1). The present analysis focussed on summer peak demand, since New England's utilities have stated that New England's summer peak load is likely to soon become the region's annual peak. (NEPOOL, 1987a).

The resulting year 2005 summer peak demand at full efficiency is displayed in Table E. The results, illustrating peak reductions which are somewhat larger than energy savings, appear conservative in light of other recent studies demonstrating that, especially in the commercial sector, peak reductions significantly outpace energy demand reductions. (See Hunn, 1986; Geller, l986; Norland, 1987; Rosenfeld, 1987).

Technology Description

A general description of the technologies applied in the commercially available technology case (C-1) follows:

Residential Measures

Appliances: The existing appliance stock is replaced with today's most efficient commercial models listed in The American Council for an Energy Efficient Economy, *The Most Energy-Efficient Appliances*, (Fall 1986).

Water Heating: Demand for hot water is reduced by installing flow-reducing shower (Energy Technology Laboratories "Turboinjector") and faucet fixtures (Energy Technology Laboratories "modulator"), as well as clothes washers (Gibson WS27M6-P) and dish washers (Caloric DUS104-19) that use the least amount of hot water of commercially available models.

The efficiency of producing hot water is increased by reducing the temperature to which water is heated, insulating the walls, top, and bottom of waterheater tanks, installing valves that reduce convection losses through water pipes connected to water heaters, and by insulating hot water supply pipes running from the heater to supply fixtures.

Lighting: Existing indoor incandescent light bulbs are replaced by commercially available compact fluorescent light bulbs (Phillips SL-18). Outdoor porch lights and mercury vapor security lights are replaced by high pressure sodium lighting.

Air Conditioning: Existing stock of air conditioners is replaced with models slightly exceeding newly enacted federal appliance minimum efficiency standards and reflective window film (Heat Mirror) is installed to reduce summer heat gain through windows.

Space Heating: Standard measures to reduce heat loss from houses are applied as retrofits to existing homes and as improvements in new construction techniques. These measures range from weatherstripping and thoroughly sealing cracks & holes to increase roof or ceiling insulation levels and installing storm doors and windows.

Commercial Measures

Lighting: Existing fluorescent lighting is replaced by highly reflective fixtures (Maximum Technology "Bright Idea") that allow the number of lamps to be reduced. Standard lamps and ballasts are then replaced by high-efficiency lamps (Phillips "Econ-O-Watt") and electronic ballasts (Diablo) that require considerably less electricity than standard equipment. Where appropriate, light-sensing control systems are also installed so lighting output becomes dependent upon the amount of natural light available to the room or area being lighted. Existing incandescent light bulbs are replaced with compact fluorescent lamps and where appropriate high pressure sodium lights replace mercury vapor area lighting.

These lighting efficiency measures substantially reduce electricity used for lighting and thus internal heat gain which in turn decreases cooling and ventilation loads and increases heating load. These load changes are considered in calculating savings potentials for heating, cooling, and ventilation end uses.

Cooling: Cooling load is reduced by diminishing internal building heat gain, by improving lighting and motor drive efficiencies and by reducing external heat gain by installing reflective window glass or film (Heat Mirror).

Cooling efficiency is improved by installing (where appropriate) more efficient cooling equipment or "chillers" (Trane Centravac) which can be smaller in size (and price) than the equipment they replace because loads have been reduced, installing chillers that can operate at variable load conditions (York Turbomodulator), by cleaning cooling equipment condenser coils to improve heat transfer, and by filtering chiller water.

Ventilation: Ventilation load is reduced as a result of lighting and motor drive efficiency improvements that reduce internal building heat gain and also by reductions in external heat gain by installing reflective glazing (Heat Mirror).

Ventilation efficiency is improved by installing (where appropriate) high efficiency motors, adjustable speed motor drives, and high-torque fan belts (Uniroyal "High Torque Drive"), which together substantially reduce drive power requirements; by reducing duct friction and leaks to further reduce drive power requirements; by installing "variable-air-volume" systems that respond to changes in heating or cooling load by reducing the amount of conditioned air flow to replace "constant volume" air systems that respond to varying load conditions by varying the temperature of a constant volume of supply air (thus substantially reducing air transport energy requirements); by installing "economizers" that bring outside air into conditioned spaces when it is cool enough; and by reducing ventilation when spaces are unoccupied by installing timer or occupancy sensor control systems.

Heating: Heat loss from buildings is reduced by installing standard envelope weatherization measures, advanced window glazing (Heat Mirror), and equipment that recovers much heat currently lost through exhaust air (Gaylord Heat Reclaim Unit).

Refrigeration: Cooling load is reduced by installing glass doors and plastic strip curtains on vertical display cases and suspending reflective film above "tub" display cases to reduce radiant heating from lighting.

Cooling equipment efficiency is improved by installing cooling systems that can respond efficiently to varying cooling loads like multiplex parallel condenser and floating head pressure systems (McQuay Seasonmizer), by keeping condenser coils clean, installing improved control systems, and various other minor measures.

Water Heating: Where appropriate, measures described under residential water heating are applied. In addition, heat pump water heaters and systems that recover heat from cooling condensers, waste water, and exhaust air are installed, as appropriate.

Industrial Measures

Motor Drive: Where cost effective, high efficiency motors (Reliance "XE") replace standard efficiency motors and variable speed drives are installed. High efficiency motors reduce losses in conversion of electrical energy to mechanical energy. Magnetic losses are reduced by using thinner steel laminations in the stator and rotor core and by using more and better grades of steel. The air gap between rotor and stator is minimized and more copper is used in stator windings. Electronic variable speed drives adjust the speed of motors they control by varying the voltage and frequency of electricity supplied to the motor. When constant speed motor drives are used in applications having variable output requirements, control valves are typically used to limit outputs when full output levels are not required. Significant amounts of energy are wasted as a result of constant speed drives providing full output levels that in turn must be limited by control valves. Variable speed drives reduce this waste by changing motor speed to meet motor output demands.

Lighting: Measures described in commercial lighting are applied as appropriate. It is assumed that existing industrial lighting is more efficient than existing commercial lighting.

Street Lighting: Remaining incandescent and mercury vapor lighting is replaced with high pressure sodium lighting. Existing street lighting is assumed to be at a relatively high level of efficiency.

Measure Costs

Efficiency measure costs are expressed in terms of the "cost of saved energy", a method developed by Lawrence Berkeley Laboratory. Such costs are calculated by dividing the net installed capital cost of an efficiency measure by the measure's discounted lifetime electrical savings. A detailed description of how to make such calculations is presented at p. 8 in RMI (1987). In most such calculations by RMI, the value of any reductions of non-electrical operating costs are also taken into consideration (for example, replacement of incandescent light bulbs with compact fluorescent lightbulbs avoids the repetitive installation labor costs since the efficient bulbs have much longer lives).

Savings Not Considered

Many potential electrical savings, and factors likely to increase the range of economic savings, were excluded entirely from the study's "commercially available" technology case (C-1). These excluded potential savings are discussed below:

New or Improved Technology: Improvements in efficiency technology occurring during the forecast period were not considered. End use efficiency factors were calculated using efficiency measures currently available or that could foreseeably enter the marketplace within a few years. Electricity efficiency technology is progressing rapidly and such progress will likely continue through the forecast period, particularly since the market for such measures will expand greatly as efficiency programs become more effective throughout the country. In many end-use areas, prototype efficiency-raising measures exist with considerably greater efficiencies than those selected for the calculations. Where available, engineering analysis of such measures generally shows potential for considerable efficiency improvements beyond the prototype levels.

Cost Reductions: Future efficiency technology cost reductions were not considered. Most efficiency measures used to calculate end use efficiency factors are either not in full scale production or will be produced in much greater numbers as the marketplace for them expands. As production increases, efficiency measure costs are likely to drop. The market share of efficiency measures is anticipated to grow substantially even without major public policy changes. For example, an article in the January 28, 1986 London Financial Times stated that compact fluorescent light bulbs "are expected to take two-thirds of the [U.S. screw-in bulb] lighting market by the year 2000".

Retrofit Applications vs. New Buildings: End use efficiency factors were in most cases calculated using efficiency measures that are cost-effective in retrofit applications. These efficiency factors thus generally underestimate the savings potential in new buildings and plant, which comprises a substantial portion of the baseline forecast demand increase between 1985 and 2005.

Transmission and Distribution Improvements: Forecasted improvements in the efficiency with which electricity is transmitted and distributed (see NPPC 1986 at p. 62-63) are excluded from the study's "commercially available" technology case. These improvements, if included, would further decrease the generation requirements set forth in Table B.

Conservatisms on Industrial Savings

■ **Uncertainty of existing eficiencies:** Uses of electricity by New England industries and the efficiency of "embedded" industrial electrical equipment is not well understood. The progression of increasingly detailed electricity efficiency studies over the past decade suggests that as electricity use becomes better understood, estimates of efficiency potential increase. This situation is likely true for industrial electricity use.

■ **Industrial drive trains:** Substantial improvements in the efficiency of industrial drive trains, which link motors to process equipment, may well be possible and have not been considered. Olivier (1983) considers such opportunities in British industry and projects substantially greater potential for reductions in industrial electricity use than do this study's calculations.

■ **Process Improvements:** Possible future industrial process improvements reducing drive or other electricity end-use requirements have not been considered. One example is an experimental pulping process using genetically engineered organisms to break down wood fiber into pulp which, if perfected, could substantially reduce pulping electricity requirements.

■ **Usage trends:** While the long-range demand forecasts underlying base case year 2005 electricity demand assume recent trends of increasing electricity use per unit of industrial output will continue through the forecast period, recent research on industrial electricity use trends in both the U.S. and Japan (Kahane 1987, 1987a) has found that "[industrial] productivity increases and strong market performance need not necessarily be accompanied by increases in unit electricity consumption". This work finds that Japanese electricity consumption per unit of output in 1984 was lower than in the U.S. Part of this difference was "due to higher Japanese penetration of electricity efficiency equipment, including EAF conservation technology, variable speed motor controls and more efficient cement industry grinding equipment, i.e. the result of faster Japanese adoption of technologies which are also economic in the U.S.".

Note on "Khazoom Effect"

New England electricity demand forecasting conducted by NEPOOL for the region's utility companies incorporates an assumption that residential consumers will make more use of efficient home appliances since they cost less to use, resulting in some (or all) of the theoretical electrical savings provided by such appliances being "taken back" by consumers. This "effect" was suggested in Khazoom (1980), and has been recently critiqued in Goldstein (1986). Goldstein finds almost no scientific study of efficiency take-backs due to increased appliance efficiency, and concludes that while the so called "Khazoom effect" is superficially plausible, it is likely to be small and difficult to even measure, if it occurs at all. Goldstein further cites studies of energy usage, product utilization, and efficiency trends for televisions, air conditioners, and automobiles that show no signs of measurable take-back effects. ❑

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Table A
End Use of Electricity
New England 1985 (GWH)

End Use	ME	VT	NH	CT	MA	RI	Total	% of Total
Industrial Motor Drive	3209	1190	1941	3966	7079	923	18308	20.7
Lighting	2109	820	1402	5105	9377	1153	19966	22.6
Residential appliances	1787	806	1205	3873	6375	1113	15159	17.2
Space heating	1108	461	1105	1909	3608	513	8704	9.9
Water heating	804	505	579	1606	2231	330	6055	6.9
Space cooling	116	49	143	1690	2419	287	4704	5.3
Ventilation	223	88	154	954	1224	266	2909	3.3
Commercial refrigeration	202	80	139	964	1436	168	2989	3.4
Process heating	103	76	229	823	816	118	2165	2.5
Commercial cooking	35	13	25	266	274	15	628	0.7
Electrolysis	71	26	138	587	283	106	1211	1.4
Miscellaneous	58	238	40	1755	3011	437	5539	6.3
Totals	9825	4352	7100	23498	38133	5429	88337	

Sources: New England Utilities; *EPRI Journal*, October 1984, p. 3; *ESRG* (1986); *RMI* (1985); See "Methodology" section of this Appendix.

Table B
New England Electricity
Generation Requirements

Projections	1985 Production	Year 2005 Production	Year 2005 Savings	% Savings over Utility Efficiency
Utility without efficiency	95757	152924		
Utility with efficiency		145732		
NEPOOL		144222		
Commercial efficiency technology (C-1)	60740	95466	50266	34.5
Potential efficiency technology (C-2)	39444	63406	82326	56.5

Notes

1. "Utility" projections are totals of state projections scaled up from major utility forecast data. Individual utility projections are within or extended from long-range load forecasts. (See "Methodology" section of this Appendix).

2. NEPOOL projection is extended from a year 2002 projection in *NEPOOL* (1987), p. 4.

3. Current transmission and distribution losses are assumed to be 7.8% of net energy, from *NEPOOL* (1986), p. 10.

4. Conservation voltage reduction (CVR) and distribution circuit management (DCM) measures are assumed in the "potential efficiency" (C-2) projection. These measures are assumed to save 2% of gross input in Case C-2. See NPPC (1986), p. 6-2 to 6-3 for CVR/DCM measure discussion.

Table C-1
Sources of Electricity End-Use Efficiency Data (Commercially Available Technology Case)

End Use	Measure	Savings	Cost (cents/kwh)	Source
Residential				
Refrigerator	*Whirlpool ET17HK1M*	uses 744 kwh/year	1.2	Geller (1987), p. 3-40 note 17, & p. 3-12.
Freezer	*Woods OC50* (chest)	uses 450 kwh/year	0.4	Geller (1987), p. 3-40, note 20.
	Frigidaire UFE16DL (upright) (weighted ave. @ 50/50)	uses 610 kwh/year (530 kwh/year)		Geller (1986a), p. 5.
Cooking	Improvements: increased insulation improved door seals reduced thermal mass new heating element configuration reduced contact resistence (surface) more reflective pans beneath elements	18.6%	2.1	Geller (1987), pp. 3-24 and 3-25
Lighting	**Package of measures:** compact flourescents for incandescents *Phillips/Norelco SL-18* high-pressure sodium for porch & yard security lighting	60%	2.1	Krause (1987),; Geller (1987), p. 3-16 to 3-18; Davis (1987) (fitting problems).
TV	**Best available models:** color tv	uses 150 kwh/year	0.0	Hunn (1986), pp. 253–254.
	b & w tv	uses 25 kwh/year	0.0	Hunn (1986), pp. 255–256
Clothes dryer	moisture sensor model *Sears #26F66811N*	10–15%	4.7	Geller (1987), p. 3–20
Dish washer	models w/no-heat drying cycle *Sears #22F15071N*	33%	0.0	Geller (1987a) Sears (1987), p. 1592
Clothes washer	N/A	0%	N/A	

End Use	Measure	Savings	Cost (cents/kwh)	Source
Water heating	**Package of measures:**	50%	<2.5	Hunn (1986), pp. 89 & 212–220.
	tank wrap & bottom board insulation			*id.*, pp. 213–214, & 222
	anti-convection valves			*id.*, p. 220.
	pipe insulation			*id.*, p. 220.
	low-flow fixtures			*id.*, p. 215.
	front-loading clothes washer			*id.*, p. 164.
	Gibson WS 27M6-P			NPPC (1986), V.II pp. 5-29.
	water-efficient dishwasher			Hunn (1986), p. 164.
	Sears #22F15565N			NPPC (1986), V.II pp. 5-29.
Room a/c	upgrade to EER of 9.0	24%	4.2	Krause (1987)
Central a/c	upgrade to SEER of 10.0 and reflective window film	34%	4.5	Geller (1987), Table 3.11 & p. 3–22. Krause (1987)
Space heating	envelope improvements (package costing up to $0.02/kwh)	40%	2.0	Krause (1987)
Heating auxiliary	heating load reduction from envelope improvements	30%	<2.5	Krause (1987)
Commercial				
Cooling	**Combined savings** (load reduction & improved efficiency)	50% [1]		
	load reduction from: lighting savings (about 15% of lighting savings)	30%		
	reflective windows/film (Heat Mirror)			Usibelli (1985), pp. 6-1 & 6-60 to 61.
	Package of measures:	30%	2.0	
	economizers			Usibelli (1985), p. 2-19.
	high-efficiency chillers *Trane Centravac*			*id.*, p. 2-8.
	chiller downsizing			
	chiller capacity modulation *York Turbomodulator*			Usibelli (1985), p. 2-12.
	filter chiller water			
	clean condenser coils			

End Use	Measure	Savings	Cost (cents/kwh)	Source
Ventilation	**combined savings** (load reduction & improved efficiency)	60%[1]		Usibelli (1985), p. 2-74.
	load reduction from lighting savings (15% of lighting savings)	35%		
	package of measures:	40%	4.3	
	high-torque fan belts *Uniroyal High Torque Drive*			RMI (1986d), pp. 23 – 24
	duct/fan cleaning			Usibelli (1985), pp. 2-67.
	high-efficiency motors			*id.*, p. 2-73.
	variable air volume (VAV) conversion			*id.*, p. 2-62 to 2-64.
	cut duct friction			*id.*, p. 2-68.
	tape duct leaks			*id.*, p. 2-67.
	scheduled controller			*id.*, p. 2-70.
	occupancy sensors			*id.*, p. 2-71.
Heating	**net savings** (load increase from lighting savings & improved efficiency)	0%[1]		
	load increase	(20–25%)		
	package of measures:	24.6%	<2.5	Gardiner (1984), pp. D-30ff.
	shell improvements			Mazzuchi (1982)
	O & M improvements			
	advanced glazing *Heat Mirror glass*			
	heat recovery from exhaust air *Gaylord Heat Reclaim Unit*			Mazzuchi (1983)
Lighting	**package of measures:**	70%	<2.0	P,H & B (1987), Table VI-1, pp. VI-5 to 9.
	Davis (1987)			
	high-efficiency bulbs *Phillips–34W Econ-o-Watt Lite White lamps*			Usibelli (1985), p. 5-13.
	electronic dimmable ballasts *XO Industries*			*id.*, pp. 5-5 to 5-6.
	specular imaging reflectors *Maximum Technology "Bright Idea"*			Davis (1987)
	day-light dimming			Usibelli (1985), pp. 5-5, 5-6, 5-28, & 5-29.
Refrigeration	**best available measures (typically):**	50%	<2.0	EPRI (1986a) PG & E (1986) Usibelli (1985), Ch. 3.
	glass doors and strip curtains for display cases			
	multiplex unequal parallel compressors			
	evaporatively cooled condensers			
	hot gas defrost			
	floating head pressure			
	mechanical/ambient subcooling			
	energy management controls			
	dedicated dehumidification			

End Use	Measure	Savings	Cost (cents/kwh)	Source
Water heating	**package of measures:**	40%	<2.5	
	residential measures as appropriate			Hunn (1986), pp. 89 & 212–220.
	flow reduction devices			*id.*, p. 215.
	heat recovery systems			Mazzuchi (1983), p. iii.
Cooking	best available equipment	20%	1.0	RMI (1987), p. 25 RMI (1986d), p. 12–13.
Miscellaneous	package of motor improvements & selective purchase of office equipment	30%	2.0	RMI (1985), pp. 142–143
Industrial				
Motor drive	average savings from high efficiency motors & adjustable speed drives	18.3%	3.4	Geller (1987), pp. 3-3 to 3-7.
Electrolysis	n/a	0%	n/a	
Process heating	**package of measures:**	10%	0.2	RMI (1987), p. 44
	insulation			Train (1985), at II:304-312.
	control systems			
Lighting	**package of measures (typically):** high pressure sodium for mercury flourescent upgrade (applied to scenario based on Arkansas industrial survey)	32%	2.0	Geller (1987), p. 3-7 to 3-9.
Space heating	**package of measures:**	25%	<2.0	RMI (1985), pp. 144–145
	weatherization			
	heat recovery			
Agriculture				
Dairy farming	**package of measures:** more efficient milk coolers heat pumps for residual water heating lighting improvements fanpower reductions	48%	<2.5	RMI (1985), p. 146–147.

Notes

1. Ventilation and cooling load reduction is assumed to be 30% of lighting savings [reduced to be conservative, from the 35% figure assumed in Putnam, Hayes, & Bartlett (1987), p. VI-7]; savings are allocated equally (in amount) between ventilation and cooling (see RMI (1987), p. 18 for a review of simulation results regarding lighting savings/HVAC interactions). Heating load increase is estimated to be 20-25%. Cooling and ventilation savings from efficiency measures are substantially reduced (to be conservative) from combined eligibility & savings calculations for these end uses in RMI (1987).

2. Costs of "packages of measures" are typically weighted averages for the entire package. Package cost scenarios for commercial cooling, ventilation, and water heating are from RMI (1987). Package cost scenarios for industrial motor drive and lighting are from Geller (1987).

3. Example product names and model numbers are listed for selected measures.

Table C-2
Sources of Electricity End-Use Efficiency Data (Potentially Available Technology Case)

End Use	Measure	Savings	Cost cents/kwh	Source
Residential				
Refrigerator	Advanced technology	uses 176 kwh/year	3.0	Geller (1986), p. 3-16, 3-9, Table 1.
Freezer	Advanced technology	uses 135 kwh/year	3.0	Geller (1986), p. 3-20, Table 3.
Cooking	**package of measures:** microwave ovens increased insulation improved door seals reduced thermal mass improved oven controls bi-radiant ovens new heating element configuration reduced contact resistance (surface) more reflective pans beneath elements reduced heat capacity elements induction cooktops	50%	<4.7	RMI (1986c), pp. 15 - 17 & 20 - 21. Geller (1986), pp. 7-1 to 7- 16.
Lighting	**package of measures:** compact flourescents for incandescents (advanced lamps) high-pressure sodium for porch & yard security lighting	85%	2.1	Krause (1987) Davis (1987), fitting problems.
TV	best available models: color tv b & w tv	 uses 60 kwh/year uses 25 kwh/year	 0.0 0.0	 RMI (1986c), p. 17. Hunn (1986), pp. 255 - 256
Clothes dryer	heat pump dryer	55%	6.6	Geller (1987), p. 3-21, Table 3.10
Dish washer	Ecotech (water pressure driven)	100%	<3.0	Geller (1986), p. 4-20, Table 3

End Use	Measure	Savings	Cost cents/kwh	Source
Clothes washer	**package of measures:** improved controllers high-efficiency motors power factor controllers	55%	1.4 - 3.3	RMI (1986c), p. 14 & 17 - 18.
Water heating	**package of measures:** tank wrap & bottom board insulation anti-convection valves pipe insulation low-flow fixtures front-loading clothes washer *Gibson WS 27M6-P* water-efficient dishwasher *Ecotech* heat pump water heater solar heaters	83%	<2.5	Hunn (1986), p. 89 & 212-220 *id.*, p. 213-214 Hunn (1986), p. 164. NPPC (1986), V.II p. 5-29. Hunn (1986), p. 164. NPPC (1986), V.II p. 5-29.
Room a/c	upgrade to EER of 11.5	31%	<5.0	Krause (1987)
Central a/c	**package of measures:** reflective windows/films internal gain reductions upgrade to SEER 11.0/downsize	41%	<5.0	Geller (1987), Table 3.11 & p. 3 - 22.
Space heating	**package of measures:** envelope improvements: retrofit measures up to $0.06/kwh superinsulation advanced glazing heat pump heating systems solar heating systems	80%	<5.0	RMI (1985), p. 139.
Heating auxiliary	load reduction from envelope improvements	30%	<2.5	Krause (1987)
Commercial				
Cooling	**combined savings** (load reduction & improved efficiency) **load reduction from:** better lighting efficiency reduced internal gain from motors advanced glazing envelope improvements	80%[1] 50%		RMI (1986d), p. 42.

End Use	Measure	Savings	Cost cents/kwh	Source
Cooling	**package of efficiency measures:** economizers high-efficiency chillers chiller downsizing chiller capacity modulation filter chiller water clean condenser coils	50%	2.0	RMI (1987), p. 33 - 34. Usibelli (1985), p. 2-19. *id.*, p. 2-8. RMI (1987), p. 28–30. Usibelli (1985), p. 2-12. RMI (1986d), p. 17. RMI (1986d), p. 16 - 17.
Ventilation	**combined savings** (improved efficiency & load reduction from lighting savings (15% of lighting savings) **package of measures:** high-torque fan belts duct/fan cleaning high-efficiency motors variable air volume (VAV) conversion cut duct friction tape duct leaks scheduled controller	60%[1] 35% 40%	 4.3	Usibelli (1985), p.2-74. RMI (1987), p. 33 - 34. RMI (1986d), p. 23 - 24. Usibelli (1985), p. 2-67. *id.*, p. 2-73. *id.*, p. 2-62 to 2-64. *id.*, p. 2-68. *id.*, p. 2-67. *id.*, p. 2-70.
Heating	**net savings** (load increase from lighting savings & improved efficiency) **load increase** **package of measures:** shell improvements O & M improvements advanced glazing heat recovery heat pumps	25%[1] (20-25%) 50%	 <2.5	 RMI (1987), p. 31. Gardiner (1984), pp. D-30ff.
Lighting	**package of measures:** high-efficiency lamps (advanced lamps) electronic dimmable ballasts *XO Industries* specular imaging reflectors *Maxiumum Technology "Bright Idea"* day-light dimming day-lighting improved maintenance (cleaning)	85%	1.2	RMI (1987), p. 23 & 34 Davis (1987)

End Use	Measure	Savings	Cost cents/kwh	Source
Refrigeration	**best available measures:** multiplex unequal parallel compressors evaporatively cooled condensers hot gas defrost floating head pressure mechanical/ambient subcooling energy management controls dedicated dehumidification **gain reduction measures:** flexible air barriers food case enclosures	50%	<2.0	Usibelli (1985), Ch.3 EPRI (1986a) PG&E (1986) RMI (1986c), pp. 9-11
Water heating	**package of measures:** flow reduction measures heat recovery heat pump water heaters standby loss reduction measures	85%	0.1	RMI (1987), p. 24 Mazzucchi (1983)
Cooking	**best available equipment**	30%	1.0	RMI (1987), p. 25 RMI (1986d), p. 12 - 13.
Miscellaneous	package of motor improvements & selective purchase of office equipment	30%	2.0	RMI (1985), p. 142 - 143
Industrial				
Motor drive	**package of drive improvements:** efficient motors adjustable speed drives fast control systems power-factor controllers improvements in mechanical drive train			RMI (1985a)
Process industries		22.5%	<2.0	RMI (1985), pp. 144 - 145.
Other industries		40%	<2.0	RMI (1985), pp. 144 - 145.
Electrolysis	n/a	5%	<2.5	RMI (1985), pp. 144 - 145
Process heating	**package of measures:** insulation control systems heat recovery	20%	0.2	RMI (1987), p. 44 Train (1985), at II:304-312.

End Use	Measure	Savings	Cost cents/kwh	Source
Lighting	**package of measures:** high-frequency HID ballasts commercial sector measures as applicable advanced lamps	70%	<2.5	RMI (1985), pp. 144 - 145. RMI (1986a)
Space heating	**package of measures:** weatherization heat recovery	25%	<2.0	RMI (1985), p. 144 - 145
Agriculture				
Dairy farming	**package of measures:** more efficient milk coolers heat pumps for residual water heating lighting improvements fanpower reductions	48%	<2.5	RMI (1985), p. 146 - 147.

Notes

1. Ventilation and cooling load reduction is assumed to be 35% [Putnam, Hayes, & Bartlett (1987), p. VI-7]; savings are allocated equally (in amount) between ventilation and cooling (see RMI (1987), p. 18 for a review of simulation results regarding lighting savings/HVAC interactions). Heating load increase is estimated to be 20-25%. Cooling and ventilation savings from efficiency measures are from combined eligibility and savings calculations for these end uses in RMI (1986d, 1987).

Table D-1
Total Efficiency Potential with Commercially Available Technology – New England 1985

Sector	Electricity sales 1985 (GWH)	Efficiency factor	Efficiency Sales (GWH)	Savings (GWH)
Residential	31929	0.62	19659	12270
Commercial	29357	0.49	14307	15050
Industrial	25156	0.81	20463	4693
Streetlighting	794	0.70	556	238
Other	1101	0.63	693	408
Totals	88337		55678	32659

Table D-2
Residential Sector Efficiency Potential – New England 1985

End use	% sales	1985 GWH	1985 KWH/year	Effic. KWH/year	Efficiency factor	Efficiency sales (GWH)	Savings (GWH)
Refrigerator	0.192	6136	1203	744	0.62	3795	2341
Freezer	0.043	1361	1123	530	0.47	642	719
Range	0.078	2478	754		0.81	2007	471
Lighting	0.093	2974	689		0.40	1190	1784
TV	0.060	1901	336	175	0.52	990	911
Clothes dryer	0.070	2225	889		0.88	1958	267
Clothes washer	0.009	277	78		1.00	277	0
Dish washer	0.018	589	302		0.67	395	194
Water heater	0.159	5076	3485		0.50	2538	2538
Room a/c	0.030	971	385		0.76	738	233
Central a/c	0.009	299	1096		0.66	197	102
Space heating	0.131	4169	9281		0.60	2501	1668
Heating aux.	0.028	903	271		0.70	632	271
Miscellaneous	0.080	2570	508		0.70	1799	771
Totals		31929				19659	12270

Overall efficiency factor: 0.62

Table D-3
Commercial Sector Efficiency Potential - New England 1985

End use	% Sales	Electricity sales (1985) (GWH)	Efficiency factor	Efficiency sales (GWH)	Savings (GWH)
Cooling	0.12	3379	0.50	1690	1690
Ventilation	0.10	2873	0.40	1149	1724
Heating	0.11	3151	1.00	3151	0
Lighting	0.43	12581	0.30	3774	8807
Refrigeration	0.10	2952	0.50	1476	1476
Water heating	0.03	902	0.60	541	361
Miscellaneous	0.10	2897	0.70	2028	869
Cooking	0.02	622	0.80	498	124
Totals		29357		14307	15050

Overall efficiency factor: 0.49

Table D-4
Industrial Sector Efficiency Potential - New England 1985

End use	% Sales	Electricity sales (1985) (GWH)	Efficiency factor	Efficiency sales (GWH)	Savings (GWH)
Motors/process	0.364	9153	0.82	7478	1675
Motors/other	0.355	8922	0.82	7289	1633
Electrolysis	0.048	1198	1.00	1198	0
Process heat	0.085	2141	0.90	1927	214
Lights	0.134	3369	0.68	2291	1078
Space heating	0.015	373	0.75	280	93
Totals		25156		20463	4693

Overall efficiency factor: 0.81

Table D-5
New England Electricity Consumption with Commercially Available Technology (C-1) (2005) (GWH)

State	Actual 1985	Utility w/o efficiency (2005)	Utility w/ efficiency (2005)	Commercial technology (2005)	Savings
Maine	9825	19814	17365	13316	6498
New Hampshire	7100	12565	12110	8039	4526
Vermont	4352	6967	6526	4227	2740
Massachusetts	38133	53055	52518	32742	20313
Rhode Island	5429	7688	7127	4638	3050
Connecticut	23498	40985	38793	25106	15879
Totals	88337	141074	134439	88068	53006

Table D-6
New England Electricity Consumption with Potentially Available Technology (C-2) (2005) (GWH)

State	Actual 1985	Utility w/o efficiency (2005)	Utility w/ efficiency (2005)	Potential technology (2005)	Savings
Maine	9825	19814	17365	9456	10358
New Hampshire	7100	12565	12110	5355	7210
Vermont	4352	6967	6526	2779	4188
Massachusetts	38133	53055	52518	21871	31184
Rhode Island	5429	7688	7127	3209	4479
Connecticut	23498	40985	38793	17034	23951
Totals	88337	141074	134439	59704	81370

Table E
New England Summer Peak Demand (MW)

	Actual 1985	Projected 2005	% Savings
Utility-Based Forecast	17059	27749	NA
Efficiency Forecast	NA	16500	40.5

Notes

1. Projected 2005 peaks calculated using efficiency factors from Table C-1 and end use peak factors from ESRG (1980) renormalized to NEPOOL actual 1985 peak by 1.082 multiplier.
2. Extending the current NEPOOL forecast (NEPOOL 1987) would yield 2005 peak demand of 25683 MW.
3. Projected 2005 efficiency forecast peak excludes additional savings possible from load management measures described in report.

Appendix 2

A Twelve Point Electric Efficiency Action Plan for New England

To realize the full "technical potential" of electrical efficiency improvements outlined in this report, the region's decisionmakers should take the following twelve specific steps to overcome obstacles to those improvements.

These twelve steps are divided into short-term and long-term actions. The short-term actions are aimed at taking advantage of all cost-effective efficiency opportunity within our existing knowledge base and market structure. The longer term actions are designed to improve that knowledge base and market structure to put efficiency improvements on a truly equal footing with electricity generating investments.

A. Short-Term Actions: Pump-Priming By The Utilities

Much has been written about the desirability of allowing electrical efficiency technologies simply to compete on their own merits on the open market place with electricity itself, rather than having utilities plan for increased efficiency investments on behalf of their customers. Many utilities have argued, with some justification, that their expertise is in producing and distributing kilowatt hours, and that it is a tall order to expect them to reorient their business toward delivering electrical services (that is, light, heat, motor drive) with the fewest possible kilowatt hours. Better, some say, to leave it all to the "free market."

However, as we have seen, numerous obstacles stand in the way of a completely free and efficient market for electricity savings: lack of readily accessible information; the inability of customers to reap the full value of their efficiency investments; and the shorter paybacks required by end-use customers. As a result, large energy efficiency potential is going untapped and in some cases lost forever (new residential and commercial construction, for example).

The region's utilities have the capital and obvious incentive to achieve very large efficiency gains in their customers' use of electrical services over the next several years. By taking a far more active role in efficiency improvements than is presently the case, the utilities can buy valuable time for the region, create markets for efficiency technology, and defer the need for new generating capacity until a fuller transition to market-based efficiency can take place.

Several specific actions should be taken within the next year to ensure that the region's utilities play this role:

1. Comprehensive End-Use Efficiency Design.

Recent analysis has suggested that New England utilities' traditional focus on providing information and providing limited rebates on specific hardware measures will be of limited effectiveness for several reasons:

- The utilities' information and market incentive efforts have often been limited to "first generation" efficiency measures such as water heater wraps and 34W fluorescent tubes rather than on the full range of current available technology in high-efficiency lighting, motor drive, etc.
- As discussed in Section VI., electricity consumers (even large and sophisticated businesses) lack the time, information, incentive, and necessary capital to respond fully to rebates and informational programs;
- The focus on specific hardware or third-party "shared savings" contractor programs risks harmful "cream-skimming" in which only the easiest measures are installed (e.g., lighting tube replacement), to the exclusion of other measures with higher costs but even greater savings (e.g. installing task lighting and sophisticated lighting controls).

All of these factors have pointed to the need for more active utility involvement in designing and funding comprehensive efficiency improvements for their end use customers. Only the utility can capture the full system value of efficiency measures; just as important, the utilities have a significant reservoir of credibility with customers (particularly industrial and commercial customers) which could be utilized to overcome skepticism toward new technologies.

A recent report commissioned by the Boston Edison Company and prepared by the consulting firm Putnam, Hayes & Bartlett (Appendix 4) sets forth a proposal which capitalizes on the utility's resources and overcomes many of the barriers identified above. The proposal, if adopted New England-wide, would require each utility to develop the capability to perform or have performed for it site-specific efficiency designs. The utility's "design teams" would determine the full package of efficiency measures which beats the utility's marginal cost of supplying power over a period comparable to the life of the measures.

The utility would be required to draw from up-to-date measures whose cost and performance had been certified by a special engineering division or affiliate of the company; ultimately, this certifying function could be replaced by the New England Energy Laboratory (see 7 below). For a typical office building, for example, the "design team" might determine that significant savings could be gained through installation of new lighting measures (compact fluorescent bulbs, high-frequency ballasts, daylight dimmers, occupancy sensors, "task" lighting), installation of triple-glazed windows, high-efficiency air conditioning units, etc.

After determining the optimal package of efficiency measures, the utility would be required to install the measures and fund them (possibly with appropriate cost-sharing by the customer).

Recently, the Boston Edison Company announced that it would pursue such a program for its 1500 largest commercial customers.[1] Because it will take some time for this program to reach its full effectiveness New England-wide, the initial focus — as with Boston Edison — should probably be on the utility' largest commercial and industrial customers and on areas where savings potential is known now to be the largest: lighting and motors.

2. Customized Rebates

In addition to offering comprehensive end-use efficiency design, the utilities should be required to provide funding to reimburse customers for their purchase of efficiency measures. Rebates would be made per kw or kwh of demonstrated savings, with the maximum rebate amount equivalent to the present value of the utility's long-term marginal cost. Periodic re- audits may be necessary for small buildings to ensure that savings, and concomitant energy management practices, are being maintained. To encourage the full adoption of all cost-effective measures, this program should include joint utility-customer sharing of the cost of feasibility studies to determine specific end use improvements and their cost.

Pacific Gas and Electric Co. has successfully implemented such a program, and reports both high penetration rates and significant savings.[2] The Bonneville Power Administration has also recently introduced such a program to encourage electrical efficiency improvements in the Pacific Northwest's aluminum sector; in this program, the utility pays aluminum smelter operators a fixed amount for every kilowatt hour saved, however that savings is accomplished.[3]

3. Targeted Mass Retrofits

While in general it is preferable to install efficiency measures as part of a comprehensive site analysis, many measures (e.g. low flow showerheads, compact fluorescent light bulbs, residential weatherization) are so cost-effective and easy to install that utilities should be required to distribute or install them for nominal cost on a mass basis.

Along these lines,

- Mass commercial lighting retrofits have been proposed recently for Austin and Seattle;
- Nearly all electrical resistance-heated houses in Hood River County (Oregon) were weatherized; and
- The municipal utility in Traer, Iowa, in cooperation with North American Philips Lighting Co., recently distributed high-efficiency light bulbs to all of its residential customers, for an estimated savings of $50 per year per household.

4. Programs to Increase the Efficiency of New Construction

As discussed in Appendix 3, a large portion of growth in electricity sales and peak demand over the next 15 years can be accounted for by sales to new buildings and facilities. Yet, if present patterns continue, that building stock will be highly inefficient; many new mix-used developments create new capacity demand equivalent to that of a small city.

This pattern is in part due to the failure of existing building codes to require maximum electrical efficiency, and in part due to the fact that developers and their customers are not forced to bear the economic impact of the marginal electricity costs associated with the addition of inefficient buildings to the system. These failures represent enormous lost efficiency opportunity, since it is far easier to incorporate energy-efficient features into a building at the time it is constructed than to retrofit those features later.

New England utility regulators should take strong steps to ensure that the region's new building stock incorporates the maximum cost-effective electrical efficiency:

- **Hook-up Fees and Incentives.** Utilities should pay developers or home purchasers an incentive for incorporating high-efficiency design into new construction, and, conversely, assess the developer or owner a service hook-up fee to help recover the additional power demands caused by inefficient design.

The hook-up fee would vary with the intensity of the peak power demand placed by each customer on the system beyond a certain minimum level. The fee would be based on the estimated summer and winter peak demand of a building per unit of space, and the estimate of the capital cost of new capacity to meet this demand. The fees collected would be earmarked to fund the utility's other efficiency improvement programs.

For highly efficient buildings that exceed a given efficiency "baseline," the fee would be negative i.e. an incentive payment to the developer. To avoid subsidizing increased electrical usage, however, buildings with electrical resistance heat would be ineligible for an incentive payment.

These fees would transfer some of the costs of electricity-inefficient development from all ratepayers to the developers of inefficient buildings, thus creating a strong incentive for efficient construction.

Such programs have strong precedent around the nation:

- Central Maine Power Co. has recently instituted hook- up charges for residential customer.[4]
- The Modesto (Ca.) Irrigation District provides incentive payments of up to $475 to purchasers of homes whose electrical efficiency exceeds an average baseline, which is 13% higher than required by the California State Building Standards, some of the most stringent in the nation.[5]
- The Bonneville Power Administration has instituted a pilot project in which developers are paid the added design and construction costs of making new commercial buildings at least 30% more electrically efficient than required by a model regional building code; program participants are selected through a competitive process.[6]

- **Efficiency Design Assistance**. Utilities should make available to developers at nominal cost expertise on high- efficiency building design and fixtures. In addition, the utilities should provide a "high efficiency certification" for new buildings incorporating prescribed efficiency measures; the certification could be used by developers in marketing the buildings.

5. Load Management Initiatives

Approximately 10% of New England's total electrical generating capacity is needed simply to meet dramatic leaps in demand during a few afternoon hours on a handful of days of the year (typically in January and July/August)[7]. Rather than building expensive new capacity to meet these infrequent demand "spikes," New England regulators should require utilities to develop programs which will enable and encourage customers to scale back their electrical demand during these few crucial hours.

At present, however, the region's utilities have tapped only a small fraction of the potential peak savings pool.[8] *If NEPOOL is correct in its assertions that the region's capacity is presently inadequate to reliably serve peak load, immediate implementation of these programs is imperative.*[9]

These actions would include:

- **New Rate Structures.** Several opportunities are available to structure electric rates to signal the high system value of electricity use during peak periods. These include "time of use rates" which vary in predetermined increments according to hour of use, and "interruptible rates" which are essentially discounted rates to large industrial and commercial customers who agree to interruption of service on short notice during peak periods. All of the region's utility commissions should require their utilities to adopt rate structures which more directly reflect the long-run cost of new capacity to the region, and thus encourage cost-effective curtailment.

Item: By offering a special discount Large Power Seasonal Time of Use Rate to its large industrial and commercial customers, United Illuminating was able to shift 29% of the participating customers' load away from the 1986 summer peak hour.[10]

- **Direct Utility Control of End-Uses.** Many small businesses and residential customers would find it burdensome to respond to differentiated rate signals. For these customers, it may be more appropriate for the utility to directly control the use of large end-uses such as water heaters and air conditioners during peak periods. Several New England utilities have already implemented such programs, utilizing radio controls and direct control through the power line. These programs should be expanded throughout New England.
- **Utility Purchase of Load Management Technology for Customers.** Numerous technologies are available which enable electricity users to reduce their demand during peak periods. These technologies include "chilled storage" (cooling water at night for use in space conditioning during the peak period of the following day), air conditioner cycling, and standby generators. A recent study prepared for the Washington Electric Cooperative (Vt.) estimated that *the utility could reduce its peak load by more than 20% through the use of load management technologies.*[11]

The utilities should be required to fund these technologies in the same manner as traditional "conservation" measures (see item 1 above).

- **Load-Shedding Cooperatives.** While important, the use of rate signals alone and demand reduction equipment may be insufficient to achieve all cost-effective curtailment from large industrial commercial and industrial customers. The reason: not all large customers are able to commit to shed load on 30-60 minutes notice.

"Load-shedding cooperatives," currently in place in California and now being implemented in New York, provide a promising supplement. Under this program, the utility makes a contract with several "cooperatives" (each consisting of about ten large commercial and industrial customers) to cut back their load collectively by as much as 50% when needed, although the allocation of that curtailment among cooperative members is decided by them. In return, the utility pays the cooperative an amount equivalent to that which a peaking power plant would cost. By allowing sequencing and sharing of potential load interruptions, the program enables many more businesses to participate, maximizing the load-shedding "pool." A recent report to the Boston Edison Company by Putnam, Hayes & Bartlett estimated approximately 200 MW of load-shedding potential on that 2500 MW (peak) system.[12] New England utilities should be required to implement this program immediately by funding the computer control equipment necessary to the sequencing of loads within the cooperative, and providing technical assistance to potential cooperative members.

■ **Avoidance of Inefficient "Load Management."** While requiring the development of useful load management efforts such as those just listed, the region's regulators should also firmly discourage poorly conceived utility load management programs that focus on building load during off- peak demand "valleys." While valley-filling programs (such as promotion of electric heating) may offer some immediate financial attractions, in the long run they cause load growth and thus tend to advance the date at which new major power plants are required to serve load.

6. Regulatory Treatment of Efficiency Investments

The region's utility commissions should implement generic approaches to signal to the region's utilities the urgency of undertaking efficiency investments. These approaches should include:

■ **Rate-Basing of Efficiency Investments.** While there is wide agreement that demand-side options should be treated equally with supply-side alternatives in the supply planning process, this commitment to equality is not always reflected in the rate-making process. Efficiency investments should be rate-based, and be given reasonably short useful lives and high depreciation rates for rate-making purposes, so that electric utilities will have adequate incentives to make those investments. Since accounting conventions for rate-basing of efficiency technologies have yet to be developed and the lack of certainty may impede utility action, the region's regulators should develop a clear and uniform region-wide accounting protocol adaptable to each jurisdiction.

■ **Minimum Efficiency Targets and Guidelines.** Because efficiency expenditures have not been historically a major focus of utility financial planning, the utilities may have concerns about the level of efficiency investment which, as a matter of public policy, is deemed desireable, prudent and recoverable. New England utility commissions, perhaps jointly, should enunciate clear standards for the evaluation and recovery of efficiency investments. At a minimum, such standards should provide that utilities must invest in all efficiency measures which are less than the utilities' avoided cost as determined for small power generation. A version of this approach, recently embraced by the Public Service Commission of Wisconsin, essentially provides "safe harbor" advanced approval for efficiency investments which cost less than a specified threshold (in the case of Wisconsin Electric Power Co., $200 per kw of peak demand and 2 cents per kwh of energy savings); expenditures above this cost are examined on a case-by-case basis.[13] Any efficiency targets should be adjustable to reflect changing technologies, markets, and projected increased service demand.

■ **Rate of Return Incentives.** Utilities should be given direct monetary incentives to pursue cost-effective efficiency improvements, beyond the built-in incentives of lower risk and lower cost. In particular, utility commissions could adjust a utility's allowed rate of return to reward aggressive efforts in efficiency and other least-cost planning efforts and to discourage delay.

B. Longer-Term Actions: Improving Planning and the Market

To get the maximum cost-effective electrical efficiency improvements in place, utilities and consumers must develop the requisite information, and experience the requisite incentives, to undertake these improvements. Creating the proper balance of planning and a correct market environment for efficiency will take more than simply utility action, including:

7. Development of a New England Energy Laboratory

As noted above, much of customers' — and utilities' — slow pace in adopting efficiency measures stems from lack of information about the availability of various technologies, concerns about their reliability, and an incomplete understanding of the efficiency of existing end-uses, particularly in New England industry.

To rectify this gap, the New England states should establish and fund a New England Energy Laboratory. With a full-time staff advised by experts from the utilities, the electrical manufacturing industry, universities, and independent research institutes, the New England Energy Laboratory would:

- Test and certify the reliability and savings yield of available electrical efficiency improvement technology, and make the results available to both the public and the utilities for use in planning comprehensive efficiency designs (item 1 above);
- Undertake studies of existing electrical efficiency in various end-use sectors in New England; and
- Work with New England universities to develop research and development programs for electricity improvement technology and curricula for the training of electrical engineers specializing in end-use energy efficiency.

8. Integrated Least-Cost Planning

Planning for future electrical services must put efficiency improvements on a true level playing field with supply options such as new plants and bulk power purchases. Presently, utility investments are evaluated by regulators largely in isolation from other available options. Typically, this has lead to over-investment in costly and risky, high-capital, long-lead-time generation projects.

To rectify this piecemeal approach, all utilities should be required to prepare and submit for periodic public and regulatory review integrated least-cost electrical service plans which identify the costs, risks, and environmental impacts of various options available to meet projected need. Efficiency improvements should be evaluated as capacity and energy equivalents of new generation options, with an added quantified credit for avoided line losses, avoided reserve margin, lower risk, and avoided environmental impacts. No new utility investment or borrowing would be allowed unless it were the least-cost option identified by the plan.

The New England Governors provided a strong endorsement for such least-cost planning in their December 1986 *Final Report.*[14] Excellent models for such a planning process exist in Iowa and Nevada,[15] and could be readily adapted to New England.

9. Creation of an "Efficiency Auction"

To encourage the ultimate development of a truly competitive market for electrical efficiency, the region's utilities should develop an auction process.

As in the current system for buying power from independent power producers, each utility would be required to determine a supply decrement and develop a request to solicit bids to fill this decrement with efficiency measures. Starting at, say, $0.01/kwh, bids up to the utility's long-term marginal costs would be accepted. Bids could be submitted by individual customers, by private firms (vendors, energy service companies, etc.) or by the government or non-profit organizations. Proposed projects could involve work at one facility, such as a large industrial facility, or at many locations, such as in 1000 different residences. Central Maine Power Co. already has under-way such a program for its commercial and industrial customers.[16]

Ultimately, the auction could be expanded to include bids for power supply as well as for efficiency improvements, thus forcing small power and utility-built plants to compete directly against efficiency measures.

10. More Energy-Efficient Building Codes

As noted above, increasing the electrical efficiency of new construction is a regional imperative. While incentives and hook-up fees may encourage such efficiency, New England would benefit greatly from establishing a legal "floor" for the efficiency of new construction in building codes. Despite some recent revisions, no state building code in New England fully captures cost-effective efficiency levels.

A regionwide model code should be prepared for adoption by each state. The Model Conservation Standards prepared by the Northwest Power Planning Council could serve as a useful starting point for such code revisions.

C. Longer-Term Actions: Regional Least-Cost Efficiency Markets And Coordination

New England's electricity generation and distribution system is more tightly integrated than perhaps anywhere else in the nation: essentially, all power in the region is dispatched interchangeably, as if by a single utility. Consequently, when cost-effective efficiency investments go untapped in one utility's territory, the customers of other utilities suffer through a higher-cost regional power mix and the necessity of maintaining an additional, higher regional "reserve margin."[17]

Just as the region's policy makers should implement policies to ensure that market distortions do not prevent adoption of cost-effective efficiency improvements within individual utility territories, so also *policies should be implemented to ensure that the New England region as a whole does not miss out on cost-effective improvements.* These policies include:

11. Reducing Impediments to Market-Justified Efficiency Investments

To ensure that the region as a whole taps maximum efficiency opportunity, several remedies must be applied to existing regional market distortions:

■ **Modifying Regional Power Pooling Constraints.** New England utilities trade electricity and capacity among one another on a nearly constant basis. But there is reason the believe that the rules under which those trades take place may understate the value of efficiency investments.

First, utilities caught short of capacity receive only a "deficiency" charge for capacity provided by the regional power pool to fill the gap. This charge has historically been well below the cost to the region of providing such marginal capacity. This below-"market" pricing has perversely shielded those utilities which have made the least effort to control their peak demand. Regional regulators should insist that deficiency charges more closely reflect the marginal cost to the region of making up the deficiency.

Second, the region's utilities have historically capped their non-emergency wholesale sales of capacity to one another at the "embedded cost" of that capacity, rather than at the market value of that capacity. This both rewards slow efficiency improvements by the purchasing utility and understates to the selling utility the true economic value of efficiency investments that may "free up" more of the seller's capacity. The region's regulators should encourage the utilities to explore capacity sale arrangements which more fully reflect the economic value of such capacity.[18]

■ **Make Off-System Sales a Component of Avoided Cost.** As noted, utilities in New England sell power and capacity through intermediate- and long-term contracts with other New England and northeastern utilities. Yet the revenue of these sales is rarely reflected in the "avoided cost" used to measure the value of efficiency programs which free up new capacity for potential sale and thus provide real benefits to the selling utility's ratepayers. This arrangement results in a systematic under-valuation of efficiency. Regulators should explicitly include off-system sales as a credit to efficiency investments which make those sales possible.

■ **Encourage Intra-NEPOOL Wheeling of Efficiency Gains.** Presently, New England's utilities have invested in efficiency gains in their own service territory almost exclusively. There is no reason, however, why this limitation should exist; utilities should be encouraged to invest in cost- effective efficiency opportunity wherever it exists, and be permitted to "wheel" the saved power back to its territory or other utilities for sale — just as utilities currently do with jointly owned regional generation facilities.

The region's regulators should expressly permit such cross- territory investment in, and transmission of, new "supply" from efficiency investment. The region's regulators should also require utilities to eliminate any physical and legal transmission barriers which may currently prevent such investment.

12. Regional Power Coordination.

New England's regional utility system is run as an integrated whole. To a large extent, power supply planning is also done on a regionwide basis by the New England Power Pool (NEPOOL), a consortium of public and private utilities which account for virtually all electric power sales in the region. NEPOOL continually evaluates projected electric demand, and its Generation Planning Task Force provides analysis to member utilities on the combination of generation and transmission facilities which will meet that demand in the most economical way. These analyses have led to the construction of, and provided the public justification for, a number of large baseload power plants in the region, including Seabrook.

Despite the fact that private power planning takes place on a coordinated regional basis, public investment review is fragmented over six state jurisdictions. This fragmentation often results in wildly divergent policies and practices which together frustrate the ability to plan rationally for electrical services at the lowest possible cost to the entire region.

The New England Energy Policy Council believes this situation is unacceptable, and may account in part for the utilities' continued emphasis on new power generation as opposed to aggressive efficiency investments. New England must develop a regional, public forum for considering power planning issues that intimately affect the economic and environmental fate of our region.

Although present efforts by the New England Governors' Conference Power Planning Committee to share information among states are laudable, considerably more staff and resources will be necessary to develop and implement detailed least-cost electricity supply plans and policies that make sense for the region as a whole.

At a minimum, the New England Governors should staff and fund an ongoing regional electricity planning body. That body would research regional electricity needs and develop and evaluate specific policies of the type contained in this report, and, where appropriate, propose a coordinated regional strategy to implement them.

A still more effective approach might entail the creation of a regional power planning council, members of which would be appointed by the governors of each state. The council, in addition to studying the region's electric needs and preparing a regional strategy to meet them, would be authorized to intervene in any state utility commission proceeding that has a potential impact on the region's power supply. ❑

Footnotes

1. *Boston Globe,* Business Section, p. 2, 6/10/87.
2. Pacific Gas & Electric Company, *A Report on 1985 Conservation Activities* at p. 7.
3. See Bonneville Power Administration, Division of Commercial and Industrial Programs, Office on Conservation, *Bonneville Power Administration Program Description for the Aluminum Smelter Conservation/Modernization Program* (November 1986).
4. Stipulation, Central Maine Power Company, *Investigation Into Cost of Service of Customer Classes and Rate Design,* Maine Public Utilities Commission Docket No. 86-2.
5. Gordon Ryan, *A History of the Development of the Power Saver Program: 1985-1987* (Paper presented to the Massachusetts EOER Conference, Boston, Massachusetts, January 1987).
6. Bonneville Power Administration, "The Energy Edge Project: 'A Design Challenge That Pays': Project Description" (October 1986).
7. For example, about 10% of Boston Edison's and Central Maine Power's capacity is needed for 2% of the year. See Boston Edison Company, *Long-Range Forecast of Electric Power Needs and Requirements,* (January 17, 1986), Vol. I at p. K-13; Central Maine Power Co., *Conservation and Load Management Update* (April 1987) at Figure 1.
8. The region's utilities claim only 373 MW of peak load reduction capability for August 1987, or 2% of unadjusted peak load. New England Power Pool, *NEPOOL Forecast Report of Capacity, Energy, Loads and Transmission 1987 - 2002* at 1 (1987).
9. NEPOOL Chairman Stephen Sweeney recently stated that the region's utilities "continue to be concerned about the potential deficiencies ... in the high growth contingency case. ... [W]e have serious reservations whether sufficient gas turbines could be built by 1990 or 1991 to cover the deficiencies in the event they are the preferred alternatives." Letter to New England Governor's Conference, November 18, 1986.
10. Energy Planning Department, United Illuminating, *A Preliminary Evaluation of the Load Impacts of the Optional Rates Approved in Docket 85-12-04* (December 15, 1986) at p. 3.
11. Energy Solutions, Inc. (Barre, VT), *Energy Efficiency Supply Options for Washington Electric Cooperative,* Volume I at 3 (November 1986).
12. *BECo Report* at VI - 22.
13. See Wisconsin Electric Power Company, *Wisconsin Public Service Commission Docket No. 6630-UR-100* (1986) at 53-54.
14. *Governor's Report* at 55.
15. See Cavanagh, "Least-Cost Planning Imperatives for Electric Utilities and Their Regulators," *10 Harvard Environmental Law Review* 299 (1986); Wellinghoff & Mitchell, "A Model for Statewide Integrated Resource Planning," *Pub. Util. Fort.,* Aug. 8, 1985 at 19, 19-20; Colton, Conservation, "Cost-Containment and Full Energy Service Corporations: Iowa's New Definition of 'Reasonably Adequate Utility Service'", 34 *Drake L. Rev.* 1, 3 (1984-85).
16. Sixth Stipulation Regarding Energy Management and Conservation, *Maine Public Utilities Commission Docket No. 85-83* (November 3, 1986).
17. The addition of new large power plants to meet regional demand increases the regional reserve requirement necessary to hedge the risk of the new plant's outage. For example, New England's newest baseload unit, Millstone III, lead to an increase in regional reserve margin of between 2 and 4% — or the equivalent of an additional small coal plant. See Ex. CLF-WTS- 12 at 3; Ex. CLF-WTS-35 at 5-9, Western Massachusetts Electric Company, DPU 85-270.
18. The Federal Energy Regulatory Commission has recently signalled its intention to open regional bulk power marketing to greater competition, and has accepted rate filings designed to achieve this end. See, e.g., Pacific Gas & Electric Co., 38 *F.E.R.C.* Rep. 61,242 (Docket No. ER87-97-001) (March 12, 1987).

Appendix 3: Current Electric Use In New England and Future Trends

The region's utilities estimate that industrial and commercial users — factories, offices, stores, schools, and hospitals — account for over 60% of electric demand.[1] Interestingly, these users comprise only 10% of all New England electricity customers.[2] *This fact suggests that many of the biggest efficiency "chunks" can be achieved from a small number of users.*

As Table A of Appendix 1 shows, electricity use is highly concentrated upon a few specific tasks. For example, lighting, industrial motor drive and space heating alone account for over half of all electricity consumed.

These patterns suggest that investments in improving the efficiency of several large electric "end uses" — lighting, space conditioning, and motor drive — could go a long way toward reducing total annual electricity consumption in New England and toward reducing the total amount of new capacity needed to service peak demand.

Current trends point to an even further concentration of energy sales and peak demand, particularly in commercial sector lighting and space conditioning. For example, New England's commercial sector accounted for nearly half of all demand growth from 1971–85.[3] In 1985 alone, the commercial sector increased its electrical service requirements by 5%, compared with only 1.3% for the residential sector and .5% in the industrial sector.[4] This is not surprising, as new office and residential complexes in growing areas of the region may place as much new electrical demand on the regional system as a medium-sized town. Just one recent development — Boston's Copley Place — placed an additional 25 MW peak power demand on Boston Edison's system, equivalent to the peak demand created by 10,000 homes.[5]

These facts underscore the importance of seeking increased electrical efficiency in new buildings. Indeed, in some utility service territories, new commercial and residential buildings account for nearly all projected load growth.[6] ❑

Footnotes

1. Electric Council of New England, *Electric Utility Industry in New England: Statistical Bulletin 1985* at 17, Table C.
2. *Id.*
3. See Electric Council of New England, *Electric Utility Industry in New England: Statistical Tables 1985* at 7.
4. *Id.*
5. Charles Stein, "Can Boston Edison Keep Up?", *Boston Globe* (Nov. 20, 1984) at p. 53.
6. See, e.g., Testimony of Steven Nadel, *In Re Western Massachusetts Electric Company, Mass. DPU 86-280,* at 31 (March 11, 1987).

Appendix 4:
Excerpts from Putnam, Hayes and Bartlett, Supporting Documents on Conservation and Load Management Prepared for Boston Edison Review Panel (March 1987)

Conclusions

This review of the economic potential of lighting conservation measures leads to the following conclusions.

- Theoretical calculations of economic potential lead to results that are very nearly unbelievable.

- The results of more applied analysis suggest that, while the theoretical calculations may be subject to a fair degree of uncertainty, even under pessimistic assumptions the savings that can actually be achieved right now are still so cheap, compared with BECo's avoided costs, that a major reorientation of BECo's supply/demand planning program appears to be in order.

II. RECOMMENDED C&LM PROGRAM FOR BECO

A. C&LM Market Failure

The obvious question that presents itself at the end of a review of the technical and economic potential of C&LM is, "If this works so well and is so cost-effective, why isn't everyone buying it?" To get an answer, we interviewed a number of landlords and tenants in Boston's commercial sector to find out how they view their incentives to invest in C&LM. We spoke with those responsible for evaluating technologies and making recommendations to management. Due to time and resource constraints, we chose to concentrate on lighting technologies. Most of our findings are, however, broadly applicable to the full array of electricity-consuming technologies.

Results of Commercial Landlord and Tenant Interviews

The first theme that emerged in our interviews was confusion. The pace of development in efficient energy-using and energy-conserving technologies has been accelerating in the past few years,* and the people we spoke with evinced a certain bewilderment at the array of choices now being touted by vendors and the trade press.

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* According to the RMI report cited above ("Advanced Electricity-Saving Technologies and the South Texas Project"), "Most of the best electricity-saving devices on the market today were not on the market a year ago. The same was true a year ago."

A second theme was that new technologies often do not perform as well as -- or at least in the same way as -- those they replace. Some of those whom we interviewed professed skepticism toward the notion that C&LM measures could reduce costs with no degradation in the quality of services for which they use electricity. Landlords, in particular, noted that tenants are extremely sensitive to even the smallest alterations in lighting level or quality, or to the appearance of fixtures, and that experiments with new technologies often elicit negative reactions from tenants. Both tenant and landlord interviewees noted also that new technologies had been vetoed on occasion by architects retained to maintain their building's design standards. We suspect this is another indication of the proliferation of technologies, and of the wide variation in performance that can be found.

A third theme was that three years is often the longest acceptable payback for C&LM investments. A variety of reasons was given. One software development company said their industry was too volatile to take a longer view. An employee of a building management company said he couldn't trust the DPU to maintain any given rate structure for more than three years. Others simply indicated that three years is a limit fixed by business practice.

A fourth theme was that the structure of leases blurs economic incentives. Commercial tenants in the Boston area commonly pay a fixed fee for electricity regardless of usage, up to some ceiling (e.g., 3.5 watts/square foot). Usage is monitored occasionally, and if it exceeds the ceiling, meters are installed and the tenant is billed directly for use above the ceiling. For tenants whose use does not exceed the ceiling, to benefit from C&LM economics would require renegotiating the fixed fee in their lease. This is certainly possible, but the electricity fee is usually so small relative to the rent (1 to 4 percent), that renegotiation seems unduly difficult.

Tenants are also billed for their share of the building's "common area" electricity consumption. Here the initiative for C&LM measures generally would have to come from the building management company. But the building manager's incentive to invest is blurred because (1) he passes common area electric costs through to tenants automatically; and (2) he would need the consent of all tenants to make a C&LM investment.

Conclusions from Interviews

We concluded from these interviews that there exist substantial failures in the operation of private incentives in the market for C&LM savings. Therefore, exclusive reliance on the private sector to achieve the appropriate social level of C&LM investment is likely to take much

longer than if the private market is aided by a push to overcome consumers' confusion and skepticism on the performance and economics of C&LM technologies.

B. Description of Proposed Program

We propose a C&LM program for BECo consisting of the following elements:

1. BECo would establish an affiliate to perform research, testing, and certification of C&LM technologies. An advisory board of outside C&LM experts would be formed to assist this affiliate (hereafter, "BECo Labs").

2. BECo would also establish -- either in-house, by contract, or both -- a capability to perform C&LM site designs throughout its service area, concentrating first on lighting in buildings with high lighting concentrations (commercial, institutional, industrial, and apartment buildings). Using the most current projections of BECo's avoided costs, the design teams would determine the optimal C&LM plan for each site, using up-to-date measures whose cost and performance had been certified by BECo Labs.

3. BECo would invite third parties to bid to supply and install the C&LM measures specified by the design teams for individual buildings or portions thereof. (BECo could establish an unregulated affiliate to compete in this bidding process.)

4. Third parties could also bid to install measures that departed from those approved by BECo Labs and/or did not conform to the package specified by the design team, on two conditions. First, the total amount of proposed KW and kWh savings could not be less than the quantities proposed by the design team for the job in question; and second, savings would have to be measured or certified.

5. BECo would submit to the owner and tenants (if any) of each building a report summarizing the work of the design team and explaining the economics of the recommended investments. BECo would then invite each owner or tenant to bid the amount it would be willing to contribute to the cost of the recommended measures (if the owner/tenant wished to finance its contribution) or the share of the savings it would be willing to relinquish to the utility (if it wished the utility to provide financing).

6. BECo would then calculate the "net bid" for each building. This would be the difference between the installation bid and the owner/tenant's contribution (or relinquished savings) bid. It is the amount that ratepayers would have to pay for the design package of C&LM measures in a particular building.

7. BECo would then calculate for each building the ratio of the net bid to the projected generation costs that would be avoided by installing the design C&LM package. BECo would rank buildings according to this measure -- cost per dollar of avoided cost -- and proceed to sign contracts with installation firms and owners/tenants, beginning with the bid that saves a dollar of avoided cost at the lowest price.

8. BECo would move up the ranked list of bids, signing contracts until the cost per dollar of avoided cost matched the cost being paid in the QF process. Beyond this, no costlier C&LM savings would be purchased.

9. Contracts signed with firms bidding to install C&LM measures would generally entail full payment of the bid amount at the time the installation work was complete. In exceptional cases, payment for measures whose savings were especially difficult to predict would be made annually and on the basis of kWh actually saved, with periodic measurement to ascertain actual savings. The amount paid per kWh saved would, however, be established at the time the contract was signed, and would not depend on actual avoided costs.

10. For ratemaking purposes, the costs of BECo Labs and the design teams would be recoverable as cost-of-service. We recommend that as a gesture of support, the DPU allow these costs to be collected on a prospective rather than an historical basis. BECo would be entitled to include up-front payments for kWh savings in the rate base. Annual payments per kWh saved would be recovered as part of the fuel adjustment.

11. As an incentive to BECo, the DPU would also allow the utility to retain a certain percentage of the net avoided costs "below the line" for ratemaking purposes. In this way, the benefit of these savings would be shared between BECo's ratepayers and shareholders.