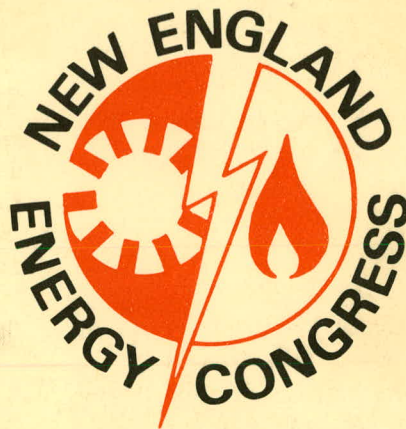


MASTER

PRELIMINARY REPORT for PUBLIC REVIEW



November 1978

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~~THE~~ NEW ENGLAND ENERGY CONGRESS:

Preliminary Report for Public Review

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The New England Energy Congress is sponsored by the New England Congressional Caucus and Tufts University. The New England Congressional Caucus is a bi-partisan organization composed of all 25 members of the U.S. House of Representatives from the six New England states.

The New England Energy Congress is funded by grants from the Economic Development Administration, U.S. Department of Commerce and the Office of the Environment, U.S. Department of Energy.

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A distinguished Advisory and Selection Committee assisted the New England Congressional Caucus and Tufts University in late 1977 and early 1978 in laying the foundation for, and outlining the format of, the New England Energy Congress. In addition, the Advisory and Selection Committee was responsible for selecting the 120 delegates from a list of over 500 applicants.

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INTRODUCTION

The future of New England is becoming increasingly threatened as the region's energy situation continues to worsen. New England is overwhelmingly dependent on oil, with fully 80% of its energy requirements derived from this single source. This statistic poses a double threat to the region and its economic prosperity, as oil dependency means extreme supply vulnerability and substantially higher prices than the national average.

The New England Energy Congress, sponsored by the New England Congressional Caucus and Tufts University, represents the concerted effort of a highly diverse group of New Englanders to address these problems. The Energy Congress is funded through grants from the Economic Development Administration of the U.S. Department of Commerce and the U.S. Department of Energy. The 120 Delegates participating in the process are working to frame and substantiate consensus-based energy action recommendations. During the first six months of the Energy Congress, the six full committees and the 24 subcommittees have convened for a total of more than 100 meetings.

As is evident in the text of this report, significant progress has already been made towards the substantive energy policy goals of the Energy Congress. What might be less immediately evident, but of equal importance, is the success to date on an interpersonal level. A group of New Englanders, who approach energy issues from a variety of backgrounds, has been drawn together for a common purpose. They have demonstrated over and over again their good faith towards each other and towards the task they are pursuing. It is perhaps this achievement that is the most encouraging indication of New England's potential for effectively addressing regional energy problems.

Finally, a special note should be made in recognition of the assistance by those individuals who are serving as Resource Consultants to the Energy Congress. Appointed to committees to provide added support and information, many Resource Consultants have participated actively and regularly. Their contribution has been of great value.

The timetable below summarizes the important deadlines for the remainder of the New England Energy Congress.

TIMETABLE

Mid-November	Release of <i>Preliminary Report for Public Review</i>
December 1	Working Session of Energy Congress Delegates
December 2	Energy Congress Convention
December 5 - 15	State Public Hearings
January, 1979	Meetings of Committees to incorporate public and Delegate input
mid-January	Working Session of all Energy Congress Delegates (if required)
January 31	Final drafts of Committee reports
February 24	Plenary Session of Energy Congress to approve final report
March 15	Release of a <i>New England Blueprint for Energy Action</i>

PREFACE

The release of the *Preliminary Report for Public Review* marks the beginning of a three month process of public comment on the preliminary findings and recommendations of the six committees of the New England Energy Congress.

The goal between now and February is to ensure that the work of the Energy Congress benefits from maximum public input. To this end, Public Hearings will be held in each New England state to allow individuals and organizations an opportunity to comment on the findings and recommendations presented herein. In addition, working sessions of all Delegates are planned to allow maximum interaction between the committees of the Energy Congress. Please note that written comment is actively being encouraged and can be mailed directly to the Energy Congress office or can be submitted to the staff at any of the Public Hearings.

During January, the Energy Congress committees will incorporate all input into their findings and recommendations and finalize their reports. After approval by the full Energy Congress, a *New England Blueprint for Energy Action* will be released in mid-March.

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COMMITTEE OVERVIEW

The Supply Committee has delegated its fact-finding and preliminary recommendations-drafting work to three subcommittees: Fossil Fuels, Nuclear and Alternatives. Meeting at least once per month, the subcommittees have considered in turn four central tasks:

- 1) Assessing the contributions their respective fuel sources are making to New England's current energy supply mix and the maximum potential contribution each source could make by 1985 and 2000;
- 2) Establishing current prices, and estimating end-use prices for 1985 and 2000;
- 3) Projecting a most desirable and feasible fuel mix for 1985 and 2000, taking into account the environmental, social, technological and institutional constraints inhibiting the availability of each fuel source.
- 4) Recommending legislative, financial and regulatory changes to Congress which facilitate the realization of the previously agreed to desirable fuel mix.

Supply Committee

Meeting once per month, the full committee has heard reports from the subcommittees, modified and accepted their findings and acted upon various recommendations. In August, the committee tentatively approved the availability projections from each subcommittee for the years 1985 and 2000. In September, the committee accepted some revisions in the availability estimates and approved the subcommittee projections of future prices to end-users. In October, the committee agreed to an optimal supply mix for 2000, and adopted six recommendations designed to aid the implementation of that mix.

In November, the subcommittees and the full committee will make additional and more specific recommendations to Congress pertaining to subsidies, demonstration projects and the removal of institutional barriers for those alternative energy sources the committee has agreed to push for the region. Secondly, measures designed to alleviate the cost disadvantages associated with New England's consumption of fuels will be discussed. Third, appropriate proposals to facilitate the future role nuclear power will play in the region and in the nation will be considered. All recommendations to the full committee will be drafted to fulfill the realization of the desirable fuel mix.

In the subcommittee's fact-finding efforts and in the committee's deliberations, many nationally recognized experts have been called upon to address the delegates. In addition to personal presentations from twenty "resource consultants" representing utilities, universities, hardware manufacturers, environmental and consumer organizations, energy delegates have consulted scores of knowledgeable experts in various energy areas by telephone, and scoured hundreds of governmental, public interest and industry reports and documents. On the committee itself sit no less than nine people with an extraordinary understanding of a particular energy area. Sixteen individuals have submitted more than twenty reports for the committee's consideration. Many of these appear in the documentation section of this report.

The decision-making process within the subcommittees and with the full committee has been one of consensus. Within the full committee, the agreements upon availability and cost projections, the optimal supply mix and recommendations to Congress have followed the same procedure: subcommittee chairmen make reports, deliver findings, and make recommendations for full committee adoption. The full committee discusses, modifies and agrees upon issues unanimously. Formal votes have not been taken. Availability and cost estimates, optimal fuel mixes and recommendations are modified until everyone agrees. To date very few subcommittee findings or recommendations have been rejected because consensus could not be reached. In a few cases, as in the projection of future nuclear costs for newly constructed plants, different opinions are expressed as a range or band of potential costs.

Major areas in which consensus has not been reached have been remarkably few. Many difficult issues have undergone hours of discussion, reams of material, and a process marked by good will, trust and compromise. Developing the consensus process has taken months of hard work. Mutual trust, respect and friendships have been nurtured in an atmosphere punctuated by collegiality in subcommittee meetings and good will, patience, dedication and skilled leadership in the larger committee sessions. Without the extensive time commitments, the willingness to compromise, and the belief in the process shared by all the delegates, the consensus reached on a wide variety of issues could not have been achieved.

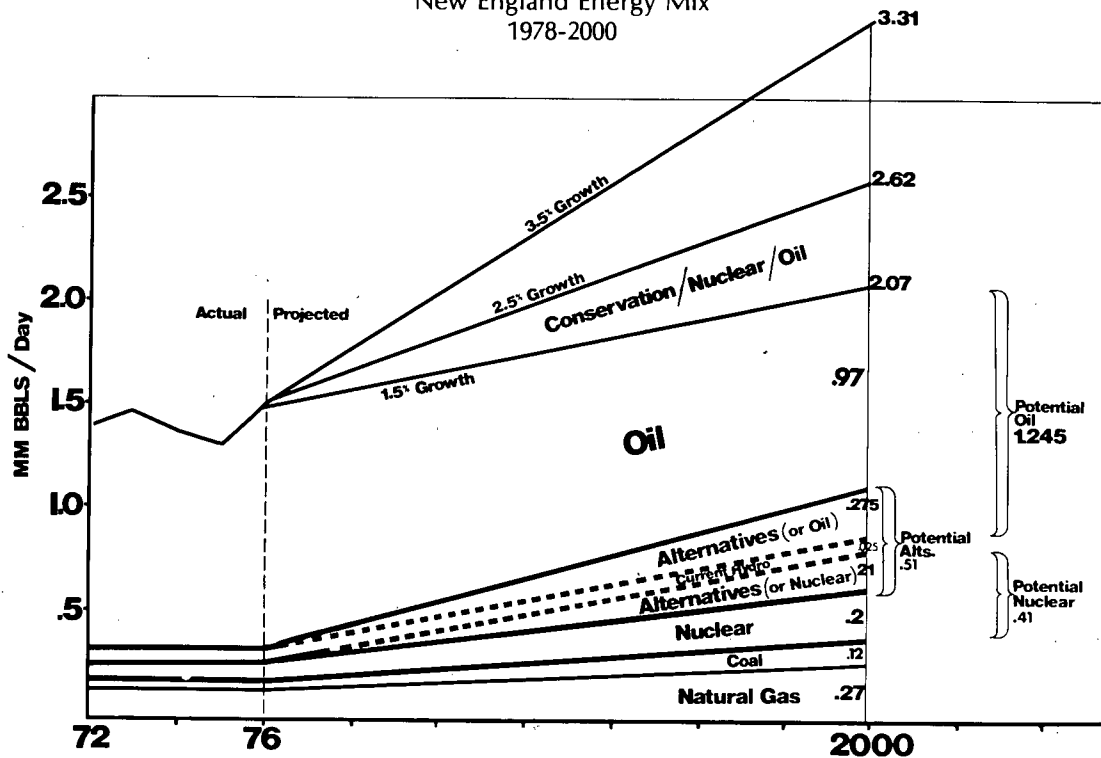
Three unanimously shared operating assumptions have guided the committee's work: (1) the future supply mix should reduce the nation's 45% and New England's 79% petroleum dependence upon imported oil; (2) the future supply mix should enable our region to compete more economically with the rest of the country; and (3) consistent with (1) and (2), we should develop indigenous, environmentally acceptable energy sources wherever possible. It has been recognized that these premises may conflict with one another in specific instances. Agreeing upon the supply mix which optimizes the meeting of these criteria has been a central charge of the committee.

FINDINGS AND POLICY RECOMMENDATIONS APPROVED BY THE FULL COMMITTEE

FINDINGS

The Supply Committee of the New England Energy Congress reached unanimous agreement on a *balanced, flexible energy mix* (see Fig. 1) for New England by the year 2000 which would meet the objective of reducing New England's overwhelming dependence on imported oil. This proposed supply mix balances the environmental, social, and economic needs of New England with the energy needs projected for New England. The energy mix has the flexibility to allow for a major development of alternative energy sources by the year 2000 by providing for a back-up of nuclear power and/or coal if the development of alternative sources doesn't proceed in a timely manner. We agreed that when new energy facilities have to be developed in New England, they should be built as expeditiously and inexpensively as possible.

Figure 1
New England Energy Mix
1978-2000



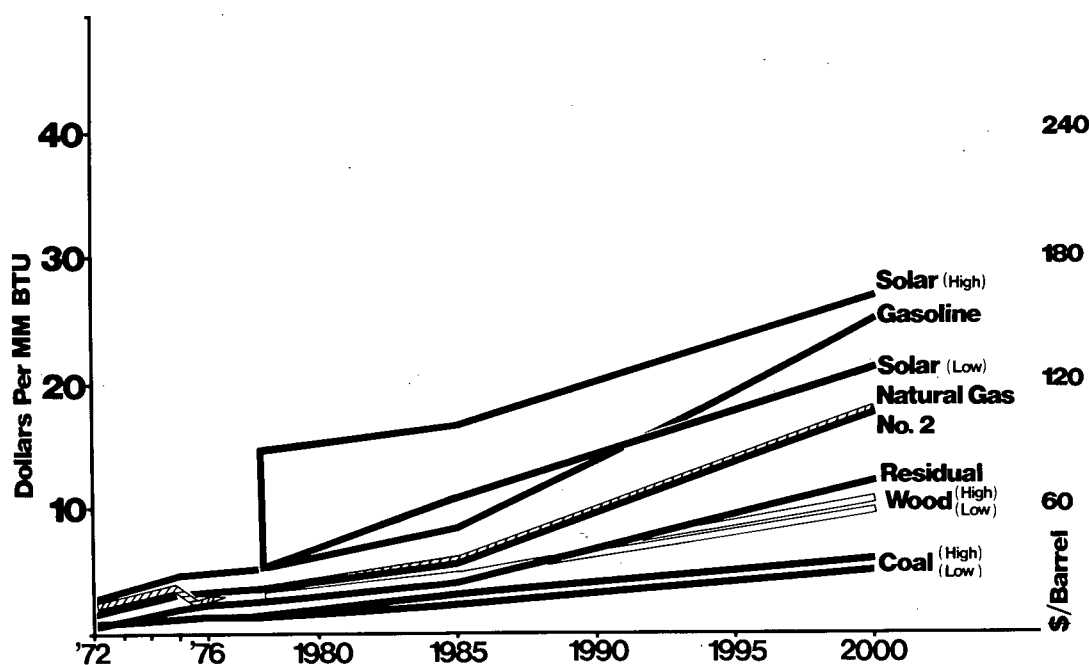
Three significant agreements allowed the committee's unanimous consensus on an optimal energy mix for the region in the year 2000:

First, the committee emphasizes that conservation is the most sensible and effective strategy for facilitating our transition to a more desirable energy mix. To the degree that timely, appropriate, and cost-effective conservation efforts are directed at our residential, commercial, industrial, and transportation sectors, we can refrain from building more costly power stations, reduce our dependence upon imported oil and gas, and allow more time for the development of renewable energy technologies. While the recent passage of the Energy Bill does represent a national commitment to a serious conservation effort, it is only a start.

Second, the committee has determined that sufficient energy resources are available to New England to the extent needed through the year 2000. We do not expect to run out of any energy resources by the end of the century, but we do expect to pay a higher price for energy. Our subcommittees have thoroughly explored and projected the available energy potential for coal, oil, natural gas, nuclear, and solar alternatives for 1985 and 2000. Coal offers an abundant national supply for at least another century or more, and the alternatives have the potential to supply a large share of the energy we expect to consume by the year 2000. While oil supplies may tighten in the 1990's, we expect New England would still be able to supply at least one-half of its energy needs with petroleum in 2000. Imports from Canada and Mexico, the development of synthetic gas from coal and conversion of wood and animal wastes to gas, and additional LNG imports could offset a decline in natural gas production by the 1990's. This will allow a higher percentage of gas consumption in New England.

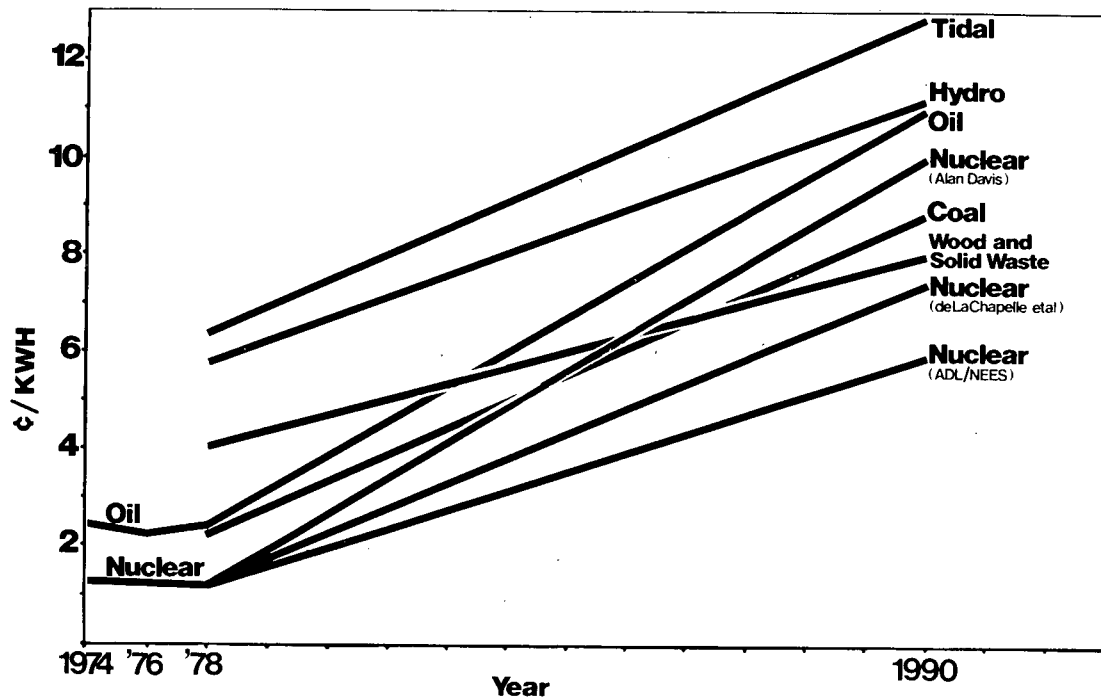
Third, all energy sources which will be available will also be very expensive (See Fig. 2 & 3.). The alternative energy sources will not come cheaply. Wind, tidal, solar, and photovoltaic will require various forms and degrees of subsidization to become cost competitive. The most competitive alternatives today are solar hot water heating, wood, and solid waste. We believe significant penetration by these energy sources in the region will take more time than is deemed prudent unless the correct policies are pursued by the U.S. Congress and the various state governments now.

Figure 2
Projected Fuel Costs (to consumer) To the Year 2000 (current \$)



High energy prices will bear most heavily upon our nation's poor. Many people will be unable to afford the energy prices of the year 2000 without substantial assistance from taxpayers. We believe that a program should be established now to enable low income people to pay for today's rising energy bills and tomorrow's much higher prices. A guaranteed annual income, pegged at a decent standard, energy stamps, lifetime rates or some combination of these must be

Figure 3
Bus. Bar Cost of Electricity
By fuel type (current \$)



instituted now to assist low-income people in paying for their essential energy needs. Our committee is still investigating policies in this area on which we can reach consensus.

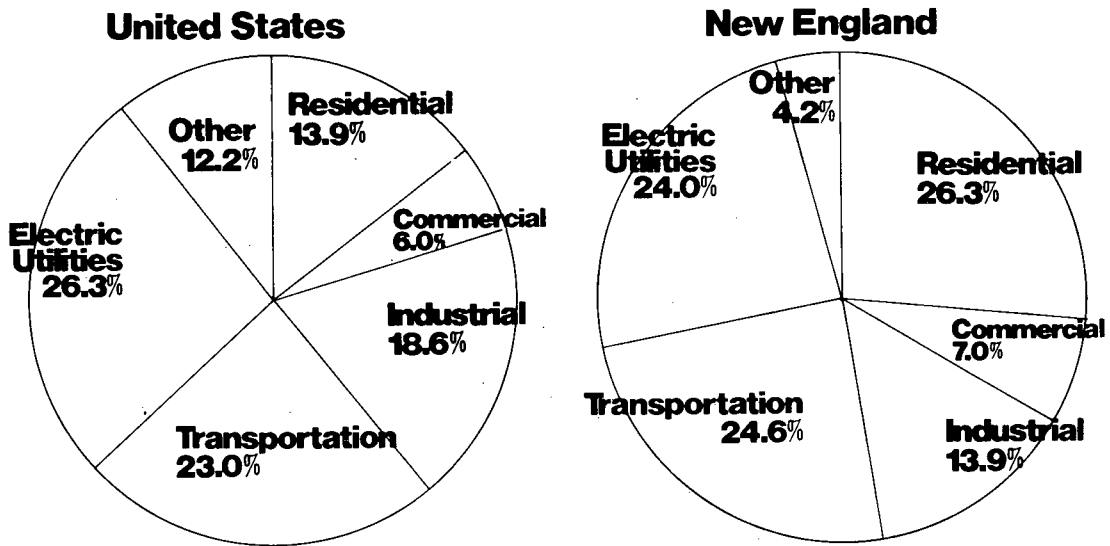
In striving for an optimal energy mix, the committee agreed that price as well as environmental and social impacts should be given weight in our recommendations. Moreover, complete agreement was reached that by the year 2000 oil consumption in New England should be about the same per cent as in the rest of the U.S. — today New England's consumption is about twice that of the U.S. on a per capita basis (See Fig. 4, 5, & 6.). Realizing therefore that even our near-term energy prices will be very high, we are committed to evaluating a program now to help the poor pay their energy bills.

The optimal supply mix agreed to by the committee reflects a process of compromise and an unanimous commitment to the principles outlined in the Overview section of our report. While individual delegates are more or less comfortable with various energy source projections for the year 2000, all agree that our mix is desirable and achievable if adequate incentives are provided by Congress and the states.

A. Demand

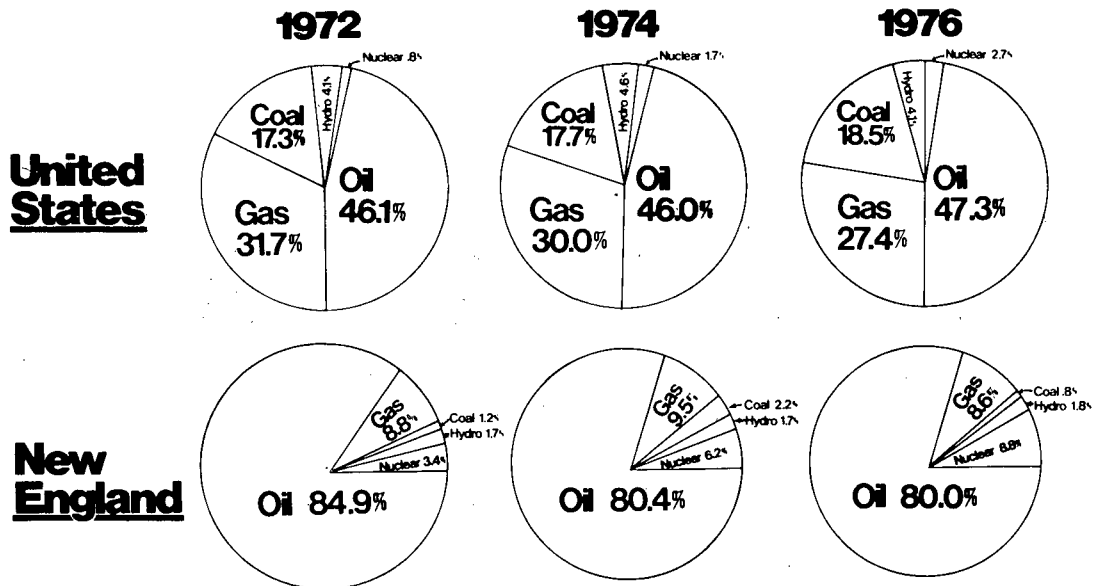
From preliminary data communicated to us from the Demand Committee, we adopted a 1.5% annual growth rate as a planning objective for the purposes of our supply mix. The Committee made its projections with the full understanding that energy growth rates do not always conform to the desires of even the best guesses of forecasters and are not predictable. If we have guessed too low, we must compensate with an increased reliance upon oil and nuclear fuels. If we project more than will be required in 2000, oil, nuclear, or coal may be reduced in the mix.

Figure 4
Energy Consumption by Sector
1976



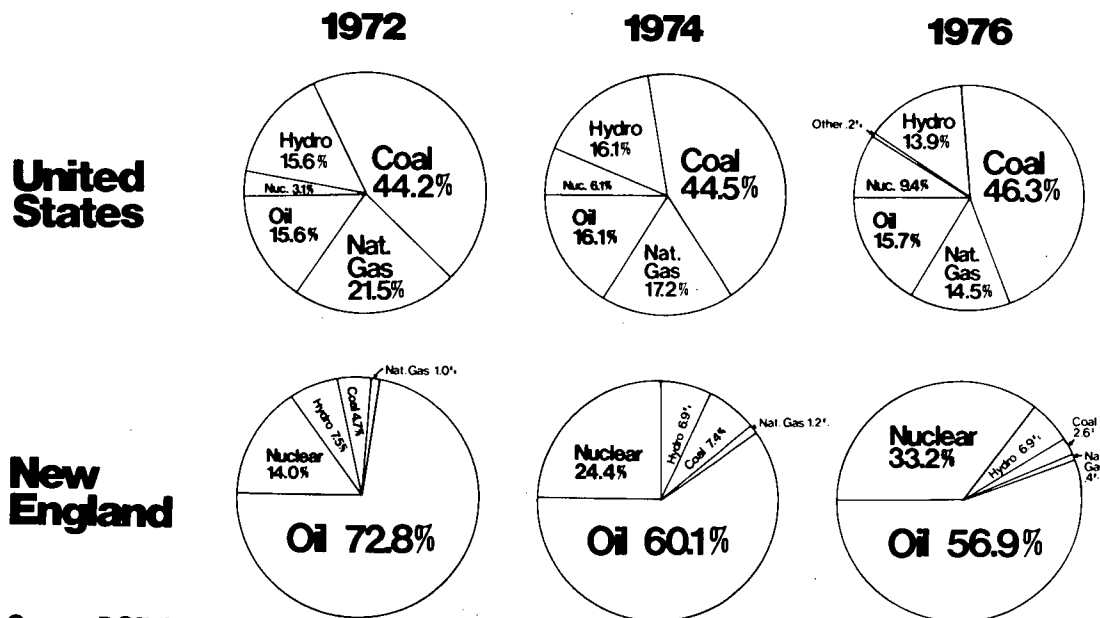
Source : S.H. Clark Associates

Figure 5
Total Energy Consumption (by source)
United States and New England — % of Total



Sources: U.S. - DOE Monthly Energy Review
N.E. - DOE Boston

Figure 6
Fuel Sources for Electric Power
United States and New England — % of Total



Source: DOE Boston

B. Coal

Figure 1 shows that the committee does not place a great emphasis on coal: only ten million tons of coal per year is projected for the year 2000. Beyond the conversion of ten percent of our current industrial boilers, the conversion of three boilers at Brayton Point, the construction of a Sears Island coal burning plant in Maine, and the coal boilers in use in N.H., this number reflects a commitment to probably no more than one or two additional coal burning plants by the end of the century. The high cost of coal electric power generation, along with the probable environmental and health dangers combine to produce a desirable coal burning range for New England radically different (much lower) than for the rest of the country.

C. Nuclear

The committee is agreed that all nuclear plants now under construction plus at least one additional nuclear plant will be required even if all the projected alternative fuels proposed are developed. The committee is agreed that nuclear would supply 410k bbls/day of oil equivalent by the year 2000, or almost four times the present supply, in the event that the alternatives considered and/or coal do not fulfill their projections. In the event that the overall energy growth rate is higher than 1.5% and the electricity growth rate is higher than 2.2% even more nuclear or coal plants will be required, as seen on Figure 7.

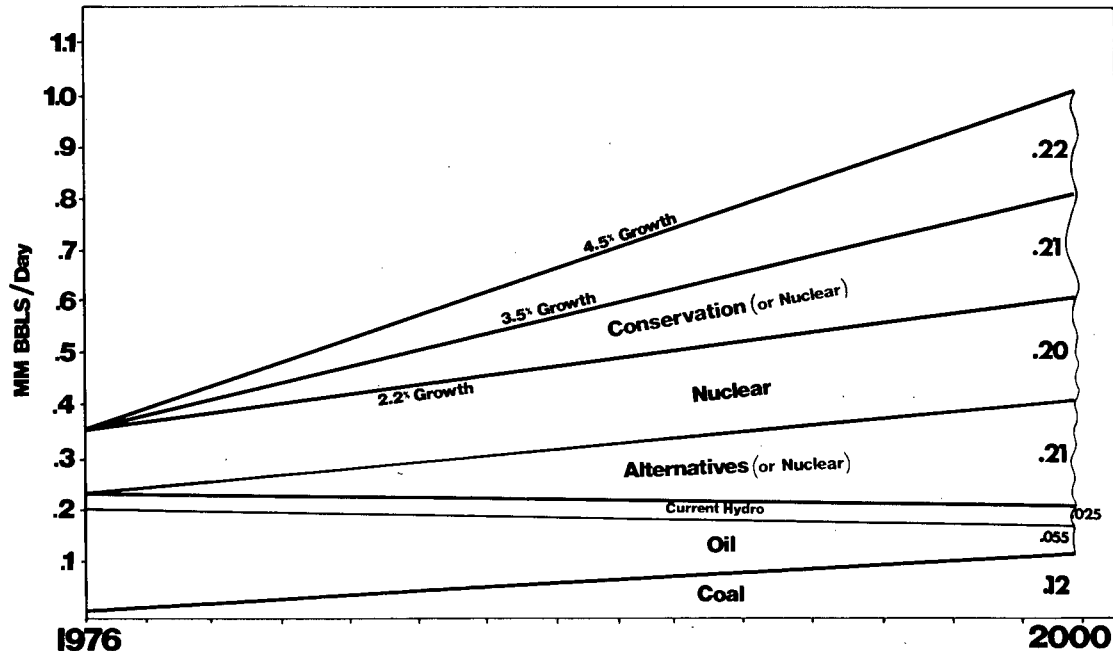
D. Alternatives

The projected contribution of the alternative energy sources ranges up to the equivalent of better than 500,000 barrels of oil per day, or 25% of the region's needs in 2000. To develop such a large energy source will require very significant financial incentives and investments as well as a large R&D program. If the alternatives do not achieve the desirable potential agreed to by the committee, oil, coal, or nuclear power must fill the gap created. The alternatives total reflects a commitment to double the contribution of hydroelectric energy by the turn of the century. It projects the equivalent of a ten per cent increase in wood-burning every year from now until 2000. The direct solar contribution is calculated with the assumption that 25% of new housing from now until 1985, and 50% afterwards, are fitted with 1000 square feet of solar collectors. One-half of existing units are assumed to be retrofitted with solar hot water heaters. Agreement was reached that the alternatives with the most potential for New England by the year 2000 are wood, hydro/tidal and solid waste cogeneration. Other alternatives considered offer potential for development also.

E. Oil

Oil is counted upon to provide about one million barrels per day, or one-half the total energy requirements for 2000. This represents a significant drop in New England's reliance upon oil, and reduces to about half our present 80% dependence upon oil. It must be emphasized, however, that a higher growth rate or the failure of alternatives to meet our projection will require a greater dependence on oil, up to 1.2 million barrels daily, in our projection. (See Figure 7.)

Figure 7
New England Electric Energy Mix 1978-2000



Supply Committee

The utility requirements for New England by the year 2000, assuming a 2.2% electricity growth rate, total approximately the equivalent of 600,000 barrels of oil per day. To the degree energy conservation is not achieved or alternative energy development is delayed, this percentage must increase.

With the Congressional prohibition against new oil burning boilers, utilities must look to nuclear, coal, or alternative energy sources to provide electricity in the future. To the extent that alternatives cannot achieve their projected potential in New England, nuclear or coal must fill the gap created by their shortfall. Consensus was reached within the committee by recognizing that the shorter the time required between the decision to build a nuclear or coal plant and its completion, the longer the time available to develop the alternative energy sources. If the growth rate is underestimated, nuclear is expected to make up the additional demand.

General Recommendations

The committee has reached unanimous agreement on six general recommendations:

- 1) *Subsidize state of the art alternatives as necessary to expedite a market development.*
- 2) *Support prototype development in New England of certain alternative energy sources.*
- 3) *Resolve the interface issues between alternative energy sources and the current energy systems.*
- 4) *Encourage the deregulation of crude oil price controls — subject to an agreement on how to handle poverty issues.*
- 5) *Licensing of nuclear power plants should be done more expeditiously, and heavy water and other type reactors should be given equal treatment in licensing procedures.*
- 6) *Establish a national waste disposal facility operational by 1990 for disposal of high level nuclear waste.*

SPECIFIC RECOMMENDATIONS*

Fossil Fuels

Objectives

- *Promote conservation and energy efficient use.*
- *Reduce dependence on foreign oil.*
- *Reduce the average cost premium which New England pays for its fuel compared with the rest of the United States.*
- *Promote the development of energy resources indigenous to the New England region.*
- *Provide economic assistance to lower income sectors of the region to provide transitional relief as energy costs rise as a proportion of total living costs.*

* The following recommendations have received the unanimous approval of the Supply Committee and await only final approval by mail from delegates for wording changes adopted in November 13 meeting.

Supply Committee

- *Evaluate costs and benefits of all energy proposals in light of their environmental and social impacts and take all steps to minimize or eliminate adverse impacts.*
- *Advise the Congressional Delegation and others involved to feel and act upon a real sense of urgency in implementing the steps recommended.*
- *Balance financial incentives currently in place or contemplated for fossil fuel exploration, production or processing and nuclear electric generation with comparable incentives directed to New England's needs in support of conservation, reduction in demand and development of alternative energy sources.*

The committee believes that specific policy proposals should meet the test of promoting one or more of the above objectives. In reviewing the prospect for the transition from oil dependence to the energy alternatives which will be required in the next century, the committee endorses action to promote conservation and energy efficient use. It also endorses a research and development program to reduce the cost of and demonstrate alternative energy technologies to the use of fossil fuels, particularly those which offer the most promise for indigenous development to the New England region. It also recommends early clarification of uncertainties which presently cloud the nuclear program. Fossil fuel requirement projections for the region, especially for coal, are largely dependent on the degree to which current nuclear capacity is expanded; which in turn depends upon the future cost of its regulation.

With regard to policies directly affecting fossil fuels, the committee recommends those which will help to:

- *Stimulate U.S. oil and gas supply to reduce import dependence.*
- *Remove subsidies to producers and consumers which tend to increase the cost differential of the New England region and make it more difficult for alternative energy sources to compete.*
- *Ease the international oil demand/supply balance so that the future needs of the region which still have to be met by imported oil will be met at reasonable cost.*

Recommendations

I. Natural Gas

The committee supports the deregulation of natural gas now. Regulation has: (a) reduced the national availability of natural gas, severely limiting the amount obtainable by states furthest from producing areas such as New England states; (b) subsidized consumers and inflated non-priority use demand in states in closer proximity to producing regions. Consequently, gas makes up 8% of New England's energy supply compared with a U.S. average of 27%. The committee believes that we should work towards a target of 25% of supply by the year 2000.

In addition to phased deregulation, the committee recommends the following.

7) Regional State and Local Initiatives

- A) *Encourage state public utility commissions to create incentives for gas utilities to make investment in subsidies to develop their own gas supplies.*
- B) *Encourage state public utility commissions to allow promotion of increased use of gas as a substitute for oil and electricity, when economic, to the extent that additional gas supplies can be obtained.*

Supply Committee

8) Federal Initiatives

- A) *Establish a mechanism whereby New England's gas companies would be guaranteed pipeline transmission of gas supplies which they develop outside of the region.*
- B) *Expedite purchases of Mexican and Canadian gas and planning for an Alaskan gas transportation system.*
- C) *Provide federal loan guarantees for commercial scale high-BTU coal gasification and liquefaction plants and encourage the rapid development of environmental standards for such plants.*
- D) *Facilitate and streamline regulatory approval process for new gas projects and in particular determine a federal policy for the import of liquified natural gas including facility siting and safety standards, and transportation safety standards.*
- E) *Remove pricing limitations on availability of feedstocks for synthetic natural gas manufacture to permit the economically efficient utilization of feedstocks. Remove the limitations on those hydrocarbons used for synthetic natural gas manufacture.*
- F) *Establish a prototype peat gasification process in cooperation with a Maine utility.*

II. Indigenous Fossil Fuel Resources

- 9) *Incorporate in the D.O.E. budget a program to evaluate the Narragansett Coal Basin. A 7-year program at an approximate cost of \$10 million is proposed for 650 drill holes to an average depth of 1,000 feet supplemented by related downhole and surface geophysical studies. This program would establish whether commercial development of this potential resource is feasible.*
- 10) *Proceed with the orderly exploration and development of North Atlantic potential oil and gas reserves. Prior to so proceeding, the Department of Interior (DOI) shall acknowledge the importance and uniqueness of Georges Bank as a fishery and shall implement administrative actions to coordinate consideration and design of a leasing program on Georges Bank with the Department of Commerce and New England Regional Fisheries Management Council. A Georges Bank Lease Sale shall be subjected to all sections and requirements of the Outer Continental Shelf Land Sales Amendments recently enacted, and all regulations necessary to fully implement the Amendments shall be finally adopted prior to the Lease Sale.*
- 11) *Establish a federal program for exploration and evaluation of Conway (N.H.) and other uraniferous and thorium-bearing granites to determine the feasibility and steps necessary to their development as fuel sources. This program would establish whether commercial development of this potential resource is feasible prior to the time that any commitments are made to private development on federal lands.*

III. Oil

- 12) *Decontrol of crude oil prices is recommended to stimulate U.S. oil supply, encourage conservation, simplify regulation and permit the abolition of the "entitlements" program which, in effect, subsidizes imports to the detriment of development of alternative energy sources. Decontrol could be accomplished by freeing from controls all crude oil except "old" ("lower tier") oil in May 1979. Controls on oil would be phased out by 1984 due to natural decline of these reservoirs. To stimulate investment in old fields to increase recovery, oil produced in volumes above a rate approximating the*

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natural decline rate should be free of controls. Decontrol shall be subjected to requirements that ensure the reinvestment of their proceeds in exploration, and development and production of domestic sources of energy.

- 13) Imports of refined products into the United States are heavily concentrated in the New England region, particularly residual fuel. The committee supports a free market in refined products in which imports should be allowed to compete equally with U.S. sourced refined product. If on grounds of security or other reasons, federal policy protects or otherwise subsidizes U.S. refiners, the New England region should not be penalized. Exemption relief should be offered or a comparable subsidy made available to development of alternative energy sources in this region.
- 14) The development of additional refining capacity on the East Coast of the U.S., if economic, is desirable provided an environmentally acceptable site can be found. The committee notes that the Pittston project, as presently proposed, may be inconsistent with the plans for a tidal power project.
- 15) Funds should be appropriated to restore the national strategic storage system to its originally proposed timetable. Steps should be taken to establish as a part of the total system residual fuel oil storage easily accessible to the New England region with adequate environmental safeguards.

IV. Coal Burning Regulations

The following recommendations are designed to minimize the public health dangers associated with coal burning:

- 16) Encourage the speedy development of National Air Quality Standards for fine particulates, sulfates, and acid nitrogen particulates.
- 17) On new coal plants require the application of Best Available Control Technology (BACT) for sulfur and particulate controls.
- 18) Encourage utility experimentation with fabric filtration for particulate control.
- 19) Fund research to utilize the existing data base for determination of health and environmental consequences of coal combustion—then determine need for additional data.
- 20) Focus international attention on CO₂ buildup in the atmosphere.
- 21) Provide additional funding to research the relationship between the emissions from coal (e.g. NO_x) and photochemical oxidant pollution.

V. International Policies

- 22) Oil Sharing—Because of its dependence on imported oil, New England's representatives should support international programs designed to share available oil supplies during an international supply shortage. Particular attention should be devoted to the allocation of product supply during any shortage.
- 23) Non-OPEC Oil Production—The development of oil and gas in non-OPEC countries should be encouraged. In particular, the United States must avoid measures and regulations which place U.S. oil companies at a competitive disadvantage with foreign firms in the development of overseas oil deposits. For example, the U.S. should retain foreign tax credits and avoid constraints on foreign investment.

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- 24) *Natural Gas—The increased use of natural gas will mean an increase in international LNG trade and the construction of major international gas pipelines. New England should support measures which increase the safety and lower the cost of both.*
- 25) *International Economic Integration—Sudden OPEC oil price increases which disrupt the world economy can be discouraged by integrating OPEC countries into the world economy. Increased OPEC foreign investment also has the potential for stimulating economic growth and should therefore be encouraged.*

Nuclear

- 26) *The nuclear and coal options for future electricity generation should not be foreclosed. Alternative energy sources and the technologies of conservation should be pushed to their maximum potential. To the extent that a nuclear versus coal choice must be made for a new generating station, all costs— environmental, social, and economic—should be calculated and applied to the decision-making process.*
- 27) *Establish a national waste disposal facility to be operational by the date recommended by the President's Interagency Review Group (1988-1992) for disposal of high level nuclear waste. If such a facility is not operational by 1988-1992, a moratorium on starting new nuclear power stations should be called.*

Alternatives

Assumptions

- Demonstration projects constitute the best means of developing the additional data needed to better assess the engineering and economic feasibility of alternative energy development programs.
- In order for New England to efficiently develop an adequate energy supply, a strategem should be prepared which would properly consider every indigenous resource in terms of its potential contribution to the region's energy mix. A diversified renewable mix will insure a certain degree of reliability and eliminate overdependence on one single source.
- Economic constraints are the major factors that significantly limit the utilization of most renewable resources.
- Promising alternative sources should be elevated to a level of development, or a critical mass from which their potential contributions can be realistically ascertained for the region.
- Because of its overdependence on foreign oil, New England should have a greater than per capita allowance for alternative energy development. The technical and scientific expertise is available; however, monetary assistance is needed as a catalyst to researchers, developers, municipalities and state and federal agencies.

For these reasons and by virtue of its significant amount of indigenous resources, New England should therefore be placed at the forefront of alternative energy development in the U.S. and serve as an example for similar efforts elsewhere.

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Recommendations

General recommendations selected on the basis of funding priorities are listed below. Specific proposals for the development of individual resources are enumerated separately in the Documentation section.

- 28) *Subsidize state-of-the-art alternatives as necessary to expedite their market development.*

A) *Demonstration Projects*

- i) *200 MW of wood-fired generating plants: one 50 MW plant in each of the northern New England states: Maine, New Hampshire and Vermont; one 50 MW total from several smaller plants in Massachusetts, Connecticut and Rhode Island. Cogenerate steam wherever possible.*
- ii) *50 MW of wind generation; 18 two MW stations and smaller machines at federal installations, such as airports and Coast Guard stations*
- iii) *80 MW of small resource recovery solid waste plants. Construct five plants consuming 200 tons per day. Cogenerate steam. Construct two in Massachusetts, two in Connecticut, and one each in the other four states.*
- iv) *One tidal and nine low-head hydro installations.*
- v) *Six installations of biomass methane digestion. Two of each on farms, lumber mills and waste disposal sites.*

B) *Direct Application*

- i) *Solar — Three-tiered approach providing high subsidies to poor households and low subsidies to upper income households should be substituted for the present tax credit system.*
- ii) *Wood — Systems study to determine harvestable resource, constraints to development and optimal forms that wood energy should take for appropriate end-use application.*

- 29) *Support prototype construction and development studies in New England of certain alternative energy source.*

- A) *Systems study of region to determine optimal placement, size and economics of refuse recovery plant producing steam and/or electricity.*
- B) *Study the production of methane and its integration with the gas distribution system in New England.*
- C) *Conduct appropriate R & D programs in areas directly related to the near-term implementation of renewable energy systems in general; e.g., energy storage.*

- 30) *Resolve the interface issues between alternative energy sources and the current energy system.*

- A) *Establish a just and reasonable rate for small power producers, including the sale of surplus energy and the purchase of supplementary energy.*
- B) *Revise the public utility commission guidelines for reviewing alternative energy systems.*
- C) *Determine the associated business and employment benefits resulting from the development of alternative energy systems.*

Low-Income

- 31) A combined low-income weatherization and solarization program, where appropriate, should be passed by the Congress. This program should include provisions for labor, materials and administrative costs. The program should be administered by the Community Services Administration and operated by community action agencies. Cost: \$1 billion annually for 10 years.
- 32) Congress should establish an energy assistance program for low-income persons.
 - A) Eligibility should be based upon 150% of federal poverty level guidelines.
 - B) The initial appropriation should be \$2 billion with annual increases tied to fuel and utility prices indices.
 - C) Ten per cent of the appropriation should be set aside for an emergency energy program for the heating season
 - D) Benefits should take the form of cash payments administered by the IRS or HEW.
 - E) Levels of individual payments should be based upon a formula which takes into account age, household income and regional energy consumption.

This recommendation is to be considered an integral and necessary part of the recommendations of the Supply Committee to further deregulate gas and to control oil. In other words, our support for further deregulation and decontrol is conditioned upon firm support for the recommendations described above. Even without further deregulation and/or control, the Supply Committee recommends that Congress establish a permanent energy assistance program for low-income persons, with annual increases tied to the fuel and utility price indices. there should be an initial appropriation of \$200 million.

- 33) All public service or utility commissions in New England should adopt the following National Energy Act guidelines, where not already approved.
 - A) No electric service to an electric consumer may be terminated unless reasonable prior notice (including notice of rights and remedies) is given to such consumer and such consumer has a reasonable opportunity to dispute the reasons for such termination, and
 - B) During any period when termination of service to an electric consumer would be especially dangerous to health, as determined by the state regulatory authority (with respect to an electric utility for which it has rate-making authority) or nonregulated electric utility, and such consumer establishes that:
 - i) He is unable to pay for such service in accordance with the requirements of the utility's billing, or
 - ii) He is able to pay for such service but only in installments, such service may not be terminated.

Such procedures shall take into account the need to include reasonable provisions for elderly and handicapped consumers.

- 34) Regulatory agencies should require electric rate structures which embody the following principles:
 - A) Minimize price increases associated with minimum and necessary basic consumption to the extent that such actions can be cost-justified.

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B) Encourage conservation.

- 35) The Congress should mandate a special modernization fund which is used solely to weatherize and solarize public housing units. Cost: \$500 million annually.
- 36) Through the McCormick Bill, Congress already has authorized \$1.5 billion for R & D and federal government purchases of photovoltaics. A portion of the federal government purchases should be utilized for demonstration projects on the multi-family assisted housing projects.
- 37) Congress should require HUD and DOE to study the economic and institutional feasibility of weatherizing of private rental units without passing the costs on to low-income tenants and community scale solar heating systems, and, if feasible, to set up demonstration program.

SUPPLEMENTAL RECOMMENDATIONS

Alternative Subcommittee

The following recommendations supplement those promoting alternative energy sources that have been accepted by the full committee. These recommendations have been developed by the Alternatives Subcommittee.

I. Wood

- 1) Expand U.S. Forestry Service, county extension service and State forestry departments to:
(1) work with land owners, informing them of environmentally acceptable wood energy harvesting technologies; (2) undertake accurate and periodic region and subregion entire biomass surveys and; (3) work with land owners and wood harvesters teaching good forest management practices.
- 2) Aid utility construction of 50 MW electricity plant using wood chips as fuel by guaranteeing long-term supply, including environmentally acceptable harvesting of nationally owned land if necessary.
- 3) Enact accelerated depreciation for tax purposes to commercial harvesters for new equipment purchases.
- 4) Offer commercial tax credit to facilities installing wood-burning furnaces and stoves.
- 5) Increase funding to educate the public about the virtues and precautions involved in residential and commercial wood-burning for space-heating in regional media.
- 6) Undertake study of environmental impact of substantial wood-burning for space-heating in urban areas.
- 7) Fund a systems study to determine optimal forms which wood energy should take for industrial, utility, residential and commercial use.
- 8) Provide loan guarantees to public and private parties to enable New England to build 200 MW capacity by 1985 in appropriately sized units near the supply, ranging from 5-50 MW.

II. Solid Waste

The following are offered as amendments to these statutes:

- 9) The National Energy Act—Electric Rate Reform (HR 4018—House Report 95-175-, Senate Report 95-1294)—Section on Small Renewable Power Producers, Cogenerators.

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- a) *It is recommended that the "just and reasonable rate" clause be analyzed and determined for any and all classes of small power producers, as defined, within the New England grid. The determination shall include a just and reasonable cost for the distribution and marketing of said power. Hook-up to the grid should be provided and included in the ratebase.*
 - b) *It is recommended that the statement concerning exemption from the Federal Power Act and Public Utility Holding Company Act be immediately analyzed and interpreted such that the conditional exemption be changed to an unconditional exemption. This will not only clear the way for alternate sources production of electricity but also will provide incentives to large utilities to expand supply by building small dispersed plants rather than large centralized ones. In this way, additions to supply by smaller modules will reduce planning problems of over or under capacity and will tend to decrease waste by reducing line loss.*
- 10) Department of Energy Authorization Act of 1978—Civilian Application (PL 95-238) and Resource Conservation and Recovery Act of 1978 (PL 94-580) have heightened the need for an effective and clear understanding of the respective roles of DOE and EPA in augmenting the recovery of energy from waste. The objectives of the EPA program is to provide grants to state and local governments for planning and study activities. The objective of the DOE program is to carry out full-scale demonstrations of recovery and conservation of energy, and the commercialization of alternate energy sources. A Working Committee is being formed to coordinate the missions of the two agencies in energy recovery. A specific national objective of the programs is to process at least 100,000 tons per day by 1985.
- Therefore, it is recommended that New England be designated the first region on which this program is focused. It is further recommended that their goal be to process at least 7,500 tons per day by 1985 in New England—an objective 50% greater than the national per capital goal. It is recommended that this goal include an immediate siting-economic feasibility study of the region considering 1500, 1000, 500 and 200 tons per day installations and the legal and institutional constraints thereto.*
- 11) *Under PL 95-238 Title II (loan guarantee) and IV (municipal support), DOE should support construction of eight small (200-500 TPD) resource recovery plants in New England which generate electricity and cogenerate steam. At least six of these are to be sited in southern New England.*
- 12) *Encourage the development by DOE of combined biomass fuel recovery power plant. Furnace and boiler designs to handle municipal solid waste, wood and sewage sludge (Potomac Electric Power Company, PEPCO's Dickerson Plant).*
- 13) Interface Issue:

Provide loan guarantees to assure construction of planned facilities at reasonable interest rates to attract private capital.

This should supplement Title II, PL 95-238: which provides Federal-State Planning resources for energy buyer long-term take or pay commitments and waste supplier long-term put or pay commitments. Recovery plants require long term commitments for both incoming waste and outgoing energy. Because of the newness of technology, lack of long term commitment of the buyer, the energy buyer may not be willing to enter long term agreements, hereby abrogating adequate revenue streams over the life of the plant. Assurance of waste supply through put or pay agreements by municipalities is often regarded as long term debt obligations—which many times can't be made because of statute or constitutional ceilings.

III. Solar

The following recommendations comprise a funding total approximately equivalent to the current yearly appropriations to nuclear power research and development. While it is recognized that this sum—approximately 3.7 billion dollars—is a sizeable departure from our present commitment to direct solar subsidization, this substantial federal commitment is justified. First, the commitment is justified because, unlike most other alternative and all other conventional fuels, the potential energy generation is unlimited. Second, the limitations to solar development are primarily economic. The best available information indicates that ten doublings of current production levels of solar will enable it to become competitive with oil for space heating. Our recommended subsidy levels should make solar competitive with oil by 1990—after which oil prices are expected to rise sharply. Third, the substitution of solar for oil has important strategic advantages in the event of another oil embargo or supply disruption. Fourth, the installation of solar in low-income homes is a much better long-term investment than fuel grants, which totalled \$200 million for FY 1976. Fifth, the solar industry will generate jobs and dollars which will remain in the region, reversing a damaging and long-term trend of exporting our energy dollars.

The following recommendations are based on three assumptions: (1) Distribution of funds should be on the basis of need. The lowest income should get the highest subsidy per household. The highest income should receive the least. (2) Total funding should be of sufficient size and length of time to assume ten doublings of production. At that point, solar will be cost competitive with oil and no further subsidies will be needed. (3) In most instances, the most cost effective subsidization would be for direct application rather than research and development.

A) Residential Sector

A three-tiered approach providing high subsidies to poor households and low subsidies to upper income should be substituted for the present tax credit system. Following are the details of this program.

- 14) *A low income solarization program should be established, utilizing the current low-income weatherization programs. 2,895,000 poverty homes should have solar systems (e.g. hot water, passive greenhouses, window boxes, etc.) which average \$2,000 per installation. Additionally, 250,000 homes to be retrofitted for solar space heating. Total cost for this segment is \$6.9 billion, \$692 million per year. This is approximately 3 and 1/2 times the present DOE weatherization budget.*
- 15) *Lower middle income (up to \$15,000/year for a family of four) should receive loan subsidies to bring the effective loan rate down to 3% for a 15 year second mortgage. (Example: \$2,500 loan would cost \$26.11 per month at 9 and 1/2%, \$17.28 per month at 3%, government subsidy of \$1589.40. Oil at 50¢ per gallon would cost \$18.25 per month for equal energy use.) The goal should be to install 5,000,000 units. Total cost is \$7.5 billion or \$750 million per year over ten years.*
- 16) *Higher income assistance would be based on sliding tax credit scale ranging from 0 to 50%, with an average of 20%. Total cost would be \$7.2 billion, or \$720 million per year for ten years.*

Results:

18 million homes solarized

\$22.6 billion expended over ten years

\$2.3 billion expended per year over the life of the program

Expect 11% of national installations to be in New England, resulting in 2,000,000 by 1989.

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B) Commercial Sector

- 17) Continue DOE demonstration grants at the level of \$150 million per year until 1985. Total expenditures would be \$900 million.
- 18) Allow accelerated depreciation of solar equipment. The total expected cost is \$14 per square foot installed per year, over a ten year period. The total cost for 144 million square feet is \$10 billion over ten years, or \$1 billion per year over standard depreciation.

Results:

194 million square feet of collectors installed

\$11.5 billion expended over 10 years

\$11.5 billion expended per year over the life of the program

IV. Tidal Power

- 19) Support the construction of a demonstration project as the first step in the development of tidal power. This plan should be implemented in the following sequence:
 - a) conduct a feasibility study of the proposed Half-Moon Cove tidal power project. A request submitted to DOE is awaiting action, (approximate cost \$260,000).
 - b) Coordinate this study with the U.S. Corps of Engineers, who have recently embarked on a three year study of the Cobscook Bay tidal project. This will assure a proper consideration of any innovative design, construction, or operational plan appropriate to the research and development objectives of a demonstration project.
 - c) Streamline the licensing procedure for the pilot plant in order to save time and reduce delays.
 - d) Conduct scientific and technical studies during the actual construction stages of the project; i.e., pre-actual, and post. The areas of investigation should include the following topics: environmental impact, material protection, public utility integration, structural analysis, and tidal dynamics (approximate cost \$250,000/yr. for seven years).
 - e) Partially subsidize the construction of the project in the form of research and development grants, loan guarantees (e.g., inflation indexed bonds) and operating credits (approximate cost from \$370,000/yr. to \$80,000/yr. over a ten year period).
 - f) Continue the planning phases of the larger projects within Cobscook Bay.
- 20) Employ life-cycle cost analysis when comparing the long-term return of a project that uses a renewable supply with a project that depends on a depletable fuel.
- 21) Increase federal grants and/or improve information transfer for research and development in allied fields (e.g., energy storage, more efficient turbo-generator, material protection).

V. Hydro

A) General Recommendations

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- 22) Improve the operating efficiency of old, existing installations in the form of replacements and modifications. This same concept can also be applied to retired plants in need of rehabilitation.
- 23) Increase the number of demonstration projects that include the following considerations:
 - a) The use of high technology for fully automated facilities, control, storage, and monitoring
 - b) Use sound engineering expertise
 - c) Properly designed interface network.
- 24) Standardize hydroelectric generating equipment and develop simplified hydrology, reservoir yield, and power plant capacity analysis techniques.
- 25) Define the public utility commission's role and authority to affect wholesale prices of electricity. Streamline federal regulatory requirement and decrease institutional barriers (i.e., federal/state law, agency policies).
- 26) Classify project cost, especially from the results of pilot plants. Topics that should weigh heavily in this evaluation include the following:
 - a) Life-cycle cost analysis
 - b) Cost of fishway; i.e., developer's or agencies cost.
- 27) Streamline FERC permit application procedures for hydro sites under 5 MWe.
- 28) Identify all New England rivers which are targeted for reintroduction of anadromous fish.
- 29) Relocation of DOE's Low Head/Small-Scale Hydro Program to a more appropriate division within DOE.
- 30) Mandate utility purchase of hydro power.
- 31) Exempt small-scale producers from classification as public utilities.
- 32) Prohibit price discrimination.
- 33) An economic study should be made to determine if and how a subsidy should be used.
- 34) The Department of Energy (DOE) should develop low-cost, low-power turbines/generators, power trains, and interface equipment.
- 35) Some demonstration projects should use high technology, such as storage systems.
- 36) An ecological/environmental study of major river basins should be made to determine the impact of fish ladders on the present fish and wildlife mix.
- 37) "Major disaster" insurance should be included with general dam safety laws, not handled separately.

B) General Measures for Implementation

- 38) Provide low-interest development loans.
- 39) Provide increased funding for low-head turbine design and non-turbine based low-head hydropower technology.

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- 40) *Establish a regional DOE hydropower office to offer technical assistance, to promote this type of development, to coordinate information transfer, and to offer economic assistance.*

C) Specific Measures to Aid Implementation of General Recommendations

Demonstration projects constitute the best means of developing the additional data needed to better assess the engineering and economic feasibility of a small-scale hydropower development program. At least a few of the demonstration projects should be at retired hydropower sites, since these dams offer the best opportunity to quickly and inexpensively construct prototype power houses and concentrate effort and funds on important technological considerations.

In addition to the demonstration program, a research program to develop small-scale hydropower planning, design, construction, and implementation techniques is needed.

- 41) *Develop and refine small-scale hydropower turbine technology*
 - a) *Direct federal research and development funds to the basic study of low-head turbine design*
 - b) *Direct federal R&D funds to the development of non-turbine based low-head hydropower technology*
- 42) *Develop simplified hydrology, reservoir yield and power plant capacity analysis techniques.*
- 43) *Consider major rehabilitation of retired hydroelectric installations*
- 44) *Perform a state-of-the-art study to determine the most effective way to interface small-scale hydropower plants with existing and planned regional grids.*
- 45) *Conduct a short-term study of the relative economic efficiency of alternative electrical generation systems.*
- 46) *Special areas of concern include the following:*
 - a) *Diverting reservoir storage from current use to hydropower production could be inefficient and cause significant economic stress*
 - b) *The ecological impacts of peak load power production by small-scale hydropower plants are possibly significant*
 - c) *The social effects of a small-scale hydropower program are numerous, diffuse, and largely unknown.*
- 47) *Conduct a study to identify and define institutional barriers due to existing federal law, regulatory processes, or agency policies.*
- 48) *Demonstration projects should use the latest state-of-the-art technology for automation, control, storage, and monitoring hydroelectric facilities. Emphasis should be on sites smaller than 5 MW. In those situations where energy storage by means of water storage is not possible, alternate forms of energy storage need to be explored. More data on low-cost flywheels and other energy storage systems need to be gathered.*
- 49) *Cost reduction should be sought by standardizing hydroelectric generating equipment. (i.e., using less completely site-optimized equipment). At the same time, the development of high-rpm power trains for possible cost-reduction potential should be explored.*

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- 50) *The potential role and authority of state public utility commissions to affect wholesale prices of hydroelectric energy should be further documented.*
- 51) *More information about dam insurance availability and costs is needed. The availability of insurance must be assured by some means, if private firms cannot provide adequate and reasonable coverage.*
- 52) *The actual environmental impacts of raising and lowering reservoir levels need to be documented and made known to the general public.*
- 53) *Allocate appropriate funding to encourage the development of small dams, i.e., less than 15 megawatts.*
- 54) *The cost of fish ladders, when required, should be borne by an agency other than the small hydroelectric site developer.*
- 55) *Low interest development loans should be made available to assist the developer.*
- 56) *Federal governmental regulatory requirements for these facilities should be streamlined to reduce cost and time.*
- 57) *Federal research and development funding should be made available to encourage the development of fully automated facilities.*
- 58) *Appropriate laws should be amended to permit life-cycle cost feasibility assessments.*
- 59) *Federal research and development funding should be made available to encourage the development of low cost, efficient, low-head hydroelectric power plants.*
- 60) *The development of the initial sites should be accomplished with sound conservative engineering expertise and in a responsible manner. It is recommended that initial demonstration funding be spent to maximize the sound development of these initial sites.*
- 61) *Federal funds should be made available to the states so that they may better define and streamline regulatory procedure.*
- 62) *Federal funding should be made available to develop suggested technical standards for low cost, effective interface equipment that meets the requirements of small hydroelectric facilities.*

VI. Wind

- 63) *Enact a federal program for the purchase of wind systems, with a portion earmarked for small business; a minimum purchase might include 200 units, with limitations placed on the number purchased from a single manufacturer and the number of systems of the same type.*
- 64) *Curtail federal wind turbine research in favor of increasing research monies for storage batteries, compressed air and hydrogen utilization and other technologies.*
- 65) *Initiate a federally funded program to develop a site inventory of New England, including annual wind data collection program.*
- 66) *Appropriate \$100 million per year for five years for federal purchase and installation of windmills at federal facilities, allocating at least \$7.5 million for New England (at least 3.75 MW per year in New England).*

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- 67) *Facilitate the licensing procedure by establishing definite regulatory and institutional guidelines.*
- 68) *Coordinate related research and development programs through information transfer to assist in the development of off-shore facilities. For example, progress on hydrogen production as a means of energy storage would enhance the economic viability of such an undertaking.*
- 69) *Quantify operating parameters at a demonstration project to take into account public utility integration, cost of operation and maintenance, and to estimate societal attitudes.*

VII. Peat

- 70) *Undertake an accurate study of peat reserves in Maine.*
- 71) *Conduct a feasibility study of a 20-40 MW plant.*
- 72) *Fund an appropriately sized prototype plant in Maine if feasible and environmentally acceptable.*

VIII. Animal Manure

- 73) *Fund a demonstration of an appropriately sized station adjacent to a large chicken farm which cogenerates steam in Maine—\$500,000(est.)*

AVAILABILITY AND COSTS FINDINGS

Each subcommittee has been charged with making availability and costs estimates for 1985 and 2000 for energy sources within their respective jurisdiction. Third, they were asked to project an optimal supply mix for the year 2000. The optimal supply mix agreed to by the full committee formed the basis for the recommendations of the subcommittees, and ultimately, the full committee.

Fossil Fuels Subcommittee

I. Perspective

From the perspective of the Fossil Fuels Subcommittee, even an optimistic New England energy supply projection for 1985 will leave the region uncomfortably dependent upon imported oil (perhaps 80% of our petroleum requirements). In addition, the subcommittee agrees that no single conservation or fuel strategy will significantly improve this situation during the next seven years.

The subcommittee has identified the following factors as central causes of New England's disadvantageous energy situation: the regulation of natural gas, higher costs due to the region's location at the end of the transportation pipeline, the absence of developed economic indigenous fuels, and the vulnerability to an OPEC boycott of significant price increases.

The subcommittee organized its work by fuel sources: coal, oil, and gas.

II. COAL

A. Potential

We are in no danger of running out of coal in this century. President Carter's goal of doubling domestic coal production from 600 million to 1.2 billion tons by 1985 is, however, an unrealistic objective, given the current and expected additional environmental constraints Congress has imposed on coal burning. Coal is America's richest existing energy source—accounting for 90% of all proven U.S. energy resources. Yet New England's coal utilization currently comprises only 1% of the region's energy consumption. During the last twelve years more than 20 N.E. utility boilers have switched en masse from coal to oil for oil's economic and environmental advantages. The Arab oil embargo prompted Congressional passage of the Energy Supply and Environmental Coordination Act in 1974, mandating utilities return to coal-burning boilers wherever feasible. In New England, no one has yet converted back to coal, but NEES is planning conversions in two or three boilers at Brayton Point, Somerset, MA in the early 1980's.

In New England today 11 utility boilers are under Prohibition Orders from the Department of Energy to convert from oil to coal. According to a study by the New England Congressional Caucus' Energy Task Force, we can save 22 million barrels of oil annually if all eleven boilers do convert. This represents 30% of the total oil currently consumed by the utility sector. In addition, seven other boilers have received DOE issue notices of intent to issue prohibition orders. Should all 18 of these boilers convert to coal, coal use would increase by 6.9 million tons. This figure corresponds to a 41% saving of utility oil consumption, or a 7% saving in total petroleum consumed by the region.

There are also over 150 major industrial fuel burning installations in New England. They use about 50,000 barrels per day. At best the subcommittee feels 10% of these could be converted to coal, resulting in an additional 1 million tons of coal burned per year.

Currently nine steam-electric plants are projected to come onstream during the next 15 years in New England, but only one—Sears Island of Central Maine Power, a 600 MW unit—will be coal-fired. It would require about 1.2 million tons of coal per year. Beyond the utility and industrial sectors, coal has no significant end-users in New England. By the late 1980's the most optimistic coal use scenario envisions coal comprising 7% of our region's total energy needs, amounting to approximately 8.4 million tons annually. It appears the most optimistic scenario will not be realized, since only three boilers will probably be converted in this time-frame, unless the nuclear option is eliminated.

By 1985 coal is expected to supply no more than 1-2% of the region's energy needs. Beyond 1985 coal consumption is more difficult to predict. Cost considerations loom critical to any long-term projection. The price of oil, prevailing environmental standards, the development of synthetic fuels from coal, the potential of the Narragansett basin, the demand growth rate and the future of nuclear significantly affect New England's need for coal after 1990.

B. Costs

The economics of coal conversion for both utilities and industrial customers in New England are at best only marginally attractive, even with coal-capable boilers. Existing sulphur emission standards are more rigorous than a decade ago, requiring the burning of more expensive low-sulphur coal or the addition of expensive flue gas desulfurization systems to treat high-sulphur coal. If 1.5 percent medium-sulphur coal can be burned without scrubbers, the fuel cost saving in burning coal might offset the additional costs of operation and investment in particulate control equipment. If scrubbers are required, a 150 MW plant may be forced to spend \$20 million or more in

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pollution control equipment. The addition of scrubbers also reduces the unit heat rate of coal-burning, reducing the plant's efficiency. The fly ash and sludge wastes generated by pollution control's equipment create costly and difficult disposal problems for utilities, many of which lack the acreage for even temporary storage. The failure to control the emissions would result in the release of harmful pollutants into the air.

In previous reports to the Supply Committee, our subcommittee has indicated that the U.S. coal industry will be able to meet any foreseeable demand for coal in New England. The limit to the use of coal will be set by demand not supply. The cost of coal is likely to reflect the cost of mining in the Northern Appalachian region. Beyond 1985 additional mining capacity requirements may cause an increase in current costs of some 10% in constant dollar terms. Because coal is not expected to be in short supply its price, unlike that of natural gas, it is not expected to reflect the cost of alternate imported oil fuel. Competition within the coal industry is expected to maintain stability of prices. However, action by the UMW in successive contract negotiations, action by the federal government on health, safety and environmental control regulations, and action by state governments on severance taxes could eat into the relative cost advantage of coal compared with other fuels and may not be offset by productivity increases. Some allowance has been made for these factors in the following projection but it is recognized that the projection may be on the conservative side.

Coal Price Projections
(\$/MMBTU in 1978 Dollars)

Items	1985	2000
Mining	\$1.15-1.35	\$1.27-1.46
Transportation	.39-.51	.39-.51
Pollution Control	.40-.50	.40-.50
Labor and Regulation	.21-.34	.21-.34
Total	\$2.15-2.70	\$2.27-2.81

For the electric utility market, coal will remain an economic option in many parts of the country and cost pressures are not likely to make it a more expensive option than nuclear in areas close to the coal fields. Should nuclear no longer be economically viable in New England, it would mean that it has ceased to be a viable option in the rest of the United States since it is in New England more than in any other region that coal will have the greatest difficulty in providing competition.

C. Synthetics

The technologies for coal gasification and liquefaction are developing rapidly, but the costs are still uneconomical. Present estimates indicate that synthetic fuels will cost \$30-40 per barrel by the late 1980's when they become commercially available. Before 1990 they could not contribute significantly to New England's energy consumption. The subcommittee agreed that the benefits of synthetics from coal are too distant and speculative to be counted upon as a major contributor to our energy supply before 2000.

D. Narragansett Coal

The potential reserves, quality and extraction costs of Narragansett coal are still largely unanswered questions. The Weston Observatory estimates that at least 90.5 million tons of mineable coal lie beneath 60 of the 600 square miles in the region. Such a find would represent a BTU value of 1.8 quads of 310 million barrels of oil—one estimated total of New England demand in 1985. Yet the estimates are based on inadequate data—only twenty holes have been drilled to date. The anthracite (high fixed carbon

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percentage, low moisture) coal has been found largely in steeply dipping seams difficult to mine. This pattern, if representative, indicates expensive, unconventional mining techniques.

The quality of coal ranges considerably in the experimental drilling to date. A Portsmouth, RI hole yielded an anthracite low-sulphur, low-ash (10%) 13,000-14,000 BTU coal. Another hole in West Mansfield, MA yielded a high-ash (48.5%) impure coal with a .7% sulphur content. The Weston Observatory estimates the mined coal would sell for \$50 per ton and generate \$4.5 billion. Mining could not generate significant quantities until at least 1990. Because of the uncertain volume, quality, and mining difficulties, Narragansett coal is not expected to contribute to New England's energy supply before 1990.

E. Contribution to 2000 Desirable Energy Mix

Coal is counted upon to provide about ten million tons per year for New England in 2000. While this is approximately ten times the current consumption level, it represents less than 20% of New England's future base-load electricity needs. Our region's reliance upon coal will be minimal compared to the future utilization of this fossil fuel elsewhere in the country. Beyond one New Hampshire plant, Brayton Point conversion, Sears Island, and one or two additional coal-fired electricity plants, the remainder of the coal utilization will be confined largely to industrial boilers.

III. Oil

- A. Diminishing our reliance on foreign oil is a priority. The weight of world opinion on the U.S. to cut our oil consumption in order to reduce the pressures faced by other countries competing for a limited OPEC supply, and our own difficulties generated by a worsening balance of payments situation militate for a strong policy redirection. The subcommittee is agreed that our reliance on foreign oil is a major hindrance to the region's improving its energy cost-competitiveness with the rest of the country. Oil represents 80% of New England's energy use versus 47% for the nation as a whole. Imported oil accounts for 79% of New England's petroleum use, versus 45% for the entire country.

The lack of cheap natural gas and coal are the primary factors responsible for making New England's energy costs 30% higher than the rest of the country, and explain our disproportionate reliance upon imported oil. The subcommittee is seeking to reduce our reliance on foreign oil without further exacerbating our cost-disadvantage with the rest of the country.

B. Availability

In 1976 we consumed 409 million barrels of petroleum in New England, or about 1.1 million barrels per day. Congressional Research Service estimates of 1985 U.S. oil and natural gas liquids production range from 9.5 to 13 million barrels of oil per day. Today we produce about 10 million barrels per day. In 1970 we used 11 million barrels daily.

The high 1985 figure assumes locating new fields in the frontier area of the lower 48 states and Alaska. Estimates of total oil reserves yet to be discovered range from a high of 590 billion barrels (USGS 1962) to a low of 72 billion barrels (Hubbert 1974). The oil companies' estimates range between 88 and 118 billion barrels. Higher than predicted price rises may increase the level of estimated economic reserves. The Department of Energy and Exxon estimate domestic oil production will be between 9.9 and 9 million barrels per day respectively in 1985; they estimate that 10.9 million barrels per day of imported oil will flow into the U.S. in that year. Today the figures are 9.5 million barrels domestic and 6.1 million barrels imported oil per day.

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C. Costs

The subcommittee has reviewed a representative sample of international oil supply forecasts for the period 1978 through 2000. It has rejected the most pessimistic (CIA) and optimistic (Stanford Research Institute) of the forecasts. The remainder predict that oil supply will be adequate to meet demand at current price levels for at least a decade. Eventually the supply situation will tighten to force an upward movement in prices in constant 1978 dollars. (Prices in current dollars are expected to move upwards with inflation throughout the period.) The subcommittee recognizes that it is very hard to predict when this supply tightness will occur. It could be as early as the late 1980's and as late as the late 1990's. It considers the most likely scenario to be the average of the forecasts and typical of more recent forecasts which would indicate tightness developing in the mid-1990's.

Such a scenario would suggest a constant price for oil in 1978 dollars until 1995 with a substantial increase thereafter. However, the subcommittee believes that in order to avoid a sharp jump in prices in the mid-1990's, OPEC with the tacit consent of the U.S. and other consuming nations will begin to increase the real price of oil once the current glut created by initial supplies from Alaska and the North Sea has been absorbed and the balance of payments between oil producers and consuming nations have been brought into better equilibrium. The subcommittee believes that some increase in the price of oil in 1978 dollars is likely to occur from 1983 onwards.

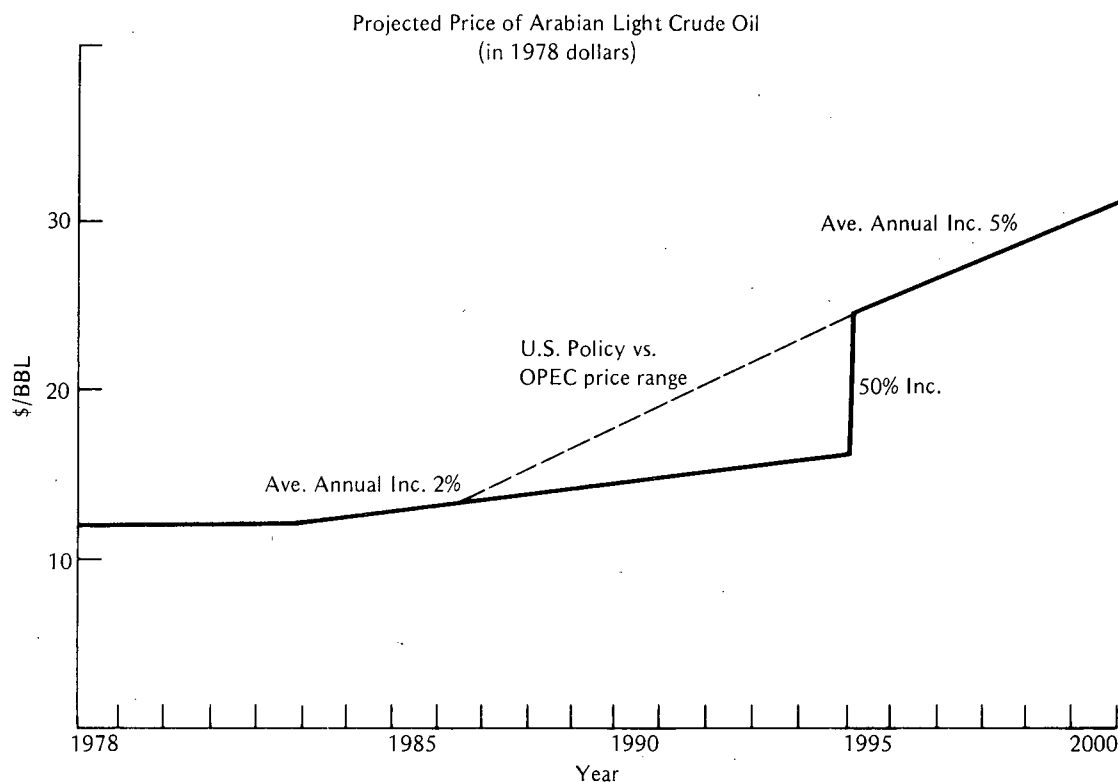
Accordingly its price forecast is as follows.

**Oil Price Forecast 1978-2000
(In 1978 Dollars)**

	Arabian Light		#6 Fuel Oil (.5% Sulfur)		#2 Heating Oil		Unleaded Regular Gas
	\$/Bbl	\$/MMBTU	\$/Bbl	\$/MMBTU	¢/Gal	\$/MMBTU	¢/Gallon
1978-82	12.70	2.19	14.88	2.36	48	3.46	65
1985	13.48	2.32	15.79	2.51	51	3.68	69
1990	14.88	2.57	17.43	2.77	56	4.04	76
1994	16.11	2.78	18.87	3.00	61	4.40	82
1995	24.17	4.17	28.31	4.50	91	6.56	124
2000	30.85	5.32	36.13	5.75	117	8.44	158

The subcommittee has a further caveat about the adequacy of supplies between now and 1995. Political disturbances, both internal and external, could disrupt supplies from one or more major producing countries at any time throughout this period. Our supply is very fragile depending as it does on the production of a very substantial volume of oil by Saudi Arabia and Iran which supply 30% of the total Free World availability. The subcommittee urges that policy recommendations by the Congress should include measures to reduce the impact of possible supply interruptions.

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D. Contribution to Desirable 2000 Energy Mix

The committee has reduced oil's percentage of the region's total energy needs in 2000 from 80% to about 50% in its desirable fuel mix. Assuming a 1.5% annual growth rate, this still represents about one million barrels of petroleum per day. If the alternatives projected do not achieve their desirable potential, we could expect as much as 1,250,000 barrels daily. Demand for residual oil is expected to decline slightly as we supply future electricity stations with nuclear, coal, and alternatives. Gasoline demand is similarly expected to decrease slightly during the next twenty-two years. Slow population growth, the tougher EPA standards, and higher gasoline prices provide the sources for this estimate. Distillate oil demand should remain close to current levels two decades from now. Conservation, direct solar, and natural gas are expected to fill many of the water and space heating functions now provided by distillate.

IV. GAS

A. Perspective

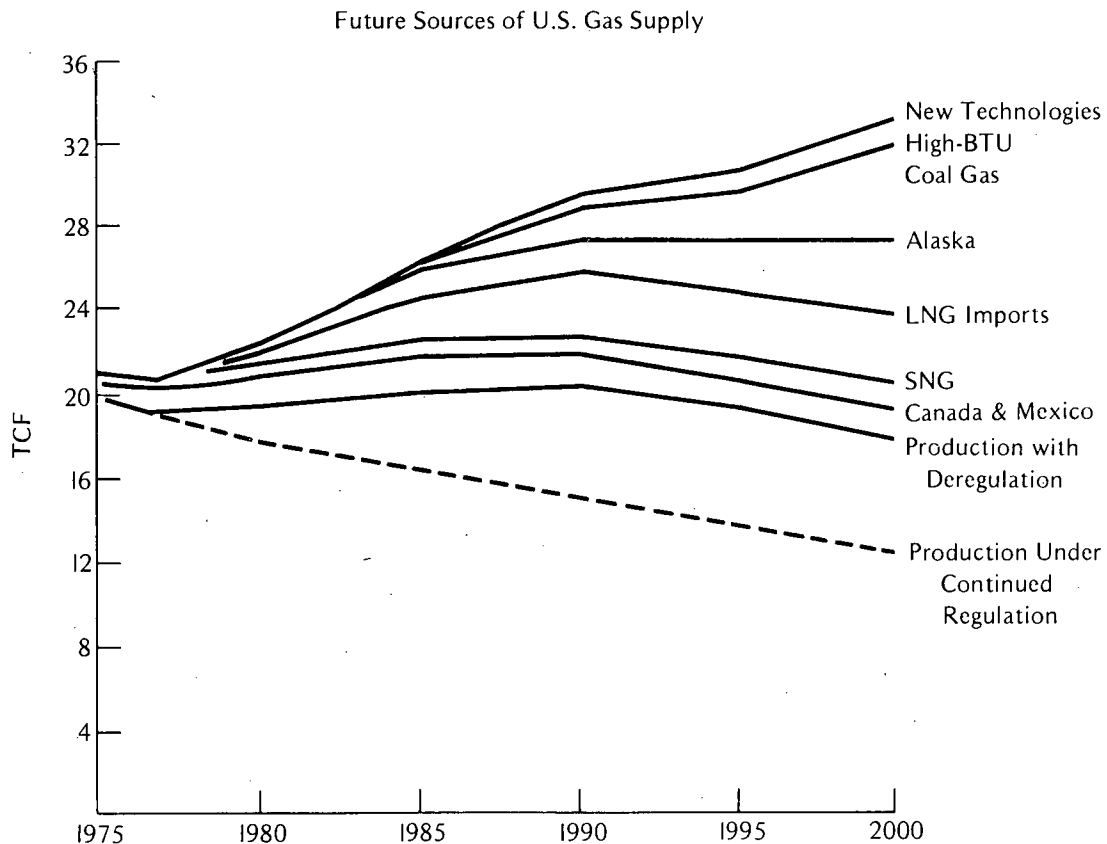
The action Congress has taken to offset the current regulated price structure of domestic natural gas determines to a great extent the potential availability and cost of this fuel to New Englanders in 1985 and beyond. The impact of price regulations upon natural gas has damaged New England more than any other section of the country. Two deleterious effects can be attributed to our legacy of regulated prices: (1) we have gone from a national surplus to a deficit supply situation since 1954; and (2) the allocation of newly discovered gas has been disproportionately channeled into the intrastate markets,

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worsening the shortage for many regions, particularly New England. Our region's inability to procure more than 1/3 of the national average consumption (8% vs. 27%) of the country's cheapest and cleanest burning fossil fuel explains more than any other single factor New England's disadvantageous energy position relative to the rest of the country. Farthest from well-head production, with substantial unused transmission and distribution capacity, New England also pays a great deal more for the scarce gas we do receive: residential consumers pay about 70% more than do consumers nationwide. Narrowing the region's energy cost differential with the rest of the country requires in part: 1) increasing the cost of gas; and 2) enabling our region to purchase more of it as long as it is economical to do so.

B. Availability

In the U.S. gas accounts for 36% of all energy produced today. Estimated U.S. reserves range from 700 to 1200 trillion cubic feet (TCF), enough to supply the country at our current 20 TCF/year rate for 35-60 years. Worldwide recoverable reserves are estimated at 10,000 TCF, or 200 times current annual world production. With deregulated prices, the American Gas Association (AGA) estimates that yearly production would increase 25% in 1985 over today's output, and 28% in 1990. With appropriate federal subsidies unconventional gas resources—geopressed reserves, high BTU oil shale gasification, synthetic natural gas from biomass (SNG), liquefied natural gas (LNG) and others—can contribute 5.5 TCF by 1985 and 14 TCF by 2000. In the year 2000 the AGA estimates that conventional and supplemental gas resources could generate 32 TCF yearly in a deregulated market. This represents 3.2643 quads.



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The New England available potential could triple its contribution to the region's supply by 1985. The existing transmission infrastructure (pipeline) can handle 30% more gas by merely adding more compressing stations to the current pipeline—from 900,000 to 1,200,000 billion cubic feet per day. The 15% of the market which is now hooked up along existing mains can be expanded to 35%. Only 56% of all New England households with gas for stoves and water heating use gas for space heating, compared to an 80% average nationwide. Total New England consumption could increase from the 250 billion cubic feet today to 760 billion cubic feet using the existing distribution infrastructure. This represents the energy equivalent of approximately 1/4 of our current energy consumption.

C. Costs

Today natural gas is expensive relative to the rest of the country: approximately \$3.40 per million BTUs to consumers versus \$2.00 nationwide. The wholesale costs to utilities average 40-65¢ higher than the U.S. average, historically looking closer to the lower end of this range. In 1985, in a deregulated market, gas prices should track #2 oil prices for New England. Assuming 8% infrastructure cost increases yearly, prices to consumers should range between \$5.50 and \$6.40 per million BTUs, depending in part upon the expansion in the rate of gas usage in the region.

In a deregulated market, the well-head price of gas will rise; but if as expected additional availability results there will be savings in distribution costs from greater utilization of distribution facilities. Assuming the natural gas compromise is passed by the Congress, uncertainties will remain as to the volume of additional natural gas that will be produced. If a substantial proportion of additional supplies has to come from LNG imports of synthetics from coal, incremental raw material costs will be significantly higher than projected.

D. Contribution to 2000 Desirable Energy Mix

Deregulation and favorable state regulatory actions designed to promote the use of natural gas in N.E. promise the desirable and feasible potential of the equivalent of 270,000 barrels of oil daily in 2000. This represents a tripling of natural gas's current contribution of 275 trillion cubic feet per year. The committee felt a 5% yearly increase in natural gas consumption should be encouraged to diminish our reliance on foreign oil and allow the burning of the cleanest fossil fuel.

Nuclear Subcommittee

I. Perspective

The role of nuclear in the region is more extensive than in the rest of the country: one-third of our current electricity needs are now met by nuclear, versus 9% for the country at large. Our region's unique energy mix and future energy objectives encourage an even greater reliance upon nuclear from now until the end of the century. Yet nuclear's future is clouded by regulatory delays, cost escalations, safety problems, and citizen opposition. The industry's recent trend of constructing very large plants (1000 MW and larger) also makes planning for new nuclear construction more sensitive to vacillations in energy demand, especially given the long lead time required for nuclear licensing and construction.

II. Availability

The Nuclear Subcommittee has agreed to nuclear's potential for N.E. in 1990 and 2000.

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1978	Potential MW Capacity		2000
	1985	1990	
4189	7569	13,319	15,619

III. Costs

Future costs have consumed most of the subcommittee's attention. The subcommittee estimated the future costs in present dollars of a nuclear plant brought on line in 1990. Since the planning, licensing, and construction period for a nuclear plant requires twelve years, this exercise is relevant for today's planning. Despite three full days of discussion, hundreds of hours of research, and the active participation of several of the region's more knowledgeable people in this field, the subcommittee could agree only a range of bus-bar costs between 3.7¢ and 6.6¢ per kilowatt hour. In contrast, today's generating cost figures reveal that nuclear is the cheapest of the conventional fuels. A utility survey conducted by the Atomic Industrial Forum reveals these N.E. total generating cost figures for 1976: coal 2.2¢; oil 2.9¢; and nuclear 1.5¢. In 1977, nuclear was 1.6¢ and oil 3.2¢.

The subcommittee division on the cost issue reflects a general uncertainty about the future costs of nuclear facilities in New England. Two subcommittee reports, with differing assumptions and methodologies, are included in this report to indicate how the range of costs was determined. The greatest divergence occurs in the projection of capital costs and capacity factors. While nuclear construction costs have increased at a rate of 22% per year, including inflation, from 1970-1976, three members feel the real cost escalation will be less than 3% per year; one estimates a 7% yearly increase in real costs. Capacity estimates are 69% and 60% respectively. These two estimates explain 90% of their differences in final cost projections.

IV. Contribution to 2000 Desirable Energy Mix

The full committee has agreed to a range of nuclear generation from approximately 7600 MW to 15,000 MW for the year 2000. Our region's current nuclear capacity is 4189 MW. The percentages of baseload generation represented by these members are 33% and 66% respectively in 2000. The lower estimate is desirable given a 2.2% electricity demand growth rate and the achievement of the optimal contribution projected for the alternatives. If the growth rate is higher than 2.2% and/or the alternatives do not realize their potential, nuclear's contribution would be larger.

Alternatives Subcommittee

I. Perspective

The subcommittee feels that New England should receive a substantial infusion of federal financial incentives to support the development of renewable energy sources. Specifically, the region requires 12-15% of the national funding allotted for research and development, demonstration programs, loan guarantees and grants for renewables—despite a population

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comprising only 6% of the national total. The subcommittee considers this request both equitable and necessary for three reasons:

- 1) The national objective to reduce our reliance on OPEC oil must focus on New England, which consumes 60% more oil per capita than the rest of the country.
- 2) New England pays higher prices for energy than the rest of the country—26% higher in 1976 than the national average.
- 3) New England, which is resource deficient in fossil fuels, is relatively rich in untapped renewable energy sources. Our potential for wood, low head hydroelectric, solid waste, wind and tidal energy is as promising, or more promising than in the rest of the country. Our economic disadvantage relative to the rest of the country makes direct solar an attractive alternative for the region.

The subcommittee approached its tasks of estimating availability, costs and desirable contributions of renewable energy sources with this premise paramount in their deliberations.

II. Wood

A) Availability

Wood may be New England's most promising renewable resource over the next 25 years. Over 80% of the region is forested and wood grows and rots three times faster than it is harvested. Most of New England forested land is classified as commercial forest (capable of producing more than 20 cubic feet of industrial wood per acre per year). New England has more than 31 million acres of commercial forest land, over 2/3 of which is not owned by forest industries. Wood can be used to generate electricity, process steam, provide district heating, automobile fuel, and heat stoves. Dry wood has an average value of 8500 BTU/lb.

The annual potential yield for the region's forests is staggering: by 1985, New England could provide over 700×10^{12} BTUs from wood heating and wood-electric sources. By 2000, the potential renewable yield rises to 1500×10^{12} BTUs. Mill and logging residues, land clearings, diseased, dead, and undesirable standing trees, thinnings from overstocked acreage, annual surplus growth of tree parts not merchantable and biomass plantations represent the energy sources from New England's wood. Except for the harvesting from land-clearings, overstocked acreage, and diseased, dead and undesirable standing trees—which are harvested theoretically over a twenty year period—the wood energy sources are sustainable. This total includes consideration of two serious barriers to harvesting: negative land-owner attitudes and inaccessible stands. Improved forest management priorities and harvesting techniques could double or triple our harvesting yield per acre by the end of the century.

The cogeneration and small (5-50MW) wood-electric potential for the region has already attracted investors. Burlington Electric now operates a 10 MW wood-burning electricity station, converted from coal, and plans to convert another 10 MW boiler soon. Burlington Electric is planning to build a 50 MW generator, to be completed in 1983. Wheelabrator-Frye proposes four 50 MW biomass plants in northern New England over the next ten years, and New England Electric is interested in building a 50 MW prototype. The potential for the region is estimated to be 1500 MW by the year 2000.

B) Costs

Wood is delivered today for \$60-80 per cord, or \$2.80-3.70 per million BTUs. No. 2 fuel oil is priced at \$3.40, and electricity is \$10.30 per million BTUs (in Maine). In northern New England states the price per cord is closer to \$50 (assuming trucking of 75 miles); in

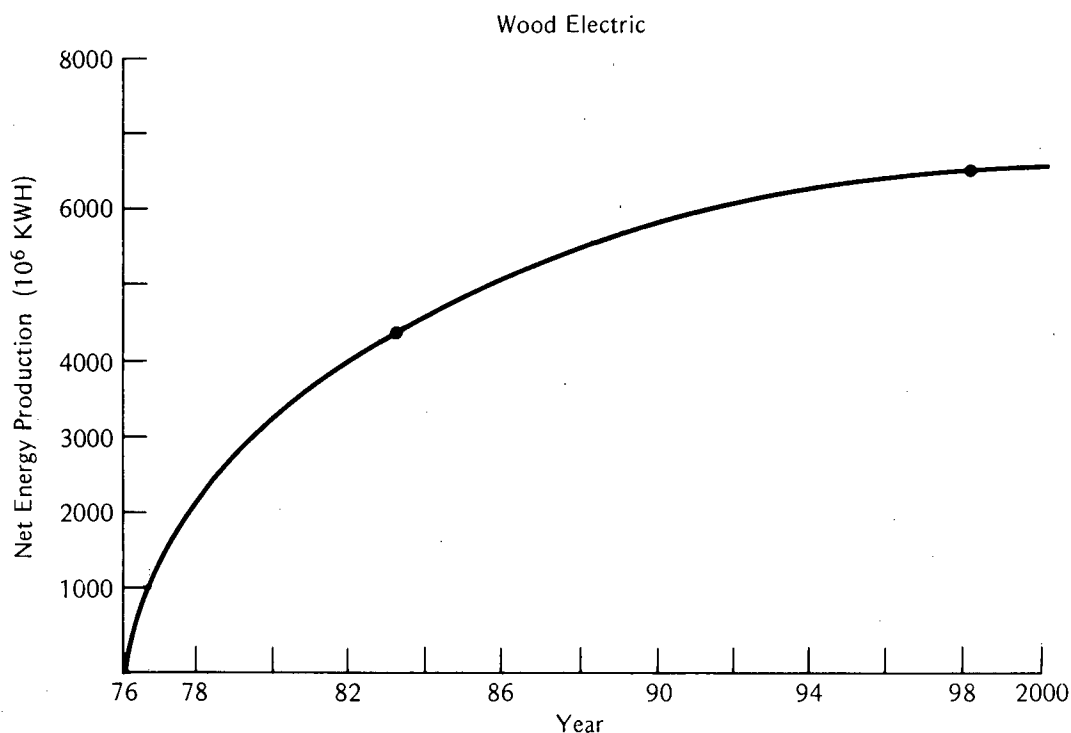
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the southern states \$80 and higher prices are commanded for delivered wood. With a rapidly expanding market all over New England the regional differential should close somewhat in future years. A recent Maine study indicates that new wood furnaces in that state will cost the average homeowner the same as an existing oil furnace in annual costs (\$474/yr.) and a new wood stove costs \$60 more per year than an oil furnace.

Burlington Electric's 10 MW plant costs consumers 23 mills/KWH on a 75% wood/25% oil over-fire basis. They expect their 50 MW boiler to generate electricity in 1983 at 34.7 mills (1978 dollars). Competition with the pulp industry may drive prices up slightly, but real price increases are not estimated to be significant.

C. Contribution to 2000 Desirable Energy Mix

The expected desirable and feasible contribution of wood to our energy mix ranges between 1/5 and 1/3 of the available estimated supply. If wood use grows at a rate of 10% per year from now until 2000 (1977 consumption was 1.1—1.2 million cords), approximately 300×10^{12} BTUs can be generated. If financial incentives are sufficient to build up the infrastructure more quickly, if landowner attitudes change more quickly, and if oil prices increase more rapidly than expected, wood could provide up to 500×10^{12} BTUs yearly to New England's supply mix.



Note: 1. Wood supply is based on harvesting refuse presently being left behind by cutting operations

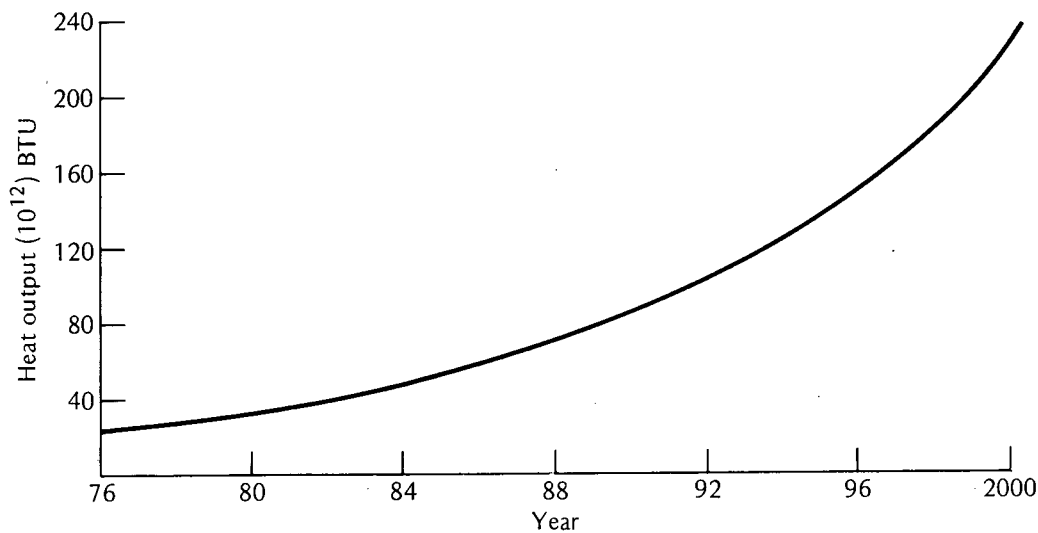
Assumptions: 1955 — 1000 MW, (20) 50 MW

2000 — 500 MW, (10) 50 MW

Capacity Factor: 0.5

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Wood Heating



Note: This estimate is greatly dependent on 1977 base-line figure which could be well below actual amount of wood burned for home and commercial heating.

Assumption: N. E. Total (1977) $1.1 - 1.2 (10^6)$ cords
 $2.3 - 2.5 (10^{13})$ BTU

- 1985 — Assume a 10%/yr growth which translates into $53.59 (10^{12})$ BTU
- 2000 — same growth # $223.86 (10^{12})$ BTU

III. Solid Waste

A) Potential

Electricity generation from urban solid wastes is an economical proposition today. The 1978 market potential for electricity production is 480 MW. By 1985, 730 MW could be generated. This latter figure represents 7.5 million barrels of oil. If all urban refuse in New England was used to fuel electric generating plants, utilities could cut their present day residual fuel imports by 22%. By 2000, 1100 MW, providing 58×10^{12} BTUs of electricity at a 55% capacity factor could be generated.

B) Costs

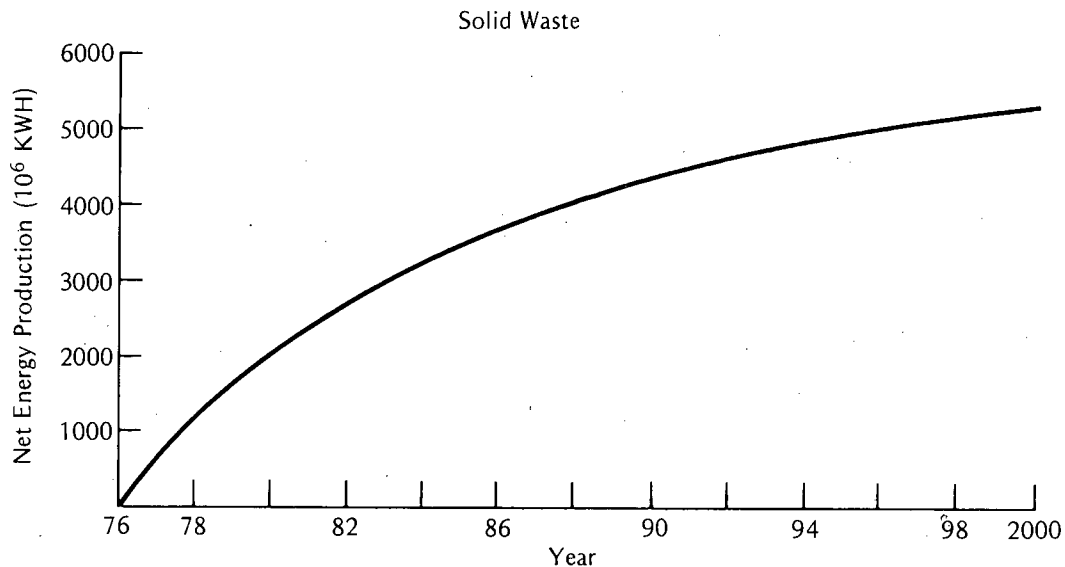
A currently operating 1200 ton per day Saugus, MA plant cogenerates steam for \$2.50 per million BTUs—a cost-competitive figure today. Building future installations which range between 100 (5MW) and 3000 (60MW) ton waste capacities, the region can build approximately 30 plants in the next decade which should generate electricity selling for the same rate as larger scale fossil fuel or nuclear plants. The capacity to cogenerate steam and the additional service performed by reducing community disposal and landfill dilemmas may promise an attractive economic potential for solid waste electricity generation over the next twenty-five years.

C) Contribution to 2000 Desirable Energy Mix

The solid waste contribution to the 2000 desirable energy mix is 55×10^{12} BTUs or 1100 MW of capacity. This is a realizable target if the recommendations suggested are enacted. Such a role for solid waste envisions scores of small (5-10 MW) facilities servicing

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medium-sized cities (50-100,000 population) and an equivalent number of relatively small generators serving a regional catchment area. Additionally, every city or metropolitan area with a population over 100,000 is projected to have a solid waste facility.



Note: 1. 1985 estimates refer to projects presently being planned and considered.
 2. Alternative use of this energy is as waste heat which would supply approximately three times the amount of BTU by eliminating the efficiency of electrical production.

Assumptions: 1985 — 740 MW
 2000 — 360 MW
 Total — 1100 MW

Capacity Factor: 0.55

IV. Solar

A) Availability

Solar hot water and space heating has a large potential for New England's residential and commercial sectors, but federal financial incentives will have to be forthcoming and institutional barriers removed for that potential to be realized. Potential availability, expressed in millions of barrels of oil equivalencies, is estimated for several end-use categories and time periods. Assumptions follow:

Total Potential (in MMBL)						
	RESIDENTIAL		NEW	COMMERCIAL		TOTAL
	RETROFIT			Retro	New	
	Water Heating	Space				
1985	3.8	.6	5.2	2.9	3.5	16
2005 cumulative			23.2		18.4	46

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Assumptions

A) Retrofit—Residential

- 1) 48% of all housing is feasible for retrofitting.
- 2) 5% of this 48% build ft² of solar collectors
- 3) 95% of this 48% build 100 ft² (for hot water heating, 25% efficiency annually).

B) New Housing—Residential

- 1) 75% of new housing will average 1,000 ft².
- 2) housing growth is 2% per year.

C) Commercial Heating; same assumptions as in A and B.

D) Margin of Error 50%

B) Costs

Solar heating is competitive today with electrical resistance heating at \$35/ft². To be competitive with oil and gas by 1985, the price per square foot (construction, operation and maintenance, 25 year life) would have to be down to approximately \$10/ft² to compete with #2 fuel oil. Inflation, fuel escalation and interest rates are three factors which can alter the numbers. Dan Waitroob presents a table of possible subsidies to lower the installed costs from \$20/ft² (or \$8.62 MMBTU) to a competitive level. The subsidies are based on a current \$3.57/MMBTU price for #2 fuel oil and are applied to the total N.E. potential supply (16 MMBL by 1985; 46 MMBL by 2005).

	Inflation Rate		
	0%	2%	5%
Retro	\$ 1,142 MM	1,142 MM	1,142 MM
1985	3,244 MM	3,180 MM	2,750 MM
1995	4,942 MM	4,130 MM	1,752 MM
2005	6,271 MM	3,750 MM	No subsidy required
Total	15,599 MM	12,202 MM	5,644 MM
Per Year	577 MM	452 MM	332 MM until 1995

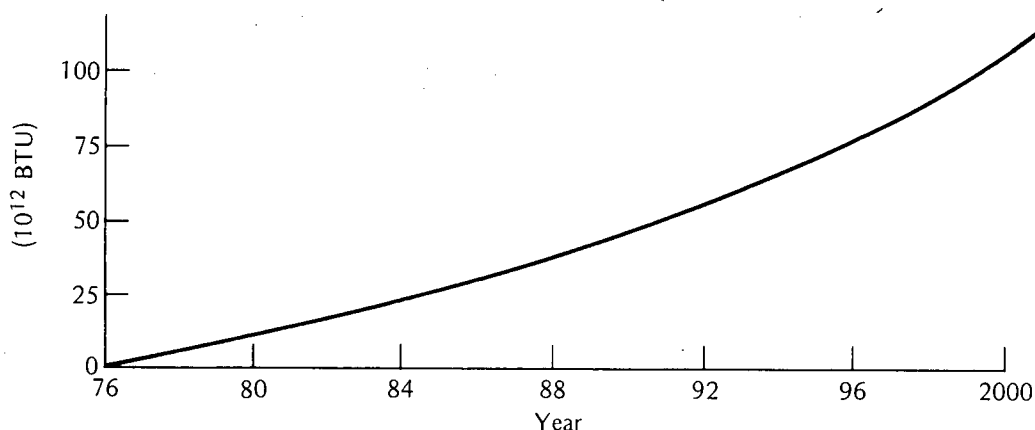
C) Contribution to 2000 Desirable Energy Mix

By the year 2000, 105 x 10¹² BTUs of direct solar energy can be provided to the region, based on the following three assumptions:

- (1) 1.8 million homes (almost 48% of the total) are retrofitted by 2000 for solar hot water; 93,600 homes are retrofitted for space heating (600 square feet of collectors).
- (2) 800,000 new homes (50% of the total) are fitted for solar space and water heating (1000 square feet) by 2000.
- (3) Commercial and industrial sectors receive together 1/10 of the collector space which the residential sector receives.

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Direct Solar



Assumptions: A. 48% of Existing Homes Applicable to Solar Energy 5% Space Heating with 600 ft²
for 1200 BTU/ft²/Day and for 25% Eff. 95% Solar Water Heating 100 ft²

	# of Units	(10 ¹² BTU)
Solar Water Heating	1,749,000	19.64
Solar Space Heating	78,000	5.12

B. 25% New Housing Will Have 1000 ft² of Collector Area

	Units	(10 ¹² BTU)	Retrofit (10 ¹² BTU)	Total (10 ¹² BTU)
1986	214,150	23.45	6.19*	29.64
2000**	747,330	81.83	24.76	106.59

* 25% Complete by 1985

**Cumulative

V. Tidal

A) Potential

By 1985 tidal power could provide a capacity of 12.5 MW of electricity, and by 2000, 380 MW. This capacity could deliver .038 x 10⁹ KWH in 1985, and 1.29 x 10⁹ KWH in 2000. These figures represent .43 x 10¹² BTU and 14.71 x 10¹² BTU respectively, or .07 million barrels of oil in 1985 and 2.35 million in 2000. This potential is based on single-pool systems at Cobscook Bay (U.S. Corps of Engineers International Project, DOE All-American, Half Moon Cove Demonstration Project); one linked-based system utilizing two adjacent tidal basins; a paired basin site, also in Cobscook Bay; and other sites along Maine's upper coast.

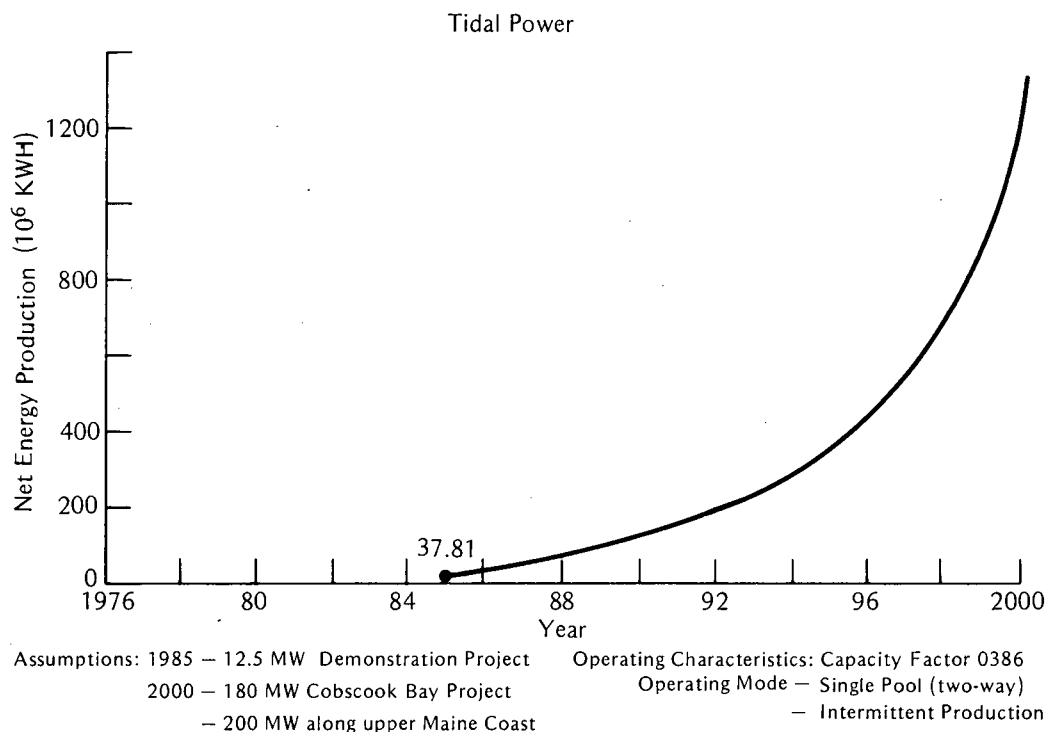
B) Costs

Estimates of average power costs range from 49.6 mills/KWH to 62.5 mills/KWH (\$4.35-5.48/MMBTU). Capital costs, expressed in 1976 dollars, could vary from \$1979/KW to \$3600/KW. Cost discussion requires closer examination of variables and assumptions indicated in Normand Laberge's draft in the documentation section of this report.

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C) Contribution to 2000 Desirable Energy Mix

The desirable contribution for tidal power assumes that all of the planned projects, including an international project, will come on line. By so doing, 34.229×10^{12} BTUs can be generated in electricity from 1212 MW capacity by 2000.



VI. Hydroelectric

A) Potential

The most optimistic scenario envisions 1135 MW new additional installed capacity (of which 750 is Dickey-Lincoln) by 1985, and 1238 new installed MW by 2000. This capacity could generate 2.765×10^9 KWH in 1985. These figures represent 31.52×10^{12} BTU in 1985 and 52.38×10^{12} BTU in 2000, or the equivalence of 5.01 and 8.33 million barrels of oil respectively. This potential aggregates small-scale, conventional and pumped storage estimates. Capacity factors range between .19 and .50, depending upon specific sites and type of project. More detailed capacity and cost information is available in Laberge's draft. Existing capacity is 2694 MW.

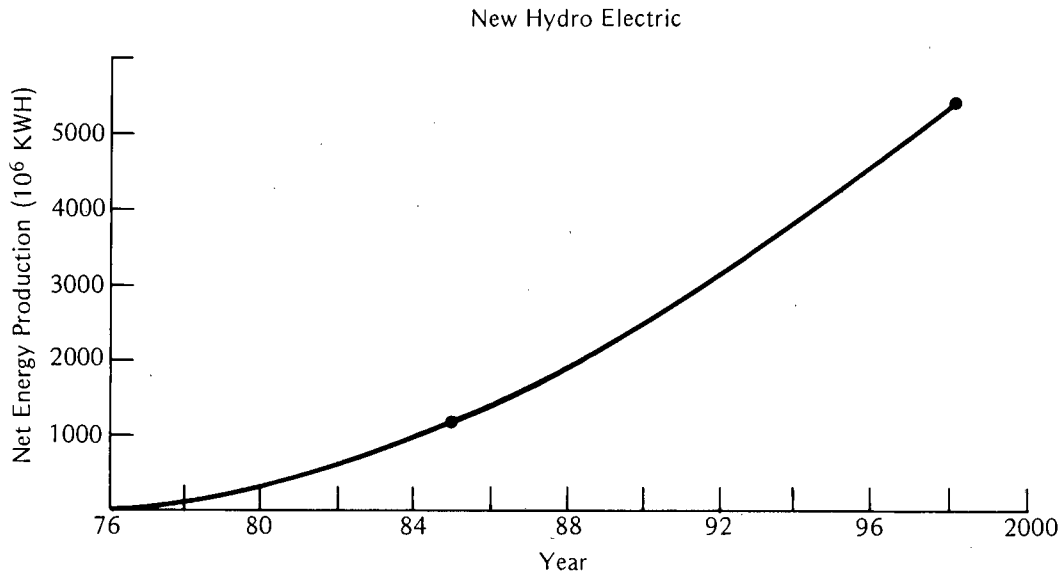
B) Costs

Proposed average power costs for a large project (i.e. Dickey-Lincoln) and a relatively small project (i.e. Black River) are 38.16 mills/KWH and 58 mills/KWH respectively. The existing average power cost is 38.16 mills/KWH or \$3.39/MMBTU.

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C) Contribution to 2000 Desirable Energy Mix

The desirable contribution for new hydroelectric capacity assumes 1200 MW by 2000. (Today we have 1217 MW in conventional capacity and 1477 MW with pumped storage). This total does not include Dickey-Lincoln. It does include almost 500 MW from the best sites identified by the Army Corp of Engineers, and 580 MW from small-scale sites where there are existing dams. The total also includes 400 MW from "marginal" locations. Hydroelectric would generate 38×10^{12} BTUs in New England.



Note: 1. Does not include Dickey-Lincoln Project

2. Assumes that Regulatory and Institutional Constraints are reduced; otherwise estimates of production would lag actual implementation from two to five years.

Assumptions: 1985 — 195 MW, (4) "best sites"

180 MW, small scale

2000 — 195 MW, (4) "best sites"

193 MW, (3) marginal

850 MW, small-scale

Total 1,613 MW

VII. Wind Power

A) Potential

While no new significant installed capacity is expected by 1985, the potential for 2000 ranges between 5400 MW and 10,800 MW. With an average capacity factor of .3, annual electrical output could reach 14.28 million KWH, representing a value of 160-320 trillion BTUs, or displacing 25.5-51 million barrels of oil.

B) Costs

Wind systems today are not yet competitive, and not numerous enough to permit average cost conclusions. The American Wind Association estimates current costs at 10¢/KWH. The industry predicts costs of 1-2¢/KWH by 1984. If their projections are

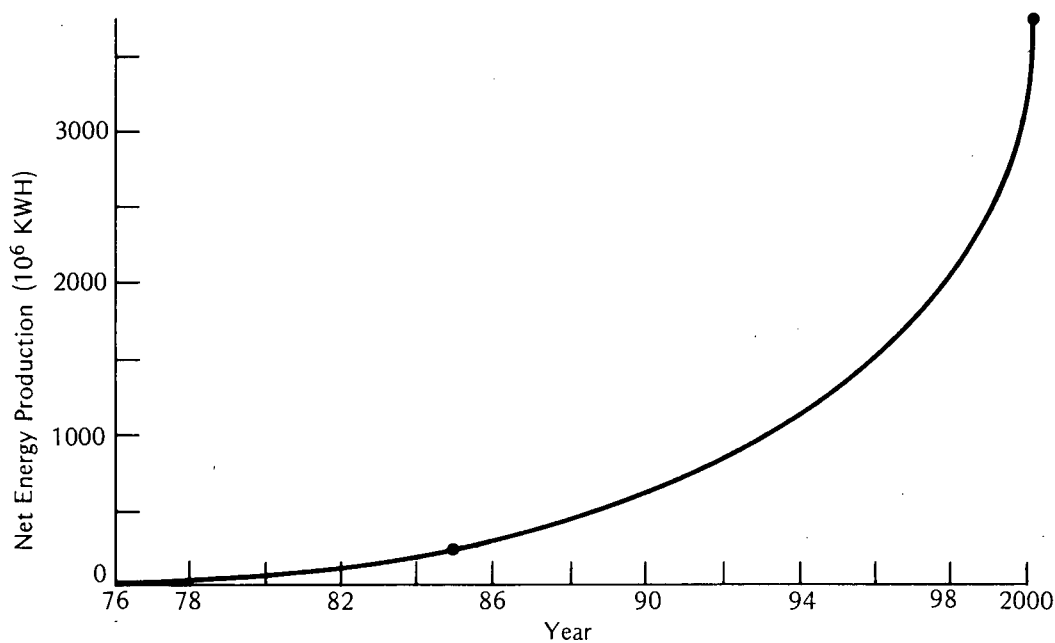
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correct, wind systems will be competitive by 1981. Capital costs are now approximately \$2,000 per kilowatt of capacity; the industry predicts a \$1200 per kilowatt cost by 1985 for newly designed systems and \$750/KWH for mature systems. Larger systems are even more favorably priced: by 1985 prices are projected as \$600-900/KWe for initial systems, and \$400-600/KWe for mature systems. Subcommittee members felt that the industry's projections might be too optimistic, but were unable to find independent evaluations.

C) Contribution to 2000 Desirable Energy Mix

Wind is targeted for 1820 MW by 2000, and 50×10^{12} BTUs of electricity. This total includes 1320 MW on-shore and 500 MW off-shore. The largest units are projected to be 2MW, and most are expected to be much smaller.

Wind — Electric System



Operating Characteristics: Plant Factor, 0.3

Assumptions: 1985 — 100 MW, (50) 2 MW units

2000 — 1320 MW, (600) 2 MW units

Total 1420 MW

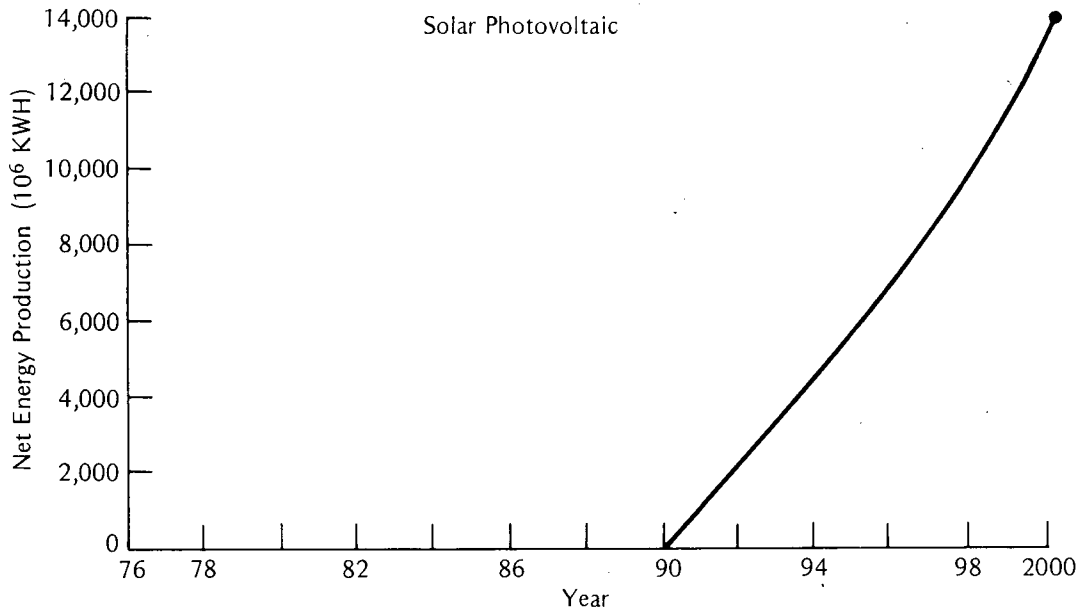
VIII. Photovoltaics

The future deployment depends upon reducing its present \$14 per peak watt cost to about \$0.10-\$1.00 per peak watt. Both the thin-film photovoltaic and the single crystal silicon technologies require further development and larger scale manufacture before costs can be reduced substantially. Small on-site application may be more feasible than large-scale power production, particularly because storage is a larger barrier to adapting this technology to use in power plants. While an American inventor, Stanford Ovshinsky, claims the development of inexpensive material for building photovoltaic arrays which could reduce the price to less than 10¢

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per peak watt, and the Congressional Office of Technology Assessment released a recent study contending that small on-site photovoltaic facilities might be economically competitive with electric heating within 10-15 years, all estimates at this time are very unreliable. Joseph Loferski, Chairman of the Alternatives Committee and a national authority on photovoltaics, estimates that 10% of the region's electric requirements in 2000 can be met by photovoltaic systems. The subcommittee accepted his prediction recognizing its speculative nature.

The subcommittee projected an optimal contribution from photovoltaics of 13.7×10^9 KWH and 142.7×10^{12} BTUs for 2000. Rooftop systems would comprise most of that potential, with less than 100 MW estimated from central power stations.



Note: This figure arrived at from staff conversation with Dr. Joe Loferski of Brown University.

Assumption:— 10% of electricity demand by the year 2000 (for a 2½% growth rate)

IX. Peat

The subcommittee has not undertaken a comprehensive examination of this resource, but a preliminary report indicates that Maine in particular has a sizeable peat reserve. (See Documentation section). Costs have not yet been estimated by the delegates, but the subcommittee does advocate the construction of prototype gasification and electric facilities. Based on their understanding of Ireland's successful experience with peat-electric stations, the subcommittee includes 1000 MW of peat-electric in their optimal supply mix for 2000.

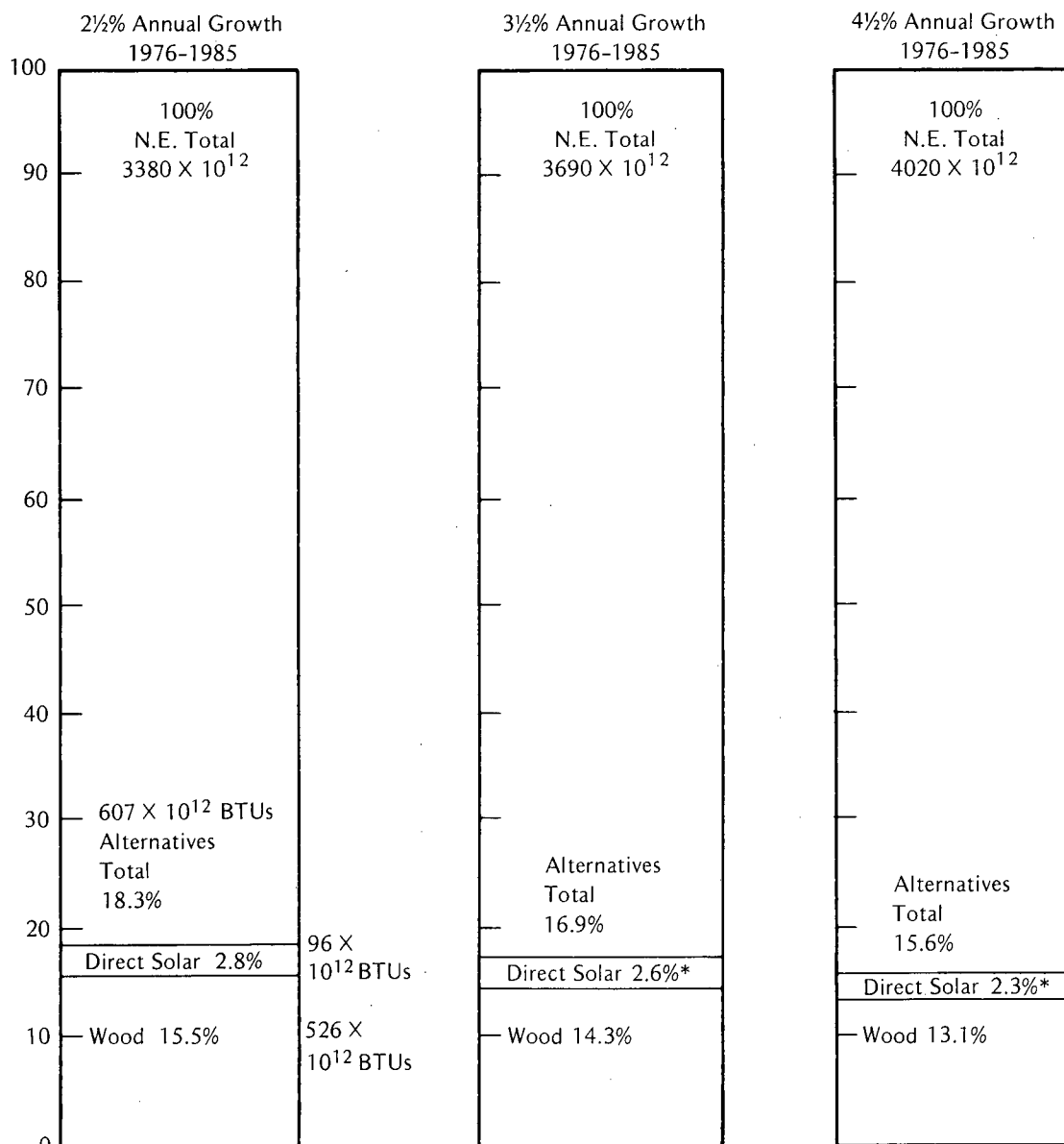
X. Chicken Manure

The subcommittee has only taken a brief look at this energy resource, which promises to be an attractive venture for Maine chicken farms. A Des Moines, Iowa experiment in converting manure by anaerobic digestion to methane for 100 KWH of electricity generation and fertilizer has been very successful. Since Maine chicken manure alone offers the methane equivalent of 54.6 trillion BTUs, the subcommittee is committed to exploring this resource for the region. The committee includes in its optimal supply mix for 2000 $.75 \times 10^{12}$ BTUs from chicken manure.

XI. Alternatives Contribution to Future Energy Supply: 1985 and 2000

The following graphs represent the Alternatives Subcommittee's first attempt at an estimate of their energy sources contribution to the region's energy needs. The numbers are subject to revision, and reflect a maximum technical potential for the region. The potentials do not represent a feasible or desirable total for the renewables. The calculation for the optimal contribution from each renewable source began with their maximum potential numbers and underwent changes as various constraints were considered in turn.

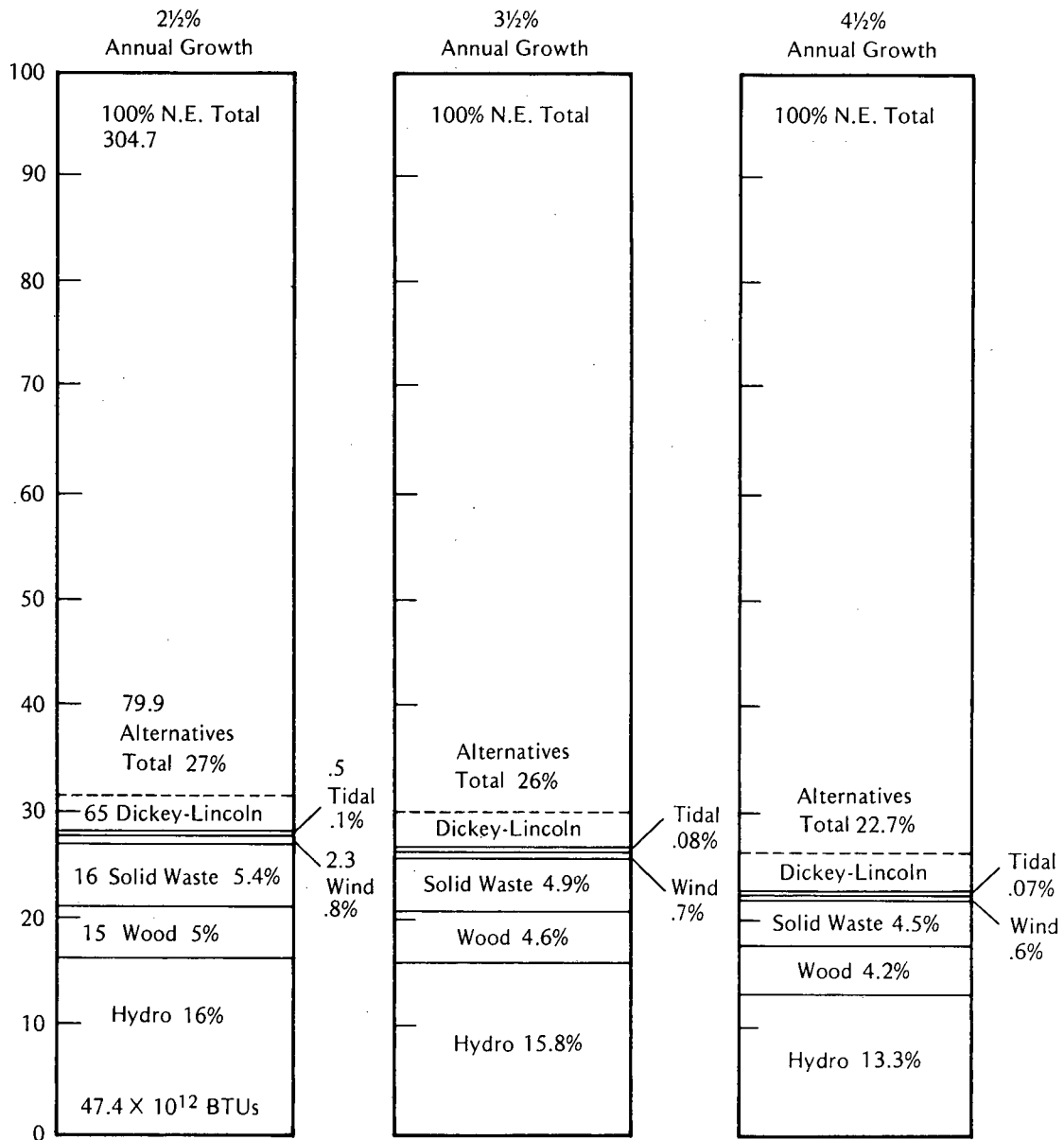
Alternatives Potential Contribution to 1985 Non-Electricity Energy Supply to End-Users
N.E. 1976 Non-Electricity Energy Consumption: 2710×10^{12} BTUs
(pp. 21-22 New England Energy Fact Book)



*Does not account for growth in solar associated with increase in economic growth.

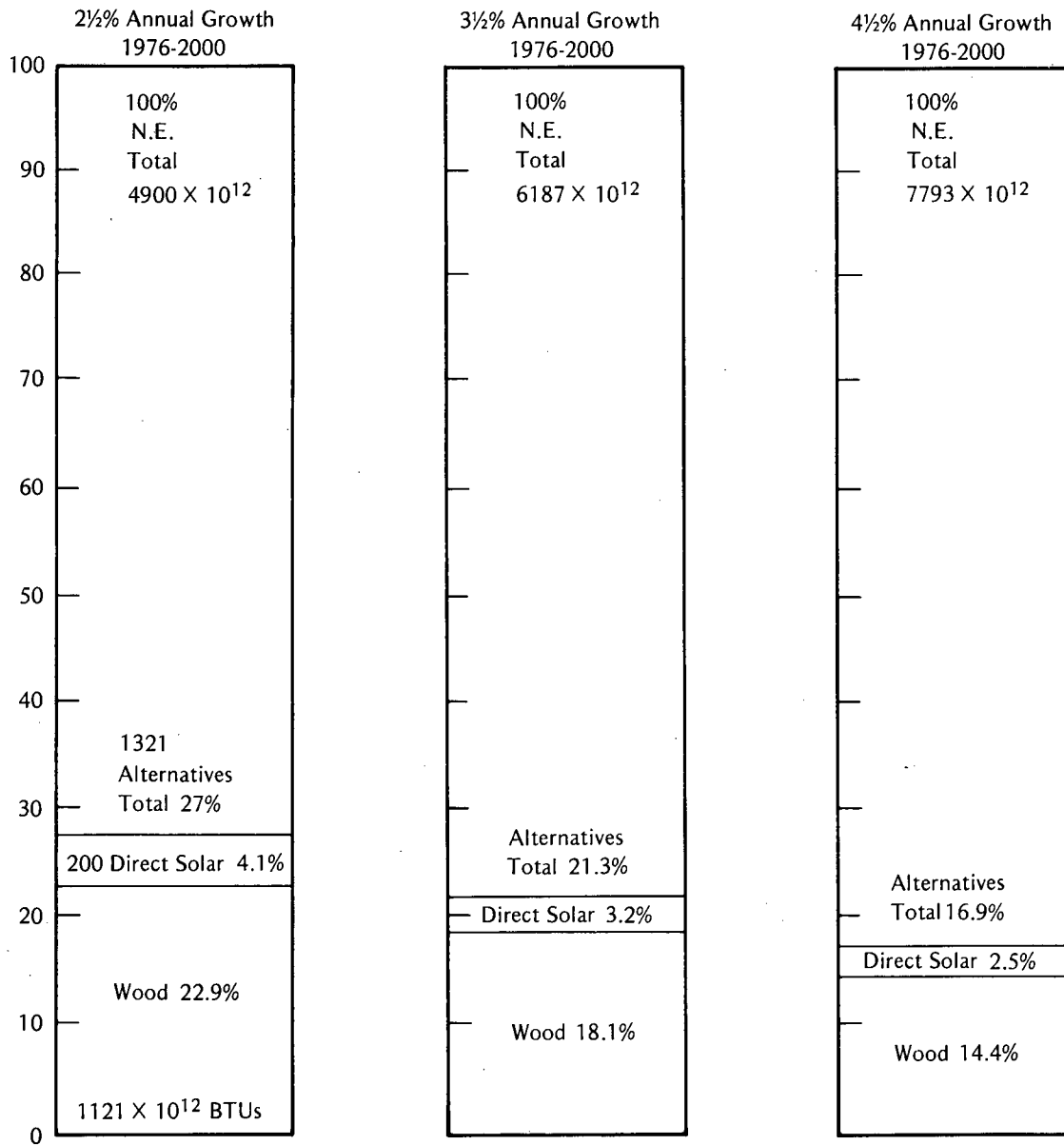
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Alternatives Potential Contribution to 1985 Electricity Supply to End-Users
N.E. 1976 Electricity Production: 244×10^{12} BTUs (N.E. Energy Fact Book)



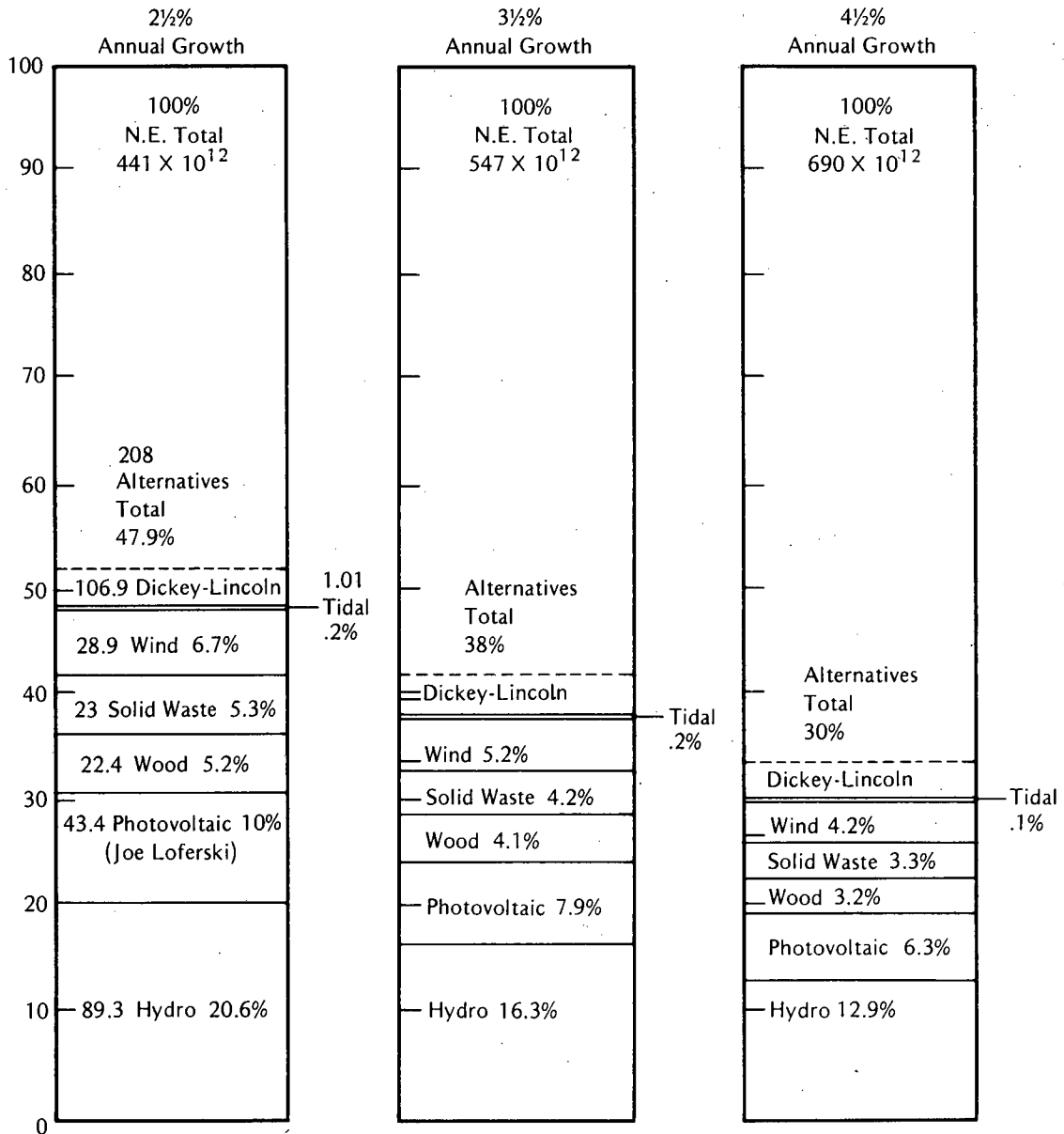
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Alternatives Potential Contribution to 2000 Non-Electricity Energy Supply to End-Users
N.E. 1976 Non-Electricity: 2710×10^{12} BTUs



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Alternatives Potential Contribution to 2000 Electricity Supply to End-Users
N.E. 1976 Electricity Production: 244×10^{12} BTUs (N.E. Energy Fact Book)



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Alternatives Potential Contribution

FUEL SOURCE	1985	2000
	Millions of Barrels of Oil	
Non-Electric		
Wood	87.6	186.8
Solar	13.5	33
Electric		
Photovoltaic	-	7.3
Wood	2.5	3.7
Solid Waste	2.7	3.8
Hydro	7.9	14.9
Wind	.38	5
Tidal	.09	.17
	114.7	254.9

1 BARREL OF OIL = 6,000,000 BTU

Alternative Costs in 1978 Dollars

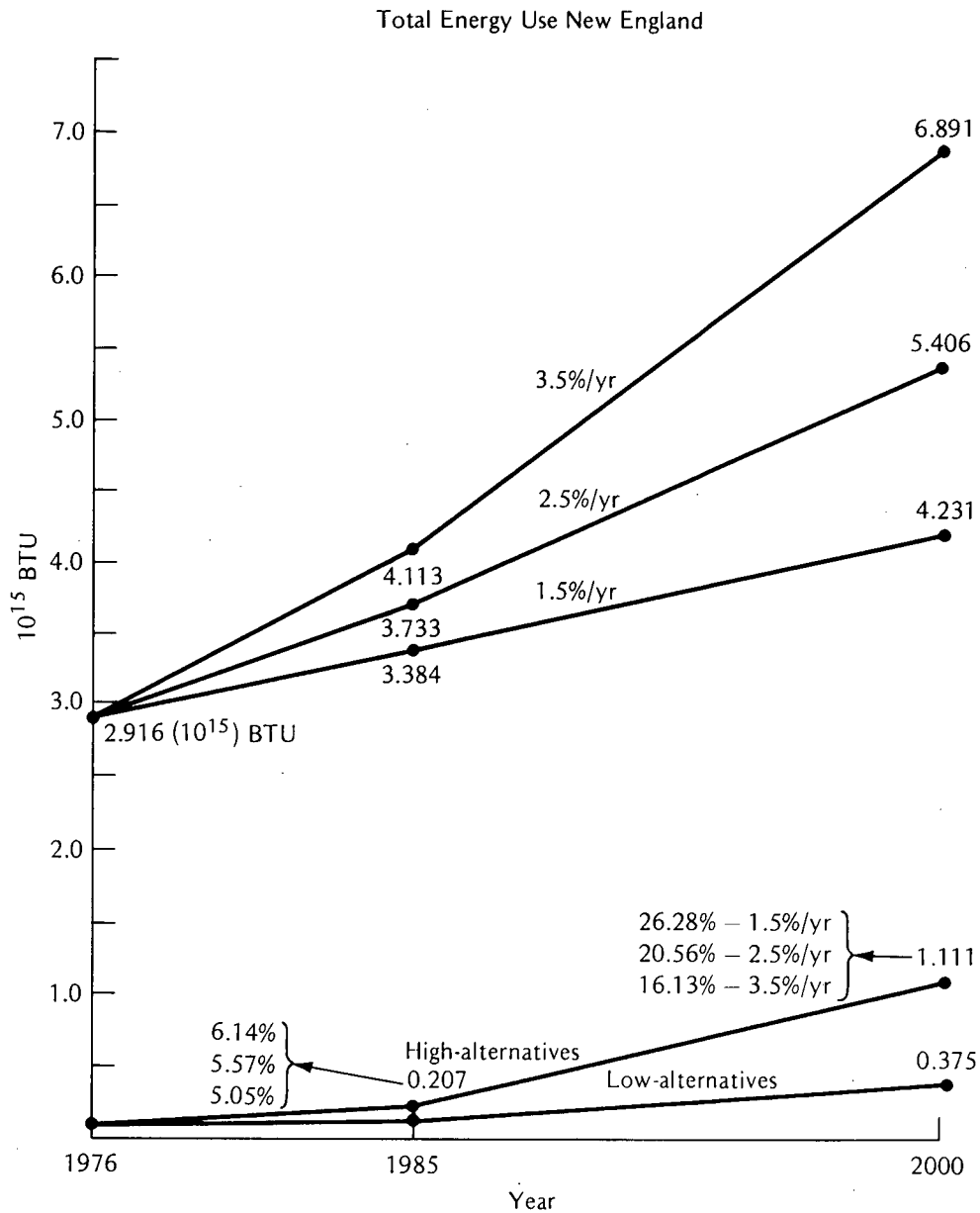
END-USE	1978		1985		2000	
	\$/MMBTU	¢/KWH	\$/MMBTU	¢/KWH	\$/MMBTU	¢/KWH
Non-Electric						
Solar	5-15		8-9	-	8-9	-
Wood	2.80-3.00		-	-	-	-
Electric						
Photovoltaic	-		-	-	13	4.5
Wood	5.25	2.1	6-12	3.5-4.5	12-13	3.5-4.5
Solid Waste	2.5*	3.5-4.5	11-13#	3.5-4.5	11-13	3.5-4.5
Hydro	12-20	5-10	12-17	5-7	12-15	?
Wind	-	-	?	?	?	?
Tidal	16.35	5.65	?	?	?	?

* heat

electricity

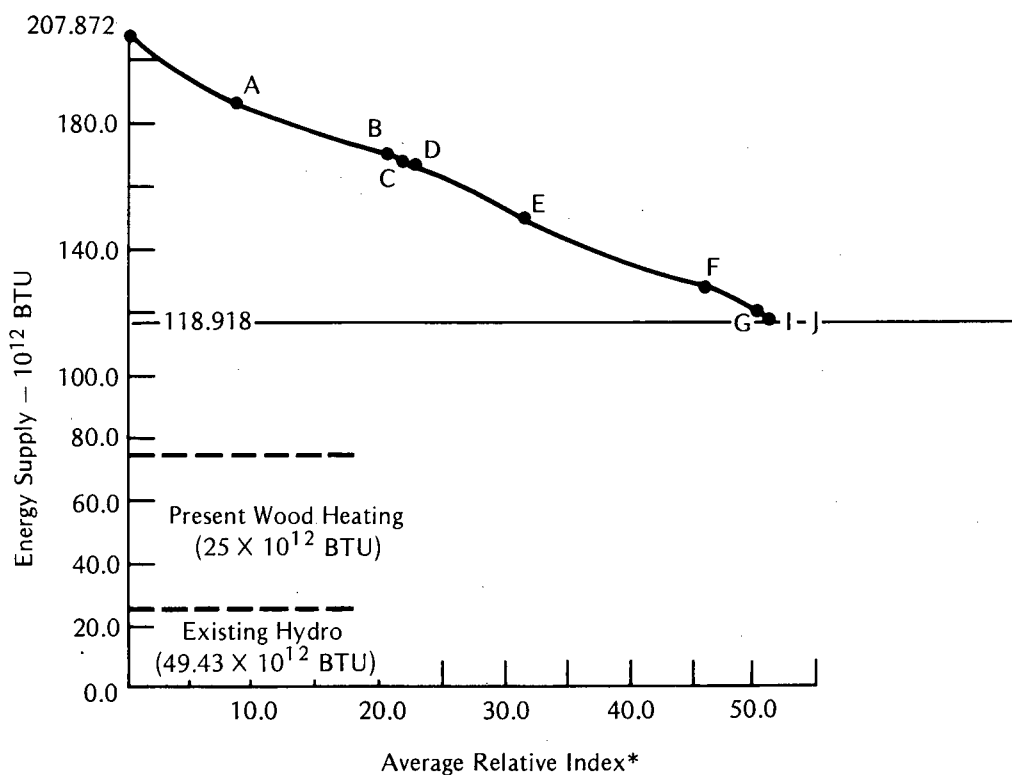
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The next four graphs represent the alternatives contribution to the optimal supply mix agreed to by the full Supply Committee.



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High and Low Alternative Scenario
for the Year 1985



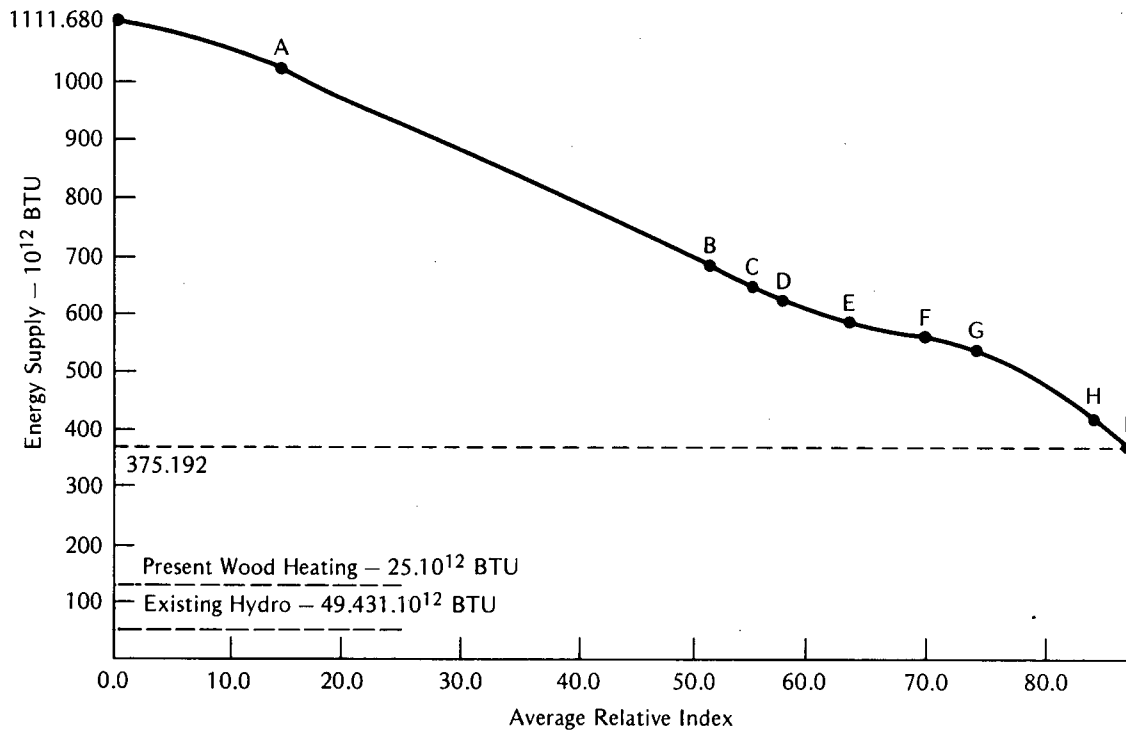
*Defined as the average percentage of the total alternative supply for the high and low scenario for the individual sources

Legend

	Supply Range — 10^{12} BTU			
	Low	High	Low	High
A. Direct Solar	5.337	26.392	F. Wood Electric	14.581 36.442
B. Wood Heating	11.986	28.590	G. Hydro (New)	3.006 11.825
C. Wind Electric	1.362	4.098	H. Voltaic	—0— —0—
D. Tidal	0.247	0.431	I. Peat	—0— 1.600
E. Solid Waste	8.018	24.055	J. Manure	—0— 0.008

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High and Low Alternative Scenario
for the Year 2000



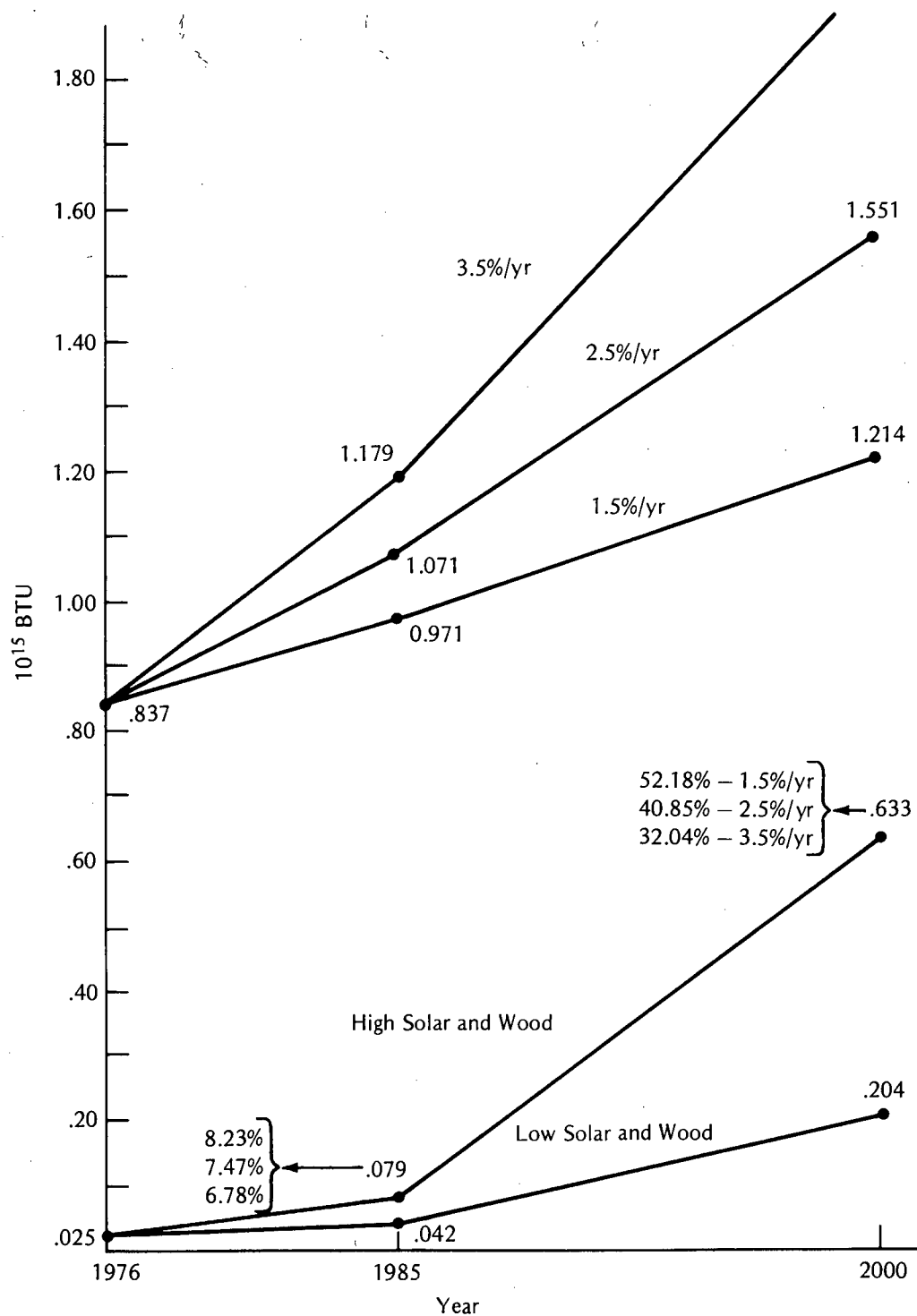
Legend

Supply Range — 10^{12} BTU

	Low	High		Low	High
A. Solar	57.906	143.861	F. Wood-EL	29.162	58.323
B. Wood-HT	146.225	489.655	G. Hydro	18.034	37.908
C. Wind	13.666	49.743	H. Voltaic	28.539	142.600
D. Tidal	6.566	34.289	I. Peat	1.600	50.000
E. S. Waste	24.055	55.120	J. Manure	0.008	0.750
				<u>375.192</u>	<u>1111.680</u>

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New England Residential and Commercial Energy Use*



*Assumes Petroleum, Natural Gas, Coal, other and 10% ELEC.

DOCUMENTATION

The following drafts have been submitted by delegates (there is one staff draft) as individuals or in small groups. These drafts formed the basis for availability and cost projections of each energy source. Some of the drafts also address environmental and institutional constraints, while others do not. Some of the documents also offer legislative recommendations, and others do not. They are included here to provide the explanation for the conclusions reached in the Availability and Cost Findings Section.

Coal in New England

(Submitted by Alan Cope)

Coal was once the leading source of energy in the United States and provided the dominant share of energy supplies to the six New England states as well. Today, although coal still accounts for some 90% of all proven American energy resources, its share of the national energy market has dropped to below 20% of the total and in New England coal today accounts for less than 1% of total energy consumption in the region.

With proven, economically mineable reserves that are sufficient to provide coal for several generations, the prospects for a renewed growth in U.S. coal consumption are excellent. Last year, American bituminous coal consumption was 620 million tons and an additional 53 million tons were exported. Despite production lost during the UMWA strike last winter it is expected that 1978 coal production will approach 700 million tons.

Looking ahead to the mid-1980's it is likely that the U.S. can almost double coal production, approaching 1.2 billion tons per annum within 10 years. Certainly, the resource base and the technical ability to mine coal are present. Any limits to growth in coal use will come from public policy restricting coal burning for environmental reasons, or from consumer preferences for other fuels.

The decline in coal use that has now ended nationally was due to the increased reliance upon less expensive and environmentally cleaner and easier to use substitute fuels, particularly oil and natural gas. Nationally, the electric utilities have become the dominant user of coal, with some three-quarters of total American coal output now going into electric generation. This market dominance is expected to continue for the foreseeable future.

However, in New England, the electric utilities have shifted away from coal onto reliance upon imported residual fuel oil. As a result, the market for coal has almost disappeared. And, unlike other regions of the country, the prospects for a recovery in coal use in New England are not great.

Consider recent history. As recently as 1966, coal was generating half of all New England electricity, and the direct burn by utilities in that year was 9.5 million tons. In 1966, an additional 1.4 million tons was used by other New England industries. Since then decline in coal has reached a point that it is used as the fuel for only 2.5% of the region's electric utility purposes and the total annual burn is below one million tons per year.

Whereas 24 utilities burned coal in 1966, today only the Public Service Company uses coal as a boiler fuel, at their Merrimack, New Hampshire plant.

The use of coal as a residential and commercial fuel has almost entirely ceased in New England. Certain industrial uses of coal remain, but coal accounts for only 0.6% of energy supplied to industries in the region at this time.

A loss of market share by coal can be attributed to the fact that other fuels are easier and cleaner to use and in most cases have been much cheaper as well. Demand for coal is not

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restrained by availability of supplies. All of the current demand for coal in New England could be met with the output of one medium-size coal mine.

Instead of supply constraints, the outlook for increased use of coal in New England will be determined entirely by the attitudes of potential consumers towards coal as a potential source of energy. It is my opinion that we will find few consumers will be willing to voluntarily choose coal as their energy source in the future. Costs are likely to remain unattractive and the environmental and handling problems are certain to remain. Thus, I see no reason to anticipate that coal can ever make an important comeback as a fuel source in New England.

A maximum effort to reconvert those electric utilities capable of burning coal and to bring coal use in major fuel burning installations up to a significant fraction of total requirements could increase total coal consumption in the New England states by perhaps a factor of 10, but even that would mean that perhaps ten years from now, coal will be providing only 6% of regional energy supplies.

Today, almost all of New England's fossil fuel-based electric generating plants use oil. Yet at one time nearly all of them burned coal, and during the oil embargo it was possible for many of them to revert to coal use. The potential for substitution for imported residual oil by coal is significant, but the economic and environmental incentives are not there.

Several electric utilities have been ordered by the Department of Energy to convert back to coal from oil. Eleven utility boilers have been issued prohibition orders that would require this conversion. In addition, seven other boilers have had the Department of Energy issue notices of intent to issue prohibition orders. Should all 18 of these boilers switch back to coal, it would result in an additional coal market of some 7.0 million tons of coal per annum being generated.

There is another prospective industrial market for coal. According to Department of Energy statistics, there are over 150 major fuel burning installations in New England. Their use of oil at this time is about 50,000 barrels per day. This is a small proportion of total oil consumption. Should it be possible to convert, say ten percent of these major fuel burning installations to coal (and that is a somewhat optimistic observation) an annual market for coal of an additional 400,000 tons might be generated. Thus, combining the conversions of the 18 boilers and 10% of the major fuel burning installations with the present use of one million tons per year, we see that total New England coal demand might top 8.0 million tons per annum, about 6% of regional energy use, late in the next decade.

If New England possessed any coal reserves that might be mined if coal prices rose, one could hope that regional energy costs could be improved in the future. However, that is not the case. The only coal deposits in New England are those of the Narragansett Basin in Massachusetts. These anthracite coal seams were mined sporadically up to the early years of the last century, but the seam thickness and the other geological constraints on these deposits make them far too expensive to be cost-competitive with coals from elsewhere.

Despite the enthusiasm of some people about the Narragansett Basin as a prospective coal source for New England, it is the generally-held view in the coal industry that these coal beds are at present too serious an economic and technical disadvantage versus alternative coal sources to offer a means towards alleviating New England's high-cost energy situation in the near future at least.

Thus, it is my conclusion that coal has only a limited potential role to play in helping New England to get lower cost energy supplies, but despite that, coal could become quite a bit more important if certain social and political decisions were made.

If it was decided as a matter of social policy that the use of nuclear power in base-load electric generating plants was no longer acceptable, then it would become necessary for coal to take the place of nuclear in meeting future growth in electric demand.

It is most likely that coal use will not grow that quickly by reconversion, and there are few new big coal-burning projects underway.

At the present time, there are nine steam-electric plants projected to come onstream during the next decade in New England, only one of which is coal. That one, the Sears Island plant of Central Main Power, a 600 megawatt unit, had originally been scheduled to be nuclear, but permit delays forced a switch in fuels to coal. If new steam-electric generating plants in New England were to substitute for uranium, then the picture would alter, although not dramatically, as New England electricity needs are not growing very quickly. Even a 1,000 megawatt plant would require only 2 million tons of coal per annum for its fuel.

The economics of coal conversion for both utilities and industrial customers in New England are at best only marginally attractive, even though the boiler may be coal capable in a physical sense. The cost of meeting present environmental laws is extremely high. Air quality standards relating to the removal of sulphur compounds impose requirements for expensive flue gas desulfurization systems that would involve outlays of tens of millions of dollars at each power plant. Capital investments on this order of magnitude quickly offset any potential fuels savings, and it is for that reason the utilities in New England have resisted strongly all federal efforts to force them to switch back to coal.

Unless nuclear is rejected for political and social reasons, I can see little likelihood that coal will matter greatly in the New England states. The locational disadvantages relative to the coal mines will remain a major cost deterrent, and the costs of overcoming environmental problems will remain prohibitive, although the transportation network of rail and barge links exists and the problems involved in unloading and coal storage areas could be resolved should purchasers come forward.

Manufacture of synthetic gas or liquids from coal could increase the use of coal as a New England fuel source. In the case of high-BTU synthetic gas, it would be less costly to make these synthetic fuels at the minemouth and ship them into New England, than to build the synfuels plant in the region. Synthetic gas from coal, although more expensive than heating oil and conventional fuels today is in fact a less expensive source of energy for space heating than would be electric resistance heating derived from a newly-built coal-fired utility power plant. But at a cost of \$5.00 per million BTU for high-BTU syngas, it is still more economic to use No. 2 distillate heating oil in New England as a space-heating fuels.

As regards the option of low or medium BTU syngas, these fuels could offer some modest economic advantage as a way to use coal at power plants, if work now in the pilot-plant stages proves out. However, gasification plants at utility sites, coupled with coal storage yards, could present a storage problem.

New England Coal Prices

I. Introduction

Estimates of economically recoverable U.S. coal reserves vary between 211 and 437 billion tons which is almost 50 to 100 times the amount of energy contained in the oil reserves of Saudi Arabia. Although these coal reserves comprise approximately 90% of the U.S. energy resource base, coal is used to supply only 1% of New England's energy requirements. This relatively low level of coal utilization in New England is the result of a number of factors.

1) Energy Prices.

After taking account of inflation, real coal prices increased between 1963 and 1972 by some 25%. During that same period, however, real oil prices fell by about 15%. This

changing price relationship increased the demand for oil and decrease coal consumption in certain parts of the country.

2) *Transportation and Handling Costs.*

The costs of transporting and handling coal are considerably greater than the costs of transporting and handling oil. These cost differences increase the attractiveness of oil and decrease the attractiveness of coal.

3) *Environmental Regulations.*

Concern for the environment resulted in the passage of legislation in the late 1960's and early 1970's which set air quality standards. Coal capable of meeting these standards is expensive and the mechanical equipment capable of cleaning less expensive coal is costly to build and operate. These costs further handicapped coal in its competition with oil.

In addition to these historical factors which have helped to drive coal from the New England marketplace, a number of uncertainties loom on the horizon which could decrease coal's competitive position in the future. These factors include: Federal Mine Health and Safety Regulations, Federal Strip Mine Reclamation Regulations, Federal Miners Health Program Standards, United Mine Workers contract demands, and state severance taxes. While coal is no longer in direct competition with oil and gas in New England (oil and gas are likely to be prohibit as boiler fuels by pending energy legislation), coal still must compete with nuclear power. Its ability to compete will once again depend on its price and the factors which influence that price.

II. Mining

A basic component of coal prices is the cost of mining the coal. Mining costs are influenced by such physical factors as the depth of the coal seam, the thickness of the coal seam and the amount of gas and water which must be removed to allow mining to take place. The bulk of the coal in the Eastern United States occurs in thin underground seams which are more expensive to mine than the relatively shallow, thick, western coal seams which can be mined by inexpensive surface mining methods.

The opening of a new underground mine requires a substantial capital commitment which is usually not made until the mining company has a firm long-term contract for the sale of the coal. Since the bulk of coal is sold under these long-term contracts, any substantial increase in coal demand would require the opening of new coal mines. The cost of these new coal mines can thus serve as a basis for estimating New England coal prices in the future.

The coal of choice for New England consumption is mineable in the region of Northern Appalachia, which extends through northern West Virginia into southern Pennsylvania. The coal in this region generally has a high energy content with low ash, both of which combined to minimize transportation costs. The sulfur content of the coal can range from medium to high.

Between now and 1985 there appears to be sufficient existing coal mining capacity to meet the demand for northern Appalachia coal at relatively constant prices. Depending upon sulfur content, this would mean coal prices in 1978 dollars between \$30 and \$35 a ton (for coal with 13 thousand BTUs per pound, the energy price is \$1.15 to \$1.35 per million BTU). Beyond 1985, increased demand and reserve depletion in existing mines may require that additional mining capacity be added in northern Appalachia. These newer mines would likely be higher-cost operations than the existing northern Appalachia mines and an increase in mining costs of approximately 10% by the year 2000 could take place. This mining cost

increase could raise real northern Appalachia coal prices to between \$33 and \$38 per ton in constant 1978 dollars by the year 2000. By way of comparison, the current N.Y. Harbor price of low sulfur fuel oil is about \$14 /bbl. or \$2.22 per million BTU.

II. Transportation Costs

While the cost of coal at the mine is a major factor in coal prices, New England coal users must also pay to have the coal transported to New England. Because the cost of coal transport depends upon the location of the coal mine, the location of the power plant using the coal and whether the coal is transported totally by railroad, or via a combination of railroad and barge, there is no single cost of transporting coal to New England. A number of recent studies have examined the question, however, and they have all come to similar conclusions.

A Bechtel Corporation study done in 1975 estimated that the cost of a 600 mile unit train haul would fall between 1¢ and 1.4¢ per ton mile. The study determined that longer hauls were slightly less expensive with hauls of 1,000 miles costing between 0.9¢ and 1.1¢ per ton mile. These costs would appear to bracket New England's transportation costs because most hauls from the coal fields to points in New England would fall between 600 and 900 miles in length. These transportation charges would mean a delivery cost of \$7 to \$9 a ton on a 700 mile run.

A more recent study done by the New England Energy Policy Council in 1976 analyzed transportation costs to four power plants in New England. The study examined the options of shipping largely by rail with a short sea voyage by barge and compared this with a long barge voyage from ports in Virginia. The costs ranged from \$9 to \$12 per ton with the longer rail route being slightly less expensive. If these rates are applied to coal with the heat content of 13,000 BTUs per pound, they raise the price of coal by between 35¢ and 46¢ per million BTUs. If transportation charges are expected to keep pace with inflation throughout the forecast period, these transportation charges could be expressed as between 39¢ and 51¢ per million BTUs in constant 1978 dollars.

III. Pollution Control Costs

A coal user also faces the costs of making coal use environmentally acceptable. The direct burning of coal releases large quantities of ash and sulfur dioxide into the atmosphere and environmental regulations strictly control the amount of each substance which can be emitted by coal-fired plants. In fact, new amendments to the Clean Air Act require that the best available pollution control technology be used on all new coal-fired plants even if relatively low sulfur coal is to be burned in the plant.

The costs of complying with these Clean Air regulations raises the costs of coal use in three ways: the costs of the pollution control equipment itself, the costs of operating that pollution control equipment and disposing of its waste products, and finally the costs associated with the lower electricity generating efficiency which occurs when the pollution control devices are installed.

Various studies have estimated that the direct capital costs involved in the installation of a flue gas desulfurization system (scrubber) capable of meeting today's standards range between \$50 and \$120 per kilowatt. Economics of scale make larger units less expensive per kilowatt than smaller industrial size scrubbers. Similarly new systems are less expensive to install than a system which would have to be retrofitted on an existing installation. These

capital costs can be combined with the cash operating expenses to produce a coal cost increase of between 40¢ and 50¢ per million BTUs in constant 1978 dollars.*

Since the new Clean Air regulations seem to require the use of scrubbers no matter what kind of coal is burned, there would not appear to be any premium associated with the use of low-sulfur coal. If the regulations (when they are finally issued) allow the use of low-sulfur coal in place of scrubbers, it would be reasonable to expect that low-sulfur coal prices would be 40¢ to 50¢ per million BTUs higher than high-sulfur coal prices.

IV. Labor and Regulation Costs

A major element in the costs of underground coal mining is the cost of labor. Currently total labor costs average around \$15 per hour or about half the price of a ton of northern Appalachian coal. The recently negotiated United Mine Workers contract contains provisions which allow for worker incentive programs designed to increase worker productivity. Hopefully, these productivity increases will offset future wage increase and result in no real coal price increase. Should productivity not keep pace with wage rates, however, either an increase in real coal prices or a decline in coal production could be expected.

A number of federal programs have also directly and indirectly affected coal prices. Recent federal strip mine legislation levies a tax on coal to fund a program designed to reclaim abandon strip mines in the eastern states. Another federal program taxes coal to fund a program which treats miners with black lung disease. These taxes, when combined with the recent United Mine Workers contract agreement, are expected to raise coal prices in 1985 by between 21¢ and 34¢ per million BTUs in constant 1978 dollars. The increase in real prices in the year 2000 could be even larger if additional federal programs are enacted or if future UMW contract wage gains outstrip productivity.

V. Outlook

Pending Federal energy legislation outlaws the use of oil and natural gas as boiler fuels in new base load utility power plants. Coal and nuclear power are thus the only fuels left to compete for the electric utility base load power plant market. Neither fuel by itself has such obvious cost advantages that it can drive the other fuel from the marketplace. Yet there are certain areas of the country which seem more likely to opt for a particular fuel choice.

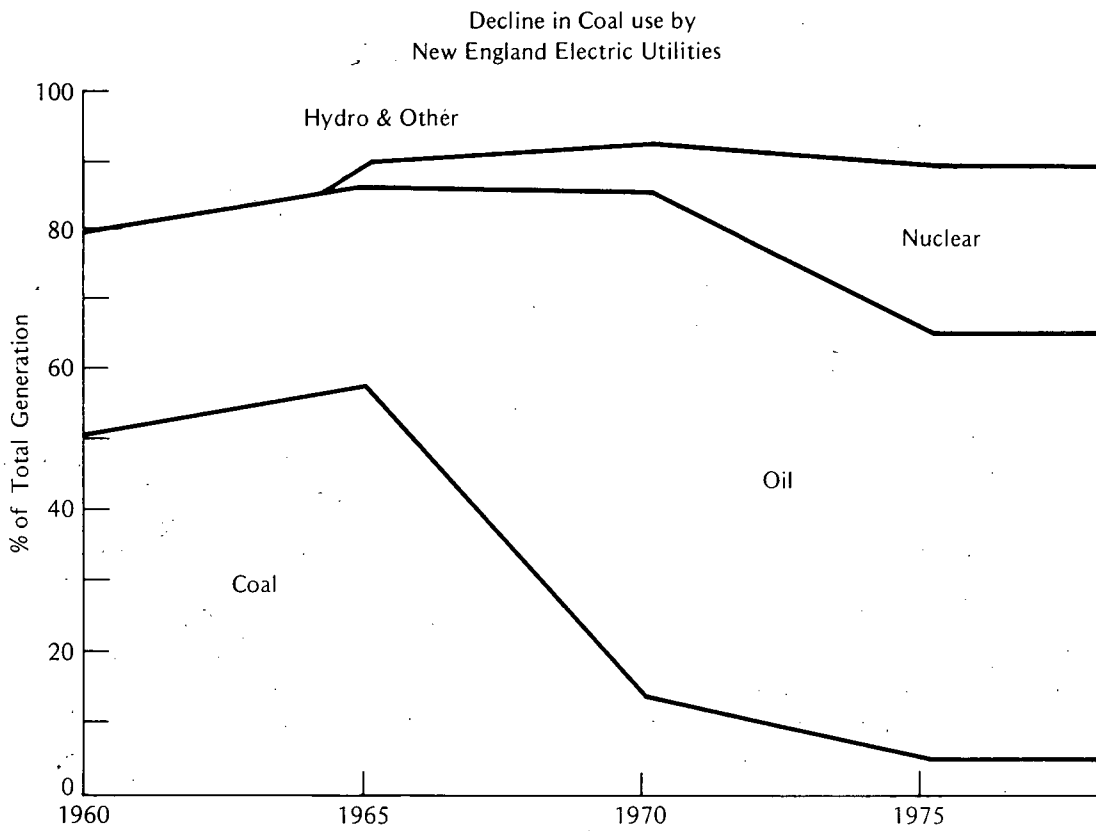
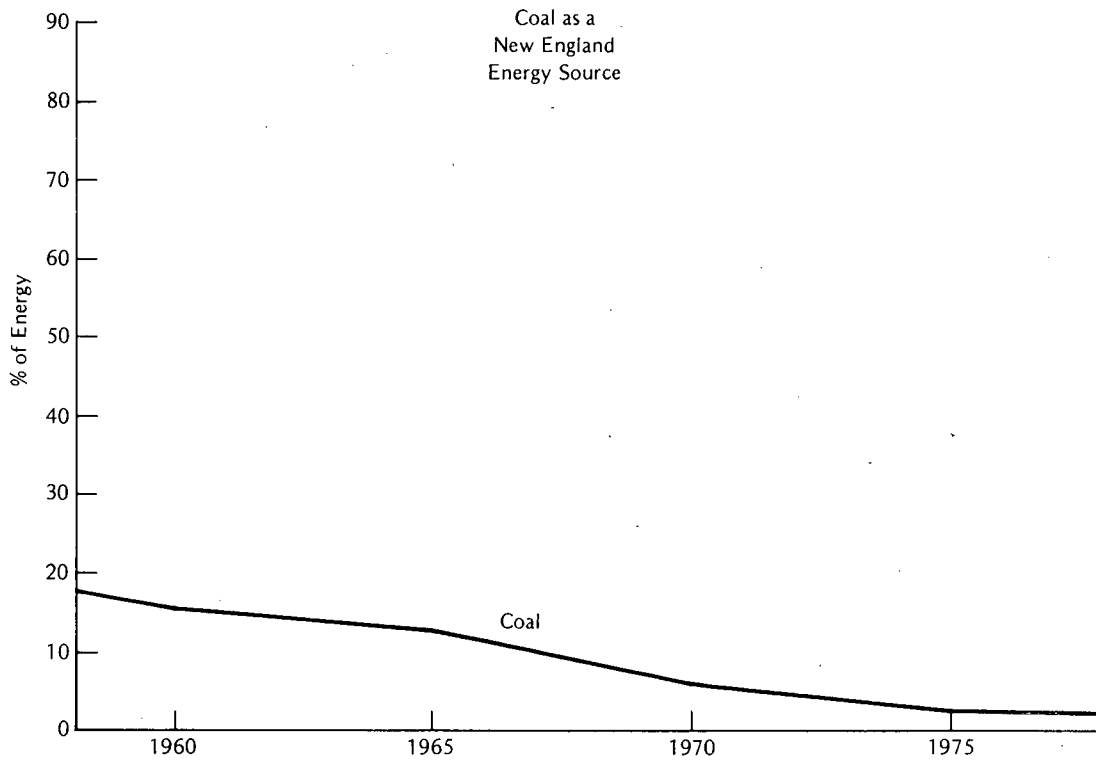
Those areas of the country near the coal fields (east, central, and western) are likely to base their electricity generating systems largely on coal. Because they are located near the coal fields, they can minimize the transportation costs which form a major component in the costs of coal use. Similarly, by the time coal is transported to the coasts (Atlantic and Pacific), the costs of coal use in new plants tend to exceed the costs of nuclear power generation. These regions can therefore be expected to rely heavily on nuclear power. The dividing line between the regions will be the focus of the battle between coal and nuclear, and the boundary can be expected to shift depending upon the competitive nature of either fuel.

New federal legislation which raises the costs of either fuel will affect the region of coal/nuclear competition. A major new factor, however, could be the imposition of state

*Forum Data Handbook for New England Energy Alternatives, Volume IV, Supplement 4, Dec. '77, Mitre Corp., pp 39-45.

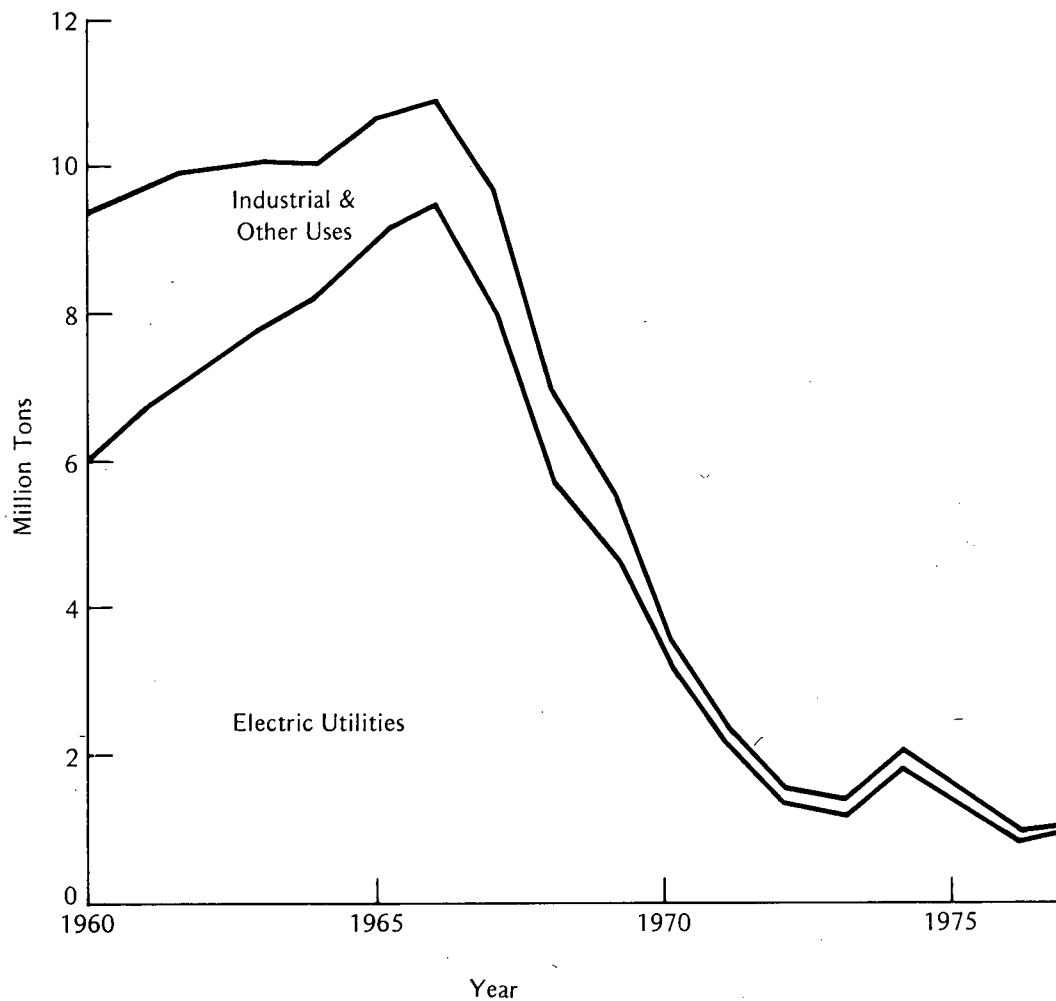
The Mitre Corporation study of coal prices in New England used projections of coal transportation and utility generating and scrubbing costs which generally parallel those used in this paper. The Mitre estimates of coal mining costs are a bit low, however, and probably stems from the fact that Mitre based its estimates on TVA contract prices. Since the TVA is the largest coal consumer in the nation, its market power is immense, and the prices TVA pays for coal may not be representative of the prices paid by other coal consumers. Therefore Mitre's estimates for coal prices should be revised upward to represent the types and volumes of coal which would be purchased by New England utilities.

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Bituminous Coal Shipments to New England



severance taxes on coal as states in the mining regions attempt to gain for their citizens some of the perceived benefits of increased national coal use. Of direct concern to New England would be any effort on the part of either West Virginia or Pennsylvania to impose large new state taxes on coal produced in those states. If the coal states perceive the market for their coal to be the metropolitan area from New York to the south, they could attempt to raise their taxes to a level which would just make coal competitive with nuclear power in the New York metropolitan region. Because of transportation costs, such a tax would make coal non-competitive in New England.

A combination of state tax pressures, government regulations and United Mine Worker contract demands can therefore be expected to push coal use costs up to the level of nuclear power costs in many regions of the country. But while nuclear power costs may place a ceiling on coal prices, coal would be unable to limit nuclear power costs except by means of replacement. In fact, if coal ever gains a major market share in New England, one of the highest coal cost regions, it can be said that nuclear power is no longer economically viable anywhere in the U.S.

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In summary, the following table compiles the various coal cost estimates for the years 1985 and 2000:

Coal Price Projections (\$/MMBTU in 1978 Dollars)

Items	1985	2000
Mining	\$1.15-1.35	\$1.27-1.46
Transportation	.39-.51	.39-.51
Pollution Control	.40-.50	.40-.50
Labor and Regulation	.21-.34	.21-.34
Total	\$2.15-2.70	\$2.27-2.81

While every effort has been made to evaluate the major variables which will affect prices in the future, the actual events of the next 22 years will undoubtedly affect these projections. These events will therefore have to be incorporated into future analyses to keep the projections up-to-date. It should also be noted that the prices are in constant 1978 dollars and therefore future inflation must be added.

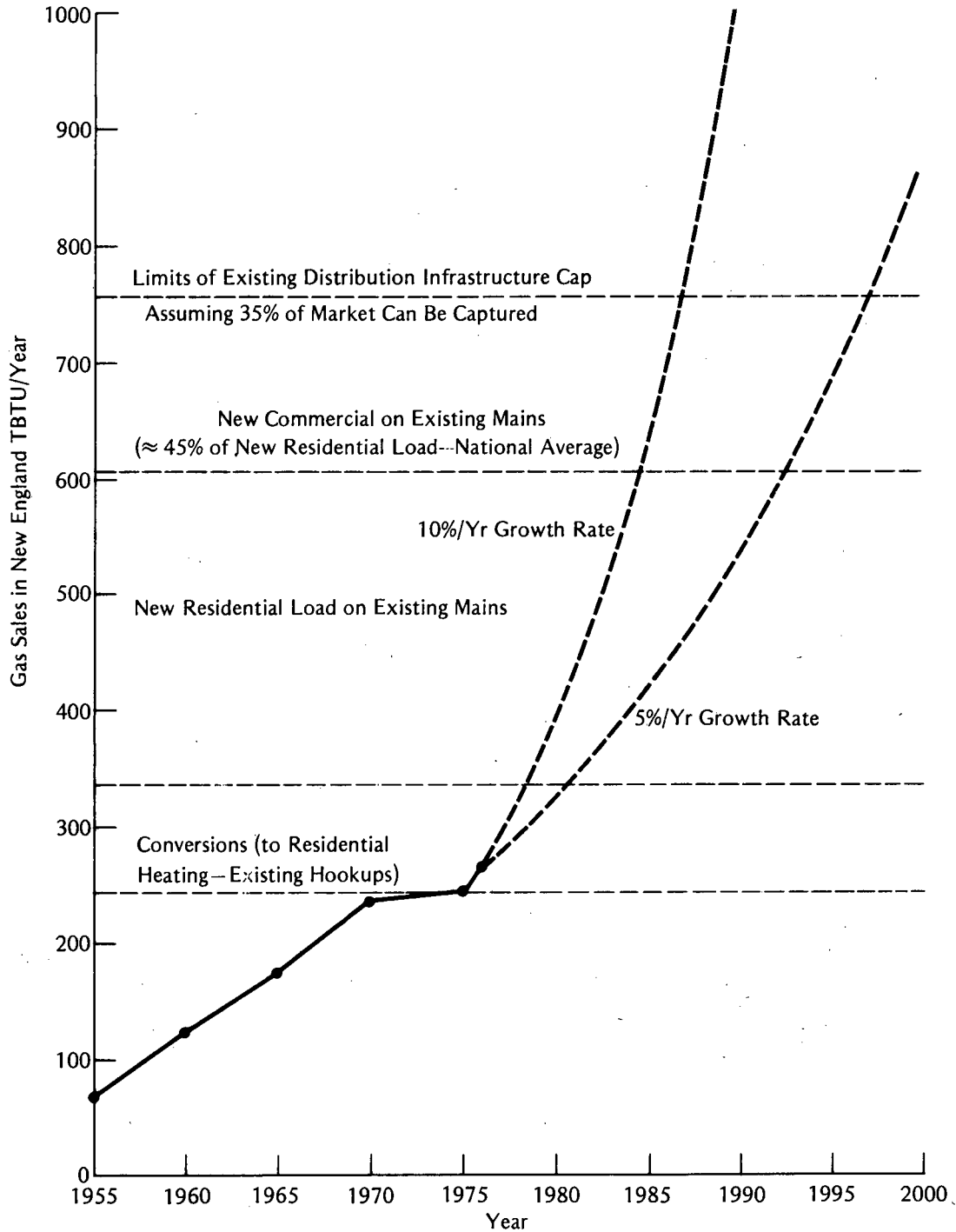
Natural Gas Availability and Cost Projections

The graphs below and the AGA paper on U.S. gas price projections provide a preliminary assessment of the prospects for gas in New England. Basically, the conclusions are as follows:

- 1) Utilizing the existing gas distribution infrastructure in New England, a threefold increase in gas use is possible. Increasing the availability of gas to New England on a preferential basis will be required. Given the fact that gas is only 8 percent of our energy mix whereas it is 27 percent nationwide, such preferential treatment would not be unreasonable.
- 2) With a 5 percent per year growth rate in gas volumes marketed, gas prices to consumers should track imported No. 2 oil, based on an 8 percent per year oil price increase.
- 3) If gas availability were such that a 10 percent gas growth could be accomplished, gas cost could beat oil by a significant margin.

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New England Potential Natural Gas Consumption 1978-2000

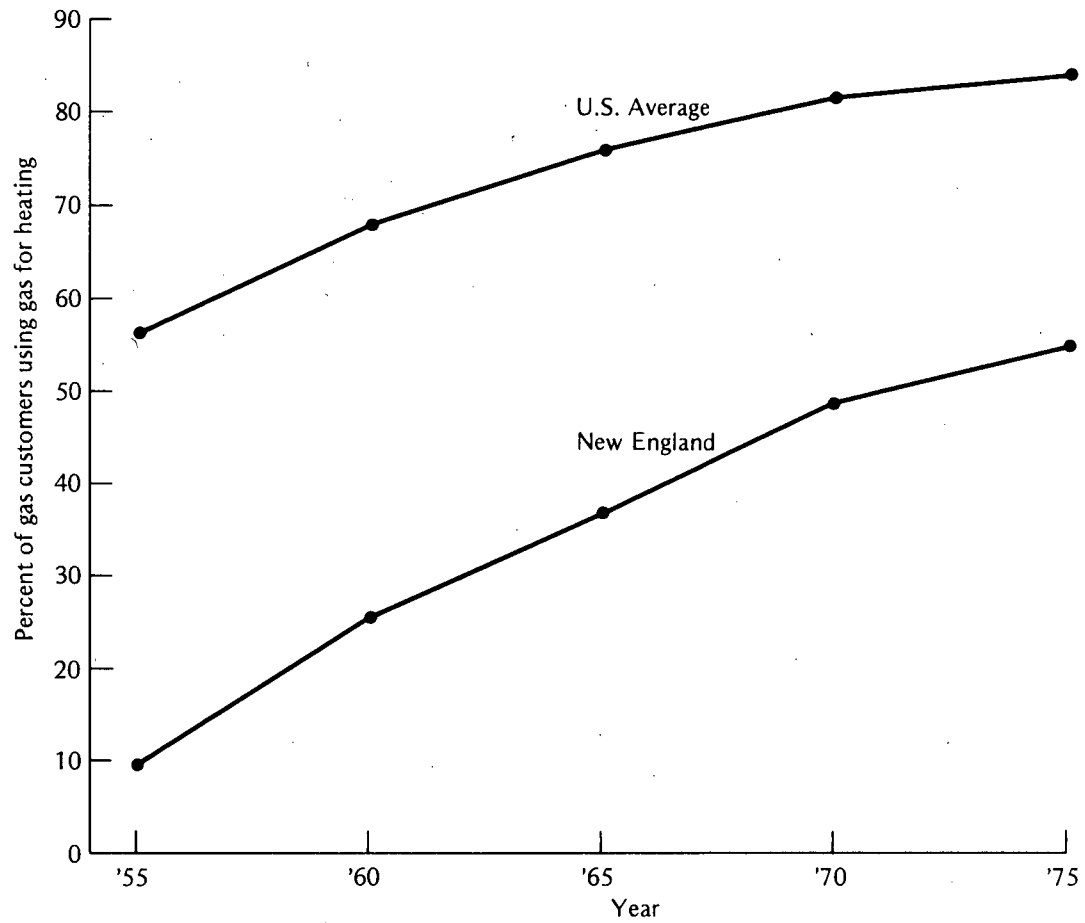


New England Gas Consumption Bases:

1. Existing infrastructure
2. No growth in total energy needs in New England

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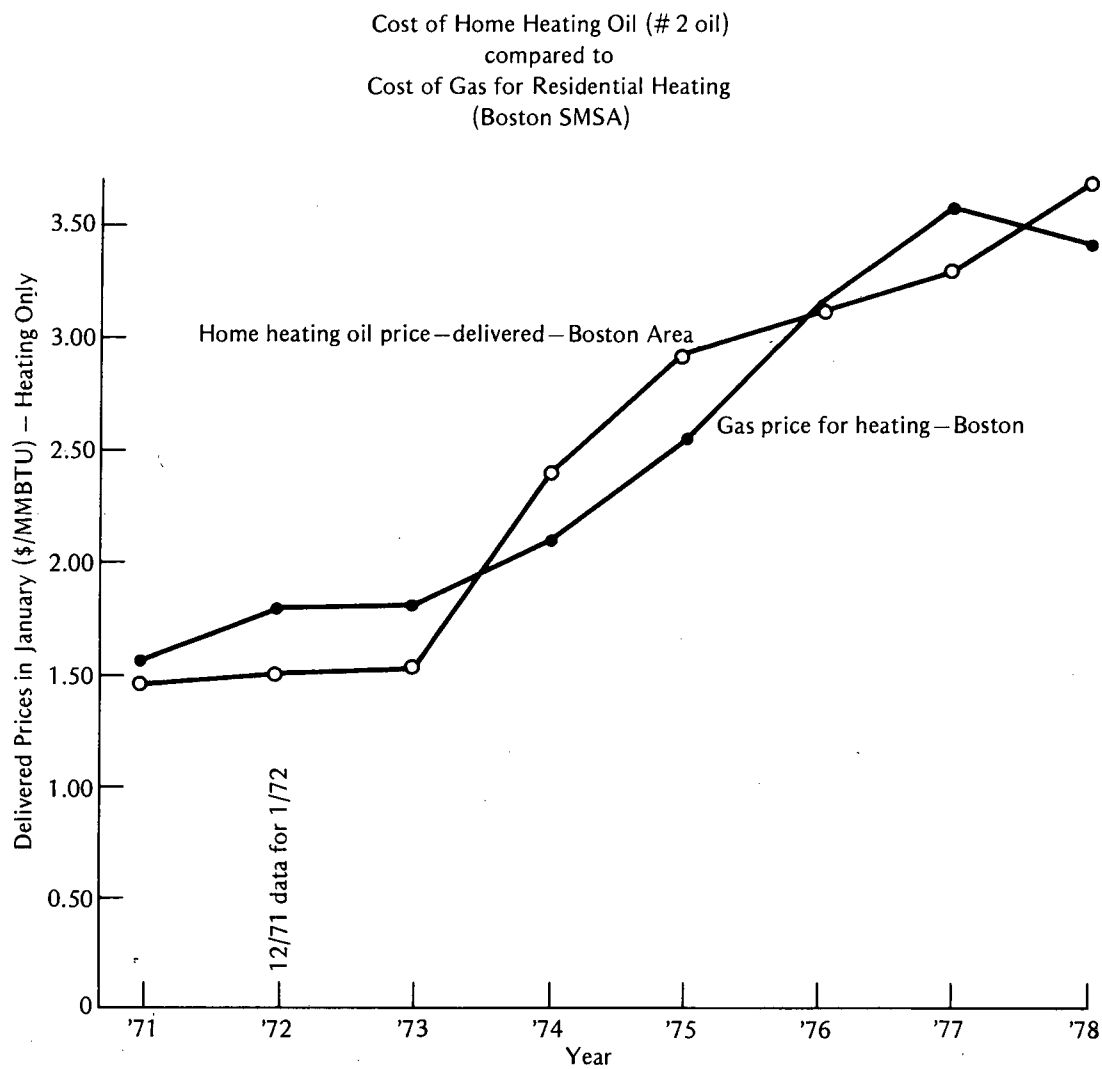
Percent of Connected Gas Customers
Who Also Use Gas for Home Heating



Source: Gas Facts, 1977. American Gas Association, Table 60, pg 74

E. J. Curtis Associates 8/78

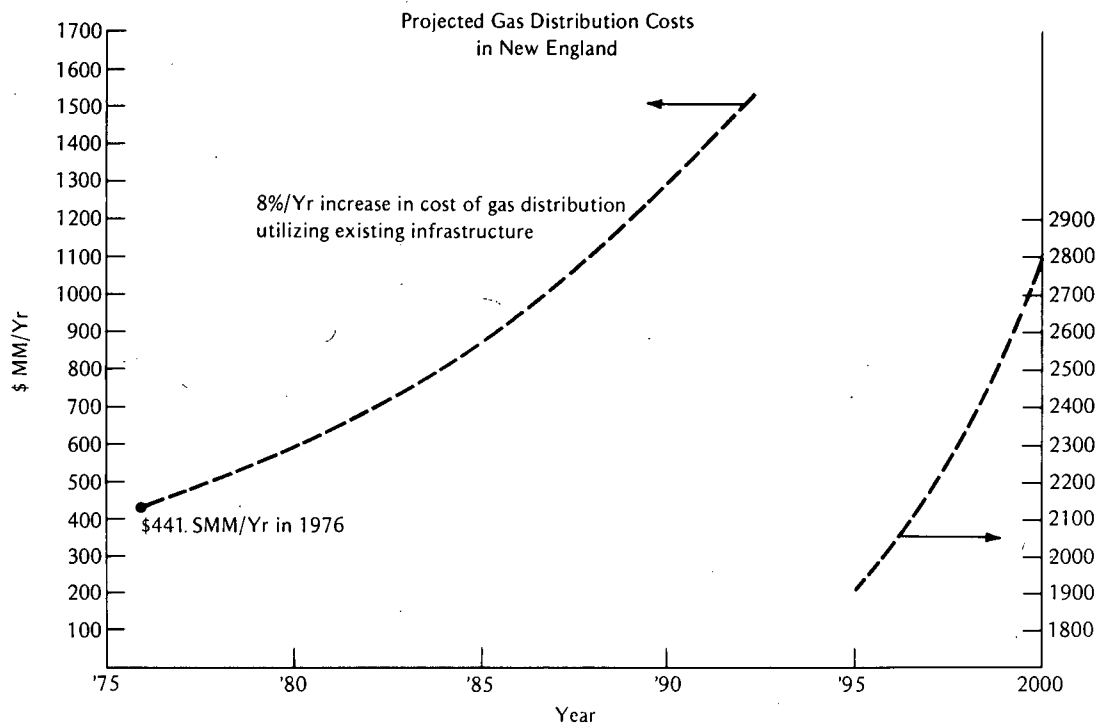
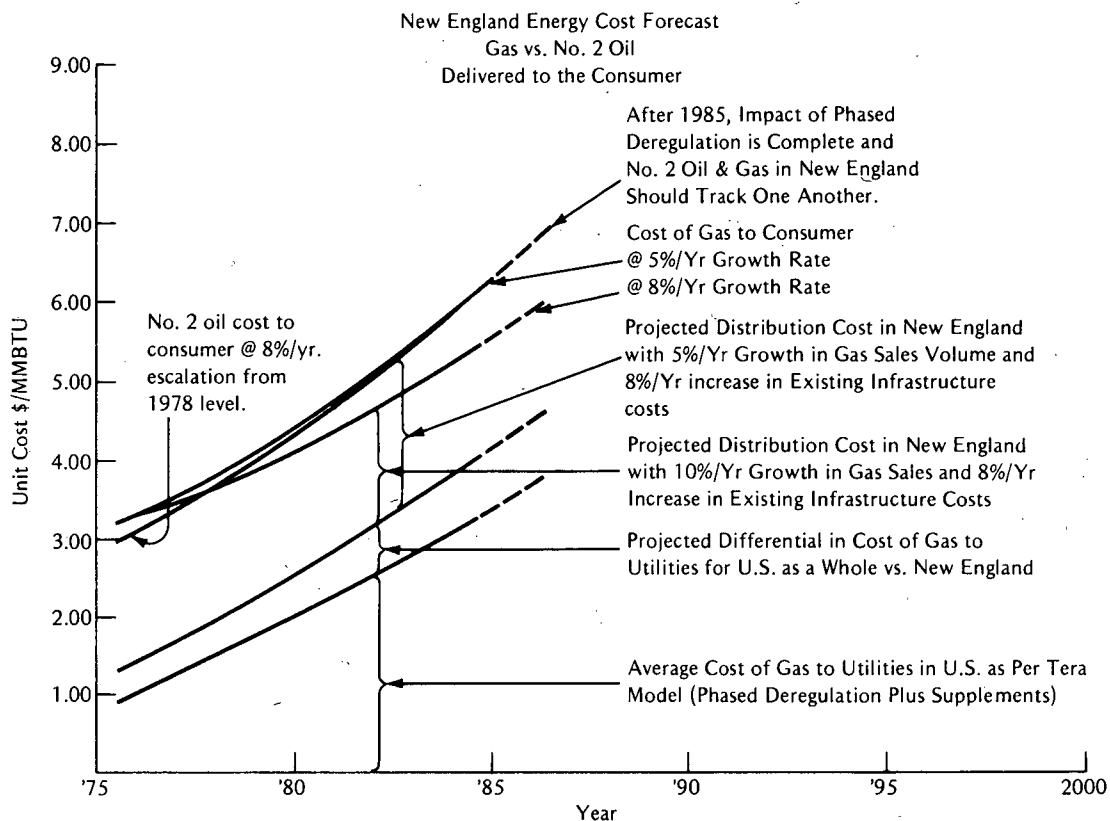
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Source: Bureau of Labor Statistics "Retail Prices & Indices of Fuels & Utilities" — Monthly
Basis: Cost delivered to homes

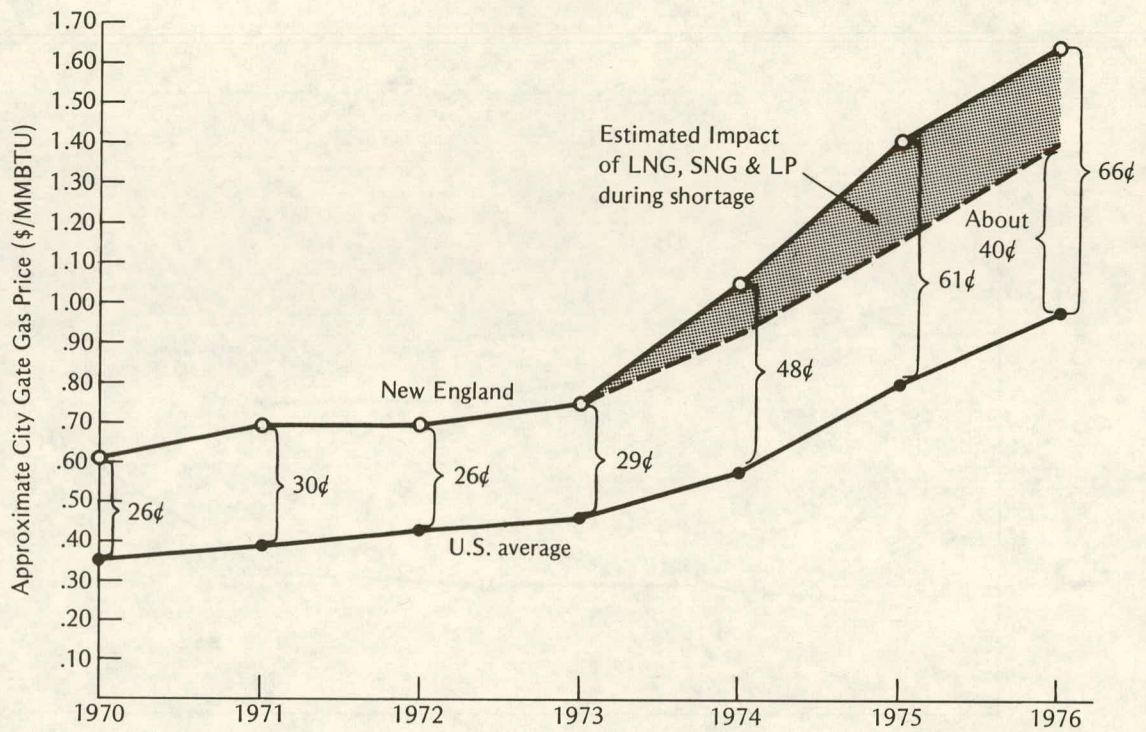
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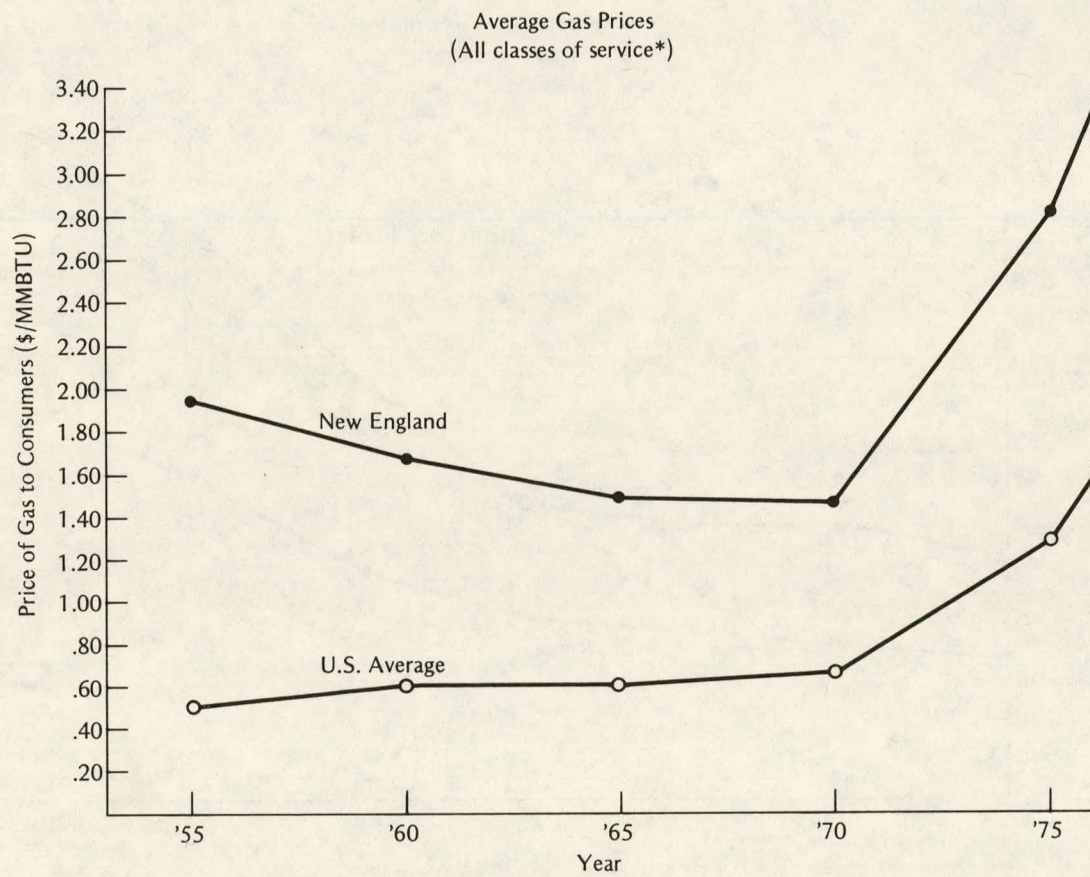


Basis: Existing Infrastructure costs escalated @ 8% per year

Historical Cost of Gas to Utilities
(Wholesale cost of gas)
New England vs. U.S. Avg.

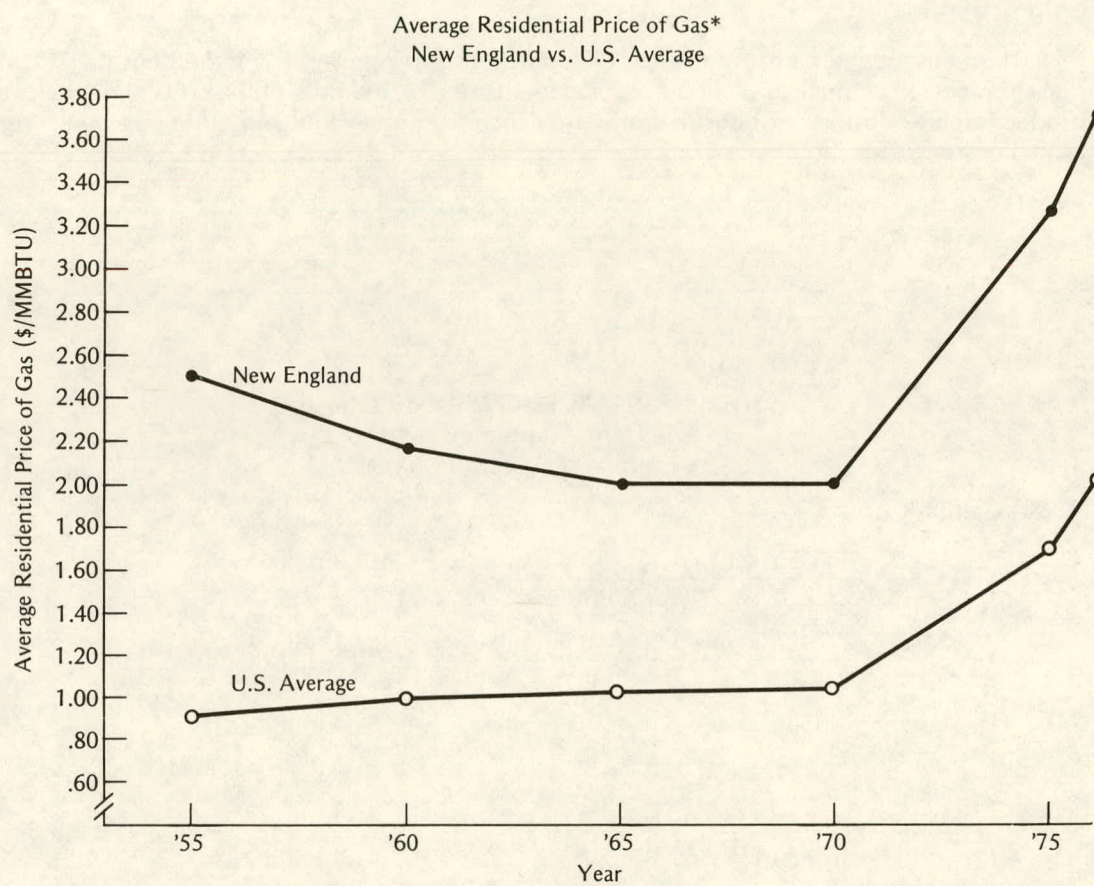


Data Source: Table 98, Pg. 122*Gas Facts*, 1977 American Gas Association



E.J. Curtis Associates 8/78

Source: Table 94, Pg. 117 "Gas Facts", 1977 American Gas Association



Source: Table 93, Pg. 116, "Gas Facts", 1977 American Gas Association

*Includes cooking & water heating uses as well as heating

Nuclear Cost Projections: The Economics of New Nuclear Construction and Generation in 1990

(Alan Davis)

I. Introduction

The following text describes the assumptions and sources for a projection of nuclear electricity generating from a new station completed in 1990. The dollars are mixed current. This analysis begins with a discussion of capital costs, and proceeds with capacity factors, fuel, operation and maintenance, decommissioning and related factors contributing to bus-bar costs expressed in Mills/KWH.

The table below contains a range of capital cost projections for a hypothetical 1,150 MW nuclear plant. Since nuclear plants are capital intensive (i.e., the bulk of the costs of their electric production arise from their construction rather than from their fuel and other operating costs), capital costs receive the greatest emphasis here.

Hypothetical Nuclear Plant Cost Estimate For Plant Completed in 1990 (in mixed current dollars)

Fixed Capital Costs

High	$\frac{3559/\text{kwe} \times (.18) \times 1000 \text{ mills}/\$}{8.766 \times (.6)}$	= 121.8 mills/kwh
Mid:	$\frac{2427/\text{kwe} \times (.18) \times 1000 \text{ mills}/\$}{8.766 \times (.6)}$	= 83.1 mills/kwh
Low:	$\frac{1588/\text{kwe} \times (.18) \times 1000 \text{ mills}/\$}{8.766 \times (.6)}$	= 54.4 mills/kwh

Fuel Costs	47.5 mills/kwh
Operation and Maintenance Costs	11.9 mills/kwh
High Total	181.2 mills/kwh
Mid Total	142.5 mills/kwh (approx. 99 mills in 1978 dollars)
Low Total	113.8 mills/kwh

Assumptions:

- 6% General Inflation
- 18% Fixed Charge Rate (FCR)
- 60% Capacity Factor
- No Allowance for decommissioning
- Does not include transmission and distribution
- Does not include line losses (only bus-bar, not delivered costs, are provided)
- Does not include capacity equivalency ratio for comparison purposes

II. Capital Costs

Estimates of capital costs for nuclear plant construction have borne little relation to the actual costs experienced by the industry. In 1967, the Atomic Energy Commission was projecting capital costs of \$134.00 per kw for plants beginning operation in 1973. The actual costs were between 50 and 280 percent greater. In 1974, the AEC said it would cost \$700 per kw for plants to begin operation in the early 1980's. But utility companies were already announcing costs of \$1000.00 per kw. In a 1975 study by economists at Harvard and M.I.T., the authors found that capital costs had risen more steeply than the costs for other high technology facilities. Most utilities experienced at least 100 percent cost overruns. Boston Edison experienced a 267 percent construction cost overrun at one of its plants, while Vermont Yankee came in 178 percent above its original estimate. Attachment 2, taken from an exhibit in a recent Wisconsin case, shows comparative cost estimates by four well-known firms—United Engineers and Constructors, Bechtel, Ebasco Services, and Sargent & Lundy. Final cost estimates have risen 25%, 18%, 24%, and 24%, respectively, on an annual basis.

There are a number of ways to project capital costs. One way starts with architect-engineer cost projections for labor and material for each year until completion. These cost predictions are based on the present scope of the project and are expressed in constant dollars. During the construction period, however, costs of factors not yet procured may escalate (or, theoretically, may deescalate) due to (1) increases in per unit costs for labor, materials, and services; (2) to increases (or decreases) in the scope of the project and regulatory, environmental, and safety requirements. Hence the estimated direct construction costs are escalated, and taxes and AFDC are computed thereon for each year. The total expenditures for each of the years are then summed, giving a total capital cost in constant dollars.

This "brute force" method was not used here because: (1) there is no architect-engineer cost expenditures schedule to use as a starting point; (2) the apparent sophistication of the method is less impressive than it seems because most construction expenditures schedules are generated from standard curves, not detailed engineering plans (this is especially true of nuclear units,); and (3) simpler methods are available which predict construction costs with accuracy.

Wilfred Comtois, a Westinghouse Corporation consultant, developed a simpler method of estimating capital costs which he presented to the American Power Conference in April 1976. His is one of two methods used here.

One starts with a base capital cost. We selected \$711/KWe, the base used by W. W. Brandfon in a paper presented to the Atomic Industrial Forum at an April 1978 conference. Brandfon, who is responsible for estimating nuclear costs at Sargent and Lund, was estimating the costs of a comparably sized, hypothetical reactor to come on line in 1990, and his is the most recent such figure of which we are aware. Since Brandfon's base cost (which does not include AFDC or, obviously, escalations during construction) was escalated from January 1, 1978, we have adjusted it upward for each of the high, middle, and low cases, to a base time of January 1, 1979. This more closely corresponds with decisionmaking in late September, 1979.

Having selected a base starting date and base cost, it is necessary to determine the appropriate time period. Here, eleven years, a conservative estimate is employed.

The most controversial factor is the appropriate annual escalation rate. We have chosen a range of 6% annual escalation, representing escalation at the projected (and agreed upon) overall general inflation rate, to 20% escalation. The mid-point between these escalation ranges is 13%.

An 8% AFDC rate, corresponding to present AFDC rates, was also assumed.

Using the three escalation rates and the other factors in the Comtois formula yields a range of construction costs expressed in mixed current dollars. The construction cost estimate based on 6 percent general and 14 percent real escalation (high case) under this method is \$3559/KWe. The low case, which assumes no escalation in costs above the general inflation rate (no real escalation

case) is \$1589/KWE. And the mid-point case between the two shows \$2427/kwe, assuming general inflation at the agreed upon 6 percent per year.

Why was the 20% "high" escalation used? The answer is that it reflects recent historical averages and thereby attempts to capture the uncertainty of projecting nuclear construction costs. Attachment 3 shows FPC data on actual increases in cost per kw for plants coming on line in 1971 through 1976—an average annual increase per kw of 22 percent over the period. One analyst has suggested that the 22 percent annual increase reflects 6 to 7 percent in general inflation, 3 to 4 percent real change in construction costs over and above the general inflation, and 12 percent additional escalation attributable to design changes, including safety-related and environmental adders.

Attachment 3 also includes a recent comment from *Electrical World*, an industry publication, citing 18 to 20 percent capital cost increases "in the early seventies, and now breaking through the 25% per year increase level."

The primary problem in projecting future capital costs is the uncertainty associated with increasingly stringent regulatory requirements which have added significantly to costs. Since the pace of additional and costly regulatory requirements shows no signs of abatement, realistic capital costs projections should attempt to capture this and other uncertainty by providing a range of estimates. Attachment 4 includes a qualitative attempt to assess the escalation in regulatory requirements (May 1977 *Power Engineering* excerpt) as well as the number of regulatory issues still pending as of November 1976 compared to those in previous years. Presidential and Congressional review of low level radiation standards could inflate costs in this area by substantial amounts as well, as the *Wall Street Journal* article of July 11, 1978 in Attachment 5 indicates.

Another method of projecting capital costs was recently released by the RAND Corporation. The author, William Mooz, examines actual costs for all nuclear plants completed through 1977 in the U.S., excluding plants completed under "turnkey" contracts (Under the early turnkey contracts the builder or the government directly bore portions of the construction costs in order to stimulate the development of the industry. Hence, the costs paid by the reactor owner did not reflect the true costs of the plant.). Since actual costs* were reported in mixed current dollars, Mooz converted the totals in 1976 dollars for comparison purposes.** The result is a series of capital costs for 39 nuclear units expressed in 1976 dollars. Mooz then performed multivariate regression analyses to determine which factors most heavily influenced costs up or down.

By far, the dominant variable was a time variable, expressed in terms of the date on which the construction permit was issued. Other important variables were reactor size, builder (architect-engineer) experience, presence of cooling tower, and location in the Northeast (defined as location in FPC Region 1, which includes the New York and states north of Virginia). The "summary" of Mooz report is attached (Attachment 6).

Because of the high level of sophistication in the analysis, Mooz's data and regressions may be used in predicting future capital costs. The table below shows Mooz's projections for capital costs expressed in 1976 dollars for the dates of the construction permits shown. Mooz assumes an 834 MW reactor (the mean size in his 39—plant sample), all new plants constructed by the same, experienced architect-engineer (a cost-minimizing assumption), and a construction rate of 15 plants every five years. In line with the assumed 7% inflation rate here, we have expressed Mooz's cost projections in 1985 dollars in the right-hand column:

*Mooz did not have actual, final cost figures on plants completed in 1977 because of reporting lags; however, the 1977 units were close enough to critically permit him to use estimates of final costs. For these 7 plants (out of 39 in the data base), "... most of the cash flow is over and the slope of the cash flow curve has tapered off. Consequently, estimates of their costs should be reasonably close to the actual expenditures if the estimate has been made recently."

**This was done by multiplying the expenditures for each of the construction years by the ratio between 1976 volume of the Handy-Whitman steam plant index and the value of the index in those years.

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CPIS*	N**	Cost (1976\$/kwe)	Cost (1985\$/kwe)
75	39	1334.65	2453.70
80	53	2019.05	3711.94
85	68	2718.31	4997.50
90	83	3417.36	6282.68

*Construction Permit Issuance Date

**Cumulative number of plants built

"These costs reflect the effect of (a) the temporal cost increases due to the coefficient of CPIS and (b) the smaller offsets that result from the cost-learning process. As can be seen, the estimate is dominated by the temporal cost increases."

We have adjusted Mooz's regression equation to factor in an 1150MW unit. In doing so, we have also included a number of extremely conservative assumptions.

First, because of the size of the Northeast sector (FPC Region 1) we have excluded that as a variable, even though it is possible that New England plant costs would contribute at least in part, to the Northeast cost disadvantage*. Second, we have excluded the tower from our calculation, even though it is conceivable that cooling towers could be required, at least on some plants.

Finally, we have made the same, cost-limiting assumption that Mooz made in his projections for 834MW units, i.e., that the same architect-engineer builds all the new plants. The following equation results (from the regression equation of p. 32 of Mooz's analysis) if we also assume, quite reasonably, that a construction permit is issued in 1980 for a plant coming on line in 1990:

$$-8,885.5 + 141.34(80) - 21943(1150) - (72.422) (\text{natural log of } 54) = \$1881/\text{KW (1976 dollars)}$$

In 1985 dollars, at the agreed 6% inflation rate, the cost per KW of 1,150MW of nuclear capacity becomes \$2113.49 KW for service in 1990. Since this result is expressed in constant dollars, rather than mixed current dollars, it does not reflect the amount which will actually be paid by the hypothetical utility, but the expression is useful for comparison purposes within the guidelines discussed by the subcommittee.

III. Fixed Charge Rate

Though we understand through conversations that fixed charge rates of as high as 20% are being used for planning purposes in New England, we have used an 18% FCR, which compares with other recent estimates.

IV. Capacity Factor

The best independent work in this area appears to be Charles Komanoff's in his *Power Plant Performance, Nuclear and Coal Capacity Factors and Economics* (1976), *Nuclear Plant*

*Mooz found, as the attached "Summary" indicates (Attachment 6), that Northeast location raised plant costs by \$130 per kw more than those built elsewhere (in 1976 dollars).

Performance/Update: Data Through December 31, 1976, (1977), and Nuclear Plant Performance Update 2: Data Through December 1977 (1978). We have been impressed not only with the depth of his analysis, but also with his detailed responses to critics¹ and his use of explicit assumptions and regression analysis based on actual plant performance.

Komanoff's latest update predicts a 10-year, levelized capacity factor for an 1,150MW PWR at 58.9% (The projections for 1,150MW PWR's are much lower—43 to 46%). To be conservative, we have assumed that the hypothetical unit is a PWR—the better performer—and we have raised Komanoff's projection from 58.9% to 60%. In comparison to utility projections of 70% and higher, Komanoff's 58.9% is on the low side, but his estimate seems far more reasonable in light of these factors.

- 1) The larger reactors have experienced lower capacity factors, the natural result of being more complex to control, having a greater number of components that can fail, and requiring longer lead times.
- 2) He has explicitly taken into account reactor maturation and the so-called "learning curve," which he calls reactor "vintage," based on actual experience. PWR performance peaked around age five and leveled out thereafter, with a slight, though not statistically significant, decline after year five.

"In addition, the low capacity factor indicated in ages 6, 9 and 10, although not statistically significant, are evidence of a conclusion to the improving capacity factor trend evident from age 2 to 5². This evidence matches the pattern shown by the three "pre-commercial" 200-MW class units, Yankee Rowe, Dresden #1, and Indian Point #1... and also resembles the maturation pattern of PWR's."

- 3) Komanoff's 10-year averages are frequently used as surrogates for 30-year projections in economic analyses. According to Komanoff, this practice downplays potential performance problems at aging reactors due to performance buildup of fission and corrosion products which may cause component failures and inhibit repairs.
- 4) There have been shortcomings in typical industry analyses: for example, redefining maximum capacities used for calculating capacity factors after reactors are derated, redefining maximum capacities in terms of "maximum dependable capacity," etc., which dilute the objectivity of an analysis, or, simply ignoring data on plants which have not performed well.

V. Fuel, Operations and Maintenance Costs

Fuel and operations and maintenance costs were based on the detailed testimony and exhibits of Ronald L. Knecht, presently Special Advisor to the California Energy Commission, who provided a full-fledged analysis of nuclear power costs to the Wisconsin Public Service Commission earlier this year. That analysis and others are found in *Methodology for Power System Cost Assessment: A Report to the California Energy Commission*. Knecht's analysis was used as a starting point because it is recent, detailed, and comparable to the hypothetical situation here (For example, Knecht

¹See, for example, his exchange with nuclear industry spokesperson Lewis Perl, in *Nuclear Power Costs*, hearings before the Subcommittee of the Committee on Government Operations, U.S. House of Representatives, pp. 1198-1203, 127-1281

²A separate regression found a decline in PWR capacity factors starting at age 6, significant at the 93% confidence level. The decline rate, however, is very gradual, however—only 0.3 percentage points per year. Thus PWR capacity factors after age 5 follow a plateau rather than a sharp decline.

assures a 60% capacity factor on an 1100 MW plant.). In addition, there are a number of conservative assumptions in his analysis which lend weight to his conclusions. He has, for example, included costs for permanent waste disposal, costs which we believe are entirely speculative at this time because of various analyses indicating that the technology is simply unavailable at the present time.* He assumes fuel "burn-up" rates of 30,000 megawatt-days (thermal) per metric ton of uranium, an optimistic assumption compared to experience with PWR's. Knecht calculated 33.9 Mills/KWH for fuel costs (levelized) for a unit coming on-line in 1985.

VI. Decommissioning

No decommissioning costs have been included in the cost calculations because of the wide disparity in present predictions and the vast uncertainty of certain aspects of the technology. According to the April 26, 1978 report of the U.S. House of Representatives Committee on Government Operations, *Nuclear Power Costs*, dismantling a nuclear plant may cost anywhere from \$31 million to \$100 million in 1977 dollars, or 10% of the cost of a \$1 billion plant. But even higher figures do not include the costs of "perpetual care" for rubble from the plant. "The radioactive nickel may remain hazardous up to 1.5 million years. After 30 to 40 years, the expected lifespan of a nuclear plant, decommissioning costs would quadruple (assuming 5% annual inflation)," according to the report. The committee found that "...from the lowest to the highest (decommissioning cost estimate), ...no one really knows how much it will cost or who will pay the bill to decommission this nation's nuclear reactors."

VII. Comparative Factors

An analysis of nuclear power costs in New England is useful only to the extent that nuclear costs can be compared to alternative forms of electric generation, alternative energy sources, or energy efficiency (conservation) investments. In keeping with the hypothetical case, we have attempted to look at bus-bar costs for nuclear generation *in vacuo*. But to the extent nuclear generation is compared to other forms of electric generation or to other energy sources, additional costs must be borne in mind. Nuclear generation costs calculated on a bus-bar basis do not by definition take into account the substantial amounts of electricity lost in transmission. Nor have we

*Knecht's calculation assumes 1.4 mills/KWH (levelized) for waste disposal. Escalating this cost for a 1990 in-service date, the nominal costs for waste disposal became 1.84 Mills/KWH (levelized) or $(1.07)^5 \times 1.4 \text{ Mills/KWH} = 1.84 \text{ Mills/KWH}$.

Recent government studies have conflicted with industry statements that the technology for permanent waste disposal exists. As we indicated in our July 14, 1978 Memorandum to the Nuclear Subcommittee:

- 1) A 1977 U.S. Government Accounting Office report, entitled *Nuclear Energy Dilemma: Disposing of Hazardous Waste Safely*, warns that a solution of the problem "is critical to the continued growth of nuclear energy." Yet the report states: "The technology for safe disposal has never been demonstrated and a satisfactory site has not yet been determined."
- 2) More recently, a report released earlier this year by the U.S. Geological Survey claims "some key geologic questions are unanswered and answers are needed before the risk associated with geologic containment can confidently be evaluated."
- 3) The Boston Globe (July 12, 1978) reported on the results of a study by the President's Office of Science and Technology Policy. The report cast doubts on the long-range suitability for storing wastes underground.

He assumed a 7% overall escalation factor. Consequently, the 33.9 mills/kwh (levelized) has been escalated by 7% for a 1990 start in levelized costs:

$$(1.07)^5 \times 33.9 \text{ Mills/KWH} = 47.5 \text{ Mills/KWH}$$

The assumptions on which the fuel calculations are based appear here as Attachment 7. Similarly, O & M costs, shown by Knecht as 7.9 mills (levelized) for the 1985 plant, have been escalated 7% for five years:

$$(1.07)^5 \times 14 \text{ Mills/KWH} = 1.84 \text{ mills/KWH}$$

The assumptions on which the O&M costs are based appear here as Attachment 8.

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added to capital costs any of the additional capital costs which are required as a result of expansion of generation capacity. Without estimating costs in these areas, comparison of nuclear or other forms of electric generation with competing alternatives would be incomplete.

Moreover, the nuclear bus-bar costs discussed above will be inadequate in comparing the hypothetical nuclear unit with other forms of electric generation because of the sheer size of the hypothetical unit. More incremental system capacity is necessary to achieve a given level of reliability for an electric utility network if the incremental capacity is added in the form of large, rather than small, units.

This is true not only because large units tend to break down more frequently than small ones, but also because an outage for any reason by a large unit creates a greater gap in the system. Dr. Edward P. Kahn, a scientist at Lawrence Berkley Laboratory, has found that, for the power pool serving Pennsylvania, New Jersey, Maryland, and the District of Columbia, roughly every three megawatts of nuclear capacity (for units comparable in size to our hypothetical unit), could be more economically replaced by two megawatts of coal capacity in medium sized (375MW) units. Thus, the capacity equivalency ratio between large nuclear and small coal units, according to Kahn, would be 3:2. In the Wisconsin case mentioned above, the Wisconsin PSC Staff used 5:4 and Knecht used 7:6. The end result of taking capacity equivalency ratios into account for comparison purposes would be to increase large nuclear unit capital costs substantially. If the ratios above were used, the nuclear capital costs per KWE would be increased by 33%, 20%, or 16 2/3%, depending upon the ratio selected.

COMTOIS FORMULA

(for calculating future capital costs)

$$P_c = P_o \frac{(1+e)^N - (1+i)^N}{N \ln \left[\frac{1+e}{1+i} \right]} \quad (\text{if } i \neq e)$$

$$P_c = P_o (1+e)^N \quad (\text{if } i = e)$$

where:

- P_c = cost of the project at completion (C. O. date)
- P_o = cost of project at the start exclusive of
- N = number of time periods to complete the project
- e = rate of escalation per time period expressed as a decimal fraction
- i = rate of interest per time period expressed as a decimal fraction

Comtois Formula—High Range

$$P_c = \frac{860 \times (1 + .2)^{11} - (1 + .08)^{11}}{11 \times \ln \left[\frac{1 + .21}{1 + .08} \right]}$$

$$P_c = \frac{860 \times (1.21)^{11} - (1.08)^{11}}{11 \times \ln \left[\frac{1.21}{1.08} \right]}$$

$$P_c = \frac{860 \times (8.1404) - (2.3316)}{11 \times \ln 1.1204}$$

$$P_c = \frac{860 \times 5.8088}{11 \times .1136}$$

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$$\begin{aligned}
 P_c &= \frac{860 \times 5.8088}{1.2496} \\
 P_c &= 860 \times 4.6485 \\
 P_c &= \$3997.71/\text{kwe in rate base in 1990} \\
 P_o \text{ (base cost)} &= \$711/\text{kwe} \times 1.21 = \$860/\text{kwe} \\
 \text{Assumptions: } &7\% \text{ general inflation} \\
 &14\% \text{ real escalation} \\
 &8\% \text{ AFDC}
 \end{aligned}$$

Comtois Formula—Mid Range

$$\begin{aligned}
 P_c &= \frac{810.54 \times (1 + .14)^{11} - (1 + .08)^{11}}{.11 \times 1_n \left[\frac{1 + .14}{1 + .08} \right]} \\
 P_c &= \frac{810.54 \times (1.14)^{11} - (1.08)^{11}}{.11 \times 1_n \left[\frac{1.14}{1.08} \right]} \\
 P_c &= \frac{810.54 \times (4.2262) - (2.3316)}{.11 \times 1_n (1.0555)} \\
 P_c &= \frac{810.54 \times 1.8946}{.11 \times .05407} \\
 P_c &= 810.54 \times 3.185433 \\
 P_c &= \$2,581.92/\text{kwe in rate base in 1990} \\
 P_o \text{ (base cost)} &= \$711 \times 1.14 = \$810.54/\text{kwe} \\
 \text{Assumptions: } &7\% \text{ general inflation} \\
 &7\% \text{ real escalation} \\
 &8\% \text{ AFDC}
 \end{aligned}$$

Comtois Formula—Low Range

$$\begin{aligned}
 P_c &= \frac{761 \times (1 + .07)^{11} - (1 + .08)^{11}}{.11 \times 1_n \left[\frac{1 + .07}{1 + .08} \right]} \\
 P_c &= \frac{761 \times (1.07)^{11} - (1.08)^{10}}{.11 \times 1_n \left[\frac{1.07}{1.08} \right]} \\
 P_c &= \frac{761 \times (2.1049) - (2.3316)}{.11 \times 1_n .99074} \\
 P_c &= \frac{761 \times -0.2267}{.11 \times -(.0093)} \\
 P_c &= \frac{761 \times -0.2267}{-0.1023} \\
 P_c &= 761 \times 2.1605 \\
 P_c &= \$1,686/\text{kwe in rate base in 1990} \\
 P_o \text{ (base cost)} &= \$711/\text{kwe} \times 1.07 = \$761/\text{kwe} \\
 \text{Assumptions: } &7\% \text{ general inflation} \\
 &14\% \text{ real escalation} \\
 &8\% \text{ AFDC}
 \end{aligned}$$

Early and Recent Estimates of Nuclear Power Plant Costs

SOURCE	U E & C		BECHTEL		EBASCO		S & L	
Year of Estimate	1967	1976	1965	1975	1969	1977	1969	1977
Year of Operation	1972	1986	1970	1985	1976	1987	1975	1986
Base Cost	115	535	115	540	160*	689*	158	482
Escalation	15	395	55	270	66	592	35	440
AFDC	10	205	10	220	-	-	33**	340**
Total	140	1135	180	1030	226	1281	226	1232
Percentage Change/Year	25		18		24		24	

* Includes AFDC

** Includes indirect costs

Table 3: Nuclear Power Plants Cost

Commercial Operation Date	Number of Units	Year of Order	Capacity MWe	Cost Millions	Average Cost \$/KWe % Change	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1971	5	1965-1966	3,406	\$ 578	\$170	
1972	8	1965-1967	5,525	1,341	243	43
1973	7	1965-1967	5,235	1,297	248	2
1974	10	1966-1967	8,977	2,777	309	25
1975	10	1966-1967	8,206	3,450	420	36
1976 (Est.)	8	1966-1968	7,823	3,648	466	11

Percentage Increase 1971-1976:

Total 174

Average 22

Source: FPC, Factors Affecting the Electric Power Supply 1980-1985, Dec. 1, 1976.

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**N.E. Nuclear Energy Supply - NE Energy Congress Estimates
(for electricity generation only)**

Dick de La Chapelle
Ken Picha
Frank Sahlman

		Fission No Breeding	Fission W. Breeding	Fusion
MW capacity -	1978	4189(1)	0	0
bbl Oil equivalency		39.7mil(2)	0	0
Projected capacity -	1980	4189	0	0
Projected capacity -	1985	7569(3) (4)	0	0
Projected capacity -	1990 (6)	13319(3) (5)	0	0
Projected capacity -	2000(6)	15619(3)	?	?
Projected capacity -	2000+	?	unlimited	unlimited
“Bus Bar” Cost -	1976	1.5¢/kwh(7)	NA	NA
Projected cost - in 1978 \$-s	1990	3.7¢/kwh(8)	NA	NA

Impact on Human Health and Other Environmental Impact	Short term impact is minimal-long term impact is unknown and scrutiny should continue.	?	?

Social Impact Centralization

Problems	- Regulation and other delays. - Changing requirements. - Regulation pricing - political consideration. - Utility commission knowledge. - Citizen opposition. - Technical & political problems of waste disposal. - Technical problems of decommissioning. - Threat of catastrophe.

Notes:

- 1) The 4189 MW nuclear capacity generated 33% of electrical power used in 1976.
- 2) Barrells of oil which would have been required to generate same amount of electricity.
- 3) NEPOOL figures - see attachment for reactor schedule: assumes fuel availability. Does not assume alternate technology or increase in schedule. Regulatory delays are not assumed but should be expected.
- 4) Assumes Seabrook I and II, Pilgrim II which are under attack through regulatory and court procedures - questions raised are need, comparative economics, environmental considerations and financing.

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- 5) Assumes Millstone III, Montague I and II, Nepco I and II. Millstone III and Montague I and II have been indefinitely postponed as of July, 1978.
- 6) Will be influenced by demand growth. Since nuclear is only satisfactory for base load generation at this time, it can not provide more than 70-80% of the total power required. A 2% growth rate in demand and 15619 MW capacity in 2000 would mean that about 77% of NE's electric power would be nuclear generated.
- 7) This cost compares favorably with oil at 2.9¢/kwh and coal at 2.2¢/kwh. Nuclear costs do not include cost of decommissioning and cost of waste disposal.
- 8) See page 4 for cost break down and sensitivity to range of cost estimates. Calculations are shown in the appendix.

Table IV
Current Status
New England Nuclear Base Load Plants
(megawatts)

State	Site	Operational Date	Status	Current Capacity	Planned Added Capacity 1977 - 1985	Planned Added Capacity 1985 - 2000
CT	CT Yankee	N/A	Operational	575	-	-
	Milestone I	N/A	Operational	652	-	-
	Millstone II	N/A	Operational	828	-	-
	Millstone III	1982	Construction Permit	-	1150 MAY 86	-
ME	ME Yankee	N/A	Operational	790	-	-
	Richmond I	1991	Ordered	-	-	1150
	Richmond II	Ukn.	Letter of Intent	-	-	1150
MA	Yankee Atomic	N/A	Operational	175	-	-
	Pilgrim I	N/A	Operational	655	-	-
	Pilgrim II	1984	Ordered	-	1180 JUNE 85	-
	Montague I	1986	Ordered	-	-	1150
	Montague II	1988	Ordered	-	-	1150
NH	Seabrook I	1982	Construction Permit	-	1150 DEC 82	-
	Seabrook II	1984	Construction Permit	-	1150 DEC 84	-
RI	NEPCO I	1984	Ordered	-	1150 NOV 86	-
	NEPCO II	1986	Ordered	-	-	1150
VT	VT Yankee	N/A	Operational	514	-	-

Summary - Projected and Operational Nuclear Base Load Plants* (MW)

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Current Status	Totals (MW Capacity)			
	Operational	Construction Permit	Ordered	Letter of Intent
1977	4189(7)**	3556(3)	7030(6)	1150(1)
1977 - 1985	10125(12)			
1985 - 2000	15925(17)			

*Currently only one base load fossil fuel plant is planned in the 1985 stage (ME - W.F. Wyman - 600 MW, operational - 1978). Several fossil fuel plants in the 600 MW range are being considered as a result of nuclear construction delays.

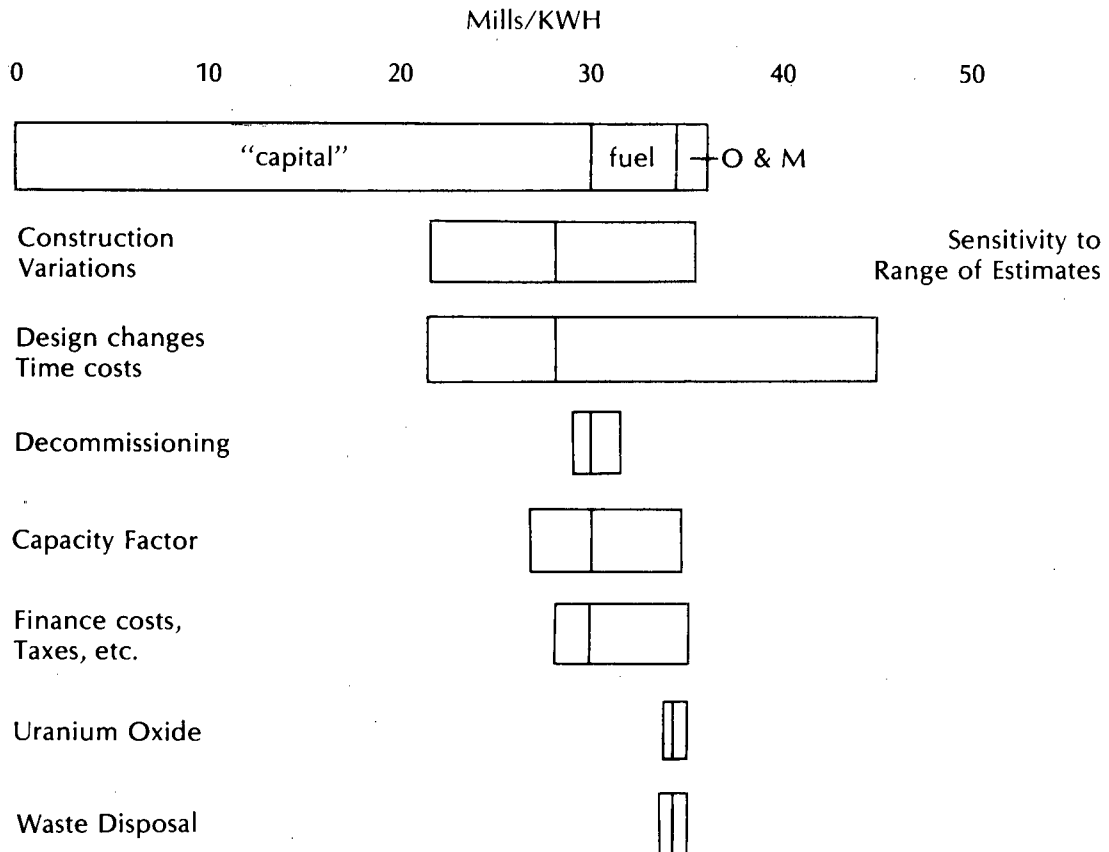
** (Number of Plants)

N/A Not available

Source: Steam Electric Factors 1976

Atomic Industrial Forum Info News Release July 20, 1977

Estimated Cost of Electricity from Nuclear Plant Started in 1978, Completed in 1990 - in 1978 \$'s



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Energy Mix

New England – MM BBL of oil equiv. consumed daily

	1976	1985*	2000*
Coal	.02 – 1.4%	.04 – 2.4%	.12 – 5.8%
Nuclear	.12 – 8.3%	.07 – 10.2%	.41 – 19.8%
Nat. Gas	.12 – 8.3%	.15 – 9.0%	.20 – 9.7%
Hydro	.03 – 2.1%	.04 – 2.4%	.08 – 3.9%
Gasoline	.33 – 22.7%	.32 – 19.3%	.29 – 14.0%
Distillate	.32 – 22.1%	.32 – 19.3%	.29 – 14.4%
Resid.	.41 – 28.3%	.38 – 22.9%	.24 – 11.6%
Other Oil	.10 – 6.9%	.12 – 7.2%	.14 – 6.8%
Alternatives	0 – 0	.12 – 7.2%	.29 – 14.0%
Total	1.45	1.66	2.07

*Assumes 1.5% overall growth rate in demand.

Appendix

Estimate of Nuclear Facility Started 1978 and put into Commercial Operation in 1990

1. Plant and Equipment Costs

1978 Estimate – \$711/kw + 25%

Given 6% inflation rate, projected rate of increase per year.

Low	6% or \$1431 in 1990 \$'s, \$ 711 in 1978 \$'s
Expected	8.7% or \$1935 in 1990 \$'s, \$ 962 in 1978 \$'s
High	12.8% or \$3017 in 1990 \$'s, \$1499 in 1978 \$'s

Low Estimate

- assumes no change in length of time to build plant; no significant changes in design/operation requirement; no improvements due to economies of scale, learning curve.

Expected estimate

- assumes no change in length of time to build plant; significant changes in design/operation requirements; no improvements due to economies of scale, learning curve.

High estimate

- assumes further increase in length of time to build plant and significant changes in design/operation requirements, etc.

The + 25% reflects geographic location, specific design, type of cooling, and many unknowns. All numbers are amounts put into rate base which is made up of mixed dollars plus AFUDC.

2. Decommissioning Costs (add to capital costs)

For an 1150 MW Pressurized Water Reactor, the following estimates were used.

Low estimate	\$25 million or \$22/kw – 1978 \$'s
Expected estimate	\$45 million or \$39/kw – 1978 \$'s
High estimate	\$100 million or \$87/kw – 1978 \$'s

The expected estimate assumes complete dismantling and removal. The low estimate would cover mothballing/perpetual care taking and/or entombment. The high estimate would cover unforeseen problems in permanent disposal of low level waste after dismantling and/or unforeseen complications in dismantling.

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3. Capacity Factor

Low Estimate	60%
Expected estimate	69%
High Estimate	77%

New England nuclear plants have averaged 74.3 % capacity factor after four years of "break-in/start up" or 76.6% after five years operation. Other parts of the country have not done as well.

The 69% estimate is made up of + for mature units, less 4-5 % allowance for start up, less 1-2% for going to larger units.

4. AFCR 5

This is the amount multiplied by the initial book value of plant and equipment to cover finance costs, federal, state and local taxes, etc. The assumption is that nuclear plants will be financed through private utilities. There is a considerable difference in the cost of capital depending upon the method of financing. — For example:

Private

51% bonds @ 9.5%
13% preferred stock @ 9.5% before tax, 19% after tax.
36% common stock @ 15.5% before tax, 31% after tax.
Weighted average 18.48%

Public:

100% tax free bond @ 7% = 7.00%

Low Estimate	17%
Expected estimate	18%
High Estimate	21%

5. "Capital Cost" (including allowance for decommissioning)

$$\begin{aligned}\text{"Capital Costs"} &= \frac{(\$/\text{KW plant cost} \times (\text{AFCR } \%) \times (1000 \text{ Mills}/\$)}{(8760 \text{ hours/year} \times (\text{capacity factor}))} \\ &= \frac{(962 + 39) \times (.18) \times (1000)}{(8760) \times (.69)} \\ &= 29.8 \text{ Mills/KWH} - 1978 \$'s\end{aligned}$$

(Note: Variations around expected value will be shown graphically)

6. Uranium Oxide Cost

Anticipated \$43/# in mid '80's (1985), perhaps as high as \$58/as low as \$40.

Low estimate	\$27/# or 1.76 Mills/KWH
Expected estimate	\$29/# or 1.89 Mills/KWH
High estimate	\$39/# or 2.54 Mills/KWH
(assuming .065 Mills/KWH for each \$/#)	

The U.S. Government estimates there are adequate domestic supplies of U_{308} in the ground to cover foreseeable needs. There are, however, individuals who disagree with the government estimates — some saying they are too high — some saying they are too low.

An extremely large find of ore of high quality has been just been made in Canada.

There may develop a milling capacity problem in the late 1980's.

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7. Enrichment Cost

\$33/SWU now anticipated to rise @ 5 - 6% a year.

Supply adequate through at least 1990 with 40,000 SWU stockpile—centrifuge going on line. Use 1.50 Mills/KWH for 1990 levelized or \$.75/KWH in 1978 \$'s.

8. Fabrication Costs

Per T. Malone—NEES—current cost is 0.7 Mills/KWH direct plus 0.3 Mills/KWH financing for time of fabrication or 1.0 Mills/KWH.

9. Waste Disposal Costs

Based on literature search only, ultimate technology has not been proven in practice. Wide range reflects uncertainty.

Low estimate	0.1 Mills/KWH
Expected estimate	0.5 Mills/KWH
High estimate	1.0 Mills/KWH

10. Stabilize Mine Tailings

One estimate only—at 8¢/# = .05 Mills/KWH.

11. Total Fuel Costs

Uranium Oxide	1.89 Mills/KWH
Enrichment	.75 Mills/KWH
Fabrication	1.00 Mills/KWH
Waste Disposal	.50 Mills/KWH
Mine Tailings	.05 Mills/KWH
Total Fuel	4.19 Mills/KWH in 1978 \$'s

(Note: Using 7% general inflation, the following are other estimates of total fuel costs corrected to 1978 \$'s: MEPO—5.7, AEC Wash 1/74—4.3, A.D. Little 5.3, NERA—4.3)

12. Operating and Maintenance Costs

Use 2.60 Mills/KWH—1978 costs for four Yankee operating plants (This is somewhat higher than AEC, Boston Edison, and MEPO estimates).

13. Total Nuclear Costs

Capital Costs	29.8 Mills/KWH
Fuel Costs	4.2 Mills/KWH
Oper/Maint. Costs	2.6 Mills/KWH (1978 \$'s)

The Availability and Costs of Wood 1978—2000

I. General Availability

The New England Federal Regional Council has recently estimated that the region can harvest as much as 2 billion cubic feet of wood every year between now and the year 2000, the total energy equivalent of 540 million tons of coal, 2.3 billion barrels of oil, or the power output of ten nuclear power plants operating from now until the year 2000.¹ A study prepared for Maine's Office of Energy Resources estimates that Maine's commercial forests can provide $.62 \times 10^{15}$ BTUs or 1/5 of New England's current total energy demand, harvesting 1/20 yearly of the state's dead trees, thinning overstocked acreage of 50% of its excess, and utilizing residues of current logging operations.² A wood availability estimate prepared by a Mitre Corporation researcher predicts that at least $.3 \times 10^{15}$ BTUs can be generated from New England's forests from mill and lumber residues, culling of undesirable wood, selective cutting of annual surplus growth, and minimal production of biomass plantations.³

Table 1
Forest Land Use in New England ¹
(thousands of acres)

	Commercial Forest Land	Productive Reserved	Unproductive ²	Density* (cu.ft./acre)	Total Forest Acreage As % Total Land A
Connecticut:	1,806	30 ³	25	1,394	59.7
Maine:	16,894	221	634	1,424	89.7
Massachusetts:	2,798	104	50	1,395	58.9
New Hampshire:	4,692	55 ³	238	1,586	86.2
Rhode Island:	395	9	-	1,029	60.2
Vermont:	4,430	44 ³	20	1,333	75.7
Total N.E.	31,015	463	967	1,426	80.5

1. Source: *USDA Forest Service Resource Bulletins* NE-26, NE-36, NE-43, and NE-46. Based on merchantable bole concept and accounts for only commercial species

2. Incapable of producing 20 cubic feet per acre per year of industrial wood (all round wood products except fuel wood).

3. Includes some acreage used for Christmas tree production.

New England has a vast energy reserve in its forest lands. Table 1 reveals the extent and distribution of the region's potential wood energy resources.

The state of Maine dominates the region, with better than 50% of New England's commercial forest land. Forest density ranges considerably from one state to the next, from New Hampshire's 1586 cu. ft. per acre, to Rhode Island's 1029.

1 New England Federal Regional Council, *The Potential of Wood as an Energy Resource in New England*, September 1977. p. 23.

2 T. von Foerster, *On the Use of Wood as an Energy Resource in the State of Maine*, January 31, 1978. p. 42.

3 Abbie Page, "Wood Energy Overview", speech for the Second Annual Conference of the New England Solar Energy Association, September 8, 1977.

II. Possible Sources of Wood Energy

Mill and logging residues, land clearings, diseased, dead, and undesirable standing trees, thinnings from overstocked acreage, annual surplus growth of tree parts not merchantable and biomass plantations represent the energy sources from New England's wood.

Table 2
Possible Sources of Wood for Energy in New England

Source	From	Consisting of
Mill Residue	Pulp & Paper Mills Sawmills Veneer Plants Plywood Plants Other	Bark Chips Sawdust End Trim Slabs & Edgings Other
Forest Residue	[Logging Operations] [Intermediate Cuttings and Thinnings Annual and Accumulated Mortality (Disease, Insect, Fire and Wind-Killed)] [Land Clearing (Road and Urban Construction etc.)]	Tops, Limbs, Leaves, Needles, Twigs, Stumps and Roots Dead Tress (Down or Standing) Cull Logs Undesirable or Uncommercial Species Tress From Stagnated Stands Urban Trees To Far From Markets
Annual Surplus Growth	Commercial Tress Not Now Harvested	Tops, Limbs, Leaves, Needles, Stumps and Roots, Plus or Minus Merchantable Bole
"Biomass Plantation" (Theoretical)	Dedicated Land Areas	Tress Dedicated to Production of Energy Crop (Usually Thought of as All Parts of the Tree Above the Stump Root System)

A. Mill Residues

The wastes generated by saw mills and the pulp industry have been calculated as follows:

Table 3
Use of Mill Residues In New England

State	Million Cubic Feet				10 ¹⁵ BTU
	Used as Fiber	Used as Fuel	Other Uses	Percent Used	BTU Content Unused
ME	26.7	8.4	13.8	82	.00255
NH	8.9	1.3	6.3	85	.000690
VT	4.5	1.8	4.4	84	.000476
MA	2.6	0.7	2.4	77	.000405
CT	0.3	0.3	1.2	86	.000069
RI	0.1	0.1	0.1	86	.000012
Total					.004202

Abbie Page.

Basic Data from James T. Bones, "Residues for Energy in New England," *Northern Logger and Timber Processor*, June, 1977.

B. Logging Residues

Abbie Page has calculated the parts of the tree left behind by loggers—everything but the merchantable bole (trunk and commercially desirable sections of wood) and the stump-root systems. It is important to recognize that logging operations take place on only a very small fraction of commercial forest land each year. In Maine, for example, where the forest industry owns almost half of all the commercial forest acreage, only 5.5% of the industry's land, and less than 3% of the state's commercial land, is harvested each year.¹ The industry's portion of the commercial land outside of Maine is considerably less, with a 32% total for the region (excluding Connecticut).²

Table 4
Annual Logging Residues In New England Forests
10³ DTE Total Log Residues

State	Softwood	Hardwood	BTU x 10 ¹⁵
ME	1509	1047	.043452
NH	91	215	.005202
VT	96	229	.005525
MA	69	137	.003502
CT	5	43	.000816
RI	2	8	.000170
Total			.058803

Abbie Page. Basic data from *Outlook for Timber in the United States*. Calculations based on methods found in MITRE/METREK *Silvicultural Biomass Farms*. Vol. VI.

Page cautions that her data is full of assumptions which cannot be easily tested. The Maine study estimates a total threefold that of Page's.³

C. Land Clearing

This is the one category in which southern New England surpasses the more heavily forested north country. More construction and new development occurs in the heavily populated states of Massachusetts, Connecticut, and Rhode Island.

Table 5
Potential Energy Wood Made Available by Land Clearing in New England

State	10 ³ Acres Cleared 1973	10 ¹⁵ BTU From Available Available Biomass
ME	14	.00787
NH	11	.00520
VT	4	.00158
MA	27	.01409
CT	17	.00967
RI	4	.00145

1 von Foerster, *Op. Cit.*, p. 17.

2 USDA Forest Service Resource Bulletins, NE-26, NE-36, NE-43, and NE-46, tabulated on p. 13, N.E. Federal Regional Council, *Op. Cit.*

3 von Foerster, *Op. Cit.*, p. 18. Includes cull and thinning as well as tops of trees, branches.

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D. Undesirable Wood

Large quantities of wood are diseased, dead, crooked, or a commercially undesirable species (i.e. red maple). In Maine alone, over 1/2 billion tons of wood fit one of these categories. Harvesting over twenty years this one-time resource yields the BTU values for New England recorded in Table 6.

Table 6
Potential Energy Wood From One-Time Harvest of Undesirable Trees on Commercial Forestland in New England

State	Commercial 10 ³ Acres	% of Forestland Designated "Commercial"	10 ¹⁵ BTU Value
ME	16894	95	1.09
NH	5020	98	.32
VT	4364	99	.28
	26278		1.70
MA	3491	99	.23
CT	2169	99	.14
RI	429	99	.03
	6089		.39

E) Overstocked Land

Much of New England's forests are now overstocked. The 1970 Forest Service Report (Ferguson & Kingsley, 1972) indicates that "95% of all trees of sufficient quality to be cleared as 'desirable' occur on stands that are stocked at less than 30% of the standard."¹ So if all stands now classed as overstocked were thinned to a medium stocking of 60—100% of the standard value for desirable species, nearly half of the trees on those lands would be removed. If this harvesting took place over a period of 20 years the following energy potential could be extracted.

Table 7
Overstocked Potential (1/20 per year)*

	Overstocked Acreage (thousands of acres)	5 of Land Participating (Estimated)	10 ¹⁵ BTU Value
Connecticut	523	30	.00133
Maine	9,120	70	.54267
Massachusetts	811	30	.00269
New Hampshire	2,392	60	.01219
Rhode Island	115	20	.00019
Vermont	1,506	50	.00640
		TOTAL	.0884

*Estimates based on # of owners per overstocked acreage and percentage of acreage owned by forest industry.

¹ *Ibid.*, p. 23. Extrapolated from Forest Service Report.

Harvesting this potential will be more costly than harvesting other categories of wood. The dense growth in overstocked areas requires smaller machines, careful felling and difficult skidding. Current large scale harvesting machines commonly in use could not be used. Unless new machines are designed, the process would require a more labor-intensive, expensive operation.

F) Annual Surplus Growth

That portion of annual wood growth which includes tree tops and branches, seedlings, and cull (rotten, crooked, diseased undesirable species) amounts to an enormous potential energy source for New England. About ten percent of the region's total energy requirements could be met by harvesting the untapped potential these wood categories represent.

Table 8
Surplus Annual Growth

	% of Available* Commercial Land Harvested	Tops and Branches	Cull	Seedlings	10 ¹⁵ BTU
CT	30	.00225	.00450	.0045	.01125
ME	70	.05022	.10040	.1004	.2511
MA	30	.00349	.00698	.00698	.01745
NH	60	.01866	.03732	.03732	.0933
RI	20	.00042	.00085	.00085	.0021
VT	50	.01034	.02069	.02069	.0517
TOTAL		.08538	.17074	.17074	.3752

*These percentages are gross estimates based on the distribution of acreage by commercial class and size, owner attitudes, and institutional constraints. Estimating physical accessibility constraints was not attempted.

Saplings or seedlings contribute a great deal to this energy potential. Thinning a forest can improve the growth of the remaining trees and the surrounding wildlife habitat. The Maine study reports that only one seedling in six grows up to become a growing stock tree; so nature removes an average of 8% of all seedlings per year over the 20—30 years it takes a stock tree to mature.¹ Harvesting these trees at the same rate should yield 1/2 ton per acre per year. The cull trees (rotten, rough, recently dead) should offer an approximately equivalent yield each year. Tops and branches are computed to yield better than 1/4 ton per acre per year.²

G) Biomass Plantations

Page's estimates can be converted into 1/10 of the tillable land defined as Class IV: "fair land with severe limitations caused by soil, slope or drainage...Suited only to occasional or limited cultivation."³ Page's best guess of what can be harvested from biomass plantations are:

¹ *Ibid.*, p. 16.

² *Ibid.*, p. 14.

³ Abbie Page, *Op. Cit.*

Table 9
Potential Energy Wood From Biomass Plantations on 1/10 of the S.C.S.
Class IV Acreage in New England

State	Acres	10 ¹³ BTU
Maine	123,341	1.05
New Hampshire	9,662	.082
Vermont	25,784	.219
Massachusetts	10,385	.088
Connecticut	27,807	.236
Rhode Island	8,968	.076
TOTAL	179,616	1.528

This is a resource we should not count upon before 2000.

H) Intensive Silviculture

Today European forests are much more intensively managed than those in the U.S., and forests with characteristics similar to ours have productivities better than 10 times as large.* Instead of harvesting 1 1/2 to 2 tons per acre, we might expect productivities of more than 15 tons per acre per year, of which 2/3 would be sufficiently undesirable for high quality uses that this portion could be used for energy purposes. Careful planting, thinning, harvesting, and soil maintenance practices could very easily double or triple present capabilities by the year 2000. To be conservative we estimate that the energy harvest from tops, branches, cull, and seedlings will double in production by 2000.

Table 10
Wood Energy Availability Generated By Doubling Productivity of Surplus Annual Growth
For Year 2000

	Tops & Branches	Cull	Seedlings
Connecticut	.00450	.0900	.0900
Maine	.10040	.20080	.20080
Massachusetts	.00698	.01399	.01399
New Hampshire	.03732	.07462	.07462
Rhode Island	.0085	.0170	.0170
Vermont	.02069	.04139	.04139
New England	.17074	.34148	.34148 Total .85370

I) Total Wood Energy Potential

Today, more than $.7 \times 10^{15}$ BTUs are available for wood energy. This potential represents 26% of the total energy demand for New England in 1975, 89% of the residual oil consumption, and 112% of the distillate consumption for that year. In 1985, forest management practices should at least double harvesting productivity for wood energy. This potential does not factor in physical accessibility constraints and institutional barriers, which would reduce the availability figures. It also does not account adequately for increasing future market pressures and advanced harvesting technologies which would alleviate those constraints. The constraints section elaborates further on these points.

* von Foerster, *Op. Cit.*, p. 30. (Rich and Bauer, 1975).

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Table 11

New England Yearly Wood Energy Potential (10¹⁵ BTUs)
Surplus Annual Growth

	Land Clearing	Tops & Branches	Cull	Seed- lings	Un- desirable	Over- Stocked	Mill Residues	Annual Logging	Total 1978-85	Biomass	2 x Annual Productivity Growth	Total 2000
Connecticut	.00967	.00225	.00450	.00450	.007	.00133	.00007	.0008	.03012	.00236	.0225	.03484
Maine	.00787	.05022	.10040	.10040	.055	.05426	.00255	.0434	.41418	.01050	.5022	.93133
Massachusetts	.01409	.00349	.00698	.00698	.012	.00269	.00041	.0035	.05014	.00088	.0349	.08592
New Hampshire	.00520	.01866	.03732	.03732	.016	.01219	.00069	.0052	.13258	.00082	.1866	.32000
Rhode Island	.00145	.00042	.00085	.00085	.002	.00019	.00001	.0002	.00604	.00076	.00042	.01096
Vermont	.00158	.01034	.02069	.02069	.014	.00640	.00048	.0055	.07966	.00219	.1034	.18525
New England	.03986	.08534	.17074	.17074	.108	.0884	.00421	.0586	.71272	.01751	.8538	1.56835

Land clearing, undesirable, mill residues, annual logging, and biomass totals are Abbie Page's; Surplus annual growth, overstocked and 2x productivity are my own.

Table 12

Annual Costs of Home Heating Systems in Maine

	Furnace		Fuel		System	
	Initial Cost* \$	Annual Cost** \$/yr	Efficiency	Unit Cost \$10 ⁶ BTU	Annual Cost \$/yr	Annual Cost \$/yr
OIL (new Installation)	800	110	0.50	3.4	475	585\$/yr
GAS (new)	650	90	0.60	3.0	350	440\$/yr
ELECTRIC RESISTANCE (new)	400	55	1.00	10.3	720	775\$/yr
HEAT PUMP (new)	1200	160	1.70	10.3	425	585\$/yr
WOOD STOVE (new)	1100	150	0.60	2.8	435	545\$/yr
WOOD FURNACE (new)	1100	150	0.60	2.8	325	475\$/yr
WOOD-CHIP FURNACE (new)	2500	340	0.60	2.0	230	560\$/yr
OIL (existing)	0	0	0.50	3.4	475	474\$/yr
WOOD FURNACE (add-on)	300	40	0.60	2.8	325	365\$/yr

* rounded to nearest \$50

** 0.135 times the initial cost

All price are estimates for 1977.

Annual costs rounded to nearest \$5.

Fuel costs based on a demand of
70 million BTU/yr, delivered to rooms.

Source: *On the Use of Wood as and Energy Resource in the State of Maine*

II. End Use and Costs—Today and Tomorrow

A) Home Heating

Residential use of wood for space heating has risen dramatically since the Arab oil boycott. While no accurate data is available for residential wood-burning in past years, an official of the Vermont Energy Office estimates that residential wood burning has increased five-fold since 1975.¹ Today, 18% of Vermont homes use wood as their primary heating fuel; 63% burn wood to some degree. The Vermont Energy Office reports that 300,000 cords of wood, or 6.7×10^{12} BTUs were burned in households last year. A 12% increase is projected for 1978 in Vermont. The New England total for 1977 is in the 1.1—1.2 million cords range, or $2.3—2.5 \times 10^{13}$ BTUs.² In 1977 prices, wood is delivered today at \$60-80 per cord, or \$2.80-3.70 per MMBTU. No. 2 fuel oil is priced at \$3.40 per MMBTU. Electricity is \$10.30 per MMBTU (in Maine). In the northern New England states, the price is closer to \$50 (assuming trucking of 75 miles); in the southern states, \$80, with frequently higher prices for delivered wood. With a rapidly expanding market all over New England, the regional differential should close somewhat in future years. The Maine study indicates that new wood furnaces in that state will cost the average homeowner the same as an existing oil furnace in annual costs (\$474/yr) and a new wood stove \$60 more per year. A wood furnace add-on would be only \$365/yr., the cheapest of all heating alternatives.

B) Commercial Heating

Today commercial heating with wood is insignificant. Yet the Maine study indicates that commercial wood heating systems would be cheaper than conventional heating today.

Table 13
Annual Costs of Commercial Heating Systems in Maine

	Furnace		Efficiency	Fuel		System Annual Cost \$/yr
	Initial Cost \$	Annual Cost* \$/yr		Unit Cost \$/10 ⁶ BTU	Annual Cost \$/yr	
GAS	100	100	0.6			
residential				3.0	2500	2650
L.N.G.				3.5	2900	3050
OIL	1500	250	0.6			
residential				3.4	3400	3650
industrial				2.8	2800	3050
WOOD CHIPS	6100	950				
green, local			0.5	1.4	1400	2350
dried, distant			0.6	2.0	1650	2600
dried, delivered***			0.6	2.3	1900	2850

* 0.0158 times the initial cost.

** including \$5/ton for handling & delivery

All prices are estimates for 1977.

All costs rounded to nearest \$50.

Fuel Costs based on annual heating demand of 500×10^6 BTU.

Source: *On the Use of Wood as an Energy Resource in the State of Maine.*

1 Telephone interview with Allen Turner, Vermont Energy Office, September 6, 1978.

2 Telephone interview with Curtis Mildner, NERCOM, September 7, 1978. NERCOM surveyed the region's state energy offices for wood heating data in the residential and industrial sectors.

C) Utility Electricity Generation

Burlington Electric is today operating a 10 MW wood-burning plant costing consumers 21 mills/KWH on a 75% wood/25% oil over-fire basis. The wood portion costs consumers 18 mills/KWH. The wood is delivered as chips at \$12.00—12.50 per ton and arrives from within a 50 mile radius. Saw mill residues and whole tree chippers provide the wood for burning. A 6.5 MW boiler will soon be converted to 100% wood. A third boiler (30 mills/KWH) is 55-45% coal-oil over-fire. Burlington Electric is planning a 50 MW 100% wood-fired plant for completion in 1980, to cost consumers 51 mills/KWH in 1983 dollars or 34.7 mills in 1978 dollars.¹ Two other studies forecast a range of 40-60 mills in 1976 dollars.² This is competitive with future coal and nuclear generation. The boiler will require 2 and 1/2 years to build and cost an estimated \$80 million in current dollars. They expect delivered wood chips to cost \$19-20 in 1983 dollars. A Dartmouth feasibility study³ predicts that delivered wood chips will cost from \$10.88 to \$17.56 in 1978 dollars. In 1983 dollars this range is \$15.26 to 24.63, well in line with Burlington Electric's projections. The boiler will burn 550,000 green tons per year or 1500/tons/day. Currently they burn 200-250 tons per day. The Dartmouth College study concludes that there is plenty of wood available and feasible for procurement within a nine county area in northern Vermont. In fact, Vermont can most probably support three 50 MW wood-burning plants, generating 20% of the state's current electricity demand.⁴ An energy consultant and principal author of another study examining the feasibility for generating electricity from wood testified at licensing hearings for the Seabrook nuclear plant that all of New Hampshire's electricity needs could be met with wood-fired boilers stocked by instate wood chip purchases.⁵ Adopting the most conservative written feasibility estimate for electricity generation and applying its parameters to Maine, Vermont and New Hampshire, twenty 50 MW wood-fired plants could be built. This estimate takes into account the inaccessibility of millions of acres at greater than 15° slope, farther than 1/2 mile from a road, and/or protected by owners unwilling to allow harvesting. It assumes only low quality wood would be harvested for electricity generation purposes. This 1000 MW capacity for New England's northern tier represents 23.5% of its current electrical capacity and almost 5% of the region's current capacity. With better than a 95% demonstrated capacity factor, wood-burning has proved to be a much more efficient electricity source than historical projections would indicate.

D) Industry—Electricity

There are only incomplete figures on the extent to which industry burns wood for heat and electricity generation. The Maine study estimates that 35-50% of the forest industry's total energy needs are now met with wood. The Vermont Energy Office estimates that Vermont industry uses 3.3×10^{11} BTUs in wood today and will burn 1.6×10^{12} BTUs by next year. A NERCOM official reports that 150 industries in the region

¹ Telephone interview with Bob Young, Burlington Electric, August 29, 1978.

² Kathleen T. Segerson, *Estimating the Cost of Wood-Generated Electricity: A Broader Perspective*, Dartmouth System Dynamics Group; and Allan J. Schultz, *Feasibility of a 50 MW Generating Plant Using Wood for Fuel*, study for the Vermont Public Service Board, January 1977.

³ Charles E. Hewett, *The Availability of Wood for a 50MW Wood-Fired Power Plant in Northern Vermont*, a report prepared for the Vermont State Energy Office, Dartmouth College, Hanover, N.H., June 1978.

⁴ Interview with Phil Rich, J.P.R. Associates, September 7, 1978.

⁵ Carl H. Reidel, *The Yankee Forest: A Prospective*, Yale School of Forestry and Environmental Studies, 1978, p. 13.

cogenerate at least 1/2 MW of electricity, a large potential market for wood-burning. Since this electricity has not been sold off the premises to date, no price data is available.

III. Jobs

A Yale University study reports that 60,000 new jobs can be created for the region by utilizing the annual surplus growth for all its potential economic uses.¹ A recent Brookhaven National Laboratory study estimates that 10-16,000 jobs can be created in the Northeast from the wood energy business alone.² One 50 MW plant is projected to create 282 jobs, 147 directly in the plant or as wood harvesters.³ For the 2-3 year construction period, 771 jobs would be created. The author also points out that a wood-fired boiler built in Vermont would most likely be located in a high unemployment area, resulting in a substantial boost to the surrounding region. Maine and New Hampshire could similarly profit by the strategic location of wood-burning plants.

IV. New Technologies From Wood

A) Pelletization

This process dries wood (bark, chips, sawdust, edgings, etc.) to 25% moisture, pulverizes the mixture and presses it into pellets. Agricultural wastes, grass, peanut shells, peat, refined solid waste and bogasse (sugar cane refuse) can also be used as feedstock for pelletizing. With a BTU value of 8750/lb. wood pellets can be burned directly as a fuel or converted to gas for use as a boiler fuel. A local firm, Bick-Com, is planning to build a plant in Maine which will produce 300 tons per day. The pellets will sell for \$34 per ton from the factory, of \$1.95 per million BTUs. The plants are being built to supply primarily industrial boilers within 50-100 miles from the plant. If wood chip transportation costs are comparable, a one-hundred mile delivery would add \$4.00-7.00 per ton to the cost, bringing the total delivered price to \$2.17 to \$2.35 per MMBTU, a competitive price with alternative fuels. Bick-Com's parent company, Biosolar R & D of Eugene, Oregon, is designing a firebox adoptable to any boiler. Even residential use of wood pellets is contemplated. Bick-Com expects to build many more plants during the next ten years in New England.

B) Wood Gasification

High combustion efficiencies ranging from 75-90%, clean burning, and relatively low capital costs are three reasons wood gasifiers coupled to boilers may be an increasing phenomenon in the industrial and residential sector. Wood chips are fed from a storage area through a dryer into a gas generator. The wood combustion maintains a temperature ranging from 1200-1600 degrees inside the gas generator. The wood decomposes by pyrolysis, yielding distillate gas and charcoal. Air supplied to the glowing charcoal reduces the charcoal to carbon monoxide and gas.⁴ The distillate and carbon monoxide gases flow through a nozzle burner assembly where secondary combustion takes place. Simultaneously the heat released in primary combustion is carried with gas stream into the secondary combustion zone, producing a gas containing 200-250 BTU/cu. ft. Industrial market sales are expected to begin next year. Demonstration units are already in place in two New England locations. The economics of wood gasification is not yet clear, but more R & D money may be justified for its implementation.

1 Brookhaven National Laboratory, *Assessing Employment Implications of Alternative Energy Supplies*, National Center for Analysis of Energy Systems, February, 1978.

2 Segerson, *Op. Cit.*, p. 6.

3 N.E. Federal Regional Council, *Op. Cit.*, p. 28.

4 von Foerster, *Op. Cit.*, p. 105.

C) Methanol

Wood alcohol is a colorless, odorless water soluble liquid produced during pyrolysis of wood. Already methanol and gasoline mixtures, containing 15% methanol have been tested in automobiles without any engine modification. While there is some controversy about the success of the initial testing, advocates claim improved energy economy, lower emission, and improved engine performance over gasoline. Methanol currently costs about 43¢/gallon at the refinery (gasoline 38-40¢, according to New England Federal Regional Council figures). Yet methanol contains only 1/2 the BTU value of gasoline, raising its costs as methyl fuel (which includes small amounts of propanol, ethanol, and isabutanol) to about 65¢/gallon at the refinery. Only as gasoline prices increase significantly (closer to \$1.00) will methanol become attractive as a fuel.

V. Competitive Uses of Wood

The harvesting of slash, cull, and thinnings will not be affected by foresters utilizing roundwood or tree boles, the raw material of most forestry products. Yet pulp, fiberboard, and possibly the chemicals industry may also have use for the low-quality wood now unutilized. The pulp industry in particular is now deriving 20% of its materials from saplings, tops and branches, and rough or dead trees. The development of the portable whole-tree chipper has accelerated their exploration of these wood resources. Chip classifiers, not in widespread use today, would increase pulp industry competition further because this machine can separate undesirable bark from wood before chipping. Yet the competition should not seriously deplete the forests. Even if the pulp industry maintains its present 3.7% annual growth, only 14 million tons of wood would be harvested in the year 2000 in the state of Maine, up from 4 and 1/2 million tons per year in 1970. With careful silviculture methods the forests should be capable of adequately supplying both the pulp and energy markets. The major effect of the limited competition between the two markets may be that of price-setting determined by the most valuable use. If fossil fuel prices increase significantly in the next decade, wood will be a popular substitute, driving prices up, resulting in an increase in the price of paper.

VI. Constraints Limiting Harvests

Five categories of constraints deserve mention: technology, physical accessibility, institutional accessibility, landowner attitudes toward harvesting, and environmental impacts. Many of these constraints vary widely by state; others are likely to undergo major changes in a short period of time; the dimensions of still others are largely unknown. The following brief discussion cannot do justice to a very complicated set of issues, but will outline the kinds of problems and opportunities accompanying wood energy production.

A) Technology

The cutting (felling), moving (skidding) and chipping of wood have all benefitted from innovations in recent years which renders previously untapped stands feasible for harvesting. The recently developed feller-buncher cuts trees with hydraulically powered cutting shears mounted on a tractor. Equipped with "accumulators", these machines are capable of carrying several felled trees at once. For small timber, production can be doubled or tripled with use of accumulators.*

Grapple skidders, four-wheel drive machines with a claw in the rear haul several felled trees to a landing. Skidding with horses is still done in some locations, minimizing the soil damage.

* *Ibid.*, p. 113-115.

Portable whole tree chippers have revolutionized forest harvesting. Operated by one person, the chipper can convert a 22 inch diameter tree into chips in 30 seconds and transfer the chips into a truck within 50 seconds of start-up. Chipping can be performed in the forest or at a processing plant.

These new technologies improve the wood procurement system several fold. As prices for wood energy products rise, it will become increasingly economical to harvest steeply sloped, or densely forested, or remotely located stands, and we can expect yet new machines to facilitate harvesting and make more readily available what today is untouched.

B) Physical Accessibility

Steep woodland slopes and the lack of roadbeds in harvest areas restrict the availability of wood for energy uses. Slopes greater than 15° are very difficult for feller-bunchers and grapple skidders to negotiate. The unsuitability of mechanized harvesting techniques for this wood requires more labor-intensive techniques and higher prices. Only higher fuelwood prices would make such harvesting feasible. Slopes of this degree are concentrated in sizeable pockets in the Massachusetts Berkshires, New Hampshire's White Mountains, Vermont's Green Mountains, and in western Maine. Less than 15% of the region is covered by slopes of this gradient.

The stands farther than 1/2 mile from an accessible roadbed make current harvesting uneconomical. These areas correspond closely to the areas with steep slopes. Again we can expect that rising wood fuel prices will result in more road-building and improved access to these areas.

C) Institutional Accessibility

Local, state and federal governments collectively own 6.2% of the area's commercial forest land. Various recreational, conservation, and wilderness purposes obviously restrict the land available for harvesting. Stricter procedures and regulations than private landowners would require would similarly limit production. Yet public lands offer the potential of early and effective forest management techniques through R & D pilot programs. It is difficult to estimate what net impact public lands will have on the availability of wood.

D) Social Attitudes

What private woodlot owners are willing to do with their land is a subject of intense speculation and scrutiny. Interviews have been conducted and attitudes questioned, but this polling is a hazardous and rather unreliable process at present. What researchers have discovered generally is that larger landowners (more than 500 acres) are more willing than smaller landowners to allow whole tree harvesting—the technique necessary for low-quality wood production for energy purposes—on their property. One northern Vermont study indicates that 3/4 of the owners of all land sizes are willing to have their land harvested, but only 1/2 are willing to allow whole-tree chipping. Thinning was not queried.* Yet whole-tree chipping is a technique unfamiliar to most landowners, so the reliability of such a question is suspect. Second, the larger landowners own a disproportionately large fraction of total commercial forest land: in northern Vermont owners of 500 acres or more own 4 times the property owned by those with 150-199 acres, and 40% more than those with 200-500 acres. Therefore those now willing to allow harvesting represent a large portion of total available land. Third, attitudes are likely to change drastically as wood energy markets cuts into the fossil fuel market and commands higher prices. Much of the present resistance among a minority of

* *Ibid.*, page 113-115

Table 14
Survey of Northern Vermont Landowner Attitudes Toward Wood Harvesting and Whole Tree Chipping on their Property

Owners of 150 to 199 Acres

	Willing to Harvest (Percent)	Willing to Whole-Tree Chip (Percent)	Acres Owned		Acres Available For Chipping	
			Number	Percent	Number	Percent
Yes	72	50	4,696	40	3,406	29
No	19	38	3,907	33	0	0
Unsure	9	12	3,157	27	?	?
Total Timber Acres			11,760			

No. of Owners Making Useful Responses: 109

Total Acreage in Survey: 18,087 acres

commercial landowners is rooted in an (1) unfamiliarity with harvesting techniques and impacts on their property, and (2) unfamiliarity with the price thin stands can command for energy production.

E. Environmental Constraints

At the harvest site and in combustion, wood as a fuel can have significant environmental effects. The carbonaceous matter in wood removed for burning does not harm the forest, but the matter taken from the soil is a more serious problem. Decomposing leaves, needles and trees provide up to 40% of potassium and 85% of the nitrogen in the soil. Hauling away tree tops, branches, leaves and twigs may deplete two-three times the soil nutrients that conventional bole harvesting removes. The removal of slash also exposes the soil to considerably more erosion and leaching from rain. It could take 45-80 years to fully restore nutrients and biomass lost after a whole-tree harvest.* Planting some rapidly growing grasses or other plants, including clover, can serve to replenish the nutrients and stabilize the soil. The ash from burnt wood is an ideal fertilizer. Logging operations also damage the soil surface from skidding operations. Carefully constructed, particularly permanent, logging roads reduces that damage considerably. Finally, removing trees at a rate enabling the forest to recover also diminishes erosion and improves forest quality.

Wood is a fairly clean burning fuel. It contains very little sulphur. Yet ash, nitrogen, and particulate emission must be monitored and controlled. The technology developed for coal-burning plants should be adequate to control the ash and particulate emissions. Wood burning stoves and furnaces in homes present larger potential problems in aggregate, because combustion is more incomplete. Therefore, suspended particulates emitted are more voluminous, and in urban areas, unacceptable pollution levels could be reached. Benzopyrene, a carcinogenic substance, is produced in wood-burning at a rate of 50 times that of oil or gas. One study estimates that wood-burning could cause up to 10 deaths per year per million people.* Yet this study also points out that people smoking one cigarette per day have an excess death rate of 200 per year per million people. There is insufficient data to assess accurately the public health effects of widespread wood-burning. A preliminary analysis indicates that some adverse effects do accompany combustion, but the adequate controls, such as more efficient furnaces and

* *Ibid.*, page 113-115.

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stoves, can reduce the dangers considerably. More study is clearly called for at the point that wood-burning becomes widespread as a home-heating fuel in urban areas.

The Biomass Subcommittee of the Economic Development through Alternative Sources of Energy Committee is undertaking a more thorough analysis of the environmental impacts associated with wood energy harvesting and burning. Their findings and recommendations should be of interest to the Supply Committee.

VII. Conclusion

On balance, wood is an excellent indigenous energy resource for New England. It can be used for two purposes currently consuming large quantities of oil—electricity generation and space heating. With a 2 1/2 year construction period and a 2 1/2 to 3 year licensing period, wood-fired electricity can be added to the grid more quickly than conventional systems. It appears to be competitive today and in the future with conventional fuels for electricity generation. It could provide 1000 MW, or 8% of today's capacity by 1990. Its potential role in space heating, which currently consumes almost 30% of our petroleum usage, and 25% of all New England's energy, is even greater. In 1975, New England used approximately 1.4×10^{15} BTUs of petroleum, or 240 million barrels of oil for electricity generation and space heating in the residential, commercial, and industrial sectors. Today we have the wood resources available to substitute for 1/2 of the 1975 oil consumption. By 1985 and later, given very conservative assumptions, we should be able to

Table 15
Energy Prices

(All prices given are estimates for 1977 values
odt = oven dry ton)

	Unit Price	Material Price	Energy Price (efficiency)
			\$/10 ⁶ BTU
Roundwood			
green, at landing	20 \$/cord	25 \$/odt	1.4
green, 25 mi. from landing	22 \$/cord	28 \$/odt	1.6
cut, split & dried*	56 \$/cord	50 \$/odt	2.8
delivered**	63 \$/cord	50 \$/odt	2.8
Chips			
green, at landing	10 \$/cord	20 \$/odt	1.1
green, at plant***	12 \$/cord	25 \$/odt	1.4
dried, at plant***	31 \$/cord	31 \$/odt	1.8
dried, 75 mi. from plant	35 \$/cord	35 \$/odt	2.0
Natural Gas			
Residential	3.0 \$/10 ³ cu. ft.	3.0 \$/10 ³ cu. ft.	3.0
Industrial	2.1 \$/10 ³ cu. ft.	2.1 \$/10 ³ cu. ft.	2.1
Imported LNG	3.5 \$/10 ³ cu. ft.	3.5 \$/10 ³ cu. ft.	3.5
Fuel Gas (No. 2 Distillate)			
Residential	50 ¢/gal.	21 \$/BBL	3.4
Industrial	17 ¢/BBL	17 \$/BBL	2.8
Coal	50 \$/ton	50 \$/ton	2.4
Electricity (residential)	3.5 \$/KWH	-	10.3

* Air Dried, 15% moisture content

** Cut split & dried, trucked 75 mi. (1 odt = 1.2 tons, air dried)

*** Plant assumed 25 mi. from landing. Chips are kiln-dried.

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develop this resource to the point that 10-15% of our total energy requirements are met by wood.* If an oil and gas shortage or significant price increases occur in the next decade, that contribution could be even greater.

Table 16

Some Representative Energy Prices

		\$/10 ⁶ BTU
Mill Residues		1
Sawdust, Maine, 1976	(1)	.029
Hardwood Bark, New England	(2)	.45
Hardwood Sawdust, New England	(2)	.90
Chips		
Hardwood Pulp Chips, New England	(2)	1.54
Softwood Chips, Maine	(1)	2.35
Chipped Logging Residues	(1)	1.77
Biomass Plantation Wood	(3)	1.96
Coal		
Industrial Resid	(4)	2.52
Residential Distillate		3.44

Sources:

- (1) Mitre/Metrek, Silvicultural Biomass Farms, Vol. VI.
- (2) James T. Bones, "Residues for Energy in New England"
- (3) Mitre/Metrek, Silvicultural Biomass Farms Vol. IV.
- (4) FEA, reported in "Energy User's Report". June 1977.

Table 17

**Summary of Delivered Cost of Wood
Chips in Northern Vermont
(\$/Ton: 1978 Price Basis)**

Production Stage	Low Cost	High Cost
Stumpage	\$0.40	\$1.00
Harvesting	8.10	13.00
Transportation	2.38	3.56
Expected Delivered Chip Price Range	\$10.88	\$17.56

VIII. Glossary of Terms Utilized for Availability Estimates

From Thomas Von Foerster's On the Use of Wood as An Energy Resource

Cull

Poorly shaped, partly rotten or otherwise undesirable trees
(averages 2½ tons per acre; annual growth ½ ton per acre)

Cops and branches

Unmercantable, represents 30% of a tree's above ground
mass (about 8 tons per acre; ¼ ton per acre annual growth)

-
- * These assumptions include (1) fewer than 1/2 of commercial landowners allow harvesting on their property; (2) none of the 15° sloping woodlands will be harvested; (3) no new wood harvesting technologies are developed; (4) no substantial noncommercial harvesting takes place.

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Seedlings

Only one seedling in six survives to become a growing stock tree; therefore nature removes about 8% of all seedlings per year over the 20-30 years it takes to become a growing stock tree (offers an annual potential harvest of ½ ton per acre)

Surplus annual growth

Annual growth of biomass not utilized for lumber: cull, tops and branches, and seedlings represent that portion of the surplus annual growth calculated for wood energy potential in this report

Undesirable

Rough, rotten, recently dead; a category which is not included in surplus annual growth; calculations are based on current estimate harvested over twenty years

Slash

Cull, saplings, tops, branches, etc., left behind on the ground in current logging operations; "annual logging" is category for slash

Overstocked stands

The 1970 Forest Survey Report concludes that 54% of all commercial forest land is stocked at more than 130% of the standard value. Yet 95% of all trees of sufficient quality to be classed as "desirable" occur on stands that are stocked at less than 30% of the standard. Thinning the forest to a medium stocking of 60 to 100 per cent of the standard value is most desirable for optimizing the growing potential of the desirable species. Systematically doing so over a period of twenty years would enable a yearly harvest of one-third ton per acre.

Mill residues

Bark, sawdust, slabs and edgings, veneer cores and other wastes not used for other purposes at lumber and pulp mills

Land-clearing

Clear-cutting which accompanies new construction

Biomass plantations

Planting, managing and harvesting a renewable biomass crop on Class IV land — fair land with severe limitations caused by soil, slope or drainage; suited only to occasional or limited cultivation"; involves land acquisition, clearing, subsoiling, fertilizing, irrigating, planting and weed control. (Abbie Page)

IX. Methodology for Calculating Availability

The estimates of Abbie Page and the per acre estimates of Thomas Von Foerster are the bases for the estimates in this draft. The categories of land clearing, undesirable, mill residues, annual logging and biomass are taken directly from a 1977 paper of Page. The categories of tops and branches, cull, seedlings, overstocked and doubling productivity are structured from the work of Von Foerster. In the calculations, a special effort was made to avoid double-counting. The one area in which overlap is most possible includes the undesirable and overstocked categories. Some of the undesirable biomass occurs on overstocked stands. Both categories describe a present condition, not a renewable resource. In an attempt to compensate for the probable double-counting in these categories, a separate category of Von Foerster's—standing dead—is omitted from consideration altogether. The Von Foerster estimates are based on average tonnage harvest potentials per acre.

Four constraints were taken into account in the estimates: overstocking percentages by state, land with 15 degree slopes or greater, stands farther than one-half mile from a logging or conventional road, and landowner resistance to harvesting. The distribution and size of landholdings and current attitudes about cutting and harvesting with current technologies are specifically accounted for in the landowner attitude category.

Several factors affecting the harvesting potential are not considered: competing uses of the biomass (except for the lumber industry), environmental restrictions, and infrastructure limitations. Each of these factors would reduce the realizable harvesting potential. Additionally, two considerations which would increase the realizable potential are not considered: the potential of intensive forest management practices of the scale undertaken in Europe; and the persistent underestimates of the biomass surveys conducted to date. The shortcomings of the biomass inventories are such that accurate estimates of any renewable categories are not possible.

Urban Waste As An Energy Source For New England

Summary

About 15% of the organic wastes generated each year in the United States is urban refuse, or post-consumer residential and commercial waste. Urban waste is generated at the rate of four pounds per capita per day and contains 4500 BTU per pound. New Englanders generate 49 million pounds per day which is the energy equivalent of 12 million barrels of oil per year.

Resource recovery plants, which burn the refuse and separate the non-combustibles for resale, produce steam and generate electricity. The Bureau of Mines assesses the 1978 market potential for these plants as being 480 MW of electricity and cogenerate process steam. This short-term goal would replace 5-million barrels of oil per year. It is shown that 25% of this goal is extant or in advanced planning stages today. The intermediate-term goal, dependent upon modular plant sizes using no more than 1200 tons of refuse per day, would supply 730 MW of electricity and process steam, and increase oil savings by another 50% to 7.5-million barrels per year.

The paper urges two changes in attitude: (1) that this is an energy resource as well as an amelioration of solid waste problems and (2) that incentives must be forthcoming to alter utility company attitudes towards resource recovery and the cogeneration of steam and electricity.

II. Background and Goals

Each day of the year New Englanders throw away material, in the form of rubbish, trash, or garbage, whose usable energy content is equivalent to some 34,300 barrels of oil (12 million per year). This wasted energy is from residential and commercial sources only, and excludes agriculture, forestry, and industrial waste. At the same time (1976 data), New England imports from 310,000 barrels a day (113 million per year) of residual fuel oil from foreign sources. (New England Situation, Chapter II, p. 16) This is used mainly in electric and process steam generating plants. Therefore, if all discarded residential and commercial wastes were used as fuel for these plants, New England could cut her residual fuel imports by 11% (34.3 divided by 310). From the viewpoint of electric generation alone, since about 50% of the residual fuel consumed is used by the electric utilities, if all urban refuse in New England was used to fuel electric generating plants, the utilities could cut their present day residual fuel imports by 22%. The derivation of these rather significant estimates is discussed in the following sections.

III. Urban Waste Generation in New England

An investigation by the U.S. Bureau of Mines (Circular #8549, 1972) into the energy potential of organic waste in the U.S. showed the following estimates:

U.S. Post-Consumer Net Solid Waste 1975

Material Composition		Functional Composition	
Paper	37.2	Newspapers, Books, Magazines	9.8
Glass	13.3	Containers, Packaging	41.7
Metal	12.2	Household appliances	2.3
Ferrous	(10.8)	Furniture, furnishings	3.4
Aluminum	(0.9)	Clothing, footwear	1.3
Other	(0.4)	Other	18.9
Plastics	4.4	TOTAL non-food	77.5
Rubber, leather	3.3	Food Waste	22.8
Textiles	2.1	Total Product	100.3
Wood	4.9	Yard & Misc. Org.	27.9
TOTAL			128.2
non-food	77.5		
Food Waste	22.8		
TOTAL			
Product	100.3		
Yard waste	26.0		
Misc. org.	1.9		
	128.2		

As noted above, municipal solid waste including post-consumer residential and commercial waste, amounts to only 15% of the total organic waste material. In August 1977, the Office of Solid Waste, U.S. Environmental Protection Agency, delivered its fourth report to the President and the Congress on Resource Recovery and Waste Reduction. That report described the principal developments and findings in the areas of resource recovery and waste reduction, as they apply to post-consumer municipal solid wastes. The report stated (p. x) that the present high material rate of waste generation (over 1,300 pounds per person per year) and low rate of resource recovery (less than 7 percent of total waste) can be explained in large part as "the material result of an expansive, highly productive economic system endowed with an abundance of natural resources." It is further stated that "there is considerable evidence and theory to indicate that certain national government policies, institutional shortcomings, and failures in our market system of resource allocation have all contributed to a situation where waste generation is too high and resource recovery is too low." Waste generation rates were projected to grow substantially over the next 10 to 15 years (p. ix).

The following two tables have been excerpted from the EPA report (p. 15 Table 2) to point out both the material and functional composition of the 129 million tons/year of urban refuse.

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Organic Wastes of the U.S.

	Millions of ton per year	pounds/capita/ day
Urban refuse	129	3.29
Industrial waste	44	1.12
Municipal sewage solids	12	0.31
Logging and wood mfg. residual	55	1.40
Agricultural crops and food waste	390	9.94
Manure	200	5.10
Misc. organic waste	50	1.27
Total	880	22.43

The Brookhaven National Laboratory reported in 1976 (*Solid Waste as an Energy Source for the Northeast*—BNL 50559, p. 15) on a model of per capita refuse generation for various Standard Metropolitan Statistical Areas (SMSA) in New England. These are listed in the following table:

Per Capita Refuse Generation Rates by SMSA (lbs/capita/day)

	1975	1990
Boston	3.74	5.16
Bridgeport	4.20	5.58
Brockton	3.75	5.17
Danbury	3.97	5.36
Fall River	3.98	5.24
Hartford	4.40	5.88
Lawrence-Haverhill	3.86	5.28
Lowell	3.93	5.38
Manchester	4.08	5.32
Meriden	3.92	5.36
Nashua	3.87	5.11
New Bedford	4.30	5.56
New Britain	4.39	5.86
New Haven	3.90	5.33
New London - Groton	3.79	5.07
Norwalk	3.79	5.17
Providence	3.87	5.21
Stamford	3.77	5.15
Springfield - Chicopee	3.24	4.52
Waterbury	4.05	5.49
Newport	3.94	5.26
Concord	4.23	5.61
Bangor	3.76	4.91
Portland	3.98	5.24
Middletown	3.52	4.93

It is apparent that a planning estimate of residential and commercial waste of 4 pounds per person per day over the next decade may be conservative. Using that figure, however, the 12.23 million people of the six New England states will generate 49-million pounds, or 24,000 tons, of urban refuse each and every day.

IV. Energy Content of Urban Refuse

The energy yield from refuse combustion depends primarily on the composition of the refuse and its moisture content. The Brookhaven National Laboratory study, referred to previously, derives the relationship between refuse composition and BTU content of raw refuse (p. 129). Reproduced below is a table from the Brookhaven study comparing their data with that of other investigators.

	Heat Content of Refuse, as Received BTU/Pound		
	1972	1985	2000
St. Louis	4500		
Philadelphia	4300	4700	
Cleveland	4200	5000	7300
National Average	5000		
Brookhaven	4500	5000	6000

To be noted is that the heat value of refuse is anticipated to rise as a result of expected increases in the combustible fraction.

Data on refuse composition and heat value was gathered from nine separate studies containing over 300 samples, and was published in *Solid Waste Management* (Van Nostrand Reinhold, p. 6) and is shown below:

Chemical Characteristics of Municipal Refuse				
Measure	Minimum	Maximum	Average	
% Moisture	20	60	38	Wet Basis
% Carbon	8	35	24	
% Nitrogen	0.2	3.0	1.0	
BTU/Pound	3000	6000	4500	
% Ash	4	9	6.5	Dry Basis
% Carbon	20	50	40	
% Nitrogen	0.3	5	1.0	
BTU/Pound	6000	10000	7700	

We will use 4500 BTU/pound as the available heat content of New England's residential and commercial refuse. Since the population of New England generates 49-million pounds of refuse per day, some 220-billion BTU's are thrown away each day from this source. The table below will permit the translation of this waste into other units (BNL 50483, p. 193):

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Refuse	- urban	9.0 million BTU per ton
Coal	- anthracite	25.4 million BTU per ton
	bituminous	24.0 million BTU per ton
	peat	6.0 million BTU per ton
Oil	- crude	5.8 million BTU per barrel (42 gals.)
	residual	6.3 million BTU per barrel
	distillate	5.8 million BTU per barrel
Methyl Alcohol		2.4 million BTU per barrel
LNG		3.6 million BTU per barrel
Natural Gas (wet)		1100 BTU per cubic foot
Hydrogen		275 BTU per cubic foot
Methane CH ₄		913 BTU per cubic foot

Every ton of refuse has a heat content equal to 1.4 barrels of residual fuel oil or one-third of a ton of anthracite coal. So the 24,500 tons of refuse discarded each day by New Englanders can be equated to 34,300 barrels of residual fuel oil per day (12 million barrels a year) mentioned at the beginning of this paper.

It is certain that not *all* the urban refuse can be converted to usable energy. So the question to be addressed concerns the determination of the location of resource recovery plants under today's market requirements and under the technology being developed today, so that feasible goals for resource recovery can be determined.

V. Market for Resource Recovery Plants

Mr. Robert Aldrich, First Vice President of White, Weld & Company (now part of Merrill Lynch) forecast, in an August 4, 1977 article of the *Wall Street Journal*, that within 10 years resource recovery will blossom into a "moderately profitable" industry with annual revenue of \$700 million to \$1 billion (in constant dollars) from about \$40 million this year. About 30%—but perhaps as much as 50%—of the 147 million tons of garbage generated each year will be converted into fuel in some 100 to 130 plants, he estimated. In the same article, Mr. Michael Dingman, Chairman and President of Wheelabrator-Frye, said he saw resource recovery as a good long-term business with a rate of return comparable to telephone and utility concerns. He said Wheelabrator-Frye expects to start two new plants a year during the next ten years.

According to *Forbes Magazine* (May 1, 1977), in an article entitled "Garbage Power," people have long realized that it was only a matter of time before some system for converting garbage into energy was adopted in the U.S. At least 11 recovery systems are in place around the country, with another 8 facilities under construction. At least 50 other cities are actively developing plans for garbage-burning plants that will help solve their landfill problems and probably make profits for those who run them. The list of companies that have already jumped into this business reads like a partial *Who's Who of U.S. Manufacturing*, the *Forbes* article goes on to state. Wheelabrator-Frye is among the more active entries. The list also includes Union Carbide; UOP, a subsidiary of Signal Oil; Grumman; American Can's Americology Division; Combustion Engineering; Carborundum; and Raytheon.

The largest U.S. facility to date is the 1200 ton per day plant in Saugus, MA that was built by Wheelabrator and opened in 1975, at a cost of approximately \$50 million. The resource recovery plant sells steam, over 7-million pounds a day, to the General Electric River Works Plant on the Saugus River. The payment of \$13 per ton of refuse by the communities plus the \$10 per ton in refuse of revenues from the sale of steam is enough to make the plant a paying proposition (*Forbes* May 1, 1977). The steam from refuse is cheaper than the steam that GE formerly purchased. Additionally, the towns save money on removal and on rising landfill costs. The refuse recovery plant uses two steam generators. Incoming refuse trucks, after weighing their load for charging purposes, deposit refuse in the large 6700 ton storage pit from which it is fed to the furnace-boilers.

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Superheated steam is delivered to GE at 625 psig, 825°F, at a maximum rate of about 350,000 pounds per hour. The GE plant has a steam capacity of over 1 million pounds per hour. Its power generating capacity is 80 MW, consisting of 60 MW of steam turbine capacity and 20 MW of gas turbine capacity.

The Solid Waste Management Corporation (Rhode Island) is now evaluating the final bids from Wheelabrator, Widmer-Ernst, and UOP for the 1200 ton per day plant for Cranston, R.I. A second round of proposals, received May 31, 1978, included co-disposal of waste treatment plant sludge and solid waste. The following is quoted from the Corporation's *Summary of Preliminary Evaluation Results for Proposal One*, dated June 2, 1978.

All three bidders propose the same refuse-to-energy system technology concept (waterwall incineration-mass burning), and all have existing facilities which are in commercial operation in various locations throughout the world, based on this technology. All three firms' proposals offer the capability for processing a minimum of 1200 tons of solid waste per day, with varying capacities to handle tonnage in excess of this amount. All three bidders propose co-generation of steam and electricity, and all plan to provide for the total energy requirements of the state institutions in Cranston, as well as the sale of electricity, in excess of 25 megawatts, to the Narragansett Electric Company. All three bidders demonstrate the capability to recover ferrous metals at the post-combustion stage. Also, each bidder has demonstrated the capability of processing the remaining ferrous-free residue to a suitable quality for use as a construction material. Consideration is being given by some of the bidders, to the potential recovery of aluminum glass and other non-ferrous products . . .

According to the May 1978 publication of the Massachusetts Energy Office, *Energy in Massachusetts*, North Andover is planning a 3000 ton per day plant to serve 50 communities in the northeastern part of the state. The cost has been estimated at \$117 million (*Boston Globe*, July 16, 1978). This plant will be a 60 MW installation. The long range plan outlined by the Department of Environmental Affairs calls for solid waste conversion to account for 4 to 6 percent of the state's public electric generating capacity by the mid-1980's (*Ibid*, p. 18). The report further states "The Commonwealth generates 3 million tons of solid waste per year, which could produce 300 megawatts of electricity. This could save the state 4 million barrels of oil a year."

Both Wheelabrator and Widmer-Ernst (personal communication) have indicated that the 1200-1500 tons per day plant is the modular size that is marketable under present day economics. However, legal restrictions on landfills, land prices, and fuel prices all argue for smaller modules. European installations tend to be smaller due to higher land prices, fuel prices and municipal ownership of the plants. The Widmer-Ernst installation at Stapelfeld, near Hamburg, Germany, is a 450 tons of refuse per day plant generating 43 tons of steam per hour and 8.4 MW effective power. The installation at Turgi, near Baden, Switzerland, is 100 tons a day producing 12 tons of steam per hour and 5.2 MW effective power. The Resource Recovery Seminar in Hartford, CN, hosted by EPA in cooperation with National Association of Counties, the National League of Cities, and the U.S. Conference of Mayors (June 22, 1978), summarized the status of the energy recovery technologies with great interest. It was pointed out that waterwall combustion was state of the art which has had a long history of success and has been proven in more than 200 plants in Europe and Japan. Additionally, it was pointed out that small modular units were a promising approach to energy recovery for small communities. (*Environment Reporter* p. 363). Thus the technology is available, the interest is present, but the economics do not yet indicate the smaller units.

The Brookhaven report referred to earlier (*Solid Waste as an Energy Source for the Northeast*, June 1976, BNL 50559) modeled the electricity that could be generated from refuse from metropolitan areas. The data for New England (Table 7, p. 45) is reproduced below:

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Potential Yields From Refuse Combustion
1970 Data

Location	10 ¹² BTU/Yr.	MW _e
Massachusetts		
Boston	14.92	226.2
Brockton	1.03	15.6
Fall River	0.42	6.4
Lawrence-Haverhill	1.26	19.1
Lowell	1.15	17.5
New Bedford	0.83	12.5
Pittsfield	0.43	6.5
Springfield-Holyoke	2.87	43.5
Worcester	1.87	28.3
Mass. Total 375.6		
Connecticut		
Bridgeport	1.69	25.6
Hartford	3.65	55.3
Meriden	0.30	4.6
New Britain	0.98	14.9
New Haven	1.93	29.2
New London-Groton	1.13	17.1
Norwalk	0.70	10.6
Stamford	1.12	17.0
Waterbury	1.13	17.1
Danbury	0.43	6.4
Middletown	0.93	14.2
Conn. Total 212.0		
New Hampshire		
Manchester	0.63	9.5
Nashua	0.36	5.5
Concord	0.45	6.8
N.H. Total 21.8		
Maine		
Lewiston-Auburn	0.39	6.0
Portland	0.77	11.6
Bangor	1.04	15.7
Maine Total 33.3		
Rhode Island		
Providence-Pawtucket	5.07	76.8
Newport	0.42	6.3
R.I. Total 83.1		
Vermont		
Burlington	0.43	6.5
Vermont Total 6.5		
48.33	NEW ENGLAND TOTAL	732.3

For the purpose of this paper we will assume that the 12-1500 ton per day recovery plant that cogenerates steam and 25 MW electricity is the minimum modular size that is economically feasible in 1978. Using the previous table, the present day market for New England is presented below:

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Location	10 ¹² BTU/Yr.	MW _e
Massachusetts		
Boston	14.92	226.2
Springfield	2.87	43.5
Worcester	1.87	28.3
	Mass. Total 298.0	
Connecticut		
Bridgeport	1.69	25.6
Hartford	3.65	55.3
New Haven	1.93	29.2
	Conn. Total 110.1	
Rhode Island		
Providence	5.07	76.8
	R.I. Total 76.8	
	32.00	484.9
	NEW ENGLAND TOTAL	

The previous table which describes the present day (1978) market for resource recovery plants in New England indicates a goal of 485 MW of electric generating capacity from 32 trillion BTU per year. Attaining this short term goal would mean a savings of 5 million barrels per year of residual fuel oil. The region is on its way towards that goal when the plants at Saugus (30 MW), Cranston (30 MW), and North Andover (60 MW) are considered. Incentives are needed to keep the momentum going and, more importantly, to develop and introduce smaller modular units.

When the European size installations of 100 (5 MW) to 450 (9 MW) tons per day become feasible, then a total of 732 MW generating capacity from 48 trillion BTU per year will be available to New England cities and towns. Attaining this intermediate term goal would mean a savings of 7.5 million barrels per year of residual fuel, an increment of 50% over the short term goal. This 7.5 million barrel annual saving is 62 ½% of the ultimate of 12 million barrels from all residential and commercial refuse discarded by New Englanders.

VI. Constraints to Resource Recovery

The growth of resource recovery plants in New England can be significantly enhanced or hindered by the mind-set of the utility industry and, behind that, the actions and philosophies of the various state public utility commissions. Much of the institutional opposition to the resource recovery industry will be based on more generic factors, namely cogeneration and small dispersed energy facilities.

There is a need for a regulatory environment that encourages innovation. There may be opportunities for non-utility industries to build resource recovery—cogeneration units that serve their own needs for steam and electricity and provide surplus power for sale to utilities, municipalities or other industries. These opportunities are unlikely to be pursued if the industry cannot sell the surplus power at competitive prices and realize full profits from doing so. Private industry needs assurance that production of electric power for resale will not make them a utility under federal and state laws. Should a non-utility industry have the potential to generate electricity for resale, it must negotiate wheeling arrangements with the utility in whose service area the industry resides. Here again guidelines are needed from the utility commissions to ensure equitable handling of the wheeling problem or innovation and competition may be stifled (1977 *Biennial Report of the California Energy Commission* p. 114-123). As is true of any cogeneration installation, an agreement will be needed with the local utility to provide power when the resource recovery unit is down or derated for whatever reason. Negotiating an agreement that allows the utility to recover the full cost of providing standby reserves yet avoids artificially pricing resource

recovery-cogeneration out of the market may require the public utility commission to intervene in the contract negotiation.

The following sections have been excerpted from a Mitre study (*Forum Data Handbook for New England Energy Alternatives*, Vol. IV, Supp. 2, p. 48, 52-54):

Solid waste combustion involves a number of institutional difficulties. Among them are:

- A. There may be fear on the part of facility owners of a politically insecure source of fuel, since municipal governments control contracts for collection and/or sale of solid waste
- B. Amounts of solid waste may be adversely affected by the success of conservation and recycling efforts and may also be effected by downswings in general economic well-being.
- C. Garbage strikes could imperil fuel supplies.
- D. Constant truck traffic would create constant road maintenance and public relations problems.
- E. Breakdown in the system could result in massive pileups of solid waste that might be costly to dispose of.
- F. Inter-and intrastate truck licensing and taxes may make garbage hauling unnecessarily difficult or expensive. This is particularly a problem in a Balkanized area like New England.
- G. Construction of too much solid waste conversion capacity could result in ruinous competition for limited solid waste supplies.
- H. Utilities or industries may be unwilling to enter into long-term supply contracts for energy.

Since resource recovery plants, as discussed in this paper are in reality small scale cogeneration plants using refuse as a fuel, the Mitre report section on constraints to cogeneration are quoted also:

- A. *Barriers to cogeneration:* The primary institutional barriers to cogeneration include:
 - 1. Current utility rate structures, such as demand ratchet charges designed to discourage occasional use of utility as a back-up power supplier and low rates for electricity purchased by the utility from industrial cogenerators;
 - 2. Securing sources of capital financing for utility, municipality or industry-owned cogeneration plants;
 - 3. A need for cooperation between the utility and industry concerning operation schedules, maintenance, and disposition of cogenerated electricity; and
 - 4. The need to initiate and successfully conclude an innovative business venture.

Different barriers arise with different ownership arrangements. Under an arrangement where industry owns the cogeneration equipment, it must finance the capital investment. This can be a barrier since most industries anticipate a higher rate of return on investments in additional manufacturing capacity instead of energy-production capacity. Municipalities have a difficult time bonding most large ventures. A second barrier can be utility rates for electricity sales and purchases. Since an industrial cogenerator cannot economically match its electricity demand pattern with its cogeneration schedule, it faces the same utility interface problem as a solar, hydro, or wind system owner.

These barriers can be eliminated with utility ownership of generating equipment or a joint utility-industrial venture. However, new barriers will arise in these cases. A successful venture of this nature requires coordination between two diverse business partners, each of whom has a differing interest in the operation of the cogeneration

power plant. Furthermore, recent trends in utility construction of new generating capacity construction have been towards large units in the 500-1200 MW range. Utility managers may be reluctant to plan or commit capital to a network of small cogeneration facilities—typically in the 10-50 MW range—if they are able to meet future electricity demand by building large central generating facilities.

B. Structural changes:

1. A shift in the nature and responsibilities of the electric utility towards distribution instead of increased generation.
2. Investment capital for electricity generating capacity construction will be delivered from utilities to industries if utilities do not invest in cogeneration facilities.
3. Utilities will have to consider industrial or municipal steam demands along with electricity demand in their scheduling decisions.

Increasing the number of cogeneration facilities may have a number of other institutional implications. Cogeneration facilities would be constructed at new or existing industrial centers, often located in urban areas. Operation of these facilities would require less fuel than building a new single-purpose power plant, but the environmental and land-use impacts of electricity generation would now occur in a high-population density area. An urban/rural conflict could develop as utilities add new capacity at many small urban cogeneration sites instead of a single, centralized rural location.

A Preliminary Assessment of Solar Heating's Potential Contribution to New England's Supply Mix (Dan Waintroob)

I. Introduction

There are widely divergent views concerning the contribution that solar energy could make to the United State's supply mix through the year 2020. The attached table summarizes a number of studies.¹ The results of the high and low scenarios are in no way comparable. The further away from the present these projections go, the wider the differences in projected solar supply. For example, in 1985 Mitre's high projection is only .2 Quads (36 MMB) while Lovins projects 5 Quads (900 MMB). By the year 2020 the gap is even bigger, the low prediction .1 Quad (1.8 MMB) versus a high prediction of 40 Quads (7.2 trillion BBL), a difference in opinion by a magnitude of 400.

These differences are due to a number of reasons, including widely differing assumptions about solar's economic competitiveness, the degree of government support, technological innovations and even the definition of what is solar energy. Also, the author's views of the general nature of our society and its future development vary considerably.

A brief discussion of these varying assumptions is illustrative of the variables that must be grappled with in order to produce solar projections.

- 1) Probably the major area of disagreement concerns the nature of future societal development. The most radical view is that of Amory Lovins, who foresees society ultimately turning away from "hard technologies" to less energy intensive and more decentralized "soft technologies". Ultimately he sees an actual decline in total energy demand by the year 2020. No other study on the chart predicts a decline although they all very considerably in their views of future supply and demand projections. These

¹ (See page 117)

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differences are not simply over the statistical availability of energy supplies, they also represent a judgment of what should supply the energy future and what should be the end use of this supply. Therefore, at the onset a subjective judgment is made which will dramatically affect the end result of any projection.

- 2) The costs of solar energy and its cost competitiveness is also an area of some dispute. A report *Prospects for Solar Energy* by Los Alamos for the D.O.E. asserts: "Solar residential space heating costs remain higher than conventional natural gas and heating oil prices in both the 20 and 30 year life cycle cost time horizons"(P.3) Congressional Office of Technology Assessment in its report, *Application of Solar Technology to Today's Energy Needs* states, "solar space-heating and hot water systems may be competitive with oil or gas delivered to typical residential or commercial customers by the mid 1980's." These differences are based on assumptions about actual costs of equipment and different views about how much oil and natural gas will cost in the next decade. The former differences are the result of the wide array of methods of application and the limited experience in monitoring solar costs. Secondly, there is a major debate in the industry as to how much the production costs of a system will drop as the industry matures.
- 3) The degree of governmental support to solar is problematical. One of the functions of the Supply Committee is to make recommendations concerning this aspect. Clearly, governmental subsidies would accelerate solar usage. Although, even here, there is no consensus as to how much. The question of subsidies is both an economic issue and a technological issue. The economic one is how much money must the government provide to end users and/or manufacturers to encourage the usage of solar energy. The technological problem is whether increased R and D funds would bring dramatic improvements in solar technology.
- 4) Finally, definitions of solar energy range from all renewable resources to strictly solar thermal and solar voltaic.

II. Rationale and Format

Obviously, it is important that I make my assumptions clear at the onset so that the results may be understood and modified as the committee desires:

- 1) I am not assuming a societal change from "hard" to "soft" technologies. To assume this type of massive shift would not in my view represent the current realm of political acceptability.
- 2) Since I am dealing with solar heating and hot water production, I am not assuming any dramatic improvements in the technology. By "dramatic" I mean that I do not believe that the efficiency of solar systems will be tripled within the next decade.
- 3) As a format, I will begin by describing what I feel are the maximum technological limits to solar supply potential for the years 1985, 1995 and 2005. Then, in the next section, various economic and institutional constraints will be weighed. Finally a cost/benefit analysis will be done as to the level of government support, and recommendations will be made for future governmental actions to promote the optimal development of solar energy.

III. A Maximum Solar Usage Scenario

Based on insolation charts taken from the "Climatic Atlas of the United States," on an average there are 1200 BTU/ft.²/day of solar energy striking the 66,000 square miles of New England. If it were possible to harness all this energy the total available would be 806 Quads, collected on a horizontal plan, roughly equivalent to 145 billion barrels of oil. This is about 300 times our current total energy budget and 1300 times our current residential space heating budget. Obviously these

figures are somewhat speculative. Nevertheless, they do indicate that there is a tremendous amount of raw energy that is available.

The technical problems of utilizing this energy when it is needed reduces this potential considerably. These technical problems are: (1) For the purposes of space heating there is less available when it is needed most. (2) System efficiency is limited to 20-25% for space heating. (3) As a general limitation solar energy is applicable for space and hot water heating and electrical production. It is unlikely that solar will be contributing much to the transportation sector in the foreseeable future.

The first two problem areas deserve further analysis since, for New England, solar's space heating potential is important.

According to a study by the Center for Energy Policy summarized in *Retrofit '78* (P.3), "The total New England energy budget is approximately 2.6 Quads (10^{15} BTU/yr.), of which approximately .4 Quads is used to heat office space and .6 Quads is used to heat the region's 3.9 million residences." Each residence is therefore using an average of 1.54×10^8 BTU/per year or 27.7 barrels of oil (1160 gallons). Broken down by degree days (DD), an average house would need approximately 25,870 BTU/DD to meet its heating load.

The following table gives an indication that would be physically required to heat a home in Rhode Island using solar energy.

Month	Degree Days	BTU's Required	Available Insolation @ 50° angle (BTU/ft ²)	Ft ² of Collector Needed at 25% Efficiency
Sept.	96	2,483,520	47,550	208
Oct.	372	9,623,640	45,260	846
Nov.	660	17,074,200	34,350	1988
Dec.	1023	26,465,010	32,054	3304
Jan.	1110	28,715,700	32,829	3500
Feb.	988	25,559,560	36,736	2784
Mar.	868	22,455,160	46,531	1932
April	534	13,814,580	42,720	1292
May	236	6,105,320	47,027	516

This table does not take into account the space needed for storage of 1.3 gallons/ft.² of collector. In any case in order to retrofit a house for complete solar heat an average home would need around 3500 ft.² of collector at a 50-90° angle, and 4550 gallons of water for storage. The economic issues involved with this size of installation will be discussed later, but the physical problems of finding this much space are obvious. A typical cape oriented directly south would only have something on the order of 700 ft.² of available roof top. Perhaps, another 100 ft.² of vertical surface could be used. Similarly for domestic hot water the experience of the HUD solar initiative seems to indicate that for 100% hot water 140 ft.² would be needed. It is easy to see why builders of new solar houses spend so much time reducing heat loss. The obvious conclusion is that it is physically impossible to retrofit New England's housing stock with 100% solar heat and hot water. Expectations must be scaled down to meet reality. 2500 homes were inspected as part of the New England Electric's Solar Hot Water Project (from Robert O. Smith and Associates' Report) of which 1200 were deemed suitable for a solar hot water installation. For the purposes of this study we will, therefore, assume that 48% of the housing stock would be suitable for some sort of solar installation. As an estimate we will say that 5% of this 48% could have an average solar collection area of 600 ft.²; the rest will be assumed to have an average collection area of 100 ft.². For the purposes of this paper 100 ft.² is assumed to be primarily for hot water heating operating at 25% efficiency, 365 days a year. The larger installations are assumed to be for heating purposes.

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Calculations are based on availability and demand. When the total available insolation exceeds demand, savings are computed on the basis of 100% demand.

Calculations for the retrofit of existing dwellings produced these results:

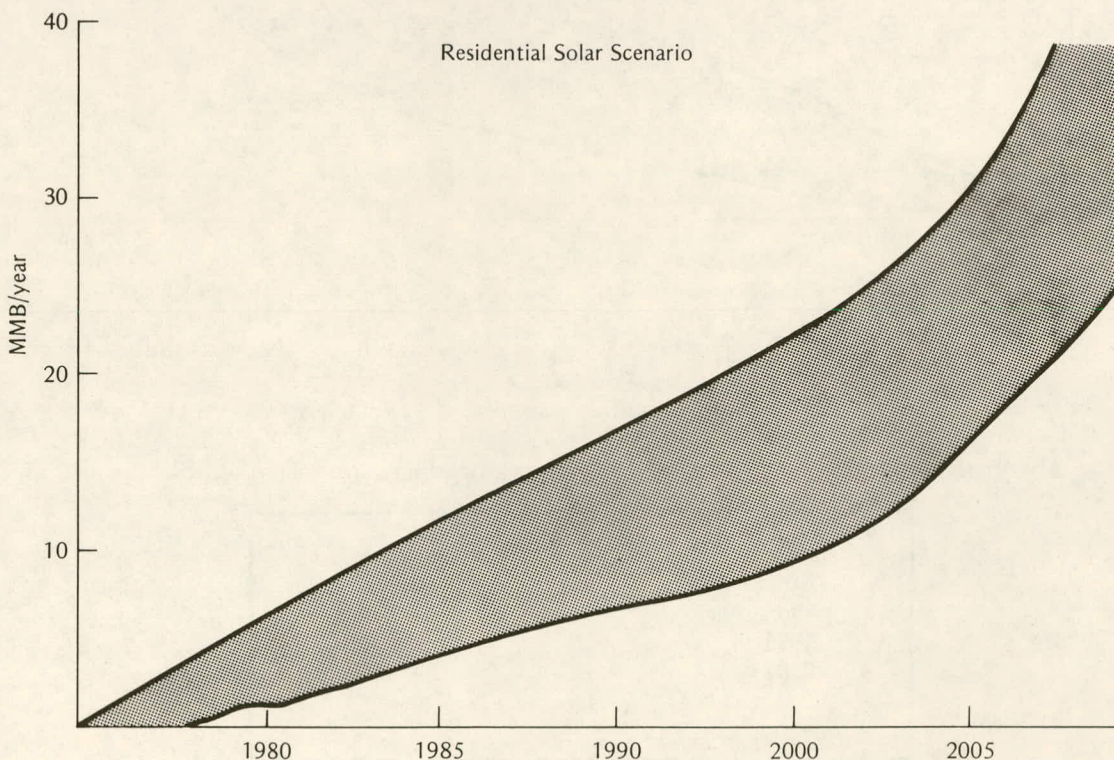
	Number of units solarized	MMB
Solar water heating	1,794,000	3.8
Solar space heating	78,000	.6
		<u>4.4</u>

The preceding is obviously quite a rough project. For graphic presentation a ± 50 variation will be used to illustrate a range of possibilities. Nevertheless, it does seem evident that solar can have a significant if limited impact on the energy uses of existing housing.

The technical potential for new construction is much greater. A house built from the ground up can, in most cases, be built to utilize solar heating. Therefore, for the purpose of this projection we will assume that 75% of the new housing will have an average of 1,000 ft.² of collector area. For its solar projection the *New England Energy Situation and Alternatives for 1985* projected a growth rate of the housing stock of about 2% per year. I am assuming the same growth rate, base year 1978.

		Units	Cumulative MMB	Plus Retro MMB
New Housing Units by	1985	642,440	5.2	9.6
	1995	1,621,000	13.2	17.6
	2005	2,862,900	23.2	27.6

There is a large margin for error since this performance could be increased substantially by changes in land use patterns and the implementation of solar parks, for example. There might for unforeseen reasons a reduction in these projections. Therefore, the following graph illustrates a band width version of these projections assuming a variation of $\pm 50\%$.

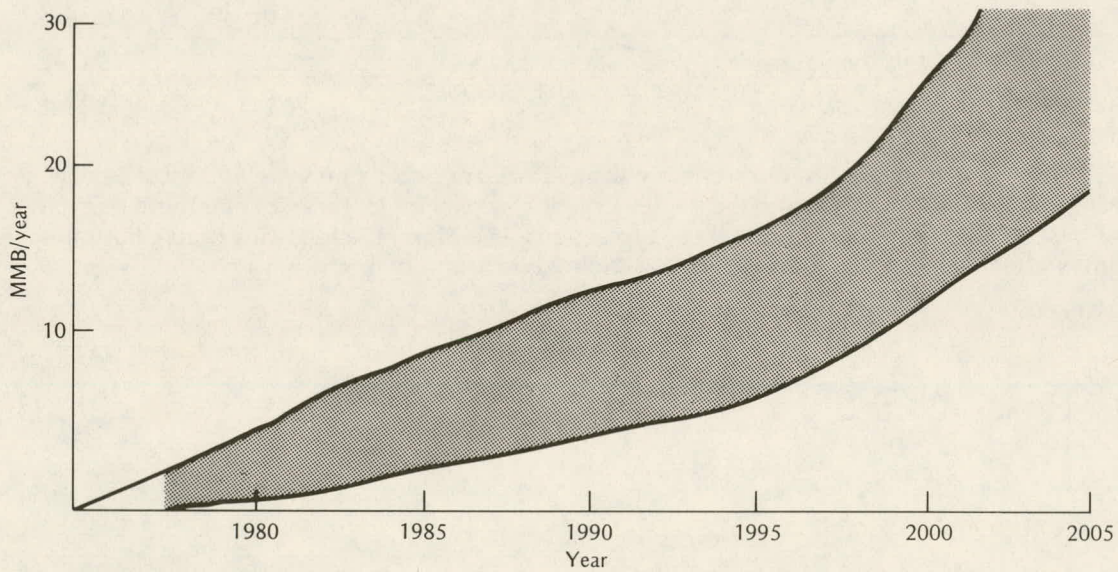


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I have not yet gotten solid data on the space heating of office and industrial space. But for the purposes of discussion let us assume a similar percentage of heat provided by solar for this sector.

	MMB	Cumulative MMB
Retrofit	2.9	
1985	3.5	6.4
1995	8.7	11.6
2005	15.5	18.4

Non-Residential Solar Scenario

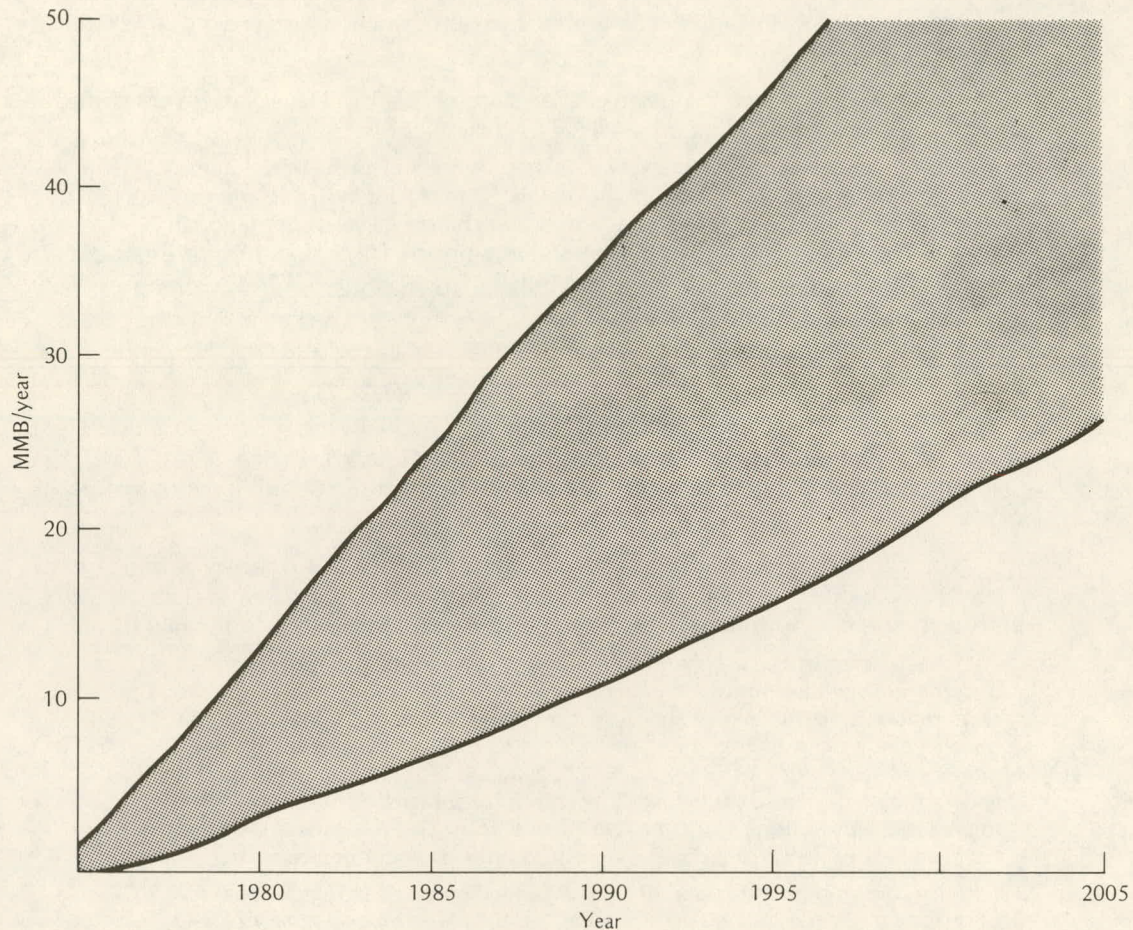


The maximum technical solar scenario therefore produces the following total projection.

Retrofit	7.3
1985	16.0
1995	29.2
2005	46.0

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Total Maximum Feasible Solar Utilization



IV. Constraints to Development

- A) Probably the foremost constraint to development is in the economic area. The problems are twofold: (1) the region-wide issue of the cost competitiveness of solar with conventional fuels; (2) given that it is a capital intensive investment, how can the individual be encouraged to buy a solar system.

Before describing the economics involved, a brief description of the technology would be useful in understanding the economics involved. The technology for solar space heating and hot water heating in particular is well developed. "Solar hot water systems are now used in 2.7 million Japanese homes, 200,000 Israeli homes and 20,000 buildings in the U.S.

(Retrofit '78). Hot water heating is accomplished through an array of collectors installed facing south through which a fluid is circulated. Once it is heated it is circulated to a storage tank. Space heating is currently accomplished in one of three ways: (1) a larger version of the system described above (active system); (2) as a boost to a heat pump (also an active system) or (3) through the effective siting of buildings, use of windows and

thermal mass (passive systems). There are homes currently in New England that nominally get 90% of their heat from solar. The more a system utilizes passive heating techniques as opposed to active techniques the cheaper it will cost initially. Operating and maintenance costs are considerably less also since there are no mechanical equipment requirements.

A recent conference on passive solar systems, Harold Hayes, an inventor in the field, described the following advantages to solar:

They often cost less than active solar systems and provide the same amount of energy to the building; The materials are readily available and can be installed without any special training; Little chance exists of operational failure; Few aspects require certification of equipment. *Energy Users Report*

Passive systems limit the options available to the builder and is therefore only applicable in limited circumstances. While active systems are more versatile they are also considerably more expensive than passive systems. Because of this cost differential there is a large degree of uncertainty in economic analysis of solar.

There are two levels that must be considered in analyzing solar economics: (1) at what cost is it reasonable for the individual investor buy a solar system; (2) at the governmental level, how large an investment will be required of public funds to meet its solar goals.

Pertaining to the individual investor Roger H. Bezdek, *An Analysis of the Current Economic Feasibility of Solar Water and Space Heating* (DOE/CS-0023, January, 1978) offers a reasonable approach to economics of investment for the individual buyer:

Years to positive cash flow is the number of years for fuel cost savings to become greater than the extra expenses of the SHAC system, after taxes. The criterion assumed is two years, because most homeowners expect rapid savings for an "energy conserving" investment. *Years to recover downpayment* is the number of years required for accumulated savings to offset initial cash payments and early cash flow losses, after taxes. The criterion assumed is five years, based on today's average housing turnover rate of five years and the expectation that homeowners will seek to recover their entire downpayment before selling.

Payback Period is the number of years for accumulated savings to repay the full cost of the system (or equal the remaining principal on a loan if financed). The criterion assumed is ten years, assuming the homeowner wishes to be paid back entirely for his investment in no more than ten years. (P. 7)

If two of the preceding conditions are met the solar system is considered competitive. If only one of the conditions are met it is considered marginally competitive.

As well as cost of the system an economic analysis must also include what is the anticipated rate of inflation for conventional fuels and how long the system is expected to last.

Initial costs vary considerably. In solar projects the DOE paid an average \$37 per square foot of collector for a system installed. For the purposes of his study Bezdek assumes a current cost of \$25 to \$40/ft² installed and future cost of \$15 to \$20 once large scale production is reached.

The Maine Audubon building installed an active system for approximately \$4/ft². The inflation rate for conventional fuels is problematic. For the purposes of this paper we will use 0%, 2%, 5% above the general inflation rate. Finally system life is assumed to be inversely related to the complexity of the system (i.e. the more complex the shorter the life span of the system). For active systems it seems likely that a major overhaul would be needed at the 25th year. Additionally, I am assuming \$50/year in other maintenance costs. Passive systems should last as long as the house itself with the possible replacement

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of glazing after 20 years and caulking every 5 years. Maintenance would, therefore, average about \$25/year for a 1,000/ft² system.

For comparative purposes the following cost for conventional fuels is being used:

Type	Fuel Cost/\$MMBTU
Resistance Electrical (.043/KWH)	\$12.60
Oil (.50/gal.)	\$ 3.57
Wood (\$65/cord)	\$ 3.25
Gas (.29/therm)	\$ 2.90

It should be pointed out that these are the costs of fuel delivered to the customer and not necessarily the actual costs of the fuel.

The following represents the costs of the fuels at the different real inflation rates:

	Real Inflation Rate		
	0%	2%	5%
Electric \$MMBTU			
1985	12.60	14.51	18.04
1995	12.60	17.76	30.13
2005	12.60	21.74	50.33
Oil \$MMBTU			
1985	3.57	3.77	5.11
1995	3.57	5.03	8.54
2005	3.57	6.16	14.26
Wood \$MMBTU			
1985	3.25	3.74	4.65
1995	3.25	4.58	7.77
2005	3.25	5.61	12.98
Gas \$MMBTU			
1985	2.90	3.34	4.15
1995	2.90	4.09	6.94
2005	2.90	5.00	11.58

Assuming a 25 year life span a solar system costing \$35/ft² would currently be competitive with electrical resistance heat. In order to compete with the other fuels it would have to come down to less than \$10/ft² installed and maintained. Currently only certain forms of passive systems can do this. At a 2% real fuel inflation rate this can be achieved at approximately \$13/ft² installed and maintained. If one assumes a 5% inflation rate the system can cost \$27/ft².

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The rate of real inflation in fuel cost obviously makes a difference in what one assumes to be a reasonable investment. The questions that will be dealt with in the cost/benefit section is how much of a subsidy would be required to make solar competitive with different scenarios.

There are several institutional barriers which must also be dealt with. Bankers and insurance companies do not have enough experience with a system to, in the case of the latter, set rates and in the case of the former, charge rates. For example, if a \$2500 solar system is financed at 9% for 25 years as part of a mortgage the additional cost would be \$21. Where at 14% for five years it would cost over \$58 per month. The monthly payment would be a problem in many cases. Other institutional problems include zoning problems (e.g. set-back requirements, inconsistent building codes and jurisdictional disputes among unions. There also may be a problem with utility loan management.

Finally there is also the problem of consumer confidence in solar.

All three areas are likely to slow solar development. The economic area is the most serious, however. The question that should be dealt with is how much public money should be invested in solar energy in order to achieve optimal development that benefits society equal to its costs.

V. Cost/Benefit/Analysis

There are several societal benefits to solar energy that should be weighed in determining subsidy levels:

- 1) Solar is an indigenous resource. Certainly if a major goal is to reduce our dependence on foreign oil, this is an important factor.
- 2) Solar energy is non-polluting.
- 3) It is diffuse and can be utilized in small increments.
- 4) Solar energy creates jobs according to the article in the September, 1977 *Solar Age* magazine (P. 11), "The Massachusetts Energy Policy Office recently concluded that if by 1985 one-half of all buildings in that state were to use solar energy for hot water production, 32,000 jobs would be created."

The public costs to implementing solar would be the money needed to make solar energy costs competitive with competing fuels. This cost is exclusive of the loan guarantees and/or subsidies that would be needed to allow the affordable financing of systems. Additionally the committee must also consider whether to make grant installations on poor people's homes.

In New England the prominent mode for space and hot water heating is fuel oil. Therefore subsidies will have to be aimed cost competitiveness at this level.

The subsidies required to bring the costs down at \$20/ft² (or \$8.62/MMBTU) would be if maximum levels were reached. These subsidies apply only to New England.

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Inflation Rate

	0%	2%	5%
Retro	1,142	1,142	1,142
1985	3,244	3,180	2,750
1995	4,942	4,130	1,752
2005	6,271	3,750	No subsidy required
Total	15,599	12,202	5,644
Per Year	577	452	332 until 1995

While these are rough figures they should provide a basis for discussion.

Resource List

Solar Technology to Today's Energy Needs, OTA, June 1978.

Prospects for Solar Energy, DOE/Los Alamos-LA-7064-MS, December 1977.

An Analysis of the Current Economic Feasibility of Solar Water and Space Heating, DOE/CS-0023, January 1978.

Solar Energy In America's Future, ERDA DSE 11511, March 1977.

World Energy Outlook, Exxon, March 1977.

Solar Energy: A Status Report, DOE/ET-0062, June 1978.

Solar Energy: Progress and Promise, Council on Environmental Quality, April 1978.

Minutes and papers presented by Alternative Energy Committee of Energy Congress.

Summary of Projected Solar Impacts Quads Displaced (Primary)

Scenario	1985			2000			2020		
	Total	Solar ¹	Percent	Total	Solar ¹	Percent	Total	Solar ¹	Percent
Mitre SPURR NEP	86	.20	.2	115	6.0	8.0	189	35.4	18.7
Mitre SPURR RTS	85	.09	.1	113	5.0	4.4	18	24.7	13.1
SRI-Reference Case	99	2.0	2.0	145	6.0	4.1	198	11.0	5.6
SRI-Solar Emphasis Case	99	5.0	5.0	148	15.0	10.1	204	44.	22.
SRI-Low Demand Case	79	2.0	2.5	89	7.0	7.9	102	14.	13.7
Solar Working Group with Behavioral Lag	90	.4	.4	115	8.1	7.0	140	19.1	13.6
without Behavioral Lag	90	2.5	2.7	115	8.8	7.7	140	19.5	13.9
MOPPS	94.6	1.2	1.3	117.3	2.8	2.4			
IERPS				132.5	5.8	4.3	195.5	29.5	15.0
Lovins (2)	95	5.	5.3	108	40	37.0	76.	70	92.0
NFS/NASA	117	.4	.4	177	11.8	6.6	300	109.	36.0
Project Indep-B.A.U.	120	.8	.7	180	10.8	6.0			
- Accelerated Solar	120	1.4	1.2	180	38.8	21.3			
CONAES - High Solar	98	3.0	3.0	146	14.0	9.6			
- Low Solar	98	0.0	.0	146	0.1	.1			
ERDA-49	100	.8	.8	150	10.	6.7	180	45.0	24.1
CEQ-April 1978 (3)			100	24.5	24.5	105	45.0	43.0	

(1) Solar components exclude hydropower. Some studies also exclude the current biomass consumption.

(2) Includes all soft technologies.

(3) Mid range of CEQ estimates for each technology.

Tidal Power

I. Introduction

The method of tidal power production presented in this paper will be limited to electrical generation similar to conventional hydroelectric production. The major difference is that the direction of flow reverses about every six hours and the water is very saline. There are other modes of generation for ocean energy production predicated on tidal current, thermal gradient, salinity gradient and osmotic pressure. The utilization potential for these sources are quite significant; however, they have been omitted from this discussion since data was not readily available and since the related technology was not immediately applicable. A tidal power plant can basically operate in three different modes for a certain percentage of the tide cycle—maximum power production (15-25%), long-time duration (40-60%), and peak hour production (typically from 4:00-6:00 P.M.) These various modes adapt to three methods of development listed below:

- 1) *Single-pool system*, capable of supplying intermittent electricity under a progressively shifting production schedule. In this case, peak hour production can supply peak power for a predetermined time period under a varying power level dependent on tidal range and high tide occurrence.
- 2) *Linked-basin system*, dependable power production through a mechanical connection of two adjacent tidal basins operating under a modified long-time duration mode.
- 3) *Paired-basin system*, also capable of dependable power production through an electrical interface connecting two, or more, tidal basins. Increasing the number of basins in the system shifts the production schedule from long-time duration to maximum power production which can theoretically optimize production in accordance with available volume flow conditions.

Tidal production is directly dependent on the tidal function's behavior for the three cases described. This results from a tidal range which varies quite dramatically for spring tide and neap tide conditions, and also from a lunar dependence which increases high tide occurrence by approximately fifty minutes per day. In New England, tidal power development is fairly well limited to areas where the average tidal range is greater than 15 ft. Therefore, under this criteria, only the upper Maine coast would qualify until economic constraints are reduced which could then make it feasible to include tidal ranges as low as 12 ft. It should be mentioned that the other types of ocean energy systems, in general, have application along the entire New England coast.

II. Potential

- 1) New England
 - a) Potential for tidal power development is listed in Tables 2 and 3 for three different scenarios, summarized below in terms of power production parameters:
installed capacity, 164 MW—1212.5 MW
annual capacity factor, 0.353—0.522
annual electrical output, 567—3008 million KWH, 1044—5454 thousand barrel, displaced, 6565—34300 billion BTU.
 - b) Three different modes of development are presented in Table 1 for comparison.
- 2) Attributes
 - a) Politically desirable since it involves the development of renewable resources
 - b) High efficiency when compared to thermal plant for supplying base-load level

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- c) Reliable and predictable supply capable of being easily integrated with power network
- d) Can be used to temporarily off-load oil-burning plant
- e) Can complement nuclear and large fossil sources
- f) Capacity to respond quickly and efficiently to load fluctuations
- g) Technology moderately well developed, a properly designed demonstration project could identify and solve most of the problems
- h) When compared with conventional hydroelectric on an engineering basis, the barrage has less static forces and no significant leakage problems.

3) Economic

- a) Total capital cost, including transmission, per installed capacity in 1976 dollars varies from \$1979/MW to \$3600/MW (see Table 3).
- b) Average power cost, defined as total annual cost divided by annual production, in 1976 dollars ranges from 49.6 Mills/KWH to 62.5 Mills/KWH (or, 4.351—5.482 \$/MMBTU—Table 4).
- c) Economic viability based on a static benefit-to-cost ratio does not exist for power production benefits (i.e., 0.344—0.533); however, by including ancillary benefits this ratio increases quite appreciably (i.e., 0.581—1.333).
- d) Table 4 (B) shows projected average power cost and construction cost for the three examples previously cited for an assumed 6%/yr escalation rate; whereas, tidal power value is assumed to increase at a 8%/yr rate. This comparison indicates that the "Corps" project would be nearly cost-competitive after only five years of operation.
- e) Actual life-cycle cost analysis listed in Table 5 (A) shows that the 5MW Half-Moon Cove plant could be competitive after less than ten years of operation for a 8%/yr., escalation in tidal power value for the assumptions listed. This is a better economic profile than the analysis performed in Table 4 (B) due to the fact that *annual cost* would not increase at 6%/yr., since fixed charges which comprise a significant percent of annual cost are constant and not inflation-controlled as the other component (i.e., operation & maintenance).
- f) Positive economic elements of a tidal power plant include the following:
 - i) Nominal running cost; i.e., no fuel cost
 - ii) Low discount rates applicable for national or municipal projects
 - iii) Long plant life with relatively little maintenance and few components that need to be replaced
 - iv) Minimum land requirement.
- g) The LaRance Tidal Power Project (France) commissioned in 1966 has shown a favorable life cycle behavior. It has been reported that tidal power is now cheaper than electricity produced by nuclear plants.

4) Environmental

- a) In general, the physical changes brought about by construction of a tidal power plant would appear to be the physical obstruction created by the dams, altered mean levels and ranges in the impoundments, change in current patterns,

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reduced velocities, reduced tidal exchange (flushing) less vertical mixing, lower rates of oxygen uptake, greater stratification, higher summer temperatures, winter icing, reduced salinity in surface layers, reduced dissolved oxygen in deeper layers, and erosion and siltation effects.

- b) Minimum water pollution and air pollution as compared with alternative forms of power production
- c) Minimum public safety hazard related to power plant operation

5) Socio-Economic

- a) Assorted number of project-related benefits attributed to increased recreational/tourist facilities, construction and indirect employment opportunities, potential for aquaculture development, and the benefits associated with research and development programs
- b) Potential effect on nearby water tables
- c) Potential effect on tidal resonance effect
- d) Construction activities and tourist influx affecting existing environmental quality and over-burdening present municipal services

6) Societal

- a) Related to an increased population and its potential effect on the socio-economic characteristic of the region; i.e., "boom-bust" effect
- b) Effect on local wage rate imposed by higher salaries available from a federal project and its imminent consequences on local industries forced to compete for a limited work-force

III. Recommendations

- 1) *Build a demonstration project as the most logical first step of development.*
- 2) *Ensure utilization of renewable resource by federal assistance and subsidies (i.e., research and development program).*
- 3) *Properly consider life cycle cost analysis as an economic measure of renewable resources.*
- 4) *Decrease institutional barriers by streamlining institutional/regulatory processes.*

Table 2: Tidal Power Potential:
Available Sites and Scenarios

	Total Potential MW	Annual Energy Production 10 ⁶ kwh	Realistic Uninterrupted Schedules				
			1980	1985	1990	1995	2000
Available Sites							
1. Cobscook Bay:							
A. Single-Pool							
i) Half Moon Cove							
	4-12.5	18-35	Planning	On-Line	On-Line	On-Line	On-Line
ii) Series (a)	59-180 (b)	250-485	Planning	Planning	On-Line, 20%	On-Line, 60%	Planning
iii) U.S. Corps	40-180	-680	Planning	Planning	Constr.	On-Line	On-Line
B. Linked-Basin							
	100-1000 (c)	-2360	Planning	Planning	Constr.	On-Line	On-Line
C. Paired-Basin							
	4-60 (d)	33-270	Planning	Constr.	On-Line, 40%	On-Line	On-Line
2. Upper Maine Coast							
	100-200	305-610 (e)	-	Planning	Constr.	On Line, 40%	On-Line
3. Other U.S. Sites							
	2600 (f)	10950	-	Planning	Constr.	On-Line	On-Line

a. Quantities based on long-term duration mode for 4 MW plant at Half Moon

b. Reference, Technical Paper No. 4, Passamaquoddy Tribe Energy Office

c. Assuming U.S.-Canada International Project

d. Note: Dependable capacity is assumed 20% of installed capacity for 13' tide ranges

e. Calculated as being proportional to the square of average respective tidal ranges

f. Proposed Capacity for largest Alaskan tidal project

Scenarios	Plant Capacity For:				
	1980	1985	1990	1995	2000
1. Low (1Ai, 5 MW; 1Aii, 59 MW; 2, 100 MW)					
164 MW 576 10 ⁶ kwh	-	5 MW	17 MW	81 MW	169 MW
2. Mid (1Ai, 5 MW; 1Aii, 180 MW; 2, 100 MW)					
285 811 10 ⁶ kwh	-	5 MW	41 MW	153 MW	285 MW
3. High (Ai, 12.5 MW; 1B, 1000MW; 2, 200 MW)					
1212.5 3008	-	12.5 MW	12.5 MW	1092.5 MW	1212.5 MW
(1Ai, 12.5 MW; 1Aiii, 180 MW;)					
2, 200 MW					
392.5 1328	-	12.5 MW	12.5 MW	272.5 MW	392.5 MW

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Table 3: Power Production Scenarios

Scenarios	Capacity MW	Annual Energy Output-10 ⁶ KWH	Total Cost in 1976 \$ Million \$	Construction Start-Up Date	Total Cost in Current (10 ⁶ for Escalation Rate)	
					6%	8%
1. Low Projection						
Demonstration	5	21.65	11.085	1983	16.672	19.000
Series of Small	59	249.30	162.900	1983-20%	65.672	82.036
				1993-40%	175.476	241.092
				1995-40%	197.174	281.231
Upper Coast	100	305.00	221.700 (a)	1993-40%	238.815	328.116
	164 MW	575.95 10 ⁶ KWH			1173.092	1674.705 10 ⁶
2. Middle Projection						
Demonstration	5	21.65	11.085	1983	16.672	19.000
Series of Small	180	458.70	485.000	1988-20%	184.581	231.001
				1993-40%	494.112	678.876
				1995-40%	555.210	791.900
Upper Coast	100	305.00	221.700	1993-40%	238.815	328.116
				1998-60%	479.404	723.230
	285 MW	811.65 10 ⁶ KWH			1968.794	2772.123 10 ⁶
3. High Projection						
Case A						
Demonstration	12.5	37.81	22.460	1983	33.780	33.496
Linked Basin	1000.	2360.00	1829.900	1989	3903.177	4977.328
Upper Coast	200.	610.00	443.400	1988-20%	178.424	223.296
				1993-40%	477.630	656.232
				1995-40%	536.691	765.486
	1212.5 MW	3007.81 10 ⁶ KWH			5129.702	6660.288 10 ⁶
Case B						
Demonstration	12.5	37.81	22.460	1983	33.780	38.496
U.S. Corps	180.	680.00	492.000	1989	1049.436	1338.240
Upper Coast	200.	610.00	443.400	1988-20%	178.424	223.296
				1993-40%	477.630	656.232
				1995-40%	536.691	765.486
	392.5 MW	1327.81 10 ⁶ KWH			2275.961	3021.750 10 ⁶

- a. Assume \$2217/KW
b. Total Cost $(1 + Y)^X$
Y-Escalation Rate
X-Year-1976

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Table 4; Estimated Economic Operating Parameters Up to 200

A. Production Parameters

	Capacity	Annual Energy Production		
	MW	10 ⁶ KWH	10 ⁷ BTU (a)	10 ³ BBL Oil (b)
U.S. Corps	500	1932	22024.8	3503.22
Doe	180	680	7752.0	1233.02
Half-Moon	5	21.65	246.8	39.26

a. Assume 11400 BTU/KWH for oil-fueled electricity

b. Assume 6,287,000 BTU/BBL Residual Oil

B. Projected Operating Parameters

Year	Project	Ave. Power Cost Mills/KWH	\$10 ⁶ BTU	Constr. \$/KW	Tidal Power Value Mills/KWH	Notes
1976	U.S. Corps	62.5	5.482	3600	33.28*	*Greater Value Due to Peaking Credit, Table 1
	Doe	56.5	4.956	2720	21.50	
	Half-Moon (5 MW)	49.6	4.351	2217	21.50	
1980	U.S. Corps	-	-	4345*	45.28**	*6%/Yr. Rise
	Doe	-	-	3434	29.25	**8%/Yr. Rise
	Half-Moon	-	-	2799	29.25	
1985	U.S. Corps	-	-	6082	66.53	*Half-Moon Cove
	Doe	-	-	4595	42.98	On-Line 1985
	Half-Moon	83.79**	7.351	3334	42.98	**6%/Yr. Rise
2000	U.S. Corps	253.06	22.200	7679	211.0 *	*On-Line 1995
	Doe	228.76	20.070	5802	136.3 *	
	Half-Moon	200.83	17.620	-	136.34	

Note: Bold figures denotes the year when constructions starts

C. Parameters: Different Scenarios

Year	1980	1985	2000				
Scenario	-	1&2	3	1	2	3-A	3-B
Installed Capacity, MW	-0-	5	12.5	164	285	1212.5	392.5
Annual Energy Output							
-10 ⁶ KWH/Yr	-0-	21.65	37.81	575.9	811.6	3007.8	1327.8
-10 ⁹ BTU	-0-	246.80	431.03	6565.8	9252.8	34289.0	15137.0
-10 ³ BBL Oil	-0-	39.26	68.56	1044.0	1472.0	5454.0	2417.0
Total Capital Investment							
In Current \$/KW - 6%	-0-	334.	2702.	7153.0	6908.0	4231.0	5799.0
- 8%	-0-	3800.	3080.	10212.0	9727.0	5493.0	7699.0

Hydroelectric Power

I. Introduction

This form of renewable source has been available for many decades and has made a significant contribution to New England's electrical supply mix. The usefulness and future development potential of hydroelectric depends on the following factors:

- 1) Availability of water resources at suitable sites
- 2) Relative escalation rate of fuel supplies
- 3) Federal/state incentives encouraging development
- 4) Reducing institutional/environmental restrictions.

Hydroelectric development has an upper saturation limit imposed by physical constraints and environmental considerations. This paper will classify hydroelectric plants into the three categories listed and described below:

- 1) *Small hydro*, typically from 50 KW up to 20,000 KW for sites with a hydraulic head less than 20 meters. Includes existing sites and undeveloped sites for intermediate power production designed for public utility integration.
- 2) *Conventional*, for installed capacity greater than 20 MW and developable in two ways:
 - a) *Storage*, used for peak production by building up a reservoir and generating for short periods during the day corresponding to peak load demand
 - b) *Run-of-river*, usually available water flow producing base-load power during most of the year and peaking power during spring runoff.
- 3) *Pumped storage*, produces peak and/or intermediate power from off-peak electricity generated at a nearby plant and used to pump water into the reservoir. Typically, three kilowatt-hours are needed to produce two kilowatt-hours of more valuable peak-load energy. Two types of pumped storage installations can be constructed:
 - i) Energy produced only from water that has previously been pumped
 - ii) Pumped water plus natural runoff

It should be emphasized that pumped storage has a negative electrical output; however, its value is measured in terms of demand for peak power.

Various hydroelectric stations can collectively produce a fairly well diversified energy mix, capable of satisfying a regional load demand curve if proper conditions exist. The sites, identified and applicable to this type of development, are fairly well distributed in New England's land mass. However, certain states have a greater number of sites for retrofit and/or new construction.

II. Potential

- 1) New England
 - a) New England's current hydro supply is listed in Table 1. Distribution of capacity by state is also listed as a footnote.
 - b) In order to measure total potential capacity it was decided to classify projects according to the aforementioned groups and to use the estimates derived from

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the studies referenced in Table 2 (A). Power production parameters are listed below:

	Small-Scale	Conventional			Pumped Storage
		(8) Best	(9) Marginal	Dickey-Lincoln	
installed capacity (MW)	85-2,970	390	585	760	34,000
capacity factor	.4-.5	.19-.30	?	.24	?
annual output (10 ⁶ KWH)	378 - 14,400	850	1,170	1,540	-
(10 ³ BBL oil)	685 - 26,100	1,540	2,120	2,790	-
(10 ⁹ BTU)	4,310 - 164,130	9,690	13,340	17,560	-

See Tables 2 and 3 for more details

2) Attributes

- a) The attributes of hydro power include the following:
 - i) Inexhaustible resource
 - ii) Low machine outage rates
 - iii) Immediate power availability
 - iv) Potential to decrease fossil fuel dependence
 - v) Technology sound and well-established with simple technical principles
 - vi) Substitute to "spinning reserve" for steam plants.
- b) With reference to pumped storage installations, the following attributes can also be included:
 - i) By pumping in off-peak hours, enables the plant factor of base-load thermal units to improve their efficiency.
 - ii) Use of base-load nuclear can decrease the cost of nuclear generation by operating at high load factors.
- c) Small-scale hydro is ideally suited to the needs of small communities, i.e. for street lighting.

3) Economics

- a) Total capital investment cost (excluding transmission) per installed capacity ranges from \$609/KW to \$1049/KW in 1976 dollars—see Table 3 (B).
- b) Proposed average power cost for a large project (i.e., Dickey-Lincoln) and a relatively small project (i.e., Black-River) are 38.16 Mills/KWH and 57.99 Mills/KWH, respectively. The cost data for Dickey-Lincoln was re-analyzed in terms of a 7% interest rate taken over 50 years, instead of 3 1/4% for 100 years, in order to reflect current cost of money.
- c) Table 6 compares the two aforementioned projects on the basis of three relevant economic indicators. The major difference is the cost per installed capacity which significantly affects the average power cost. Also it is apparent that the Black River project overestimates power value when compared to Dickey-Lincoln which has a favorable effect on its benefit-to-cost ratio.

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- d) Economic aspects of hydroelectric power plants that add to project feasibility include the following:
 - i) Low operating cost
 - ii) long plant life
 - iii) Reliable production.
 - e) Under life cycle cost analysis, hydroelectric power is competitive with other energy sources because it is relatively free from the inflationary pressures on fuel.
- 4)
- C) Environmental
 - i) Non-pollutant to (air and water)
 - ii) No hazardous materials
- 5) Socio-Economic
- a) Major benefit is associated with the commitment to a renewable resource, a transition from the utilization of depletable supplies
 - b) Additional values of recreational facilities, flood prevention, area redevelopment, and the establishment of conservation pools.

III. Problems

- 1) Institutional & Operational
 - a) Complicated regulatory requirements add time and effort to the planning phase.
 - b) Legal questions concerning private versus public control of streamflow and reservoir levels.
 - c) Environmental studies are deemed excessive for small projects since same guidelines apply to small and large plants.
 - d) Licensing procedures (i.e., FPC, PUC) are too lengthy, especially, for small projects.
 - e) Operational aspect of hydro plants are dependent on several uncontrollable factors; i.e., climatic conditions, storage/ power drawdown, streamflow variation (typically, 50% during spring runoff).
 - f) Pumped storage plants need the availability of a dependable supply (i.e., during off-peak periods) of low cost pumping energy.
 - g) Dependent on public utility cooperation and system integration.
 - h) Thermal and hydro plants are not directly interchangeable, since thermal plants can operate for extended periods.
- 2) Financial
 - a) Sites rarely close to demand, and this increases cost of transmission; i.e., initial capital and annual operation & maintenance.
 - b) The cost of prime movers and generators (per unit output) increases rapidly as the head decreases a handicap for low head hydro projects.
 - c) For small scale hydro, economic viability must come from reductions in

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equipment and operating cost; e.g., fully automated facilities, central pooled maintenance facilities.

- d) There is no established means of financing for small and intermediately-sized projects.
 - e) The cash flows during early years of operation is prohibitively slow.
 - f) Highly dependent on interest rates and discount rates.
- 3) Environmental
- a) Potential fisheries impact:
 - i) Upstream: turbine injuries to down-migrating fish, water level alterations, siltation, decrease in spawning success and in food production
 - ii) Downstream: bank erosion, bottom scouring, loss of cover & food, periodic flow shortage
 - iii) Other factors: embolism, migration blockage, bank slumping, changes in water quality and species composition, loss of stream habitats and spawning sites
 - b) Land reclamation
 - c) Transmission corridors
 - d) Potential affect on salmon restoration program
 - e) Groundwater effects
 - f) Impediment of watershed developments
- 4) Societal
- a) Associated problems related to influx of construction workers

IV. Recommendation Values: Hydroelectric Power

- 1) *Construct demonstration projects for small-scale hydro to quantify unit prices, establish mass production capability, identify and rectify problem areas, and encourage private incentive.*
- 2) *Increase federal/ state assistance and subsidies.*
- 3) *Streamline regulatory/licensing procedures.*
- 4) *Develop a comprehensive energy policy which would determine priorities considered within the framework of environmental, institutional, operational, and economic guidelines.*
- 5) *Promote and encourage the development of renewable resources.* Hydro is an excellent candidate since technology is readily available and previous experience is quite extensive for different plant types.

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Table 1: Existing New England Hydro Supply

Year	INSTALLED CAPACITY - MW		ANNUAL ENERGY OUTPUT 10 ⁶ KWH	REFERENCE
	Conventional	Pumped		
1974*	1,174	1,477	4,753	Electric Util. Ind
1975	1,287	1,632	-	NEPLAN
1975	-	-	4,359	FRC
1977	1,217	1,477	-	U.S. Corps

* HYDRO

	Conventional	Pumped
Maine	310	-
N.H.	380	-
VT.	186	-
Mass.	193	1,446
R.I.	2	-
Conn.	103	31

Table 2: Potential Hydro Sites

A) Small Dams

- 1) *Estimate of National Hydroelectric Power Potential at Existing Dams, U.S. Corps & Engineers Institute for Water Resources, July 20, 1977*

Cap: 2,970 MW
 Annual Output: 13,219 (10⁹) Kilowatt Hours
 Replacement Cost: \$200,000,000 in displacing fossil fuels

- 2) *A Report on New England Hydroelectric Development Potential, New England Federal Council, June 1976*

Number: 800 dams
 Range: 200 KW - 500 KW
 Total Capacity: 85,000 KW (30% Developed)

Number: 3000 dams
 Range: 200 KW - 500 KW
 Total Capacity: 180,000 KW (15% developed)

- 3) *Proceedings New England—Eastern Canadian Provinces Conference on Alternative Energy, Hydro Workshop, April 27-28, 1978*

Note: One estimate placed the actual utilization value at 5-10% of potential

B) Conventional (Reference 2 & 3)

- 1) Nine major sites with benefit-to-cost ratio greater than unity

	(8) Sites	Dickey-Lincoln
Range:	25 MW-80 MW	-
Total Capacity:	390 MW	760 MW
Capacity Factor:	.19 - .30	.11 - .37
Annual Output:	850 (10 ⁶) KWH	1540 (10 ⁶) KWH
Benefit-to-Cost Range:	1.00 - 1.62	-
Benefit-to-Cost Average:	1.245	2.61**
Average Cost*:	\$357. (10 ⁶)	\$463 (10 ⁶)

* Excluding Transmission

** Recently Revised to 1.22

- 2) Nine major sites with benefit-to-cost ratios between 0.8 and 1.0

Range: 20 MW - 220 MW
 Total Capacity: 585 MW
 Annual Output: 1170 (10⁶) KWH
 Cost: \$614,000,000

C) Pumped Storage

Total Capacity: 19,300 MW - 34,080 MW

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Table 3

A) Production Parameters

	Ultimate Capacity MW	Annual Energy Production		
		10 ⁶ KWH	10 ⁹ BTU (a)	10 ³ BBL Oil (b)
Small Scale	2,970	13,219.	150,697.	23,970.
	85	378. (c)	4,309.	685.
	180	800. (c)	9,120.	1,450.
Conventional				
(8) Best Sites	390	850	9,690.	1,541.
(9) Marginal	585	1,170	13,338.	2,122.
Dickey-Lincoln	760	1,540	17,556.	2,792.
Pumped Storage	34,000	-	-	-

a. Assume 11,400 BTU/KWH for oil-fueled electricity

b. Assume 6,287,000 BTU/BBL residual oil

c. Proportioned according to 2970 MW estimate

B) Escalation Effect

	Ultimate	Cost/KW ^a For		
	1976	1980	1985	2000
6% Escalation				
Conventional				
(8) Best Sites	915	1155	1546.	3705.
Dickey-Lincoln	609	769	1029.	2466.
(9) Marginal	1049	1324.	1772.	4247.
8% Escalation				
Conventional				
(8) Best Sites	915	1245.	1829.	5802.
Dickey-Lincoln	609	828.	1217.	3862.
(9) Marginal	1049	1427.	2097.	6652.

a. Total Capital Investment (excluding transmission) in current dollars per installed capacity

C) Federal Regional Council Scenario

For 1985

Annual Reclaim Hydro : 9.0(10⁶) BBL Oil Equivalence
: 56.6 (10¹²) BTU
: 4963. (10⁶) KWH (1115 MW)

No large hydroelectric projects until after 1985

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Table 4: Dickey-Lincoln School Lakes

Economic Analysis - Annual Costs and Benefits (October 1975 P.L.)

1) Total Investment - Dams	
Construction Costs of Dams	\$463,000,000
Interest During Construction	37,900,000
Total Investment	<u>\$500,900,000</u>
2) Total Investment - Transmission Lines	
Construction Costs of Transmission Line	\$162,120,000
Interest During Construction	7,900,000
Total Investment	<u>\$170,020,000</u>
3) Total Construction Cost	
Total	\$670,920,000
4) Annual Costs - Dams	
Interest and Amortization (7% for 50-year project life)	\$ 48,641,700
Operation and Maintenance	1,850,000
Major Replacement	323,000
Loss of Land Taxes	128,000
Sub-Total Dams	<u>\$ 50,942,700</u>
5) Annual Costs - Transmission Lines	
Interest and Amortization	\$ 5,760,000
Operation and Maintenance	884,000
Major Replacements	514,000
Sub-Total Trans. Lines	<u>\$ 7,158,000</u>
6) Total Annual Costs	
Dickey-Lincoln School Lakes	\$ 50,942,700
Transmission (50%)	3,579,000
Annual Costs	<u>\$ 54,521,700</u>
7) Annual Benefits	
Power: Peaking	\$ 22,204,000
Energy	34,345,000
Prevention of Flood Damages	83,000
Recreation	1,250,000
Redevelopment	1,067,000
Total	<u>\$58,949,000</u>
8) Benefit-To-Cost Ratio	
Power only	1.037
Total Benefits	1.081
9) Average Power Cost	
Mills/KWH	38.159

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**Table 5: Economic Analysis - Annual Costs and Benefits
Springfield, Vermont (Jan, 1975 P.L.)**

1) Total Investment - Dams (Including distribution system & diesel unit)	
Construction Cost of Dams	\$40,710,000
Interest During Construction	3,160,000
Reserve Fund	3,650,000
Total Investment	\$47,520,000
2) Annual Costs - Dams	
Interest and Amortization (7% for 40-year bond)	\$ 3,070,000
Operation and Maintenance	
Major Replacements	
Loss of Land Taxes	\$ 650,000
Sub-Total Dams	\$ 3,720,000
3) Annual Costs - Power	
Purchased Power	\$ 287,000
4) Total Annual Cost	
Total	\$ 4,007,000
5) Annual Benefits	
Customer Charge	\$ 235,500
Power: Peaking	2,081,010
Energy	1,350,010
Total	\$ 3,666,520
6) Benefit-to-Cost Ratio	
Power only	0.915
7) Average Power Cost*	
Mills/KWH	57.99
8) Production Parameters	
Installed Capacity (KW)	22,500 - Hydro 4,000 - Diesel
Annual Electrical Output (10 ⁶ KWH)	60,250 - Hydro 7,280 - Diesel
Average Plant Factor	0.306

$$* \frac{\text{Annual Cost}}{\text{Output (.96)}} = \frac{\$3,720,000}{(67,530,000 \text{ KWH}) (95)}$$

**Table 6: Comparison Between Dickey-Lincoln
and Black River Projects**

	DICKEY	BLACK RIVER
Total Investment ^a		
Per Capacity (\$/KW)	883	1793
Annual Cost ^b Per		
Annual Output (Mills/KWH)	35.40	59.24
Power Benefits ^c Per		
Annual Output (Mills/KWH)	36.72	54.29

a. including Transmission

b. without 5% transmission loss

c. peaking and energy credit

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Table 7

	New Cap.		Annual Output			Construction Cost (c)	Operating Cost		% of New England Projected Electric Demand (d)
	Year	MW	10 ⁹ KWH (a)	10 ¹² BTU (b)	10 ⁶ BBL (c)	\$/KW (c)	Mills/KWH	\$/MM BU	
Wind	1972	24000	168.2	1917.4	305.0	754	17.1	1.500	-
	(e)	(f)	(g)						
	1985	-	0.023	0.26	0.04	1985-7940	-	-	0.026
	2000	5400	14.0	159.60	25.39	4758-19030	-	-	11.516
		10800	28.0	319.20	50.78	4758-19030	-	-	23.031
									11.534 - 23.050
Tidal	1976	180	0.68	7.75	1.23	2720	56.5	4.956	-
	1985	12.5	0.038	0.43	0.07	3343 (1985)	-	-	0.044
	(h)					(i)			
	2000	380	1.290	14.71	2.35	Project Mix	-	-	1.061
									1.092
Hydro	1976	760.0	1.540	17.56	2.79	609	38.16	3.386	-
	(j)								
	1985	1135	2.765	31.52	5.01	Project Mix	-	-	3.175
	(k)								
	2000	1238	4.595	52.38	8.33	Project Mix	-	-	3.780
	(l)								6.054

a. Assume 11400 BTU/KW for Oil-Fueled Electricity

b. Assume 6,287,000 BTU/BBL Residual Oil

c. Construction Cost Escalated at 6 %/Yr.

d. Escalated at 2.25 %/Yr. from 1975 Estimates

e. Estimates for that year

f. Off-Shore Wind Power System

g. According To: (Cap) (Load Factor = 0.8) (8760 Hrs./Yr.)

h. High Scenario - Case (b)

i. Figures in parenthesis denote the year on-line

j. Dickey-Lincoln evaluated at 7% interest rate for 50 years

k. Assume: Dickey-Lincoln, 760 MW

(4) "Best-Sites", 195 MW

"Small-Scale", 180 MW

l. Assume: (4) Best-Sites, 195 MW

(3) Marginal, 193 MW

Small-Scale, 180 MW

Year	Projected Electrical Demand - 10 ⁹ KWH	Electric Generation New England (1975 Preliminary)				
		Type	10 ⁶ KWH	10 ¹² BTU	10 ⁶ BBL	%
1975	69.705	Oil	40493	461.6	73.4	58.1
1985	87.075 (2.25 %/Yr.)	Coal	4395	50.1	8.0	6.3
2000	121.575 (2.25 %/Yr.)	Nat Gas	192	2.2	0.4	0.3
		Nuclear	20266	231.0	36.7	29.1
		Hydro	4359	49.7	7.9	6.2

Wind Power

I. Introduction

This paper deals with wind-electric systems and its power production potential, project economics, environmental constraints, and other related topics. Wind systems can also be used in a number of different ways besides electrical generation; (e.g., pumping for irrigational purposes, and development of mechanical advantage). A major impediment to localized implementation is electrical storage (e.g., battery banks, thermal sinks, compressed air). Public utility integration is one possible solution for efficient utilization of wind energy by a regional, or community electrical market.

Wind-electric systems can supply base-load power if sufficient storage capacity is available. This type of self-sufficient system is more applicable to small units (i.e., between 2-15 KW) adapted for individual and community application. However, for wide-scale implementation an integrated network must be developed in which wind production would complement the existing supply mix. A mixture of peak, intermediate and base-load electricity would be generated for this proposed integrated network. The degree and type of interaction would depend on the percent of installed "wind-electric" capacity, wind velocity profile, transmission network, coordination between individual power plants, and the seasonal/daily load demand fluctuations. Off-shore wind-electric facilities would be more applicable to a "hydrogen economy" which would substitute hydrogen-fueled electrical generation for an expensive transmission system. Hydrogen production would also supply more reliable and flexible electricity.

Wind-electric systems could be constructed anywhere in New England and along the coast. However, regions of greater wind velocities and higher occurrence rates would produce more power and, thereby, increase the project's economic feasibility. Therefore, hilltops and coastal areas would seem to be most appropriate sites for immediate wind-electric developments. Research programs will help to reduce capital costs through development of mass production techniques and, thereby, enhance the feasibility of projects which are now only marginally economic.

II. Potential

1) New England

Potential capacity of wind-electric systems is theoretically unlimited; however, on a practical basis there are institutional, economic, and operational constraints that severely limit implementation of this energy resource. Council of Environmental Quality (March 1978) estimates for wind-electric potential for the United States in the year 2000 were scaled down for New England as indicated in Table 1. Power production parameters are listed below in a modified basis for the year 2000:

installed capacity, 5400 MW - 10800 MW

annual capacity factor, 0.3

*annual electrical output, 14 - 28 million KWH 25.5 - 51 million barrel,
displaced 160 - 320 trillion BTU*

However, Federal Regional Council estimate for 1985 is only between 8-10MW which would necessitate a tremendous effort to realize CEQ estimates by the year 2000 as proposed

- a) Power production increases with the square of a turbine's physical dimensions; i.e., propeller span.

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- b) Wind-electric generation increases as the cube of velocity which emphasizes the importance of site selection.
- c) Advanced aeronautical engineering offers the potential for improvement, especially, since wind turbine development will probably be constrained by engineering limits of propeller size.
- d) Wind technology is fairly well developed and capable of being applied immediately; however, mass production and an effective R&D program could significantly reduce the initial investment and serve as a catalytic factor for future efforts.
- e) A recent study stated that an energy mix of 8-20% wind could supply 16% of its (wind) rated capacity as base-load power. This assumes numerous wind machines distributed over a large area.

2) Economic

- a) Cost data was not readily available and highly dispersed depending on which source was referenced. Table 1 shows the results of this investigation for total installed cost per installed capacity ranging from 1175 \$/KW up to 4700 \$/KW in 1978 dollars. However, before a judgment could be reached the individual analyses would have to be evaluated.
- b) Both small and large units have the potential for marked cost reductions through mass production.
- c) Insensitive to inflationary trends which lends wind-power projects to life cycle cost economic analysis when considered in terms of its renewable quality; i.e., no fuel cost.
- d) Average power cost in 1972 dollars for off-shore wind-electric-hydrogen system is listed at 17.1 Mills/KWH (see Table 3-C). However, these figures seem extremely liberal and "wind-biased". More exact data is needed before a definitive position could be taken.

3) Environmental

- a) Non-pollutant and environmentally safe
- b) No hazardous material

D. Socio-Economic

- a) Depletable resource saver when integrated into an existing fossil-hydro-nuclear energy mix
- b) Commitment to a renewable energy resource

III. Problems

1) Institutional

- a) Intermittent unpredictable production makes it difficult to integrate with existing network, a problem which seriously affects the wide-scale acceptance of wind power as a complementary source of electricity.
- b) Rate of introduction into the energy mix depends heavily on the results of current R&D programs and on subsequent commercialization efforts.

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- c) Financial structure is not well defined for alternate energy resources which makes it additionally difficult to secure the necessary capital investment.

2 Financial

- a) Project cost estimation is speculative undertaking due to uncertainties in the following factors:
 - i) Cost of construction
 - ii) Equipment life
 - iii) System reliability
 - iv) Storage capacity and/or network interfacing most of these cost components could be adequately quantified from a properly-designed demonstration project.
- b) Transmission cost will be high for large installations since sites are fairly remote.

3) Environmental

- a) Potential effect on migratory flyways of birds, especially on hilltops
- b) Slight low-frequency noise level
- c) Potential for public safety hazard from cases of propeller breakup

4) Societal

- a) Aesthetic objection

IV. Recommendation

- 1) *Obtain firm project costs, including annual operation & maintenance, from federal demonstration projects for both small and large units.*
- 2) *Establish regulatory/institutional guidelines to facilitate project implementation phase.*
- 3) *Consider hybrid systems and non-electric utilization of wind power; e.g., pumping*
- 4) *Offer tax incentives and research & development programs to assist in attaining near-term cost-competitiveness*

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Table 1—Production and Economic Parameters

A. Wind Potential

Ultimate U.S. Potential (Excluding Off-Shore Sites)

:1-2 (10^{12}) KWH/yr

New England Potential (Excluding Off-Shore Sites)*

:35-70 10^9 KWH/Yr

:13320-26640 MW**

B. Development Scenarios

1985: Federal Regional Council Estimates Production At:

:23 (10^6) KWH/yr

2000: Council on Environmental Quality Estimates Production At:

U.S.: 0.4-0.8 (10^{12} KWH?yr

N.E.: 14-28 (10^9) KW/Yr*

5400-10800 MW**

C. Cost Estimates

Source	Cost (\$)/KW	Remarks
1	1000-1800	For 2 & 3 KW Units Sold as Reconditioned (1978)
2	610 (1.7 MW) 520 (4.0 MW)	ERDA (1975) Production Cost Only
3	10000 (100 KW)	NASA (1976) Sandusky, Ohio
4	4700 (1.5 MW)	General Electric (1978)
5	1175 (200 KW)	Quebec, Turnkey Construction

*From The Production of U.S. Electrical Demand (= 10^{12} KWH)
To N.E. Electrical Demand (= 10^{12} KWH)

**Assume 0.3 Capacity Factor, Then Projected Installed Capacity Is:
(Annual Output) (MW/ 10^3 KW)
(0.3) (8760 Hr/Yr)

2. Table—Summary

A. Production Parameters

	Ultimate	Annual Energy		
	Capacity - MW	10^9 KWH	10^{12} BTU*	10^6 BBL**
FRC	-	.023	.26	.04
CEQ	5400	14.0	159.6	25.39
	10800	28.0	319.2	50.78

*Assume 11400 BTU/KWH For Oil Fueled Electricity

**Assume 6,287,000 BTU/BBL Residual Oil

B. Project Cost

		Cost (\$) / KW *** For	
	1976	1985	2000
6% Escalation	1175	1985	4758.
	4700	7940	19030.
8% Escalation	1175	2349	7450.
	4700	9395	29800

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3. TABLE A
AEC ESTIMATED NUCLEAR AND COAL POWER GENERATION (29)
PLANT CAPACITY = 1000 Megawatts (Electrical) (in 1972 dollars)

COOLING SYSTEM:	PRESSURIZED WATER REACTOR		COAL PLANT				
	RUN-OF-RIVER	COOLING TOWER	WITHOUT SO ₂ REMOVAL		WITH SO ₂ REMOVAL		
			RUN-OF-RIVER	COOLING TOWER	RUN-OF-RIVER	COOLING TOWER	
PITAL COST (\$/kw)	365	382	297	311	344	344	358
EXED CHARGES (mills/kwh)	7.8	8.2	6.4	6.6	7.4	7.7	
L COST	1.9	3.9	3.9	3.9	3.9		
ERATION AND MAIN- NANCE COST	0.6	0.6	0.5	0.5	0.8	0.8	
TAL POWER COST (mills/kwh)	10.7	10.7	10.8	11.0	12.1	12.4	

TABLE B
ESTIMATED COST OF AN-OFFSHORE WIND POWER SYSTEM*
(In 1972 Dollars)

Output = 159 billion kilowatt-hours annually

1.	83 Wind Units, in place	\$13,630 x 10 ⁹
2.	Compressor and Deep Storage Subsystem, in place	1.341
3.	Offshore Collection Subsystems, in place	0.275
4.	(Shore) Terminal	0.100
5.	On-shore Distribution Subsystem	0.560
6.	Fuel Cell Substations (24 million Kilowatts at 50 percent efficiency)	2.200
		\$18.106 x 10 ⁹

From reference (18) W.E. Heronemus "Power From The Offshore Winds" Eighth Annual Marine Technology Society Conference Preprints (1973) pp. 435-466

TABLE C
AN ESTIMATED COST COMPARISON OF NUCLEAR, SEA THERMAL, OFFSHORE WIND, AND TIDAL POWER GENERATION (In 1972 Dollars)

	PRESSURIZED WATER REACTOR (PWR) WITH COOLING TOWERS	OFFSHORE WIND POWER SYSTEM (18)	SEA THERMAL POWER SYSTEM (22,15)		TIDAL POWER RANCE RIVER, PLANT
	LOAD FACTOR = 0.8	LOAD FACTOR = 0.8	LOAD FACTOR = 0.8		LOAD FACTOR = 0.5
	1000 Megawatt	24000 Megawatts	100-400	Megawatts	240 Megawatts
PITAL COST (\$/kw)	382 ⁵	754 ¹	390 ²	570 ³	560 ⁴
EXED CHARGES (mills/kwh)	8.2	16.2	8.4	12.2	19.2
EL COST	1.9	-	-	-	-
OPERATION AND MAINTENANCE COSTS	0.6	0.9	0.9	0.9	0.8
TOTAL POWER COST (mills/kwh)	10.6	17.1	9.3	13.1	20.0

PEAT*

I. Why Peat?

In New England it is fashionable to talk of "biomass" as a future energy resource: waste wood, manure, potatoes, sewage sludge, be what may—all have received some play. All, that is, except for that accumulation of dead biomass called peat.

There are 105 peat producing sites in the United States but virtually all of their product is consumed for agricultural and horticultural purposes. Not so in the rest of the world where 32 percent of all peat is used for fuel—mostly to generate electrical power. In the U.S.S.R. about 66 million tons of peat are burned annually to produce 14.5 billion kilowatt-hours of electricity. In Ireland, about one-third of the country's electrical power requirements are generated by burning peat. Lesser amounts of energy are generated from peat in Finland and West Germany.

The Institute of Gas Technology (IGT) estimates that the energy equivalent of the United States peat resource is 1443 quads ("quad"—quadrillion BTU's) or 240 billion barrels of oil equivalent. About 21 quads of that total is estimated to be in Maine and perhaps 4 or 5 additional quads are in the other 5 New England states. If all the potential of U.S. peat resources could be utilized in the form of synthetic natural gas (SNG) it has been estimated that the yield would amount to 1 1/2 times the present national consumption of natural gas and that such a production level could be sustained for 20 years.

II. What is Peat?

Peat is partly decomposed plant matter that has accumulated under water or in a water-saturated environment. It is the initial stage in the process that ultimately converts vegetable matter into coal. Peat comes in varying degrees of decomposition and with a range of properties resulting from the variety of plants that formed it, climatic differences, and the environment of accumulation. One simplistic classification divides peat into moss peat, reed-sedge peat, and peat humus. Peat derived from moss is called moss peat, from anything else and from mixed vegetation it is reed-sedge peat, and if it is so decomposed that botanical identity is not apparent, it is peat humus.

III. How About New England Peat?

If the world contains an estimated resources of 233 billion tons of air-dried peat and about 6 percent, or 13.8 billion tons, are in the United States, where does New England fit in?

The U. S Geological Survey has estimated the peat resources of the New England states as follows:

Maine	10 ⁸ tons (hundreds of millions)
New Hampshire	10 ⁷ tons (tens of millions)
Vermont	10 ⁷ tons (tens of millions)
Massachusetts	10 ⁷ tons (tens of millions)
Connecticut	10 ⁷ tons (tens of millions)
Rhode Island	10 ⁵ tons (tens of millions)

Other authorities consider U. S. Geological Survey figures to be conservative and have estimated Maine peat resources to be 1.8 million tons (1.8×10^9).

New England peat bogs or swamps are typically several feet to a few tens of feet thick and consist of moss, sedge and humus peat with some intermixed tree trunks, limbs, or other debris.

*Prepared by William R. Barton and Joseph M. Pecoraro for The New England Energy Task Force of the Federal Regional Council as a Briefing Paper for the New England Energy Congress.

Raised bogs, more common in Maine, may have several inches or feet of high quality and high value sphagnum moss peat as a surface layer. The bog or swamp may, or may not, be overgrown with trees or an undergrowth of shrubs and other small plants.

Raw peat typically contains 90 percent or more of water by weight. By air drying the moisture content can be reduced to 25-30 percent and for resource estimate purposes an acre-foot of bog may be considered to yield about 200 tons of air-dried peat equivalent. On a dry basis, peat has a theoretical heating value of 9,000 BTU/lb. However, air-dried peat with a 5 percent ash content would contain a net heating value more on the order of 6,000 BTU/lb and in actual practice, with less than optimal drying and with allowance for impurities 3,000—5,000 BTU/lb. might be closer to reality. Variations in peat composition from bog to bog and layer to layer within a bog also cause variation in BTU content.

The precise measurement and evaluation of United States peat resources is only now beginning. Few bogs have been explored for peat systematically. In New England, the Maine bogs are considered to have by far the greatest potential and consequently have received by far the bulk of investigation. In 1909, the U.S. Geological Survey published the 127 page Bulletin 376 titled: *Peat Deposits in Maine*, and sporadic study of the peat in Maine and other New England states has continued under various auspices to this day.

Without knowing the true energy potential of New England peat, only a theoretical yield figure can be constructed. But a 10,000 acre complex of Maine peat bogs averaging 15 feet thick, if developed, would appear to offer a harvest of about 30 million tons of air-dried peat equal in potential energy yield to about 15 million tons of coal, or 60 million barrels of oil.

IV. How Can It Be Mined And Used?

Peat can be harvested in a variety of ways. Specialized peat extracting machinery has been developed and is available, and conventional types of excavating and earth-moving machinery, or modified conventional types can be used. Equipment ranges from power shovels, bulldozers, front-end loaders and millers used in ditched and drained bogs to draglines, clamshells, and dredges for submerged deposits.

The extracted peat is air-dried to various degrees using one of several systems depending upon mining method, end use, peat type, and climate. If necessary for marketing, artificial drying may be practiced, but it is not ordinarily done for peat intended for use as a bulk fuel. In Ireland, for example, the upper bog level is drained to partly dewater the peat, the top layer of dried peat is milled off by a bogging machine which shreds the product to desired size, ridged to await transport, and finally consumed by electric utilities while still containing 40 to 65 percent moisture and averaging a net heating value of 3,350 BTU/lb. (about 30 percent of the heat content of a typical U. S. bituminous steam coal).

In Maine if a peat deposit has a surface layer of sphagnum moss peat, it could be selectively removed by milling machine or other method for shipment to horticultural or agricultural markets where higher values may attain than the estimated \$10/ton value for air-dried fuel peat f.o.b. bogside in Maine.

It should be noted that there are also unconventional methods available by which New England peat could be harvested. One with possibilities is hydraulic movement by a monitor jet followed by pumping as a slurry to drying fields. This method would offer advantages if the deposit contains a large proportion of stumps, tree roots, and hog-holes.

Peat offers the potential for conversion to energy in more than one way. Conventionally, in Europe shredded peat is blown directly into the combustion chambers in steam-electric generating plants. The plants are typically multi-unit and what may be termed "bog-mouth". Usually they are within sight of the peat site to avoid undue transportation costs. It is also possible that peat could be fired mixed with coal or oil the same way shredded waste paper can be used in

certain installations. That possibility would seem less economically attractive than "bog-mouth" power generation, and offer no particular advantages that I can conceive of for New England.

Peat has been converted experimentally into synthetic natural gas. Based on work by the Institute of Gas Technology, the incomplete combustion of peat in the presence of hot air and steam will yield an intermediate calorific value gas with byproduct ammonia and hydrogen sulfate. The cleaned gas can be upgraded to SNG by a methanation process. The method is technically feasible and is said to be economically attractive. While the full-scale commercial feasibility of the process has not been fully demonstrated, the Minnesota Gas Company in 1975 applied for a lease on 200,000 acres of state-owned peat bog containing enough peat to produce an estimated 250 million cubic feet per day of SNG for a twenty year life. That annual production would be equivalent to about 1/4 of all the natural gas consumed in Minnesota in 1974.

Minor fuel uses would include pressed briquets for domestic heating and cooking. In addition chemicals, coke, and waxes are potential byproducts.

V. What Are The Restraints To Mining Peat For Fuel In New England?

While there is a lot of peat in New England, it has not been investigated specifically and systematically as a potential energy source. Where is the best peat for fuel use? The peat with the most consistent BTU content? The peat easiest to mine? The best peat in conjunction with desirable power generation sites? The peat most environmentally and socially acceptable for extraction? Those and many other questions have to be answered.

Finding that enough peat is there, and that it is good peat is just the beginning. Can it be legally and profitably removed and used?

Environmental restrictions are a serious constraint to peat operations in many states, probably more so in New England than in most areas. New England is environmentally very aware and also capitalizes on its inherent physical beauty to attract tourists.

Most New England peat occurs in wetland areas which provide critical wildlife habitat and are important for water retention and ground water recharge. In all of the New England states except Maine it is difficult to conceive of large scale peat removal for energy purposes being permitted. The other New England states have less land area coupled with fewer and smaller peat bogs than Maine and have rigorous regulation of any wetland alterations.

A sizable peat for fuel operation in Maine, one the size proposed for Minnesota, would have considerable impact even in New England's far northern reaches. Two hundred thousand acres is about one percent of the land surface area of Maine. While it would be land of limited present economic value, it is land considered to be of significant ecological consequence and probably would involve something on the scale of one-fourth of Maine's peat bogs.

A peat operation would have to conform with all federal, state and local mining and environmental laws as well as any applicable local zoning and planning regulations (as any mining operation must).

Alteration of coastal wetlands in Maine is prohibited without a permit from the Maine Board of Environmental Protection or from the affected municipalities acting under the provisions of RSA 38-3, sec. 473 and sec. 474. The provisions of those sections effectively preclude peat operations from any area classified as coastal wetland in Maine.

Elsewhere in Maine, peat extraction is regulated but not prohibited by Maine planning and land use laws, as is any development which may substantially affect the environment. Such development specifically requires the approval of the Maine Board of Environmental Protection under RSA-38-3, sec. 482. Of direct and specific applicability, RSA 10-451 requires rehabilitation of worked land and specifically includes peat. Its declared policy includes: "enhancement of wildlife

and aquatic resources, conservation, development, management and appropriate use of all the natural resources (of an area) for compatible multiple purposes, and to protect the health, safety, and welfare of the people, as well as natural beauty and environmental values". How such a policy is interpreted and implemented would be critical to any planned large-scale peat development.

Other questions that involve Maine peat development would include increased fire hazard resulting from mining methods using bog-drainage techniques, and potential for conflicts arising from the fact that much of Maine's peat with the most attractive development potential lies in areas contested by Maine's Indian tribes.

VI. How May We Resolve Those Problems And Move Ahead?

Critical to development of peat for energy in New England will be the task of convincing people that we need the potential energy benefits to be realized from using a few percent of Maine's peat bogs and that enough of Maine's peat bogs will remain to offer an acceptable amount of ecological sustenance. And by careful development and logical planning new and desirable environments and excellent far land can be created.

Peat harvesting can be conducted to create new "Great Ponds" in Maine. By definition they include artificially created bodies of water 30 acres or more in size and under RSA 38-3, sec. 386 are recognized as "having unsurpassed recreational, cultural, historical, and environmental value to citizens". By total bog peat removal, new great ponds would be created to offset the process of entrophication adversely affecting some existing great ponds and to provide new recreational opportunities. As an alternative, using the techniques of the Irish Bord Na Mona (Peat Board), bogs are partly drained and then gradually moved down only to a pre-determined level and left suitable for subsequent use as truly prime agricultural land.

By education and proper planning the peat could be utilized and the land and water left in an attractive and useful state, although a changed one.

New England and Maine will have to decide which they want more, energy from peat or pristine bogs. Peat helps Ireland and the U.S.S.R., it could help us.

Something the size of the Minnesota peat proposal (200,000 acres) would appear to grand to be applied on a New England scale, but Yankee ingenuity should be able to devise an alternative magnitude. One that will yield a maximum of energy benefits with an acceptable minimum of adverse environmental impacts.

ECONOMIC DEVELOPMENT THROUGH ALTERNATIVE SOURCES OF ENERGY COMMITTEE

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COMMITTEE OVERVIEW

The Committee on Economic Development Through Alternative Sources of Energy (The Alternatives Committee) has focused its efforts on three central themes: (1) defining the state of the art and future directions of the technologies applicable to renewable energy resources, specifically, biomass, direct solar, and wind/hydroelectric/tidal/wave energy; (2) identifying, and formulating policies to reduce the institutional impediments and adverse environmental impacts of developing these resources; and: (3) evaluating the relationship between renewable energy systems and regional economic development.

During the first three months of study, three subcommittees of 6-7 members each were organized according to the major resources under investigation: Biomass, Direct Solar and Wind/Hydro. Each subcommittee prepared a technical discussion of its respective resource, including an evaluation of its availability, applicable technologies for each end use, institutional impediments and environmental constraints. These documents were reviewed by the full committee membership and revised accordingly. They appear in full as part of this report.

In August, the full committee restructured itself into three new policy oriented subcommittees: Capital/Financing, Jobs and Systems Integration. Members agreed that the new subcommittees would utilize the initial technical reports as a basis for formulating specific recommendations in each of the three topical areas, as well as continue their investigations, where necessary, in each of the original three resource areas.

In late October, a Recommendations Subcommittee was formed to gather and organize the proposals formulated by the various subcommittees. All proposals were examined at this time and

grouped according to the level of consensus achieved to facilitate full committee deliberation. At a final full committee meeting on October 31, this classification scheme served to prioritize discussions. Ultimately, the full committee's consensus decisions closely paralleled those of the Recommendations Subcommittee. Members agreed that all non-consensus recommendations would appear in the full committee's preliminary report to insure that all recommendations would be subject to public review. Non-consensus recommendations appear at the end of this report for that purpose.

The six reports which follow represent the consensus view of the members of each subcommittee. They vary in both length and structure. No attempt was made to impose a uniform format on subcommittee reports except for a set of flexible guidelines in outline form developed by Ms. Rosenstreich for the three original resource-oriented subcommittees. To facilitate the communication of the subcommittee work, a brief synopsis of the major findings of each report follows.

Biomass Subcommittee

Wood is by far the most promising biomass resource available in New England. On a sustained yield basis, wood can probably provide in excess of 1.5×10^{15} BTUs annually. As a home heating fuel, the use of wood is increasing extremely rapidly throughout the region. As a boiler fuel for generating electricity, wood is receiving increasing attention from utilities seeking alternatives to oil and nuclear. Exploration of wood resources must proceed in a manner consistent with the environmental risks involved. At present, the dangers of an overburdened infrastructural network and the mismanagement of the resource by unplanned utilization must be addressed as the region looks toward its forests as an alternate energy source. Effective forest management and careful selection of the type and distribution of conversion systems will insure long term benefits in the form of resource sustainability, environmental compatibility and employment opportunities.

Direct Solar Subcommittee

New England receives sufficient solar insolation to supply a major portion of the region's space and water heating requirements. The major barriers to realizing this potential are primarily economic in nature. Current costs of flat plate collector systems are \$20-30 ft.², which translates into heating costs competitive only with the most expensive conventional system, electric baseboard heating. Since most materials utilized in the manufacture of collectors are already produced in voluminous quantities, major cost reductions will be difficult to achieve. Cost competitiveness, therefore, will most likely be achieved through: (1) the rising cost of conventional fuels; (2) perfection and utilization of passive solar technologies; (3) greater public acceptance of the life-cycle cost concept and/or; (4) improved installation methods.

Photovoltaic power is an evolving power source. Single crystal cells made from silicon, gallium, arsenide or other semi-conductors are reasonably efficient but excessively costly; thin film cells, on the other hand, are less efficient but more attractive from a cost standpoint. Concentrator systems offer more promising opportunities for cost reduction, but their suitability for New England is inferior to that of flat panel cells. Encapsulation costs often equal those of the cells themselves, and further research is needed to develop a method appropriate to the climatic variations characteristic of New England. Given current average roof space and the electrical consumption of the typical 1500 ft.² single story residence in the region, retrofitting with 10 percent efficient solar cells would produce enough electricity to meet a household's needs. A major unanswered question, however, is the number of existing housing units which could be retrofitted with photovoltaic systems.

Rapid commercialization of direct solar applications for space and water heating will require a joint federal, state and local government effort. Within the federal government's purview are a range of fiscal incentives to producers and consumers and demonstration programs. The states are in a position to provide rate protection for solar users, tax incentives, demonstrations, information and building code modifications. Local governments may act to insure solar access and conduct demonstrations. The single most preferred incentive is the direct grant whose effectiveness probably increases exponentially with the amount of the grant.

As the utilization of solar systems becomes increasingly widespread, integration of the many dispersed solar systems into the existing electric grid must be achieved. A marriage of the two power sources appears to be mutually beneficial: the storage capability of solar systems may be replenished by utilities during sunless periods and, in a corollary fashion, utilities may be granted access to this storage system during daylight peak load hours.

Wind/Hydroelectric/Tidal/Wave Subcommittee

At the present time, approximately twenty small wind turbines with rated capacities of 2-15 KW are commercially available. A typical 10 KW unit will provide approximately 11,000 KWH/year at a site mean annual wind speed of 12 MPH, the upper end of the range characteristic of most New England sites. This quantity of electricity is equivalent to the average residential requirements exclusive of space heating and air conditioning. Larger turbines in the 2 MW range are under construction, but unlike the smaller units, have not been technologically proven. If wind systems are to provide a significant contribution to New England's energy mix, several major issues must be addressed: (1) reduction in capital cost through mass production of standardized units; (2) satisfactory interconnection arrangements with utilities for producers of surplus power; (3) minimization of safety hazards and adverse aesthetic impacts through adequate siting controls.

Conventional hydroelectric capacity in New England totals approximately 1500 MW, and estimates of developable capacity range from 1200-3300 MW. A major portion of the latter is the proposed 830 MW Dickey-Lincoln project in northern Maine. The remainder is accounted for by hundreds of potential small-scale sites in the 1-25 MW range most of which would operate as run-of-the-river systems with no storage capacity. In general, reactivation of existing hydro facilities is currently more economically feasible than developing new sites. Reactivation also will raise fewer environmental objections than either small or large-scale new projects. Reducing the regulatory burden on potential developers and providing up-front subsidies for feasibility studies and capital costs will facilitate the implementation of small-scale hydro projects. With such assistance, an *additional* 1500 MW of capacity (equivalent to a 600 MW thermal electric unit at 30% capacity factor) is a reasonable goal for the region.

Tidal power studies of Cobscook Bay and Passamaquoddy Bay conducted by Canada and the U.S. Army Corps of Engineers have concluded that neither is economic at the present time. The Corps has turned its attention exclusively to the Cobscook project, although it is unlikely that further study will reach conclusions different from the previous ones. A smaller 4 MW project at Half Moon Cove within Cobscook Bay has been proposed by the Passamaquoddy tribe. From an overall cost/benefit standpoint, especially when local secondary impacts are considered, the Half Moon Cove may prove worthy of implementation.

Ocean thermal and wave power projects are neither economic nor environmentally acceptable to the region at present.

Capital/Financing Subcommittee

The most effective government financing schemes for promoting renewable energy systems are those which simultaneously stimulate supply and demand. A mix of increased investment tax credits, accelerated depreciation allowances, loan guarantees, low interest loans, dividend/capital gains exemptions, together with credits, rebates and grants for consumers, is most desirable. Although such programs are costly, substantial secondary "effects" in the regional and national economy ultimately reduce the net cost to the governmental sponsor. Such benefits should be formally incorporated into the policy formulation process.

Jobs Subcommittee

Energy policy at all levels of government must account for the economic development, and especially, jobs impacts associated with each policy option under consideration. The allocation of research and development monies, fiscal incentives to various energy forms, power plant sitings, etc., all generate far-reaching impacts on the location and quantity of job opportunities. Federal policy to date, by favoring capital intensive, centralized power systems has cost the region and nation innumerable job opportunities in the more labor intensive conservation/renewable energy alternative. A formal mechanism for evaluating the jobs, and overall economic development, effects of energy options should be incorporated into federal and state decision making processes.

Systems Integration Subcommittee

Policy impacting alternate energies must be framed to achieve four basic objectives: (1) equalizing incentives with conventional energy forms; (2) elimination of discriminatory regulations; (3) demonstration of economically attractive alternatives to potential consumers; (4) stimulation of supply markets for those systems already demonstrated. For example, home heating with renewable energy systems, including conservation, requires a variety of unit, neighborhood and community-scale demonstration projects. In contrast, interfacing hydro/wind electric power generation with the existing grid is primarily a regulatory problem. Greater flexibility must be allowed for the non-utility, small-scale producer of electricity, including provisions for backup power and market guarantees. Finally, wood combustion, at both centralized and dispersed sites will be facilitated by improving the supply network to consumers. Such improvements, however, must be undertaken with an awareness of the risks of "over-incentivizing" suppliers of the resource.

Preview

The remainder of this report is divided into three parts. In the following section, recommendations which have achieved full committee consensus are presented according to seven topical areas: general recommendations, biomass, direct solar, wind/hydroelectric, financing, economic development/jobs and miscellaneous. In cases of overlap between two or more of these areas, recommendations are classified, where possible, according to the energy resource in question. This is followed by the full text of all subcommittee reports. Finally, all recommendations which have yet to achieve full committee consensus are listed in the same topical order as the committee's consensus recommendations.

CONSENSUS RECOMMENDATIONS

General

- 1) *The committee views the federal government's longstanding favored treatment of conventional energy sources versus renewable energy sources as one of the greatest impediments to the rapid development and commercialization of alternative energy systems and realization of the economic development and employment opportunities they present. The committee, therefore, recommends that the federal government thoroughly investigate the extent of such inequality and immediately take the necessary steps to insure that renewable energy systems are, at a minimum, as favored as conventional systems.*

Biomass

- 2) **Wood Air Quality Studies**

The committee recommends that the Department of Energy, Environmental Protection Agency and other appropriate federal agencies immediately undertake studies of the air quality impacts of wood energy systems including, but not limited to, the following topics:

- A) *Characteristics of pollutants and the relationship between pollutant emissions and the characteristics of the wood resource.*
- B) *The relationship between system design and operation, and pollution.*
- C) *The impact of creosote on household safety.*
- D) *Chemical content and health effects of pollutants.*

- 3) **Methanol and Ethanol Demonstrations**

The committee recommends a feasibility study of a New England methanol-from-biomass demonstration project, and assurances that New England is given fair consideration as a location for one of the Department of Agriculture's ethanol demonstration projects.

- 4) **Forest Management Services**

The committee recommends an immediate increase in the level of support for forest management services available to commercial, public and small woodlot owner, including:

- A) *Increased funding and manpower for forestry services of the Department of Agriculture's County Extension Services*
- B) *Increased funding for public education on multiple uses of forestland, utilizing a variety of communications media.*
- C) *Increased funding levels for forest management assistance programs administered by the Department of Agriculture, including direct grants, matching funds, etc.*
- D) *The provision of tax incentives for forest owners to properly manage their lands for fuel wood and forest products. This could be accomplished through current use property tax reductions which favor land which is under management by a*

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certified forester and for which a plan has been approved by the County Extension Service.

- E) In states with timber tax laws, require that before a cutting permit is issued, a forest management plan must be submitted to the County Extension Service for review and comment.

5) Study of Harvesting Techniques

The committee recommends that further study be undertaken of the impact of whole tree harvesting, and other intensive harvesting techniques, on nutrient balances in the soil before major investments of federal money are made to increase forest production through these methods of harvesting. In addition, it is recommended that study should be made of the environmental impacts of measures to mitigate nutrient losses due to whole tree harvest, e.g., the impact of artificial fertilization to replace nutrients on water quality, soil pH, wildlife and other non-target plant species.

6) Incentives for Wood Cogenerators

The committee recommends an ammendment to the National Energy Act to provide increased incentives to cogenerators using wood as a primary fuel.

Direct Solar

7) General Solar Recommendations

The committee recommends the following scope of governmental action to accelerate the utilization of solar systems:

- A) Federal: equalization of solar incentives with those currently applied to conventional fuels; low interest, long term loans and grants; investment tax credits; support for continued demonstrations; expansion of solar systems in new and existing government buildings; increased funding and support for state solar commercialization efforts.
- B) State: information dissemination; prohibition of discriminatory utility rates for solar users; modification of state building codes to facilitate residential solar systems; development of enabling legislation to permit municipalities to incorporate solar access into their zoning ordinances and general plans; elimination of restrictive trade licensing; income, property and sales tax incentives for solar users.
- C) Local: use of solar systems in new and existing government buildings; enactment of solar access ordinances.

Wind/Hydroelectric

8) Federal Jurisdiction Over Small Wind/Hydro Projects

The committee recommends the reduction and streamlining of federal review of small scale wind and hydroelectric energy projects.

9) Exemption of Small Wind/Hydro Producers From PUC Regulations

The committee recommends that for purposes of PUC regulation, small wind/hydro electricity producers—under 5 MW aggregate—not be considered a public utility where the output of such producers is to be sold wholesale.

10) Guaranteed Market for Small Wind/Hydro Operators

The committee recommends that the various states require utilities to purchase the output of small wind/hydro stations at equitable rates.

11) Federal Financing, Grants, Insurance, and Tax Credits for Small Wind/Hydro Energy Systems

The committee recommends that the federal government:

- A) *Provide increased financing and grants for feasibility studies of small wind and small hydro projects.*
- B) *Establish a guaranteed liability insurance program for small hydro systems, linking such a program to a mandated dam inspection program.*
- C) *Allow accelerated depreciation of investments in small scale wind and hydro systems.*

Financing

12) Retrofit of Public Buildings

The committee recommends the enactment of state legislation enabling state and municipal government to issue general obligation bonds to finance the retrofit of public buildings and buildings owned by non-profit institutions, for purposes of energy conservation and conversion to renewable energy systems, when such projects are economically justifiable on a life-cycle cost basis.

13) Streamline Application Requirements for Small Producers

The committee recommends that the Economic Development Administration, Small Business Administration and Federal Housing Administration application requirements be streamlined to eliminate overlap and excessive cost to the small producer who uses renewable energy resources.

Economic Development/Jobs

14) Jobs Impact Analysis

The committee recommends that Congress enact legislation requiring all federal agencies involved in energy-related programs to evaluate, and incorporate into their program selection, development and funding decisions, the jobs and other economic development impacts of the various policy options. This evaluation should be based on forecasts of the number, occupational mix and geographic distribution of all employment associated with such options. These forecasts shall be used as one criterion in the allocation of federal funds to all energy-related expenditures such as research and development of new technologies; grants, credits, rebates and other subsidies to end-

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users, equipment manufacturers and utilities. Furthermore, the Department of Energy shall be responsible for utilizing the best available forecasting techniques to fulfill this responsibility.

15) Dispersed Waste Recovery Systems

The committee recommends that the various states mandate, where economically feasible, the creation of regional solid waste disposal districts. The states should also coordinate with local government in the identification of available sites appropriate for waste recovery systems in terms of environmental acceptability. Such waste recovery systems may be operated publicly, privately, or as joint public/private ventures, and may be financed through the issuance of municipal bonds. A system may provide steam and/or electricity under long term contract with industrial and commercial customers and, under new Federal Energy Regulatory Commission (FERC) guidelines, be allowed to purchase power from utilities at non-discriminatory rates. It is further recommended that the states establish working groups comprised of representatives of the departments of economic development, environmental affairs, public utilities, local economic development organizations, municipal governments and other relevant bodies to coordinate the necessary planning efforts.

16) Training Programs

The committee recommends that the Community Services Administration, the Department of Energy, the New England Regional Commission and the Department of Labor employment and training programs emphasize alternative energy and conservation as their first priorities. A larger percentage of the funding for such programs should be aimed at preparing trainees to enter labor markets associated with these activities in their local communities.

17) Weatherization Programs

The committee recommends increased funding of existing weatherization programs and that a study be undertaken to determine the most effective and efficient working relationship between the Department of Labor, Community Services Administration and Department of Energy in managing and funding weatherization programs. This study should focus on the Department of Labor as a source of labor; the Community Services Administration as an advocate for low-income people; and the Department of Energy as a funding source.

Miscellaneous

18) Public Education

The committee recommends that the various state departments of education mandate and finance the development of energy related curricula in all elementary, secondary and vocational schools. The curriculum should include treatment of both conventional and alternate energy sources as well as conservation technologies.

19) Rate Reform

The committee recommends the revision of utility rate structures to encourage conservation and the utilization of renewable energy systems.

20) Comprehensive Cogeneration Program

The committee recommends the development of a comprehensive program on

state and federal levels for the purpose of encouraging cogeneration. Such a program should provide incentives and assistance to cogenerators and should eliminate or reduce the regulatory and institutional barriers to cogeneration. It could also examine utility regulations and rate structures as they impact cogeneration.

Biomass Subcommittee

I. Introduction and Summary

New England is blessed with extensive and underutilized biomass resources which hold much potential for the region. The total energy eventually available on an annual basis from biomass in New England is probably greater than 1.5 quadrillion BTUs, virtually all of which is from wood and wood residues. Solid and agricultural wastes, the remaining biomass sources, are limited resources usable in certain applications. Wood energy is potentially convertible to all of the needed energy forms, including heat, steam, electricity and transportation fuels, although the near term potential for different applications varies tremendously. Home heating with wood is an established practice and is increasing rapidly within the region. Use of wood as a boiler fuel in industrial and commercial applications has achieved limited acceptance, and several facilities use wood for producing electricity (all but one are cogenerators). Alcohol produced from wood is not currently available as a fuel, and will not likely play a significant role by 1985.

There are a variety of problems which prevent the biomass resource from being fully utilized. The single greatest problem at this time is the lack of an established supply network for wood fuels. Ideally, such a network would fulfill the multiple goals of protecting the resource from overutilization, coordinating the supplies of wood for energy with other forest product industry needs, providing adequate supplies at reasonable prices, and insuring product quality control. Meeting these goals would eliminate the major constraints to using wood for energy, and would allow other problems, such as lack of public acceptance, high initial capital costs and possible air quality impacts to be addressed more easily. Perhaps the greatest danger at this point is that the lack of a supply network will mean that any demand pressures, such as those from major government incentives for wood energy use, could result in precipitous, uncontrolled harvesting of the region's forestland, with consequent loss of value and long-term sustainability.

Developing the region's biomass resources in an environmentally sound manner will have tremendous positive economic consequences. Aside from the obvious benefits of reducing energy importation, the productivity and value of the forest resources will improve substantially, a major job-creating industry will be developed, and knowledge and expertise in biomass utilization will be developed which can be marketed outside the region.

II. Resource Assessment

Biomass is available in a variety of forms in the region, although the wood resource, quantified below, is the dominant source. Solid waste is a significant source of biomass and has also been quantified, but agricultural wastes and sewage, which can provide energy only in very limited applications, have not.

Estimates of wood resources available for energy use have been compiled by a number of sources. The most significant sources of wood for energy are mill wastes, forest non-commercial wood, and harvest of non-commercial (for other forest products) trees and species. The best quantitative estimates available have been compiled and documented in the draft report to the Supply Committee of the Energy Congress on the *Cost and Availability of Wood 1978-2000*,

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September 8, 1978. As a reasonable "guess" for the total potential resource available the figures in the report are more than adequate, and they are presented in Table 1 below.

Table 1
New England Yearly Wood Energy Potential (10¹⁵ BTUs)
Surplus Annual Growth

	Land Clearing	Tops & Branches	Cull	Seed- lings	Un- desirable	Over- Stocked	Mill Residues	Annual Logging	Total 1978-85	Biomass	2 x Annual Productivity Growth	Total 2000
Connecticut	.00967	.00225	.00450	.00450	.007	.00133	.00007	.0008	.03012	.00236	.0225	.03484
Maine	.00787	.05022	.10040	.10040	.055	.05426	.00255	.0434	.41418	.01050	.5022	.93133
Massachusetts	.01409	.00349	.00698	.00698	.012	.00269	.00041	.0035	.05014	.00088	.0349	.08592
New Hampshire	.00520	.01866	.03732	.03732	.016	.01219	.00069	.0052	.13258	.00082	.1866	.32000
Rhode Island	.00145	.00042	.00085	.00085	.002	.00019	.00001	.0002	.00604	.00076	.00042	.01096
Vermont	.00158	.01034	.02069	.02069	.014	.00640	.00048	.0055	.07966	.00219	.1034	.18525
New England	.03986	.08534	.17074	.17074	.108	.0884	.00421	.0586	.71272	.01751	.8538	1.56835

Land clearing, undesirable, mill residues, annual logging, and biomass totals are Abbie Page's; Surplus annual growth, overstocked and 2x productivity are my own.

Source: Steve Morgan, *Cost and Availability of Wood: 1978 - 2000*, Supply Committee Report, New England Energy Congress, September 8, 1978.

Quantitative data on solid waste is also available and has been compiled in a number of sources. In the August draft report to the Supply Committee by Clement Griscom, the New England market potential for solid waste energy recovery was estimated to be 29.4×10^{12} BTUs/yr in the near term and 44.1×10^{12} BTUs/yr in the intermediate term. This source is variable, as consumer tastes, packaging practices, and the volumes of material recycled may change.

Wood biomass is available in several forms, and the quality of the resource as a fuel can vary considerably. The most common sources in New England will be:

A) Mill wood wastes

This is the most readily available and predictable type, usable at both decentralized and centralized conversion plants. The proximity of mills to household and industrial consumers permits steam generation at 60-70% thermal efficiency. Electrical cogeneration potential is substantial, and the "waste-based" price pattern makes conversion viable today.

B) Forest non-commercial wood

This resource may be disaggregated into a) dead and deformed trees and non-commercial species and b) waste left from commercial harvesting. Dead and deformed tree wood is generally located in more remote regions, and is subject to high transport costs. Conservatively estimated to cost \$40 per bone dry ton (BDT) for on-site harvest, it is most easily produced in the form of chips. However, because this source is associated with periodic woodlot thinning and requires a substantial capital investment, regional or cooperative small scale processing of the fuel will be required. Tops and limbs form the

bulk of the waste from commercial harvest. Collecting this resource for energy use is feasible under whole-tree harvesting or dual chipping schemes, and would be difficult (expensive) for small woodlot owners and jobbers. A substantial market currently exists only for hardwood chips. The volume of this waste represents on the order of 10-15% of the mass of the tree.

C) Harvested wood

This category would include the clearing of land, clearcutting or harvesting of biomass plantations, thinning of forests and woodlots, and harvesting of non-commercial species for energy. Large operations would generally produce wood chips and use whole-tree harvesting techniques. This fuel would be marketed to industrial and commercial (and possibly utility) users within a specified radius of the operation. However, there is also a significant role in the production of cordwood for home heating. Small and intermediate woodlots can benefit considerably from selective cutting of non-commercial hardwood species, of overstocked stands, and of dead and deformed trees. Cordwood operations are a small but growing industry and can provide a valuable function for the smaller woodlots.

The cost of wood fuels is a function of quality and of many individual characteristics such as local supply, transport mode and cost, and existence of competing demand for the supply. In many areas of the region where even a rudimentary supply network for wood fuels or wastes has developed, wood is considerably cheaper than competing fuels. Although it is dangerous to generalize this result across the region due to the high variability in the demand for wood fuels, most sources agree that wood is now price competitive with conventional fuels for much of the region and the wood prices will escalate slower than conventionals.

III. Technical Considerations

Table 2 summarizes the development stages, most appropriate biomass resource, and end-use for the five primary conversion processes available for converting wood to usable energy. Fireplace, wood stove, furnace and boiler combustion are known and time-tested processes for generating heat, process steam and even electricity. Gasification, pyrolysis, methanation and fermentation are in varying stages of development and offer medium and long-term potential for generating heat, steam and electricity for gas and oil production, and for producing alcohol fuels. Although the last category in Table 2 is the least developed, it should be pointed out that methanation is commonly utilized in the treatment of sewage sludge and that portions of the fermentation process have been used for some time in the pulp industry.

One common problem with biomass is the quality of the fuel. Successful and profitable utilization of wood energy does require some consistency in the fuel source. Quality is not now assured because of the lack of a supply infrastructure. Cordwood can be satisfactorily aged by either user or producer or even burned green without too great a loss in efficiency, but this is not the case for larger and more sophisticated combustion systems or other conversion systems. The best technologies for providing a consistent fuel include chipping and drying, pelletization, and charcoal manufacture. Chipping is the easiest and will contribute significantly in the near term, but it does not provide a truly consistent product and is still quite expensive to transport any great distance. Pelletization provides a much more consistent and easily transportable fuel, but has not been commercialized in New England. Charcoal is a high grade solid fuel which can be used in a variety of applications, but its use has become rare since petroleum fuels became so common.

The uses displayed in Table 2 represent applications in virtually all sectors of the New England economy. Residential, industrial, commercial and utility applications are immediately feasible on a technical basis. Although the dispersed nature of the resource limits the size and density of the use within any particular area, it is clear that the potential market for the biomass resource is as great as the resource itself. The uses with the greatest immediate potential are those in the forest products

and related industries where wood wastes are produced in very close proximity to the energy demand. Cordwood also represents an immediate potential, and in fact has grown rapidly in recent years. As the supply networks for wood energy products develops, the biomass energy resource can be expected to reach a good portion of the potential markets in the region.

Table 2
Conversion Process, Development Stage, Resource and End-Uses for
Biomass in New England

PROCESS	DEVELOPMENT STAGE	RESOURCE	END-USES
1. Fireplace and wood stove combustion.	feasible, active commercially available	cordwood	heating
2. Furnace and boiler combustion	feasible, demonstrated	wood chips, crop residues, and solid waste	process steam, electricity, misc. heating
3. Gasification combustion	feasible, need for market development and further demonstration	wood chips, crop residues and solid waste	process steam, electricity, misc. heating
4. Pyrolysis	feasible, need for further demonstration	wood chips, crop residues and solid waste	gas, oil, charcoal and/or heat and steam
5. Methanation and fermentation	probable feasibility, need for further demonstration	wood chips, crop residues, solid waste, sewage and livestock waste	methane gas or alcohol for fuel

IV. Commercial Potential

The resource availability and technical feasibility of using the biomass resource indicates substantial commercial potential. The fact that this commercial potential has not been realized points to the many difficulties which remain. Economics has played a role in discouraging biomass utilization and will continue to do so, particularly if the subsidies enjoyed by conventional fuels continue. The somewhat higher initial capital costs required for processing and handling a solid fuel is also a barrier, as is the uncertainty of acquiring a consistent supply at a reasonable price. Nevertheless, lower fuel costs should make biomass economically attractive for many applications now or in the very near term. Technical difficulties, for instance those relating to fuel consistency, have also acted as an impediment, although these problems will disappear as the biomass energy industry becomes more robust.

The major institutional problem is that no large-scale supply network for wood fuels has yet emerged. Utilization remains an isolated phenomenon, most common in the pulp and paper industry, where wood wastes are utilized, and among small woodlot owners who cut their own cordwood. A wood energy supply industry must develop if the resource is going to be a significant contributor to the region's energy demand. Such an industry may be developing, but the necessary connections between the wood resource, the wood energy supplier and the wood energy user

have not developed. The existing forest products industry can be used as a model, and can be expected to expand into the wood energy supply network, as can the existing cordwood operations. As the wood energy supply network will involve the small and intermediate sized woodlot owners, it is clear that the County Forestry Extension Service will become a major focus of the wood energy industry. This framework for the supply network is as yet incomplete, but it does provide a glimpse of what a fully mature wood energy supply network would look like. It is important that this network develop quickly and in such a way that the multiple goals for the forest resources in the region are met.

A number of other factors affecting the commercialization of biomass energy in New England are outlined below:

- 1) Problems exist with central station electrical generation with wood. The dispersed nature of the resource will not permit substantial economies of scale to be achieved, and 50 MW appears to be a maximum size for such a facility. Even with smaller plants, disruptions in the existing forest products industries can be expected in the area, and the economic impacts could far outweigh the economic benefits of the plant. However, wood, particularly in pelletized form, could probably be used successfully in any coal-capable units as part of a mixed fuel.
- 2) Dispersed generation of electricity from wood-fired cogenerating facilities offers a number of advantages. These smaller plants would have substantially reduced economic impacts in their area and could more economically use the local wood resources. The higher efficiencies of cogeneration would also assure that maximum benefits are derived from use of the fuel.
- 3) Any large-scale use of wood for energy will affect the existing forest products industry in New England. Whether these effects are positive or detrimental will depend on how the wood energy resource is developed and how the resource is used. The forest products industry in New England is a primary industry for much of the New England region, and the potential impacts should be carefully reviewed before action is taken. Positive impacts will more likely occur if energy and other uses of wood are viewed as complementary rather than competitive.
- 4) Existing patterns of land ownership in New England are a constraint to large-scale wood utilization. Much of the wooded land is in very small, privately owned parcels, where commercial practices, such as clear-cutting or whole-tree harvesting, will not be acceptable. A great majority of these woodlots would benefit from active forest management, although such practice will require an institutional and market apparatus which is currently non-existent. Attitudes of private woodlot owners have been changing, however, and the economics of limited harvesting for commercial wood or energy uses is being seen as a potential benefit in addition to aesthetics.
- 5) Wood must be harvested according to best management practices. For wood to be a truly renewable resource, we will have to avoid mining this resource indiscriminately for short-term economic gain. Best management practices (BMP) should be required for all wood harvesting, and it should be based on the principle of sustained and multiple use of the wood resource.
- 6) The environmental effects of large-scale harvesting of wood for energy will have to be determined, and major problems avoided. BMP will provide some measure of protection, but further research will be needed in some areas, specifically, what are the near term effects on species distribution and on the general health of the forest of such harvesting; and what are the long-term implications for nutrient formation and recycling of the various harvesting schemes and practices.

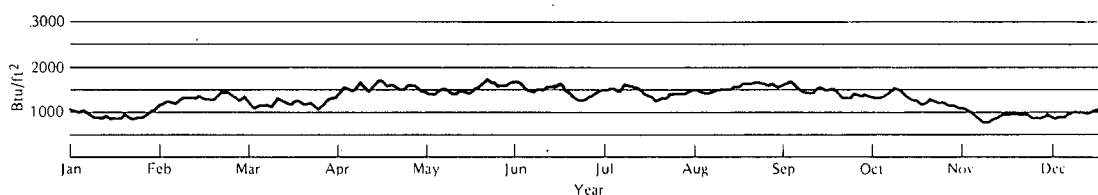
- 7) Industrial process and plant heating, and commercial heating, are extremely important potential uses of wood in New England. Although home heating with wood, in woodstoves or central heating systems, is somewhat larger in potential, industrial and commercial applications may be more attractive to the users because of their closer attention to economics. The technologies of pelletization and gasification/combustion also offer substantial benefits to this category of users, and with proper economic incentives, the market would react quickly.
- 8) The problems of wood transportation are serious and may constrain the use of the resource. Truck transport of wood on a large scale is somewhat unsatisfactory due to the high costs, the need for petroleum fuels, and the negative environmental impacts. As yet, no other alternative, such as an extensive and operating rail system, is readily available.
- 9) In order for wood to have an immediate impact on the energy picture in New England, many existing facilities will have to convert to wood. Such conversions are eminently feasible for industrial/commercial facilities, and the technology of hooking up a wood gasifier to an existing boiler should be very attractive in the near future. However, there will be problems limiting such conversions. In particular, difficulty in obtaining firm supplies of wood, the high initial capital cost of conversion, and technical difficulties will have to be overcome if retrofits are to constitute an important use of the wood resource.
- 10) New England is basically powered by portable fuels. Electricity constitutes only 10% of end-use energy. Therefore, the most pressing energy problem we face is the substitution of these portable fuels with cheaper or renewable alternatives, and conservation. This implies that the best use of wood is as a replacement for these portable fuels. Any contribution wood can make to space heating loads, industrial needs or transportation will be a valuable benefit to the region.
- 11) Although biomass developments will be more labor intensive than most other energy sources, and will therefore create jobs, it is not clear that these jobs will be attractive, or that they will ease the unemployment problem in the region. There are two major reasons for this. First, work derived from wood harvesting and collection will, for the most part, be menial physical labor and will not satisfy the expectations of the unemployed labor force in New England. Second, most of these jobs will be isolated and rural, and will not match the availability of the labor surplus. It is unlikely that unemployed central city inhabitants will move to northern New England to secure jobs in the wood energy industry.
- 12) There will be secondary labor and economic impacts as a result of biomass development, most notably for the engineering and construction trades. In particular, retrofits and small installations of wood-fired equipment will stimulate the industry in New England, creating jobs and economic benefits. However, large projects requiring heavy manufacturing and specialized engineering will tend to involve industries based outside of the region, thereby resulting in capital exportation. This consideration is very important in comparing biomass development to other alternatives such as nuclear. Indigenous industries in New England may also be stimulated by extensive, small-scale biomass conversion to the point where knowledge and equipment can be exported, thus generating income for the region.

Direct Solar Subcommittee

I. Resource Assessment

Figure 1 illustrates the average daily insolation measured in the Boston area for a solar panel inclined at 45°. In the winter months, the average is seen to be 10³ BTU/ft²/day with large daily variations. The variation of the average value over the New England area, as indicated in Table I, is seen to be about 20% over the region.

FIGURE 1
Insolation Pattern in BTU/FT²
Blue Hill Mass—1958
45 Deg Surface



Taken from *Solar Heating of New England Homes*, Mass. Design, Inc. (1976).

Table 1
Various Measures of Mean Insolation at
Specific Locations in New England

Location	Mean % of Possible Sunshine	Mean Total No. of Hours of Sunshine	Mean Daily Solar Radiation (Langley's)
Conn., Hartford	56	2541	-
New Haven	-	2704	-
Maine, Eastport	50	2309	-
Portland	-	2653	350
Mass., Blue Hills	-	2257	328
Boston	57	2615	301
New Hampshire, Concord	52	2354	-
Rhode Island, Block Island	56	-	-
Newport	-	-	338
Providence	-	2589	-
Vermont, Burlington	46	2178	-

Taken from the Appendices in *Harnessing the Sun*, John Keyes, Morgan & Morgan Publishers, New York (1975).

This supply may be compared with the energy consumption in New England in Table II for 1976. The total energy consumption, 2.1×10^{15} BTU/year, was equivalent to the solar energy incident on an area of 200 square miles, which is 0.3% of the total area of the New England states. In 1972 there were 3.7×10^6 residential housing units in New England¹, and this number together with the 1976 data in Table II leads to a figure of 2.1×10^8 BTU/year/housing unit excluding electricity, and 0.26×10^8 BTU/year/housing unit for electricity. These figures are considerably below those given for 1972 in a Brookhaven National Laboratory Energy Perspectives Study,² which are 4.2×10^8 BTU/year/housing unit excluding electricity and 1.0×10^8 BTU/year/housing unit for electricity. These numbers indicate that the residential non-electrical energy needed per unit corresponds to the insolation of between 575 and 1150 square feet of collector, and the residential electrical energy needed per unit to the insolation of between 70 and 275 square feet of collector. Since the efficiencies of solar energy systems are substantially below 100%, the areas necessary to supply the energy needs would actually be larger by factors of 2 to 10.

The BNL study quotes a 1972 figure of 9.1×10^8 BTU/year/building for heating and cooling retail stores and office buildings which corresponds to the insolation of 2500 square feet of collector.

Thus, the supply of solar energy is certainly more than adequate for the energy demands of New England. However, factors such as the space available for collectors, density and storage capability for sunless periods will act as constraints to the full realization of solar potential in the region.

Table 2
Energy Consumption in New England
1976 (Preliminary)

Residential	Electricity	95×10^{12} BTU/Year
	Total, excluding electricity	764
Commercial	Electricity	77
	Total, excluding electricity	153
Industrial	Electricity	68
	Total excluding electricity	393
Power Plant	Total	793
Totals	Electricity	240
	Total, excluding electricity	2103

Source: New England Congressional Caucus, *New England Statistical Energy Profile*, May 20, 1978, p. 28

¹ John Lee, *Future Residential and Commercial Energy Demand in the Northeast*, John Lee, BNL Northeast Energy Perspectives Heated Buildings in North America.

² Ibid.

II. Technical Characteristics

A. Space Heating

All solar technologies designed for space heating work most efficiently when structural heat loss due to induction and conduction is minimized. There must be a strong linkage with an overall program of maximum thermal efficiency for new and existing buildings. It is difficult to overstress this point.

Passive solar technologies are currently capable of providing up to 80% of a new one-family residence's heat needs in southern New England. Structures erected by various individual builders throughout the region demonstrate this point.* Passive retrofits—new southern windows, greenhouses, etc.—have been demonstrated effective by Total Environmental Action, Inc. of New Hampshire.

An efficient passive system requires: a well-insulated, tightly built structure; maximized transparent surfaces on the south, minimal transparencies on the north; and some form of thermal storage/heat moderation system. Traditional passive designs employ natural mass—masonry, rocks, water—as their storage media. The success of the new MIT House, with its use of synthetic freeze-thaw storage materials, indicates a new and useful direction.

Active flat-plate solar collectors (water or air) are also technologically mature. There are no current examples of a New England structure deriving more than 60% of its space heating needs. Active collectors are especially useful for retrofit on south facing windows or rooftops.

A passive-active hybrid called a "thermic diode" is under development by the MIT Department of Mechanical Engineering. The device is a 8' x 4' x 2' prefabricated panel with a self-contained storage system. Initial tests are encouraging.

B. Water Heating

Both trickle-top solar collectors and stationery "breadbox" systems have proven efficient devices for providing hot water. Quality varies with the manufacturer and (most especially) the installer, but the technological maturity of the systems is indisputable.

C. Decentralized Solar-Electric Systems

Photovoltaic solar cells have a demonstrated ability to generate electricity. Energy conversion efficiencies are highest with single crystal silicon cells, though costs are high. Lower cost thin-film cells are less efficient converters. The possibility of concentrator systems improving efficiencies in New England seems likely, but not yet proven. Available rooftop space in New England is probably adequate to provide room for photovoltaic arrays sufficient to meet current and projected electricity demands.

System design studies indicate the technical feasibility of a "power tower" on which an array of mirrors concentrates high-temperature heat to create steam for electrical generation. Field studies are just beginning in the Southwest, and local testing for New England would be necessary to determine a regionalized state of the art.

III. Potential of Solar Space Heating in New England

That solar energy can provide a significant part of the energy needed to heat buildings in the Northeast has been amply demonstrated by the numerous installations which have been designed,

*Based on data in: *Solar Heated Buildings*, W.A. Shurcliff, 13th Edition, Jan. 1977.

constructed and operated in the region over the past three and a half decades. One of the first solar heated houses in the country was constructed by MIT scientists, Hottel and Telkes in Lexington, Massachusetts in 1944. The system was technically acceptable but was not economically competitive, a comment as valid now as it was then.

Interest in solar heating revived in the early 1970's and solar heated buildings, financed by both private and public funds, began to appear throughout the region. During the period 1972-1976, about fifty eight solar heated buildings were constructed in New England alone.¹ As an indication of the current level of activity, HUD recently (July 1977) announced the results of the third cycle competition for grants in its solar demonstration program. About 222 solar flat plate collector space heating and hot water systems have been funded for buildings in the Northeast out of a total of 535 such systems funded for buildings throughout the nation.

Analyses of flat plate collector space heating systems for the Northeast region have shown that between 50 and 80% of the space heating needs of a "properly insulated" one story building can be supplied by a system in which the area of the flat plate collectors lies between 20-40% of the floor area of the building.

Experience in the marketplace has shown, however, that the cost of such systems in mid-1977 for a "good" system was in the range of \$200 to \$300/m² (\$20 to \$30/ft²) installed. This price includes the storage system, controls, etc, in addition to the collector panels themselves. The system is competitive with the most expensive alternate home heating method, namely—electric resistance baseboard heating—but not with the most common methods of home heating in the Northeast, i.e., fuel oil and natural gas combustion. As an example of the economics of solar collector heating systems, an analysis² of such a system, in which water or anti-freeze is used as the heat transfer fluid, concludes that the system would deliver thermal energy at a cost in the vicinity of \$16/MMBTU under the following assumptions: 1) the interest rate is 8.5%; 2) the system has a 25 year life; 3) no federal tax subsidies are involved; 4) no local property tax is assessed on solar heating system; 5) the inflation rate over the life of the system is 5.25% and 6) the installed cost of the system is \$250/m² (\$25/ft²) of panels. The price of delivered thermal energy is very sensitive to changes in these assumptions. For example, if the assumed life of the system dropped to 10 years, and all other assumptions were retained, the cost would rise to \$33/MMBTU. Systems in which air is the working fluid have a lower installed cost (\$150 to \$200/m² or \$15 to \$20/ft²) and the cost of heat delivered is correspondingly less: about \$12/MMBTU assuming a 25 year life of the system, and \$25/MMBTU assuming a ten year life, all other assumptions remaining the same for the air and fluid systems.

In the Northeast, the cost of heat delivered by an electric resistance heating system lies in the range \$12 to \$15/MMBTU; the cost of heat from oil and gas fired heating systems lies in the range \$4 to \$8/MMBTU.

This brief summary illustrates the problems of solar flat plate collector systems. The technology of the systems is acceptable; however, their cost remains somewhat too high. To be competitive with the most commonly used alternatives, the cost of solar thermal energy must be reduced by a factor of about three. This can be done in a number of ways.

The price of solar thermal energy could be decreased by reducing the initial cost of the hardware and its installation. If the installed cost were reduced into the range of \$70 to \$100/m² (\$7 to \$10/ft²), thermal energy from solar thermal collector systems would become competitive with thermal energy from oil.

The cost of the solar collector panels themselves has remained relatively stable over the past five years in spite of a substantial increase in U.S. production from a level of about 700m² in 1972 to 3.7 x 10⁵m² in 1975 and 5.8 x 10⁵m² in 1976.

¹ Ibid., P. 18

² Based on a report by the Center for Energy Policy, Inc., July 21, 1977.

To be sure, these areas are small compared to the areas which would be required to make a significant impact on the energy budget of the Northeast Region. The Northeast Region contains about 9 million housing units with a total floor area of about $1.5 \times 10^9 \text{ m}^2$. If 20% of these housing units were fitted with solar collectors having an area equal to 30% of their floor area, the required collector area would be $9 \times 10^8 \text{ m}^2$. If the accumulated production were to increase by the required factor of several thousand, the price would surely drop, but it is difficult to predict by how much. If the assumption is made that for each doubling of accumulated production the price drops by 10% (the price decrease per doubling ranges from 10-30% for new products based on experience in the artificial fibre market, the semiconductor industry, etc.), then a 2000 fold increase of accumulated production should reduce the price to about 0.32 of its initial value. Such a price reduction from the current \$200 to \$300/ m^2 (\$20 to \$30/ ft^2) would make solar collector systems competitive with alternative energy sources.

It is not obvious, however, that simply increasing production would bring about such a large price cut. Solar thermal panels of the current design are constructed from materials which are already produced in such extremely large volume—glass, steel, aluminum, copper, plastic—that the increased production needed to satisfy the solar collector market would constitute a small increment in the demand for these materials and, therefore, little impact on their price. Solar collectors are relatively simple devices, essentially a box with a transparent cover, and, therefore, it is unlikely that significant differences in design resulting in substantial price reduction can occur.

As of August 1977 there were about 200 manufacturers of solar thermal panels in the U.S. Many of these firms came into existence because their founders believed that they had improved, new designs for collectors, and all of them are striving to reduce the cost of collector panels. No significant reductions, have, however, occurred. It is often suggested that substitution of plastics for metal and glass could lead to large price reductions but this concept has yet to be demonstrated. Reductions in installation costs would result from improvements in the way panels are interconnected.

In summary, it appears that the price of thermal collector panels has been remarkably resistant to change, even after the market has been stimulated by government supported purchases of collector systems. In the recently completed third cycle of the HUD solar demonstration program, the federal government purchased about 13,000 m^2 of solar panels; in the July, 1977 solar hot water initiative would purchase about 10^5 m^2 of solar collector panels, i.e., at least 20% of the current annual production for that year.

IV. Potential of Photovoltaic Power

The only kind of solar cell which can be purchased in significant quantities anywhere in the world at this time is the single crystal silicon cell. It commonly exhibits a solar energy conversion efficiency of about 10%; laboratory models having efficiencies up to 18% (AM1 illumination) have been reported. These cells can be purchased in kilowatt quantities at a price as low as about \$9,000/KW. Studies indicate that if photovoltaic power is to be competitive with nuclear and fossil fuel produced electricity, the price of 10% efficient cells must drop below \$500/peak kilowatt by 1986. A research and development program aimed at achieving this goal has been underway since about 1973. It is not clear at this time that the DOE goal of \$500/peak kilowatt can ever be met by single crystal silicon cells. Even if that price goal were met, it is generally conceded that the prices below \$500/peak watt—which must be achieved if photovoltaic power is ever to achieve a significant impact on the national energy budget—can ever be achieved in single crystal silicon cells or, for that matter, in any cell made from single crystals.

It is for this reason that interest in alternatives to the single crystal silicon cell continues to be high. One such alternative is the concentrator—photovoltaic system. Here the onus for price reduction is shifted from the solar cell to the concentrator, commonly a Fresnel lens or a concave

mirror. Even with today's prices for solar cells, advocates of concentrator systems claim that they can achieve overall system prices of about \$2000/peak kilowatt in 1978 and \$500/peak kilowatt in 1982. Concentrator systems are more compatible with regions like the Southwest where the ratio of direct to total sunlight is significantly higher than in the Northeast. However, a recent study has shown that even in a location like Cleveland where cloudy days are frequent, the total amount of radiation collected by a tracking concentrator is somewhat larger than the total amount collected by a flat panel collector of fixed orientation. Consequently, the possible role of concentrator-photovoltaic systems in the Northeast is yet to be determined. Because the cost of the cells incorporated into a concentrator system can be an insignificant part of the overall cost of the system (this would be the case for high concentration ratios), the cells can be relatively inexpensive, high efficiency types. It is for this reason that a substantial research and development effort is devoted to solar cells made from a relatively expensive semiconductors such as gallium arsenide. Such cells have exhibited efficiencies in excess of 20% when illuminated by solar intensities up to several hundred suns. The properties of gallium arsenide make cells fabricated from it better able to tolerate elevated temperatures than cells made from silicon, and this is yet another advantage to using it in concentrator systems. Even higher efficiency solar cells like those consisting of cells made from more than one semiconductor are currently under consideration.

The other approach to lowering cost is to fabricate cells from thin films of semiconductors rather than from single crystals. To date the highest efficiency reported in thin film cells is the 9% efficiency as reported in 1977 by a University of Delaware group for the thin film copper sulfide/cadmium sulfide cell. Efficiencies between 3-6% have been reported in a number of thin film solar cells including cells made from silicon, gallium arsenide, indium phosphide, copper indium selenide, etc. Thin film copper sulfide/cadmium sulfide cells are presently being marketed in the U.S. by Solar Energy Systems, Inc. of Delaware and Photon, Inc. at a price comparable to that of silicon cells. The manufacturer claims that the cells cost considerably less to manufacture than silicon cells and promises substantial reductions in price/watt as production volume increases. The efficiency of these commercially available copper sulfide/cadmium sulfide cells is, however, only about 3%. In other words, the higher laboratory efficiencies have yet to be transferred to the pilot plant.

DOE's studies of the economics of solar cell systems indicate that the cells must have some minimum efficiency before they can be of any use for large systems. The magnitude of this minimum efficiency is a subject for discussion; however, estimates have been converging on a value in the vicinity of 10%. The cost of support structure and interconnections between cells is the reason for the existence of a lower limit on efficiency. Thus it is evident that thin film solar cells of the types currently available do not satisfy the criteria which they must meet before large scale solar power becomes economically viable. Attainment of higher efficiency requires further research, often of a rather fundamental kind, into the mechanism of the photovoltaic effect in such thin film cells.

To summarize, there exist single crystal cells made from silicon, gallium arsenide and other semiconductors whose efficiency is high enough so that they qualify as candidates for building blocks of solar photovoltaic systems but whose cost is much too high (factors of 30 to 70) for them to be economically acceptable. On the other hand, there exist thin film cells whose cost may be acceptable but whose efficiency is too low (10%) for cost effective photovoltaic power systems. Concentrator photovoltaic systems promise a more rapid reduction of cost than flat panel systems but such systems have a more limited range of applications than flat panel cells, and in particular they may not be as suitable for the Northeast as flat panel cells.

The solar cell is only the beginning of a photovoltaic power system. The cell must be mounted as part of an array and encapsulated to protect it from the weather. At present the cost of encapsulation is comparable to the cost of the cells themselves and therefore development of less expensive, more reliable encapsulation is a topic of high priority. Encapsulation may have regional aspects: the wide range of temperatures and frequent temperature cycling which solar cells will experience when they are used in the Northeast may require a different encapsulation solution

than that which is appropriate for the Southwest. The array mounting system must also be particularized to the region. This suggests that cell manufacturers may produce a different product for use in the Northeast than that intended for the Southwest.

Analyses of photovoltaic power systems conducted by various organizations (University of Pennsylvania, Westinghouse, General Electric, Aerospace Corp., Arthur D. Little, Inc., MITRE Corp., et al) have identified and concentrated on a limited number of potential kinds of photovoltaic systems. These can be classified in terms of the degree of localization of the system into 1) "roof top" systems which produce the power where it is consumed and 2) central power stations.

A. "Roof top" Systems

Such systems range in size from those intended to service single family dwellings to those intended to service low-rise, large area structures like shopping malls, factories, etc. If one assumes an average daily insolation in the region of 5 KWH/m², then 10% efficient solar cells would deliver about 0.5 KWH/m² day. If the roof area of a "standard" one story 1500 ft.² (150m²) dwelling were covered by such solar cells, they would generate 750 KWH/day and 27,000 KWH annum. The average annual consumption of electric power in the Northeast region ranges between 5000 and 8000 KWH/annum for units which do not use electricity for electric hot water or space heating. Thus the 150 m² of 10% efficient solar cells would produce at least three times as much power as is consumed by the occupants of the average unit.

Two kinds of residential power supply systems have been analyzed. In the first of these, the photovoltaic solar cells produce electric power only. In the other, the cells are incorporated into a thermal panel where they serve as part of the absorbing surface of the panel, thus forming a hybrid system which produces both electricity and thermal energy for use in the building. The economics of these two kinds of systems differ substantially: for a given price of delivered KWH, one can afford to pay a higher price for solar cells to be incorporated into a hybrid system than for the photovoltaic only system.

The Northeast region contains about 9 million housing units with a total roof area of about 1.5×10^9 m² and about 2.0×10^8 m² of roof area on its commercial structures. If these roofs were covered with 10% efficient solar cells, they would produce about 3.1×10^{11} KWH/annum which is to be compared to a total electric power generation in the region of about 3.5×10^{11} KWH/annum.

These calculations do not include all the buildings in the region because sufficiently accurate data is not available: the results are meant to show that the area of the roof of the buildings in the region is so large that if the buildings were retrofitted with solar cells of the type currently available the resulting photovoltaic power system would produce enough power to satisfy nearly all the needs of the region.

B. Central Power Stations

The Northeast region consumes about 3.5×10^{11} KWH/annum. The area which needs to be covered by 10% efficient solar cells to produce this amount of power—assuming on average insolation of 5 KWH/day—is about 2000 km² or about 770 sq. miles which constitutes about 0.44% of the total land area of the Northeast (175,000 sq. mi.). If the power were to be produced by Central Power Stations, access roads and paths would increase the area devoted to the cells by a factor of about 1.3 to about 1000 sq. mi. or about 0.57% of the total land area of the region. A central power station capable of producing as much electrical energy per day as a conventional 100 MWe plant operating at an average 60% of its capacity would require an area of about 3.8 Km² or about 1.5 sq. mi. About 670 plants of this type would need to be distributed over the region to satisfy its electrical energy generation needs.

Another type of photovoltaic power system which was originally proposed by Dr. Peter Glaser of Arthur D. Little, Inc. is the Satellite Space Power System. Studies of such systems indicate that one such satellite could deliver 10,000 MWE continuously onto a microwave receiving antenna having an area of about 40 km². About seven satellites of this type would be needed to deliver all the electrical energy needed by the Northeast and the receiving antennas would cover an area of about 280 km² (108 sq. mi.). The construction of satellite power systems of this kind would require a major national commitment comparable to the decision to land a man on the moon, and implementation would require about 20 years. No such commitment has been made as yet and, therefore, it is unreasonable to expect that satellite power systems are likely to play a role in the Northeast region power generation system until after the year 2000 if they are ever implemented.

It is likely that if photovoltaic power systems are to play a role in the Northeast, a combination of central power stations and roof top systems will constitute the system. Installation of roof top systems on existing buildings is a form of retrofitting; it is not possible at this time to estimate the fraction of buildings on which retrofitting will be viable. Consequently, residential photovoltaic systems are more likely to appear on new buildings and since new construction in the Northeast is lagging behind the rest of the nation, central power stations will probably play an important role in any photovoltaic power system designed for the region.

Photovoltaic systems which are under study include both flat plate and concentrator systems. It is usually assumed that concentrator systems are more compatible with the Sunbelt than with the Northeast where the ratio of direct to total sunlight is smaller. However, recent studies have shown that tracking concentrator systems can deliver as much or even more power than fixed flat plate systems in the Northeast. Consequently, it is not possible at this time to definitively identify a preferred system.

The average annual insolation of the Northeast is less than a factor of two smaller than the insolation in the Arizona desert which is one of the most intensely sun-illuminated regions in the world. Furthermore, sunlight is much more intermittent in the Northeast than in the Southwest and therefore the electrical energy storage problems are quite different in the two regions. Obviously, longer term storage is needed in the Northeast, and the solar cell systems intended for this region must take this into account.

IV. Institutional Roles

Government, at the federal, state and local levels has an essential role to play in accelerating solar energy development. The following is a brief description of what each level of government can do to promote solar systems.

A. Federal Government

The chief role that the federal government can play is to create the same kind of incentives for solar energy as the government has created for traditional energy sources. This means *tax credits for solar equipment* of the type now enacted in the National Energy legislation, and increased subsidization of solar through *low-interest loan and grant programs*. One such proposal, the Solar Bank Bill, would create a revolving low-interest loan fund to supply 3%, 30-year loans to solar purchasers. The federal government should also create additional *business and investment tax credits* for commercial purchasers of solar equipment. These tax proposals will begin to create parity for solar in the federal energy subsidy picture. Other energy sources have

traditionally been much more heavily subsidized by the federal government than solar. For example, the DOE has recently estimated that the value of federal subsidies to nuclear, coal and oil over the last 60 years have exceeded \$130 billion.

The federal government also has an important role to play in *demonstrating* solar energy. It should greatly expand its solar demonstrations and should increasingly administer the demonstration program through state and local government units rather than managing the program centrally out of Washington. By decentralizing DOE will create a spin-off benefits in the form of new solar enthusiasm and expertise at the state and local level. The HUD Solar Hot Water Initiative, the only state-administered federal solar grant program to date, has already built this type of solar constituency in the energy offices of the states which manage the program.

The federal government should greatly *expand the use of solar and conservation in government owned and government subsidized buildings*. The Administration should strongly support the Solar Transition Act which would require federal agencies to "solarize" a larger and larger percentage of their new and existing buildings every year.

B. State Government

State governments can play important information and advocacy roles in the development of solar energy. State government should establish special groups or task forces, within their Energy Offices or separately, to disseminate solar information and to reduce barriers to the utilization of solar systems, e.g. discriminatory utility rates, restrictive state building codes, lack of solar rights, and restrictive trade licensing programs which increase the cost of solar installation.

The state solar groups could also work for the passage of state fiscal incentive programs, such as a state income tax credit, a state property tax exemption, and a sales tax exemption for solar owners.

C. Local Government

Local governments can do much to promote solar development. They can promote solar school and municipal buildings as well as solar housing projects. With their long-term, low-interest financing, cities and towns often can take advantage better than the private sector can. Local governments can also create local solar utility districts and zoning districts, and enact ordinances guaranteeing access to sunlight for solar users.

V. Commercialization

Numerous studies, addressing the commercial development of solar power have been conducted during the past eight years. Without exception, these studies project substantial growth in this market during the next fifty years. It has been an equally unanimous conclusion that such growth would come about only with considerable pump priming on the part of the government to offset high current initial costs. The studies to date deal largely with solar water and space heating and to a lesser degree with the less economically attractive photovoltaic power.

The fundamental problem with solar energy is its near term economic viability. Although most recognize the long term need to exploit solar energy, there is no clear picture of the necessary measures to move in that direction. In a free market influenced only by economic factors, solar energy would not come into prominent use until either acute shortages occurred in the less costly energy forms or until the prices of alternate forms rose to levels which are close to the long term price of solar energy as perceived in the market place. In other words, a transition would not occur until crisis or near crisis conditions existed. It is concluded by most analysts that the lesser of two evils is to look to the federal government to lead the way and through a variety of methods, e.g., gas

price deregulation, tax incentives, and R & D subsidies, modify the economics to stimulate the solar market.

A second problem which presently exists is the perception of solar system unreliability. This results from the apparent poor quality of installation consequent high failure rate in recent years in ERDA demonstration projects. This is not an inherent problem of solar energy and is correctable in time with the development of standards based on increased operational experience.

A third problem which has to date been resistant to solution is the lack of sensitivity to the nation's energy problem. There has not been a great deal of support for conservation and the notion that one must accept some small sacrifice now to avoid a disaster 15 to 20 years from now.

Another educational deficiency relates to the concept of life cycle costing. From a financial standpoint solar energy is characterized by high initial costs and (assuming minimum maintenance requirements) very low operational costs. This again is a pay-now-and-benefit-later concept. Mortgage financing similar to that employed in the purchase of homes should help to eliminate this problem.

A. The Development of the Direct Solar Energy Market

Early studies conducted by TRW¹, Westinghouse² and G.E.³ provide a pessimistic forecast of solar market potential prior to the year 2000. They are characterized by sales estimates in the order of \$1 billion, energy contribution of less than 1/4 quads⁴ and less 2 million solar installations nationwide. These studies predated the oil embargo and their modest projections are largely attributed to that fact. Later studies have projected substantially higher rates of growth. Scott⁵ forecasts a cumulative number of 10 million units by the year 2000, and a number of others project growth rates between the Scott estimates and those of the early studies.

A recently released report from the Council on Environmental Quality⁶ forecasts that if the will to do it is present, that solar technology can provide 23% of the U.S. energy need by the year 2000, of the total, direct solar (heating and cooling, intermediate temperature systems and photovoltaic) would represent 11%. A breakdown by conversion technology is shown in Table 3.

This report admittedly presents a very accelerated market development and probably represents a 100% success view of the future incentives which provide the driving force for the accelerated market development

B. Impact of Incentives on Market Development

It is virtually a given that without federal support, commercial development will proceed at a slow pace until impending disaster forces action. The extent and nature of the most appropriate federal support is yet to be defined. A number of studies have been

¹TRW Systems Group, *Solar Heating and Cooling of Buildings Phase-0 Report*, Prepared for the National Science Foundation, NSF/RA/N-74-022A, May 31, 1974.

²Westinghouse Electric Corporation, *Solar Heating and Cooling of Buildings Phase-0 Final Report*, prepared for National Science Foundation, NSF-RA-N-023D, May 1974.

³General Electric Corporation, *Solar Heating and Cooling of Buildings Phase-0 Final Report* prepared for the National Science Foundation, NSF-RA-N-,—May 1974.

⁴The total energy demand in 2000 is estimated to be approximately 100 quads.

⁵Scott, Jerome E., *Solar Water Heating — Economic Feasibility, Capture Potential, and Incentives*, prepared for the National Science Foundation, APR 75-18330, February, 1977.

⁶Council on Environmental Quality, *Solar Energy Progress & Promise*, April, 1978

conducted to address this issue. RUPI finds that front end subsidies (grants, tax credits, or rebates) are the most effective in terms of stimulating the purchase of solar energy systems. A 40% tax credit is estimated to induce a 100% increase in installations by 1986 (Figure 2).

It is clear from the RUPI study that increasing the magnitude of the tax credit will increase the number of purchases at an even faster rate. For example, a 20% tax credit will, according to the RUPI model, result in 20% more units by 1982, while a 50% tax credit will increase the sales by 167%. This is hardly surprising behavior. When one considers that a solar water heater costs about three times as much as a conventionally fueled one, it is expected that small reductions in effective price would make little difference in quantities sold, but as the price difference is narrowed, substantial sales increases would be expected.

Table 3
CEQ Estimates of Maximum Solar Contribution to U.S.
Energy Supply Under Conditions of
Accelerated Development
[Units: quads per year of displaced fuel (a)]

	1977	2000 (b)	2020 (b)
Heating and Cooling (Active and Passive)	Small	204	5-10
Thermal Electric	None	0-2	5-10
Intermediate Temperature Systems	None	2-5	5-15
Photovoltaic	Small	2-8	10-30
Biomass	1.3	3-5	5-10
Wind	Small	4-8	8-12
Hydropower	3	4-6	4-6
Ocean Thermal Energy Conversion	None	1-3	5-10

Total U.S. energy demand in 1977 was 76 quads. Estimated total U.S. energy demand is from 80 to 120 quads for the year 2000 and from 70 to 140 quads for the year 2020.

- (a) A quad is a quadrillion or 10^{15} BTUs. Electricity is converted to equivalent fuel that would have to be burned at a power plant to supply the same amount of power. The conversion rate used here is 10,000 BTU per kilowatt-hour.
- (b) The estimates in these columns are not strictly additive. The various solar electric technologies will be competing with one another, and their actual total contributions will be less than the sum of their individual contributions.

Source: Council on Environmental Quality, *Solar Energy: Progress and Promise*, April, 1978

FIGURE 2
Non-Refundable Tax Credit;
Existing Homes – Water Heating

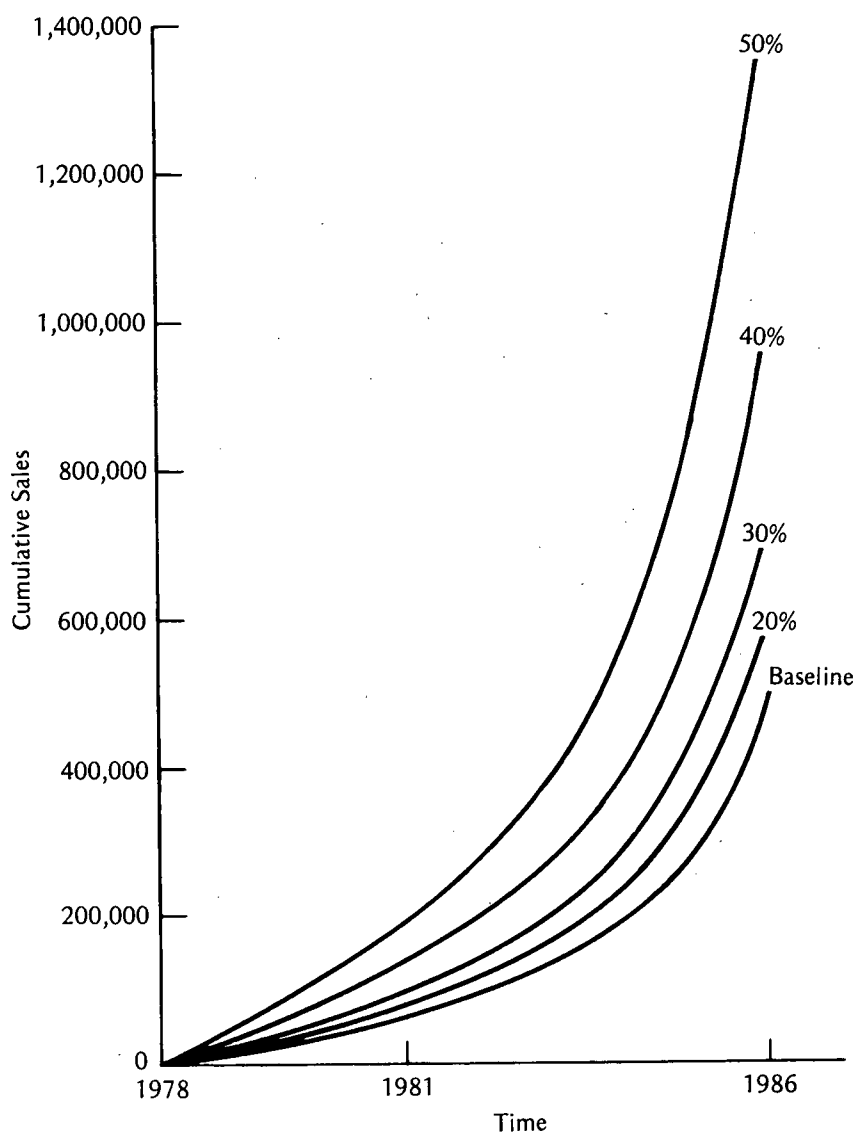


Table 4 presents another set of results from the RUPI study, comparing a variety of incentives with respect to their ability to increase sales by 50% and by 100%. The grant, because of the immediacy of payment, appears to be the most influential form of incentive. The low interest loan is the least effective incentive examined in the study. It is important to place the magnitude of a significant government subsidy in perspective. Loferski* estimates a cost of \$90 billion to outfit 20% of the 9 million housing units in the

*Loferski, J.L., "Potential of Solar Heating in the Northeast," June 1978.

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Table 4
Incentive Level Needed to Achieve
50% and 100% Increase
In cumulative Sales by 1982

	Incentive	Incentive Level Needed to Increase Sales by 50%	Incentive Level Needed to Increase Sales by 100%
New Homes: Hot Water and Space Heating 82 Baseline = 14,700 total units Baseline + 50% = 22,050 total units +100% = total units	Non-Refundable Tax Credit	20.2%	27.9%
	Refundable Tax Credit	20.0%	26.5%
	Grant	18.2%	25.4%
	Loan	3.5% interest rate: 15 years	—*
New Homes, Hot Water 982 Baseline = 64,300 total units Baseline + 50% = 96,450 total units + 100% = 128,600 total units	Non-refundable Tax Credit	33.8%	45.5%
	Refundable Tax Credit	32.9%	44.5%
	Grant	27.0%	39.2%
	Loan	1.66% interest rate; 20 years	—*
Existing Homes, Hot Water 982 Baseline = 138,600 total units Baseline + 50% = 207,900 total units +100% = 277,200 total units	Non-Refundable Tax Credit	31.1%	41.0%
	Refundable Tax Credit	31.0%	40.5%
	Grant	30.0%	39.0%
	Loan	.15% interest rate 20 years	—*

*According to projections, loan cannot achieve 100% increase by 1982.

Source: RUPI, Inc., Cambridge MA *Federal Incentives for Solar Homes—An Assessment of Program Options* November, 1977.

Northeast region with solar space heating. If such installations were subsidized at the 50% level \$45 billion in federal funds would be required. This represents 10% of the annual federal budget (1977). If the outlays were spread over 20 years, .5% of the annual federal budget would be devoted to providing solar energy to the Northeast. Of course, there would be a partial tax offset due to the GNP stimulation resulting from the new economic activity which would result. Whether this magnitude of subsidy is an appropriate price for accelerating the transition to solar power is a key policy question the lawmakers must address.

C. Solar Energy and Jobs

A significant fraction of the cost of solar heating installation is the result of high labor content. Although there appears to be low capital intensity in collector fabrication, the bulk of the labor required is in the installation process. Skill craftsmen, plumbers, sheetmetal workers, and electricians are required for proper installation.

There does not appear to be a shortage of the required labor force in the New England area. In fact, if a major effort (of the scale suggested by the Council on

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Environmental Quality) were undertaken, unemployment in this region very likely would be substantially reduced.

D. Public Acceptability

There is presently a shortage of market research data reflecting public attitudes toward direct solar energy systems. A few studies have been conducted and though they were limited in scope and depth, their findings are worth mentioning here.

In the report an *Attitudinal Study of the Market for Solar Devices*, * the following findings are presented.

About 1.1 million American residences would have home and hot water heated with solar energy by 1985 if the total cost averaged \$20/month more than the cost of heating with fossil fuels, and initial costs were no barrier. An additional 7.2 million homes would have hot water alone heated with solar energy by 1985 if the total cost was \$5 a month more. These are fairly favorable cost assumptions under current conditions.

Almost half (44%) of potential homeowners surveyed would prefer to have their living spaces and hot water heated with solar energy if the total cost averaged \$20 per month more than conventional heating and initial costs were no barrier. Although interest runs high, for various economic and technical reasons, only about 1 in 75 American families may have both their home and water heated with solar energy by 1985.

Any development that makes solar energy cost-competitive with fossil fuels for home heating will increase the level of market penetration. Another key to how quickly Americans will have solar homes is how fast builders and developers use solar energy in new homes and can assure good performance.

The Scott report cited above was based on a survey on consumer attitudes in two cities. He developed a consumer decision making model which represents what could be a valuable tool in assessing public attitudes. It is interesting to note that the Scott study projected much higher market penetration than any other studies reviewed.

In all probability, with the proper marketing and advertising approach and with favorable economics through government subsidy, solar power development will not be inhibited by negative public attitudes.

VI. Systems Integration

A. Application of Alternative Technologies

Because of the intermittent nature of energy from sunlight, solar thermal and solar electric systems must have energy storage systems associated with them. In active solar thermal systems and in solar electric systems, economic studies indicate that the optimum size system stores only one or two days supply of energy for the dispersed site. Widespread introduction of active solar thermal and solar electric systems into the territory served by an electric utility would, therefore, be accompanied by the simultaneous introduction of a substantial storage capability into that same territory. Integration of this storage capability with the utility could help in load levelling. Storage systems would be filled by the utility during the present low demand period (midnight to 6 A.M.). In the case of dispersed electrical energy storage, the utility might be interested in renting the storage system from individual owners so that it can extract the energy during peaks in demand.

Utilities are understandably concerned about dispersed installations which do not have adequate storage associated with them, since such systems would have a high

*Decisions & Designs, Inc. McLean, VA., *An Attitudinal Study of the Home Market for Solar Devices*, prepared for Federal Energy Admin., Washington, D.C. TR77-5-53, September, 1977.

demand for energy from the utility during the low insolation periods. However, there are no currently accepted designs of active solar thermal or solar electric systems which do not include some energy storage capability.

B. Suitability of Resource for Conversion to Meet Current End Use Demands

Solar energy can be converted into the low grade thermal energy needed to heat buildings by both passive and active solar thermal systems. Higher temperature thermal energy of the type needed for commercial (e.g., laundries) and industrial applications can be produced by concentrator systems. This high temperature thermal energy can also be used to operate absorption type air conditioners.

Solar electric energy when produced by solar cells is of the direct current type. Economic converters exist for transforming d.c. to a.c. power with an efficiency in excess of 90%. This makes it possible to continue using standard a.c. appliances.

C. Compatibility with Other Technologies and Utility Systems

As indicated above, solar thermal and solar electric systems can help the utility with load levelling, thus reducing the need for new energy generating plants. If solar systems are combined with wind and biomass systems, the load levelling is even more effective because the wind often blows when the sun does not shine, and the combustion of biomass can be coordinated with the availability of wind and solar energy. Utilization of all of these sources will reduce, though not eliminate, the need for conventional fossil fuel and nuclear energy sources.

Wind/Hydro/Tidal/Wave Subcommittee

I. Introduction

Some wind and hydro electric energy can be used in site-specific direct work projects such as pumping water, resistance or heat pump thermal heating, or driving factory machinery. However, widespread use of these raw energy resources is probably best accomplished by conversion to electrical energy that may be conveniently transported, bought, and sold utilizing existing utility transmission networks. These energy sources may be developed by small industries, private entrepreneurs or municipalities. Although each installation would provide small amounts of energy, the combined impact of such sites would be significant.

Potential developers would need assurance of a fair market for their product or, in some cases, the availability of backup power supply. The viability of widespread use of wind and hydroelectric systems may be inhibited if utilities and Public Utility Commissions do not establish reasonable regulations regarding interconnection requirements and pricing policies.

The major advantage of wind and hydroelectric systems is that they utilize renewable natural resources and are not currently faced with widespread societal opposition. The major disadvantages lie in the variability of the resources; the necessity that systems be designed to withstand the extreme vagaries of nature; and the presently higher capital cost for new construction of wind and hydro plants compared to conventional thermal systems. The economics of these two renewable energy systems will become more favorable as the prices for conventional fuels rise, as expected, faster than the general inflation rate.

II. Wind Energy

Wind energy is abundant and widespread; however, wind characteristics vary considerably across locations. The mean annual wind speed of most New England sites is in the range of 8 to 12

mph with a few coastal locations and high elevations recording 13 to 15 mph.¹ The best sites for wind generators are those that experience mean annual wind speeds of 12 mph or more. High winds can be destructive to equipment and velocities less than 12 mph are probably uneconomic.

The output of a windmill varies greatly with windspeed. A 100 foot diameter machine theoretically can be designed to produce 15 KW at 20 mph, 100 KW at 20 mph, and 260 KW at 30 mph. However, for economic reasons such a machine would probably be designed to attain its maximum rating at about 30% above the mean annual wind speed for the site.

There are approximately 20 commercially available small wind turbines with rated capacities of 2 KW to 15 KW. A typical 10 KW unit will provide approximately 11,000 KWH per year for a site with a mean annual wind speed of 12 mph.² This corresponds to average annual residential energy requirements exclusive of space heating and air-conditioning. If the mean annual wind speed were only 10 mph, a similarly rated unit would only deliver about 60% as much energy per year.

Larger wind turbines of 100 KW rating or greater would generally be used in conjunction with electric power networks or perhaps for an industrial or commercial application. Prototype units of 2,000 KW rating are under construction, and larger units are in the design stage. These wind turbines have blades in the 250 to 350 foot range, and for electric power network applications could be located in "farms" which might contain 100 such units suitably spaced to avoid interference, providing a total capacity rating of up to 200 MW.

Small wind turbines have been utilized for hundreds of years, and a commercial market for them existed in the United States in the 1930's before the formation of the Rural Electrification Administration. The small systems are comparatively safe and reliable, with manageable maintenance requirements. Further development will improve the small machines. Large wind energy systems, however, are still in the "first generation" development stage and present uncertainties concerning capital costs, energy costs, capacity factor and reliability.

Wind generators pose safety problems that must be considered. The risk of personal and property damage as a consequence of thrown blades can be reduced by locating machines in remote areas. The risk of continued power input into a downed transmission line may be reduced through proper protective circuitry.

Environmental problems that must be considered include the visual impact upon rural landscapes, interference with migratory bird populations, and radio and T.V. signal interference.

Many of the problems can be alleviated if small standard units of high reliability are utilized. The widespread use of 50 foot machines that can be connected to power company distribution circuits may offer the best initial use. Standardization would encourage the economies of mass production. Small size would reduce adverse visual impacts and permit the use of less expensive materials. Widespread and dispersed use would tend to diminish energy fluctuations. The small size may make it attractive for small businesses or entrepreneurs to construct units and sell surplus energy.

Utilities would not need to add energy storage facilities or reserve capacity because of wind machines until and unless they became a significant increment of capacity. It would take 75,000 wind machines of 10 KW capacity to supply 1% of New England's electrical energy needs in 1977.³

¹ Energy Research Group, *New Energy Sources*, 1976

² Estimate provided by Mr. Dan Schiff, Research Consultants, Inc.

³ NEPOOL estimate as reported by Northeast Power Coordinating Council:

	Peak Demand	Energy
NE 1978	15800 MW	83700 GWH
Wind Units*	120 MW	825 GWH
%	0.8 %	1.0%

* 75,000 units of 10 KW capacity, expected capacity credit at 16% of installed.

III. Hydroelectric Capacity — Conventional

New England has a developed hydroelectric capacity of 1500 MW.¹ Most of the large, economically attractive sites have been utilized to nearly their full capability. However, an improvement in capacity, energy output, or both may be economically justifiable and achievable at some existing sites by:

- An increase dam height and storage
- The installation of additional generators to reduce spillage during the spring runoff or at other heavy flow periods
- The installation of more efficient turbine-generators
- The conversion of some facilities to partial pumped-storage use

The potential undeveloped capacity of the region is uncertain. Estimates range from 1200 MW to 3300 MW.² A major portion of this capacity is the proposed 830 MW Dickey Lincoln Project in Maine. As planned, this federal project would flood an area of 88,000 acres to create a vast storage reservoir. The storage accumulated primarily during the spring runoff would be used during other periods for peaking power purposes and produce about 1.0×10^9 KWH per year at a capacity factor of about 14%.

A number of potential projects of medium size are under consideration. Examples include a Great Northern Paper Company development of about 40 MW on the Penobscot River and a 25 MW to 75 MW development on the Kennebec River proposed by Central Maine Power Company (CMP).

Much of the undeveloped capacity is available from hundreds of individual sites that can accommodate small machines and produce a modest amount of energy. The development and redevelopment of some of these small hydro sites is underway or being considered. Most of these sites have little storage and would generate run-of-the-river energy.

The Dickey Lincoln Project is currently under review and has met widespread public opposition. Cost-benefit analysis results are imprecise and the environmental analyses are subject to dispute. The Great Northern Project, opposed by environmentalists and "white water" canoeists, has been shelved. The CMP project does not appear economically attractive at this time, but may be in the future.

Many of the smaller projects are presently uneconomic to develop. Construction of new dams and reservoirs is very costly, although life-cycle costing may show them to be more attractive than earlier analyses. New developments also face potential opposition from environmental interests and may have severe social impacts if human settlements are relocated.

¹ Existing hydro electric installations

	Capacity	Ave. Annual Energy	Cap. Factor
Federal Power Commission	1491 MW	5935 GWH	45.4%
Corps of Engineers	1427 MW	5719 GWH	45.7%
NEPOOL*	1274 MW	4385 GWH	39.3%

* Electric utility industry only and adverse flow year.

² Potential undeveloped capacity at existing and new sites:

	Capacity	Ave. Annual Energy	Cap. Factor
Federal Power Commission	3304 MW	7267 GWH	25.1%
Corps of Engineers*	1543 MW	7499 GWH	55.5%
New England Federal Regional Council	1805 MW	3201 GWH	20.2%

* additional potential at existing sites only

** additional potential at new sites only

Redevelopment of existing inactive dams can be economically attractive at the present time. A number of small stations have been reactivated already with little or no government assistance. Further redevelopment can probably be spurred by federal assistance in providing up-front study costs. Such projects are generally environmentally benign if they are operated as run-of-the-river plants. In some cases they may meet opposition from lakefront owners or others within the impacted communities. Many of these concerns may be alleviated with proper operation of plants to assure adequate water supply for recreational and water quality needs.

With public support and government assistance perhaps an additional 1500 MW¹ of capacity could be developed. At an estimated average capacity factor of 30%, such development would yield about 4 billion KWH/year, an amount of energy equivalent to that generally available from a 600 MW thermal electric unit. This would represent about 5% of New England's current annual electrical energy use.²

IV. Tidal Power

Over the last four decades tidal projects that could utilize the enormous tidal fluctuations and flows of the Bay of Fundy have been studied. United States studies have primarily centered around a joint project with Canada that would utilize both Cobscook Bay and Passamaquoddy Bay. The project as originally planned had a capacity of 500 MW. Some studies³ estimated that it could be constructed to a maximum capacity of 1000 MW with 2.1×10^9 KWH annual energy yield. It was never constructed primarily because each of the several studies indicated it was not economically justifiable. Recently the Canadian government completed its own comprehensive study of tidal power potential in the Bay of Fundy. Based on its findings, Canada has notified the United States that it is not interested in the project.

The Canadian study⁴ involved 18 sites considered more attractive than Passamaquoddy. Among these only two were identified as potentially economically viable over the life of the units. The most ambitious project would have a capacity of 3800 MW and yield of 12.6×10^9 KWH annually. The study conclusions are worthy of note:

1. Tidal power, in its most economic role, would displace fossil-fuelled energy production. Although a tidal plant would eliminate some fossil-fuelled generation from the Maritime utilities expansion programs, it would neither eliminate nor reduce the need for nuclear generation.
2. The reassessment has conclusively demonstrated the fundamental economic feasibility of tidal power and the technical and economic feasibility of its integration into the projected generation supply systems of the Maritime Provinces.
3. Because the minimum investment would be about 3 billion (dollars) and because this would result in an inordinate financial burden being placed upon utility customers in the early years, financial feasibility of a tidal power plant would be conditional upon substantial direct participation by governments which would enable raising of the necessary capital and maintaining the cost of service to utility customers at annual levels not exceeding those which would be incurred by an optimal generation expansion program without tidal power.

¹ Potential represents upper bound of physical potential, does not include feasibility or economic analysis. Estimate of 1500 MW at 30% capacity factor intentionally optimistic. Includes 830 MW Dickey-Lincoln Project, 390 MW at 8 sites of 25 to 80 MW, and 280 MW aggregate of hundreds of small sites .2 to 1 MW. See also Supply Committee Report.

² New England electrical energy use 1977-76.3 x 10⁹ KWH. See the Electric Council of New England, *Electric Utility Industry Statistical Bulletin*, 1977.

³ Corps of Engineers, *Passamaquoddy Tidal Power Project*.

⁴ Bay of Fundy Review Board, *Reassessment of Fundy Tidal Power*, 1977.

The Army Engineers have turned their study efforts to Cobscook Bay.¹ Since this project would be far smaller than the rejected Passamaquoddy joint venture (less storage and an available tidal range of 18 feet vs. 40 feet), it is very unlikely that it will ever prove to be economically justified.

A small tidal project of 4 MW that would utilize the natural contours of Half Moon Cove within Cobscook Bay has been proposed by the Passamaquoddy Tribe. This project may have regional and social merit, e.g. employment and income impacts, that outweighs purely economic considerations.

Tidal power productions cannot be scheduled to meet system demands. Other forms of power generation must be operated to complement tidal systems. If sufficient system flexibility does not exist, it may be necessary to construct additional pumped storage facilities to fully utilize the energy available from a tidal project.

V. Pumped Storage²

Pumped storage hydro facilities simply store electrical energy produced during low demand periods for use during high demand periods. They consume 115 KWH of energy for every 100 KWH produced. In addition to load leveling they constitute a ready capacity reserve that can be quickly placed in service in the event of an electrical system emergency. A more recent innovation in energy storage is the use of gas turbine compressors that store high pressure air in salt dome cavities. These systems can be designed to burn fuel during the generation and permit increased capacity and operational flexibility.

At present New England has two large hydro pumped storage projects in operation. None are under construction. The amount of pumped storage capacity that can be constructed is far greater than the foreseeable need.

System load factors can be improved by other means that may make the near term need for added pumped storage unnecessary. Examples include time of day or off-peak rates, heat storage systems and interruptible loads. However, the need for additional pumped storage could be accelerated if widespread use is made of intermittent energy resources such as tidal, wind or solar power.

VI. Ocean Thermal Gradient and Wave Power³

Both of these possible options would use a low grade energy resource and are presently compared to other alternatives discussed above.

Because the waters off the New England coast have thermal gradients of less than 40°F and the shoreline is considered a valuable recreational asset, it is unlikely that either of these energy resources would ever be used in the region other than on an experimental basis.

An ocean thermal plant operating with a 40°F gradient would have an efficiency of less than 2%. Therefore, its capital cost for equipment could be about twenty times more than a conventional power cycle. The necessity to mount these units on platforms or barges far offshore would increase the cost disadvantage by perhaps another order of magnitude.

All proposed wave system schemes require a massive commitment of vast stretches of valuable shoreline which would meet public opposition.

¹ Corps of Engineers *Tidal Power Study—Cobscook Bay Maine*.

² New England River Basins Commission Report.

³ Energy Research Group, *New Energy Sources*, 1976.

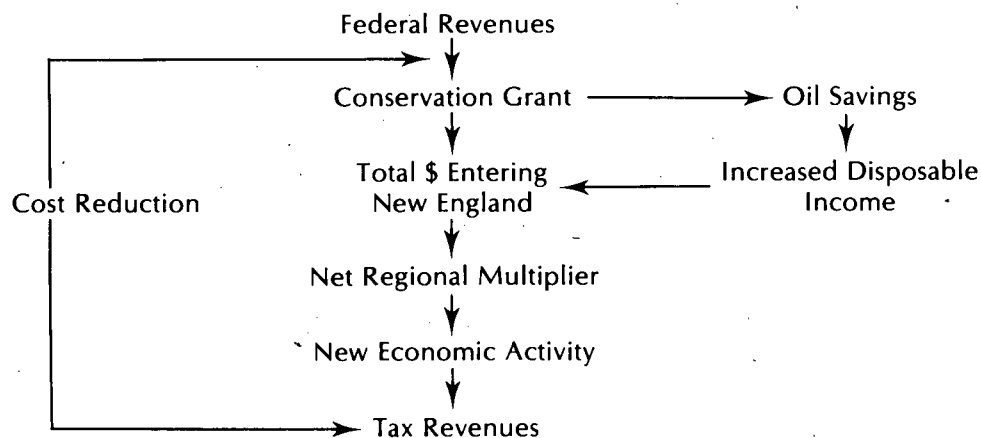
Capital/Financing Subcommittee

I. Overview

The Capital/Financing Subcommittee has focused its attention on identifying the most effective governmental financial incentives for stimulating the utilization of renewable energy systems. The committee discussed the use of the investment tax credit (ITC), and accelerated depreciation for energy related investments. In general, it was felt that a doubling of the ITC and discretionary use of accelerated depreciation would stimulate both the supply and demand side of the alternate energy industry, and that simultaneous stimulation would achieve a greater rate of market penetration than stimulating the demand side alone. For example, consumers in both the commercial, industrial and the residential sectors would be prompted to make investments in conservation much faster by a mix of incentives. Manufacturers would more quickly gear up and promote their products if they are assured of a lower cost of capitalization (ITC) and quicker recovery of their investment in production plant and equipment (accelerated depreciation). The results of such incentives would range from conservation, to material and energy recycling (heat), to primary generation or co-generation of energy from non-fossil fuel sources. For the consumer, the grant is the most efficacious device because reimbursement would be more timely (4 to 6 weeks) than a tax exemption or credit, although the credit also might be quite effective (e.g. California 55% solar tax credit). A balanced governmental program must include investment tax credits and accelerated depreciation for capital intensive alternate energy systems, loan guarantees, low interest loans, dividend and capital gains tax exemptions for small manufacturers; and credits, rebates and, most preferably, direct grants to users of decentralized residential systems.

The subcommittee next explored the relationship between government financing of renewable energy systems and the local and the national economic impacts of such financing. The principal conclusion of this discussion is that public financing schemes ultimately cost less than is generally recognized. Evaluation of the secondary impacts, or "ripple effects", of all financing schemes should be incorporated into the policy formulation process. To illustrate, these impacts and their interrelationships are presented in a simplified form in Figure 3. A government decision to provide some form of conservation grant to homeowners channels federal dollars into the New England region. In addition to this direct dollar inflow, the

Figure 3: Secondary Impacts of A Federal Energy Conservation Grant Program



resulting oil savings frees additional disposable household income, the bulk of which remains in the regional economy. Expenditure of these resources is compounded by a regional multiplier, which in turn generates new economic activity and tax revenues. Additional revenues may then be applied to reduce the public burden of continued financing of the conservation grant.

II. Example: A Federal Conservation Grant

The following recommendation was designed to illustrate some of the subcommittee's major propositions.

A. Recommendation

The Subcommittee recommends the creation of a Federal grant program to property owners aimed at reducing total BTU consumption in residential units. The grant should be tax deductible and cover 50 percent of the costs of retrofitting the average New England dwelling unit to an optimal level measured in terms of the highest net present value of the investment attainable within a five year payback period. The grant should take the form of reimbursement of expenditures on materials which have been defined as fossil-fuel conserving. In conjunction with the program, the implementing state agency should disseminate a list of optimal purchase strategies according to the present value and payback period of the savings for various prototype dwelling units.

B. Rationale

The recommendation attempts to achieve an overall reduction in heating and cooling load requirements in existing residential units in a manner which maximizes the individual property owner's flexibility and inventiveness. It is designed to supplement existing market forces and federal incentives by providing seed money for presently marginal economic investments; complete financing for high payoff investments by low income households; and partial funding for middle income owners wishing to achieve an optimal level of retrofit. Underlying the program are two basic assumptions: (1) program benefits will partially offset the costs of implementation; (2) reduction of fossil, especially imported, fuel consumption has a social benefit over and above that which accrues to the individual homeowner.

C. Economic Framework

A 25-50 percent grant represents the minimum level of subsidy necessary to achieve a significant level of market penetration. A 1977 RUPI study*, for example, concludes that a 20% tax credit for solar heating would increase sales by 20% above a baseline case (no credit) by 1982, whereas a 50% credit would produce a 167% increase. Solar water heating, furthermore, is a "lumpy" investment which, unlike many basic conservation measures, cannot be purchased in increments. In addition to a 50% grant, the present recommendation proposes a grant which guarantees the property owner reimbursement within one month of purchase as compared to the delayed reimbursement schedule generally associated with a tax credit. This, plus the level of subsidy, should insure effective market penetration. A payback period of 5 years reflects the average mobility rate of the American household. We recognize that a major disincentive to many energy conserving home improvements is the lengthy payback period which, despite a favorable present value and cost/benefit ratio, discourages the property owner interested in recouping his investment within a reasonably short time. A

* RUPI, Inc. *Federal Incentives for Solar Homes—An Assessment of Program Options*. Cambridge, November, 1977

recent study of weatherization in Maine¹ suggests that optimal (highest present value) energy conservation measures for a variety of housing prototypes falls within a payback range of 2.4—3.5 years. These measures include storm windows, and wall, floor and ceiling insulation improvements. Alternative energy, e.g. solar installations, which do not meet this criterion will receive little or no support from the proposed program. This, however, is not inconsistent with its major goals of rapid adoption of measures with the highest return on investment and neutrality with respect to the selection of methods to conserve fossil fuels.

D. Energy Savings

Existing studies of energy conservation suggest that a 20-40% reduction in the residential heating/ cooling load is feasible with an expenditure of less than \$2000/unit, and that the first \$1000 can make a significant contribution. It is the most basic conservation measures—storm windows, caulking, weather-stripping, insulation—which the proposed grant would most favor given the current economics of solar space and water heating, the major alternative within the scope of the present grant program. Examples of pertinent studies include:

*Nova Scotia*²: The provincially administered, federally funded tax deductible grant of \$350 for insulation, caulking and weatherstripping is projected to reduce energy consumption by 20-40%. Approximately 125,000 units, or 50% of the housing stock in the province, has been retrofitted to some degree since the program was initiated in April, 1977. First priority is assigned to upgrading basement insulation, followed by ceiling and wall insulation. Most grant recipients have spent less than \$1000, and a majority have spent under \$500.

*New England Regional Commission*³ (NERCOM): NERCOM has assist 70 community action agencies in the winterization of 27,000 low-income homes since FY 1976-77. Agency officials estimate an average energy saving of 25% in heating fuels, or about 300 gallons annually in an oil heated home.

*State of Maine*⁴: Based on engineering parameters, a Harvard study projects a 41% reduction in Maine's residential energy consumption if all housing in Maine were upgraded to weatherization levels similar to those of newly constructed housing. This may be interpreted as the average savings for four prototype units which collectively comprise 58% of the state's housing stock.

Based upon these findings, a 25% energy savings/unit after basic retrofit appears to be a reasonable estimate.

E. Secondary Impacts

Based upon the relationships depicted in Figure 1, we may estimate the secondary impacts of the proposed program using the following assumptions:

Total housing units in New England (1970): 3.3×10^6
Percent retrofitted under grant program: 25% or $.825 \times 10^6$
Average cost of optimal retrofit: \$2000

¹ Harvard University, Department of City and Regional Planning. *Energy Conservation in Maine: Weatherization Improvements to the Existing Housing Stock*. Cambridge, June, 1977.

² Telephone communications with John French, Nova Scotia Energy Council, September, 1978.

³ Urban Systems Research and Engineering. *Impact of the New England Regional Commission's Low Income Weatherization Project*. Cambridge, August, 1978.

⁴ Harvard University, *op. cit.*

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Amount of grant: $.50 \times \$2000 = \$1000$
Average tax rate on incremental income: 13%
Regional multiplier: 2.03
Program duration: 5 years
Average annual oil bill of participating household: \$500
Percentage of additional disposable income retained in the region: 80%

Under these assumptions, the program impacts would amount to the following:

Gross cost to the federal government: $\$825 \times 10^6$
Average annual cost to the federal government: $\$165 \times 10^6$
Additional disposable income retained in the region: $\$82.5 \times 10^6$
Multiplier effect: $\$1757.5 \times 10^6$
Additional federal tax revenues derived from the region: $\$87.1 \times 10^6$
Net cost to the federal government: $\$737.9 \times 10^6$
Barrels of oil saved: approximately 4.9 million/yr.

In summary, without considering the local and state revenue impacts anti-inflationary benefits and employment impacts, we estimate at least a 10% reduction in gross cost to the federal government attributable to increased tax revenues from New England. The subcommittee views this type of comprehensive economic assessment, presented here in simplified form, as indispensable to the formulation of rational energy policy.

Jobs Subcommittee

The Jobs Subcommittee was formed to explore the relationship between renewable energy systems (including conservation) and job creation. Specifically, the committee has sought to answer the following questions:

- 1) To what degree is economic development, especially job creation, incorporated into the decision-making of those federal and state agencies involved in the energy policy formulation?
- 2) Are there significant differences in job creation potential of conventional versus renewable energy systems, including conservation?
- 3) To what degree can jobs associated with renewable energy systems benefit low-income and/or structurally and chronically unemployed people?

For purposes of collecting information within the time constraints of the Energy Congress, the subcommittee organized a fact-finding public hearing in Portland, Maine on October 10. Oral and written testimony to date has been received by a diverse group of organizations representing labor, business, environmentalists, consumers and government. The hearing was open to all individuals wishing to testify. The subcommittee welcomes additional public input into its deliberations.

In the weeks following the Portland hearing, individual subcommittee members reviewed the transcript of the hearing and formulated recommendations based upon this testimony. During November and December, these recommendations will be further reviewed in light of public comment on this preliminary report. To date, the subcommittee's findings may be summarized as follows.

- 1) *Government agencies at all levels involved in both energy policy formulation and regulation ignore the economic development and jobs impacts of their respective decisions.*

The subcommittee has found that no formal mechanism exists among the Department of Energy (DOE), Federal Energy Council (FERC), Nuclear Regulatory Council (NRC), state public utility commissions (PUCS) and siting councils and other state and federal bodies, which require such bodies to evaluate the developmental and employment impacts of their decisions. As a result, major commitments of federal research and development and demonstration monies, federal and state fiscal incentives, PUC construction permits and other such decisions are made without proper attention to short and long term national and regional economic impacts. The favored treatment historically accorded capital intensive centralized conventional energy systems, therefore, has probably cost the New England region a substantial quantity of jobs which would have reduced unemployment during the past few decades.

- 2) *The available evidence, though still limited, is overwhelmingly in favor of conservation and renewable energy systems in terms of job creation potential.*

Preliminary figures of a New England study comparing the jobs impacts of a conservation/solar versus a nuclear scenario for meeting residential energy demand through 1985 indicate a job producing potential of about 420,000 to 35,000, or about a 12 to 1 ratio.¹ Senator Kennedy concluded after recent public hearings that conservation is "the best job creator of all energy measures by a margin of 3 to 1, considering both direct and indirect employment"². The labor input/energy output ratio of solar energy as compared to coal-fired electrical generating plant is 1.5/1; solar versus a nuclear plant is 2.5/1.³ Although conclusions of these studies are, of course, contingent upon a variety of assumptions, their consistency suggests that differences are confined to the order of magnitude of the conservation/solar advantage. It is unlikely that future studies will yield findings substantially different in direction.

- 3) *Energy strategies which maximize job creation are also preferable from an efficiency, equity, and regional economic benefits standpoint.*

Conservation/solar strategies utilize less scarce non-renewable fuels more efficiently than conventional systems; they provide employment opportunities for those groups most needful of permanent, gainful job opportunities; and, finally they strengthen a regional economy by recycling resources locally. As one example, the city of Portland, Maine has demonstrated that retrofit of public buildings offers a multiplicity of employment and fuel saving opportunities⁴. Between October, 1977—October, 1978, 28 CETA workers retrofitted thirty public schools and reduced energy costs from \$400,000 to \$325,000, or a 19% savings. Wages totaled \$225,680 and materials cost \$250,000, most of which purchased Maine-manufactured cellulose insulation. Thus, approximately 47% of total expenditures were labor costs. Perhaps most significantly, 60% of the employees in the program have since secured private sector jobs.

In summary, the Portland case indicates that conservation efforts can: (1) effectively provide job opportunities and long term marketable skills to the unemployed and under-employed; (2) offer immediate saving in fuel costs and a 5-6 year payback period; (3) recycle local resources within the local economy.

¹ Testimony of Richard Rosen, Energy Systems Research Group, Transcript of Public Hearing of the Jobs Subcommittee, October 10, 1978.

² Testimony of Senator Edward Kennedy, *op. cit.*

³ Testimony of Lawrence Levy, Northeast Solar Energy Center, *op. cit.*

⁴ Testimony of Representative Sherry Huber, State of Maine, *op. cit.*

The subcommittee recognizes the complexity of the jobs and alternative energy issued and that its efforts and findings at this point are tentative. Nevertheless, there has evolved a clear awareness of the need to link energy policy with overall national, regional and local economic development. Approaches for institutionalizing this linkage will continue to be the focus of the subcommittee's work.

Systems Integration

I. Introduction

It is generally agreed that there are specific benefits to be gained from the accelerated use of alternative, renewable energy sources in New England. These benefits include a reduced dependence on oil, a reduction in the regional balance of payments deficit, a potential decrease in unemployment, greater self-sufficiency in the event of major energy supply disruptions, etc. These benefits, of course, must be balanced against the costs of the alternatives, with proper consideration given to the question of existing subsidies for conventional energy supplies. It is this cost/benefit accounting which must determine the optimum level of deployment and penetration of the alternatives, and should guide government policy on the alternatives.

Given that some level of penetration by the alternatives is desired, the question of integrating the alternatives into the existing energy supply system becomes a question of overcoming the initial resistance to such changes by demonstrating that the technology does work, and by eliminating inequities in regulatory or economic policy. Also, the development of an infrastructure necessary for the successful deployment of the alternatives must be encouraged and a smooth transition from conventional to alternative sources must be planned. This leads us to consider four objectives as the primary goals for the alternatives.

- 1) Economic policies must be directed at giving parity to alternatives; that is, subsidies must be eliminated or equalized.
- 2) Regulations or policies which discriminate against the alternatives must be changed.
- 3) The alternatives which are attractive but have not been satisfactorily demonstrated in the context of our energy systems must be so demonstrated.
- 4) Particularly for demonstrated technologies, assistance must be directed to the development and maturation of the supply markets.

The paragraphs below address a few of the issues discussed at the subcommittee meetings. A comprehensive study of systems integration was clearly beyond the capabilities of the subcommittee, but the issues discussed below do represent a broad spectrum of the problems that must be dealt with. These issues were discussed from the perspective of meeting the systems integration challenge and achieving the objectives outlined above.

II. Heating

Energy consumption for home heating accounts for nearly one third of the total energy consumption in New England. The dominant source of heat is the use of distillate oil in central heating systems, which are meeting heating demands in generally underinsulated houses. The needs of this rather homogeneous sector are best met by a multifaceted approach including both conservation and the use of alternative heat sources. As an example of a program which could address this problem, the following programs were suggested, but not unanimously endorsed as recommendations.

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A. The BTU Grant

- 1) Amount: \$500
- 2) Eligible Grantees: All owners of residential property plus tenants of non-participating landlords.
- 3) Forms of Grant:
 - a) "Energy Stamps" redeemable at retail outlets for materials proven capable of reducing fossil-fuel-generated BTUs (pre-certified):
 - i) insulation
 - ii) caulking
 - iii) storm windows
 - iv) solar collectors
 - v) greenhouse materials
 - vi) water-saving shower heads
 - b) Reimbursement for owner-built systems using non-certified materials according to previously approved plan.
 - c) Special low-income pilot projects in which local agencies provide federally-funded audit, materials, and installation (\$500 ceiling lifted for these projects).

B. Tax Credits:

Expand the tax credits provisions of the National Energy Act to include passive and other innovative systems.

C. Demonstrations

- 1) The 200,000 Person Program
 - a) Eligibility: Any New England resident would be eligible for a two-grant program to be carried out in every district of 200,000 population (some 65 in the region). One grant for new residences, one for retrofits.
 - b) Amount: \$50,000 for new house, \$10,000 for retrofit.
 - c) Conditions:
 - i) Design should minimize reliance on fossil fuels. Special consideration for designs confronting peak-load problems; use of wood as auxiliary fuel encouraged for rural zones; food-production capabilities encouraged.
 - ii) Decision by state (VT, ME) or intra-state (Western Mass) official juries.
 - iii) Structures open to public for first four years, then sold on open market. U.S. gets grant amount plus interest, if any. Designer gets rest.

2) *Model Villages*

At amount to be determined later, a regional jury would help choose winners of contest for two new-from-the-ground-up villages of 500 persons, one urban and one rural. Designs should emphasize community scale energy systems.

III. Electricity

There are a variety of alternative, renewable techniques for producing electricity. These include wind, hydro, tidal, wood combustion, photovoltaics and solar thermal electric. By 1985 only wind, hydro and wood combustion are likely to play even minor roles in New England. Two distinct possibilities are available for utilizing these technologies. The first is that utilities will begin to use them in conjunction with existing generating capacity. Such is the case with the Burlington Electric wood-fired plant and with a few small hydro sites, although substantial changes in utility expansion plans, which favor large central-station nuclear plants, are not expected. Dispersed, non-utility applications are the second possibility. In this context, the problems of integrating these systems with the existing utility network becomes preeminent.

The interfacing problem referred to here is not so much a technical problem as a regulatory and institutional problem. Utility regulations are geared towards the large producers and towards companies whose sole purpose is the generation, transmission and sale of electricity. As such, they may discriminate against dispersed, non-utility applications of any kind which must be connected to the grid if favorable economics are to be achieved. This problem is as severe for industrial cogeneration as it is for using alternatives. In fact, cogeneration with wood is one of the most attractive of near-term opportunities for utilizing renewable resources.

In order to solve these problems, the existing regulations should be changed. In particular, the distinctions between small, non-utility producers and utilities should be clarified, and the small producers should not be burdened with unnecessary, inappropriate, irrelevant or extremely complex reporting and regulatory requirements. Also, regulations at the state and federal levels should be adopted which insure that a small producer can get a utility interconnection and a fair price for any electricity which is delivered to the grid and for any electricity purchased from the utility. The recommendations of the Massachusetts Governor's Commission on Cogeneration of 1978 address these problems in a complete and objective manner, and should be considered in the development of a comprehensive program to assist non-utility electricity producers.

IV. Wood Supply

Despite the recent interest in wood energy in New England, a wood energy supply system has not developed, with the exceptions of isolated areas where wood waste is common and of the cordwood market for home heating. Such a supply system will be very important for a number of reasons. First, wood energy will not be adopted by most potential users unless an adequate and consistent supply can be assured. Second, the resource is dispersed and is owned largely by many individuals with relatively small parcels. Therefore, there is no natural connection between the resource and the potential market. Intermediate jobbers and wholesalers are essential to the successful development of the resource. Third, there is currently very little assurance that the resource will be harvested in an environmentally acceptable manner. A supply network will provide a point of leverage for requiring that wood resources not be simply stripped for quick profits. Finally, a supply network will serve to stabilize the price for wood energy, both within local areas and across the region. The confusion over wood energy costs will thus be reduced and the attractiveness of wood energy will be increased.

Developing a mature supply network with the desired characteristics will not happen overnight, although the development should occur largely as a response to increasing demand. In fact, the first and fourth functions mentioned above, adequacy of supply and stability of price, can be assured simply by encouraging competition. This may actually turn out to be not so simple, as

the FTC investigation of the wood stove industry points out, but should not be a significant problem on the supply end. As demand develops for wood energy, supply competition should also develop, and the goals should be achieved.

However, establishing connections to the many small woodlot owners and providing for environmentally sound harvesting practices is not so easily assured. Both the resource and the woodlot owners will require protection from unscrupulous harvesters and from more subtle dangers as well. The best method of providing this protection is probably to educate the owners, as their self-interest will be with proper timber management and obtaining a fair price for their wood. The only mechanism currently available for this function is the County Extension Service of the U.S. Department of Agriculture, which provides forestry advice to woodlot owners. The advantages provided by this existing program would be hard to match with any new programs. For the above reasons, the Extension Services for forest management should be expanded, perhaps with a mandate to reach all of the woodlot owners, or a requirement that all woodlot owners file a management plan with their county forester. The service should include education on multiple use management, harvesting techniques and environmental protection, contracts for wood sales, etc. Expansion of the extension service should begin immediately, as it is even now in short supply to many who need it.

NON-CONSENSUS RECOMMENDATIONS

The following subcommittee recommendations have not achieved full committee consensus and will be deliberated further.

I. General Recommendations

1) Equalize Incentives and Disincentives for Conventional and Alternate Energies

- A) *Price existing energy at its true market value, using working capital to invest in future non-petroleum based energy facilities, taxes to finance government subsidies and to prevent windfall profits.*
- B) *Permit the use of tax free bond financing for energy facilities that utilize renewable resources.*
- C) *Provide long term low interest state and/or federal loans to developers designed to allow low or negligible payback of the principal initially with escalation over time.*

2) Local Implementation Studies

The committee recommends the initiation of more local and county-wide energy studies, e.g. Franklin County, MA and Long Island NY, to more adequately address micro-level resource and socio-economic variations which affect the energy planning process.

II. Biomass

1) Tax Credits for Wood Heating Systems

The committee recommends that residential wood heating systems be included under one or more of the state and federal tax credit programs for energy conservation and solar energy. This program should emphasize central heating systems and integrated wood/solar heating and hot water systems.

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2) Tax Credits For Capital Investments

The committee recommends the provision of tax incentives, such as an investment tax credit and accelerated depreciation, for industrial wood-fired boilers, for equipment to produce wood fuels such as chips, pellets, or industrial charcoal, and for equipment to produce wood conversion equipment such as packaged boilers. These incentives should be limited to small and intermediate sized applications until the impacts of large-scale centralized utilization of wood resources have been adequately studied.

3) Forest Resource Studies

The committee recommends that the appropriate federal, regional and state agencies commence detailed studies of the existing forest resources and the possible uses of those resources for energy, in order to identify the best and least desirable uses of the resource. These studies should address the question of scale of application, and should assess the relative benefits and risks of dispersed versus centralized wood energy systems.

III. Financing

1) Conservation Grants for Industrial and Commercial Buildings

The committee recommends the amplification of the provision of the National Energy Act which provides grants of up to 50% for building conservation to also include grants for conversion to renewable energy systems and loan guarantees for conservation/conversion for privately owned commercial and industrial buildings.

2) Life Cycle Costing

The committee recommends that life-cycle costing be made a prerequisite for all projects financed by federal, state and/or local government.

IV. Economic Development/Jobs

1) Priority for the Employment of Long Term/Structurally Unemployed People

The committee recommends that all major recipients of federal monies which are used for building conservation, and conversion to renewable energy systems, be required to hire and train long term/structurally unemployed people to do this work. These recipients include, but are not limited to, federal agencies, public housing authorities, and state and local governments.

2) Community Energy Corporations

The committee recommends the funding of pilot programs which will determine the feasibility of further implementation of private, non-profit citizens energy corporations. These projects would be funded with federal seed money and public funds, and eventually would become self-sustaining. They would employ CETA workers who had worked in weatherization programs and had reached a level of considerable competence, who are unable to find work through ordinary private channels, and whose CETA term had expired. The Hartford, CT model might serve as an example for such projects.

V. Miscellaneous

1) Guaranteed Government Contracts

The committee recommends more guaranteed market strategies such as the amendment to the recent \$4.1 billion military construction bill which requires that all

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new military housing include supplemental solar installations where it proves cost effective. Similar legislation should mandate that a portion of those major contracts awarded to small businesses be earmarked for community-based energy ventures.

2) Fossil Fuel Conservation Grant

The committee recommends the modification of existing federal residential conservation programs to permit homeowners and renters the maximum degree of flexibility in selecting methods for reducing fossil fuel consumption. The program should assume the following form:

(The following are mutually exclusive options)

- A) A tax deductible grant equal to 50 percent of the average cost of retrofitting existing units to an optimal level measured in terms of the highest net present value of the investment attainable within a 5 year payback period. The grant should take the form of reimbursement for expenditures on materials certified as fossil fuel conserving. In conjunction with the program, the implementing agency should be required to disseminate a list of optimal conservation strategies according to the present value and payback-period for various prototype dwelling units.
- B) The issuance of "energy stamps" totaling \$500 to all residential property owners and renters, redeemable at retail outlets if spent on materials pre-certified as proven capable of reducing fossil-fuel generated BTUs. The program should include special low-income pilot projects in which local agencies provide a federally-funded audit, materials and installation, all exempt from the above \$500 limit.
- C) A federally funded study to evaluate the feasibility of a Canadian type direct grant for the purchase of pre-specified conservation materials.

3) Revision of PUC Regulations

The committee recommends the enactment of state legislation to require Public Utility Commissions and Siting Councils to consider conservation and renewable energy resource potential in reviewing utility demand forecasts and requests for construction permits for new generating facilities.

4) Utility Audit of Industrial and Commercial Customers

The committee recommends that utilities be required to audit large industrial and commercial customers and supply such customers with information on the energy performance of their buildings and on methods to improve these performance levels.

5) Demonstrations

A) The 200,000 Person Program

- i) Eligibility: Any New England resident would be eligible for a two-grant program to be carried out in every district of 200,000 population (some 65 in the region). One grant for new residences, one for retrofits.
- ii) Amount: \$50,000 for new house, \$10,000 for retrofit.
- iii) Conditions:

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- a) *Design should minimize reliance on fossil fuels. Special consideration for designs confronting peakload problems; use of wood as auxiliary fuel encouraged for rural zones; food-production capabilities encouraged.*
- b) *Decision by state (VT., ME.) or intra-state (Western Mass.) official juries.*
- c) *Structures open to public for first four years, then sold on open market. U.S. receives grant amount plus interest, if any. Designer gets rest.*

B) *Model Villages .*

At an amount to be determined, a regional jury would choose winners of a contest for two new-from-the-ground-up villages of 500 persons, one urban and one rural. Designs should emphasize community-scale energy systems.

NEW ENGLAND ENERGY DEMAND COMMITTEE

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COMMITTEE OVERVIEW

Introduction

I. Background

New England consumes nearly three quadrillion BTU of energy each year. Approximately one-fourth of this (750 trillion BTU) is consumed by the residential sector, and another one-fourth of the total is consumed by transportation. The commercial sector is another large energy consumer, requiring over 800 trillion BTU annually. The fourth sector—industry—consumes about 500 trillion BTUs. With a population of about 12.5 million, New England has an energy consumption of about 240 million BTU per capita—much lower than the national average of about 360 million BTU per capita. The reason for this is two-fold: New England consumes only 40 million BTU per capita in the industrial sector vs. 120 million BTU per capita nationally. Also, New England's transportation rate is about 60 million BTU per capita vs. about 85 million BTU per capita nationally.

About 80% of New England's energy demand is met by petroleum products—for transportation, home, commercial, and industrial space, hot water, boiler water heat, and electrical power generation. Almost all of New England's petroleum supply presently comes from foreign sources, leaving New England homes, industry, commerce and transportation highly vulnerable to foreign oil costs and supply fluctuations.

Clearly, the problem faced by the Demand Committee included both determining future energy demand and ways to reduce demand, as well as means to reduce New England's dependency on oil.

II. Approach

The Demand Committee chose to form four subcommittees, covering the four classical

demand sectors: residential, commercial, industrial and transportation. The initial task of each subcommittee was to develop an historical perspective of New England energy demand in the sector, and then to make preliminary estimates of energy demand in the sector for 1985 and 2000. The Residential Subcommittee undertook the added important task of developing baseline population projections, to 2000, using a variety of federal and state sources.

Once these preliminary estimates were in hand, an effort was made to develop a series of recommendations for each sector, which were discussed by the entire committee, and endorsed by the committee, rejected, or relegated to further study.

III. Status

The Demand Committee anticipates continued analytical activity following the Dec. 1, 2 meeting of the Energy Congress. We have not yet adopted energy projections to 1985 or 2000 which meet with the concurrence of the committee, although we expect that our ultimate result for 2000 will be in the vicinity of 3.4 to 3.6 quadrillion BTU or an increase in the range of 17 to 24 percent over the 22-year period. On an annual basis this translates to a growth rate of approximately one percent per year. To achieve a demand as low as this will require significant improvements in the insulation of housing stock in New England; a reduction in the use of automotive gasoline (due to federally-mandated improvements in automobile mile-per-gallon); and considerable conservation efforts on the part of commerce and industry. This suggests that the per capita energy demand in New England will remain approximately constant at about 235 million BTU. There are no projections that suggest such constancy of per capita demand throughout the nation. In the remaining sections of the Demand Committee's preliminary report, we concentrate primarily on the residential sector, for we believe that it is there that a significant reduction in demand per-dwelling-unit can be achieved. However, we are quick to note that we project that New England will add over 2.5 million to its population (to a total of over 15 million) by 2000, and that dwelling unit occupancy may go from 3.2 to 2.7 persons. Thus, individual dwelling units may be more energy efficient, but the number of dwelling units per capita will increase. This implies that residential energy demand will continue to grow in spite of efficiency improvements.

Attention is also given to the commercial and industrial sectors. While the committee has agreed on certain recommendations in the transportation sector, there remains uncertainty concerning many aspects of how transportation energy demand may best be reduced, and the levels of reduction that might be achieved by alternative strategies.

Recommendations

I. Residential

1) *Minimum Thermal and Lighting Standards.*

Currently, states have been mandated to establish thermal and lighting standards under the ECPA/EPCA federal legislation. However no guarantee has been made that each state's standards will effectively induce conservation. This legislation would establish a minimum standard for all states in the New England region. In addition, it would provide a monetary support for training programs for building inspectors since they will enforce the thermal and lighting standards.

2) *Life-Cycle Cost Analysis.*

This legislation would require that a life-cycle cost analysis be performed on every proposed new or significantly renovated building. Such buildings would be denied a building permit unless both the initial capital cost and the life-cycle cost per square foot of floor area fell below established maximum standards.

3) *Truth in Energy.*

This legislation would require building owners and/or energy suppliers to furnish to all prospective leasees or purchasers of a building or apartment disclosure statements of the total annual energy consumption of the relevant unit for the previous three years, broken out by month.

4) *Improved Heating Efficiencies.*

Currently, tax incentives are provided to improve the efficiency of burners in a home. However, no incentives exist to correct other characteristics of a residence's heating system which may reduce its efficiency (e.g., stack dampers, oversized furnaces, outmoded furnaces). This legislation would provide for the development of a tax incentive program that will result in an overall improved efficiency of a residential heating system.

5) *Water Heaters.*

This legislation would prohibit the installation of tankless water heaters in new and significantly renovated buildings.

6) *Pilotless Gas Appliances.*

This legislation would require that all new gas appliances and gas space heating units be pilotless. In addition, it would require that the previously mentioned appliances be retrofitted upon resale.

II. Commercial

7) *There should be a locally-operated federally-supported review process which will insure that all new commercial buildings are designed and built to provide for cost-effective conservation, prudent fuel choice, and desirable operational flexibility, without imposing undue regulatory burdens.*

The Commercial Subcommittee felt that conventional thermal and lighting standards are not sufficient. They felt that both overall building performance standards and analysis of life cost of energy systems should be considered as possible regulatory tools. Both could be tested for effectiveness and efficiency in pilot programs on governmental buildings.

8) *A disproportionately large share of governmental efforts to promote or require energy conservation should be focused upon new construction in the commercial sector.*

The Commercial Subcommittee felt that the commercial sector is likely to continue to grow faster than the others. It also felt that the best time to make a building energy efficient is before it is completed. While new commercial buildings are only one part of New England's energy picture, they may present the single most important opportunity we have to help ourselves.

9) *More stringent regulatory requirements should be imposed upon larger new buildings than upon small.*

To do so would be to take advantage of economies of scale in both conservation and regulation.

10) *The design of new commercial buildings to foreclose as few retrofit options as possible should be encouraged or required. Many energy options which are now little used may play a major role in the future. Examples are roof-top solar collectors, electric heat pumps and district heating systems. Thoughtful design can insure that these options remain available, even if not utilized when a building is built.*

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- 11) *Educational and technical assistance programs to benefit the commercial sector should be expanded.*

Owners of both new and existing buildings could benefit substantially. Aid to small businesses should be emphasized on the assumption that big businesses are more likely to have the resources necessary to help themselves.

- 12) *Any benefits, tax or otherwise, intended to promote conservation in the commercial sector should be available to leasees of real property on the same basis as owners.*

Commercial tenants are more likely to assume the attributes and attitudes of owners than their residential counterparts. Every effort should be made to give both owners and tenants reason to make energy-conserving improvements.

- 13) *Comparable incentives and penalties to encourage energy conservation should be applied throughout the commercial sector—to all entities, whether profit-making, not for profit, or governmental.*

Careful attention is necessary to insure that direct and indirect incentives created by governmental actions do not lead to artificial distortions.

III. Industrial

- 14) *Assess probable impact of cogeneration, in company with Regulatory Committee which is assessing constitutional barriers to cogeneration.*
- 15) *That adoption of cost effective innovations in industrial energy-using equipment be studied both in terms of its impact on regional energy usage and the improvement of the competitive position of regional industry.*

IV. Transportation

- 16) *The federal government should substantially increase research and development of new gasoline products such as gasohol.*
- 17) *The use of commuter car and van pooling and of express buses from commuter lots should be promoted.*
- 18) *Rail service should be routed along areas of greatest population. For example, there should be an increase in service along the inland route from New Haven to Boston which passes through more major cities than the shoreline route.*
- 19) *Congress should perform energy impact analyses in connection with bills funding various types of transportation.*
- 20) *The New England states should require energy impact statements for all government-funded transportation projects.*

Residential Subcommittee Report

I. Introduction

Energy use in the residential sector comprises twenty-five percent of the total use in New England compared with eighteen percent of the total use in the United States. The reason for the proportionately larger residential consumption in New England lies in the heavy heating demand for the region. In fact, seventy-five percent of the energy used in the residential sector is for heating homes. Oil is the primary fuel used for this purpose with gas and electricity contributing in much smaller quantities.

The heavy reliance on these three fuels by the residential sector is of concern for several reasons. First, oil, gas, and electricity are diminishing resources. (Electricity in New England is largely generated by oil-fired steam turbines and secondarily by nuclear power; both oil and the uranium-235 fuel for nuclear reactors are in limited supplies.) Second, the cost of these fuels is the highest in the country. Third, these fuels are imported either from other regions in the country or from foreign countries, thereby leading to a net flow of capital out of New England. Thus, it is important to reduce the overall energy demand and, in particular, the heating demand for these fuels in the residential sector. The goal of the subcommittee, therefore, is to develop legislation and as well as other recommendations that will lead to such a reduction.

The process of developing legislation to alter energy demand involves many steps. First, the current residential energy demand has to be estimated. Then, residential energy demand through the year 2000 must be projected. Since a significant fraction of fuel demand in the residential sector is electricity, the demand for electricity, both today and in the future, must also be broken out.

Once demand projections have been estimated, the question has to be addressed as to how much demand for the diminishing conventional fuels can be reduced. In other words, the conservation potential of the New England residential sector must be assessed. Conventional fuels can be conserved by various means. To reduce demand in heating homes, thermostats can be set back, particularly during sleeping hours; residences can be weatherized; the efficiencies of heating systems in homes can be improved; and conversion from conventional fuels to renewable fuels, such as wood and solar, can be implemented. To reduce non-heating energy demand the efficiencies of home appliances, such as air conditioners and refrigerators, can be improved. The preliminary work of the Residential Demand Subcommittee on assessing both demand projections and conservation potential has been presented in the preceding section.

After assessing conservation potential, a survey of existing codes and legislation, on the local, state, and federal levels, which affect residential demand must be undertaken. Finally, analyses have to be performed to determine both the effectiveness of the current legislation and the areas where, based upon previously mentioned research, additional legislation is required.

The following report is divided into three sections. The first section is a survey of existing legislation affecting residential demand. The second section addresses the problems that remain in effecting demand modification, i.e. weakness or absence of legislation. The final section contains the recommendations of the Residential Demand Subcommittee and is subdivided into three parts. The first contains specific proposals for legislation. The second contains a list of areas of concern that requires further study before legislative proposals can be put forth. The last part proposes studies which the subcommittee strongly believes must be undertaken to better understand the characteristics of residential demand.

II. Recommendations

A) Proposed Legislation

The following drafts of recommended legislation were proposed by the Residential Demand Subcommittee and approved by the entire Demand Committee:

1) *Minimum Thermal and Lighting Standards*

Currently, states have been mandated to establish thermal lighting standards under the ECPA/EPCA federal legislation. However, no guarantee has been made that each state's standards will effectively induce conservation. This legislation would establish a *minimum* standard for all states in the New England region. In addition, it would provide monetary support for training programs for building inspectors since they will enforce the thermal and lighting standards.

2) *Life-Cycle Cost Analysis*

This legislation would require that a life-cycle cost analysis be performed on every proposed new or significantly renovated building. Such buildings would be denied a building permit unless both the initial capital cost and the life-cycle cost per square foot of floor area fell below established maximum standards.

3) *Truth in Energy*

This legislation would require building owners and/or energy suppliers to furnish to all prospective leasees or purchasers of a building or apartment disclosure statements of the total annual energy consumption of the relevant unit for the previous three years, broken out by month.

4) *Improved Heating Efficiencies*

Currently, tax incentives are provided to improve the efficiency of burners in a home. However, no incentives exist to correct other characteristics of a residence's heating system which may reduce its efficiency (e.g., stack dampers, oversized furnaces, out-moded furnaces). This legislation would provide for the development of a tax incentive program that will result in an overall improved efficiency of a residential heating system.

5) *Water Heaters*

This legislation would prohibit the installation of tankless water heaters in new and significantly renovated buildings.

6) *Pilotless Gas Appliances*

This legislation would require that all new gas appliances and gas space heating units be pilotless. In addition, it would require that the previously mentioned appliances be retrofitted upon resale.

B) *Issues of Concern*

The following are issues of concern which merit further study before legislation can be drafted.

1) *Energy Conservation in Multi-Family Dwellings*

A problem now exists regarding how to encourage energy conservation behavior in both landlords and tenants in multi-family dwellings; landlords must be encouraged to weatherize these dwellings and improve the efficiency of their heating systems, and tenants must be encouraged to reduce their heat consumption. Tax incentives may encourage landlords, while a means to encourage tenants may be to require them to pay for their heat. However, the abolition of mass metering, that is, prohibiting single metering of an apartment house may be counterproductive. Only electrical heating is conducive to individual metering. Therefore, electrical heating may indirectly be encouraged by such a prohibition.

2) *The Emergency Energy Assistance Program*

The purpose of this program is to relieve part of the energy cost burden which has fallen most heavily on the poor and near-poor as a result of several winter's severe weather and escalating energy prices. The priority of payment to these people is first to those who had energy bills outstanding and second to those with energy bills paid. The indirect result establishing such priorities has been that many people stop paying their bills; such actions have had a crippling effect on small oil dealers.

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3) *EPCA/ECPA Conservation Goals*

One of the provisions established in the EPCA/ECPA legislative actions was to mandate a goal for each state to reduce consumption in 1980 by five percent of what initial energy consumption figures had forecast. Many believe, however, that this goal is not strong enough; they claim that states aim for five percent reduction and no more.

4) *Energy Education*

One of the major problems in promoting demand modification is educating people on what conservation and alternative fuels are and what programs or incentives are available to them. Energy education is vitally important. One part of society where this education is noticeably lacking is among low income groups. The types of programs aimed at college-educated people (e.g., pamphlets on energy) are useless among the poor, many of whom lack a high school education. "Energy mobiles" may be useful education devices among these groups. Also, a developed energy education program has already been employed in the Energy Outreach Program administered by the Department of Agriculture. It may be useful to target one branch of this program to low income groups.

5) *Consumer Protection*

A major problem in promoting both energy conservation and alternative energy has been the poor quality of the work performed by some insulation and solar energy installers, and the poor quality of some of the materials used in insulation and solar installations. Consumer protection is clearly needed. Whether this protection should take the form of accreditation and testing within the trade or by the state has not yet been answered.

C) *Studies*

In attempting to determine the energy conservation potential of New England, it was discovered that very little good data exists on what the actual characteristics of the housing stock are. The reasons for this have already been listed in the section on conservation potential. It is important to know these characteristics, particularly as they relate to the socioeconomic level of the inhabitants of the houses, to develop legislation to encourage conservation. If the greatest heat loss occurs in middle or upper-income housing, a program of tax incentives and low interest loans could be developed to encourage conservation. However, if the greatest heat loss occurs in lower-income housing the program must consist more of subsidies to accomplish the same end. The Residential Demand Subcommittee therefore recommends that an in-depth program of determining the housing stock characteristics in New England be undertaken, broken out by the income level of the occupants of the residences. The information should be gathered by certified energy auditors who know how to accurately determine the heat loss characteristics of a building.

III. *Demand Projections*

The total residential consumption in the future will be dependent on the number of households. In turn, the number of households will be dependent on the future population and on the size of the families. Projections of these latter factors indicate a rising population and a decreasing size of the family unit; both will contribute to an increase in the number of dwelling units in New England.

Table 1 displays the population figures, number of persons per household, and number of households through 1977, and projects these numbers through 2000. In 1977 there were 12.326 million people in New England, 444,000 (3.73%) more than in 1970. Population increased at a 0.53%

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Table 1: Population, Persons Per Household, Households

	1960	1970	1971	1972	1973	1974	1975	1976	1977
Population (Thousands)									
Connecticut	2,544	3,041	3,077	3,080	3,080	3,086	3,095	3,117	3,162
Maine	975	997	1,010	1,026	1,039	1,049	1,056	1,072	1,071
Massachusetts	5,160	5,706	5,768	5,796	5,799	5,793	5,818	5,809	5,839
New Hampshire	609	742	758	774	794	803	818	822	841
Rhode Island	855	951	958	969	967	938	927	927	929
Vermont	389	445	453	460	466	468	473	476	484
New England Total	10,532	11,882	12,024	12,105	12,145	12,142	12,187	12,223	12,326
Persons (Per Household)									
Connecticut		3.26	3.23	3.15	3.10	3.06	3.01	3.02	2.98
Maine		3.22	3.23	3.18	3.13	3.11	3.04	3.01	2.98
Massachusetts		3.24	3.20	3.15	3.09	3.04	3.01	2.95	2.93
New Hampshire		3.30	3.23	3.17	3.13	3.10	3.06	2.98	2.98
Rhode Island		3.26	3.21	3.18	3.10	3.06	2.97	2.93	2.91
Vermont		3.38	3.31	3.24	3.19	3.12	3.08	3.03	3.01
Weighted Average		3.26	3.22	3.16	3.10	3.06	3.01	2.96	2.95
Households (Thousands)									
Connecticut		933	953	977	995	1,010	1,029	1,053	1,061
Maine		303	313	323	332	337	347	356	360
Massachusetts		1,756	1,800	1,840	1,879	1,906	1,936	1,971	1,990
New Hampshire		225	235	244	254	261	267	275	282
Rhode Island		292	298	305	312	307	312	316	319
Vermont		132	137	142	146	150	153	157	161
New England Total		3,641	3,736	3,831	3,918	3,971	4,044	4,128	4,173

(cont.)

	1978	1979	1980	1981	1982	1983	1984	1985	1990	1995	2000
Population (Thousands)											
Connecticut	3,216	3,270	3,326	3,347	3,369	3,391	3,413	3,435	3,534	3,636	3,741
Maine	1,083	1,095	1,107	1,115	1,122	1,130	1,138	1,146	1,171	1,196	1,222
Massachusetts	5,882	5,926	5,970	6,006	6,043	6,079	6,116	6,153	6,303	6,457	6,614
New Hampshire	866	892	918	938	958	978	999	1,020	1,108	1,203	1,306
Rhode Island	934	938	943	949	954	960	956	972	992	1,012	1,033
Vermont	496	509	522	527	533	538	543	549	568	587	607
New England Total	12,477	12,630	12,786	12,882	12,979	13,076	13,175	13,275	13,676	14,091	14,523
Persons Per Household											
Connecticut	2.94	2.91	2.87	2.83	2.80	2.76	2.73	2.69	2.61	2.52	2.44
Maine	2.95	2.92	2.89	2.85	2.82	2.79	2.76	2.73	2.65	2.58	2.51
Massachusetts	2.86	2.81	2.77	2.73	2.69	2.64	2.60	2.56	2.46	2.37	2.27
New Hampshire	2.88	2.83	2.78	2.74	2.69	2.65	2.60	2.58	2.45	2.35	2.26
Rhode Island	2.83	2.78	2.73	2.68	2.63	2.59	2.54	2.50	2.39	2.37	2.35
Vermont	2.92	2.87	2.82	2.77	2.72	2.67	2.62	2.57	2.46	2.35	2.24
Weighted Average	2.89	2.85	2.81	2.76	2.73	2.68	2.64	2.60	2.51	2.42	2.33
Households (Thousands)											
Connecticut	1,094	1,124	1,159	1,183	1,203	1,229	1,250	1,277	1,354	1,443	1,533
Maine	367	375	383	391	398	405	412	420	442	464	437
Massachusetts	2,057	2,109	2,155	2,200	2,246	2,303	2,352	2,404	2,562	2,724	2,914
New Hampshire	301	315	330	341	356	369	384	398	452	512	578
Rhode Island	330	337	345	358	363	371	380	389	415	427	440
Vermont	170	177	185	190	196	201	207	214	231	250	271
New England Total	4,319	4,437	4,557	4,663	4,762	4,878	4,985	5,102	5,456	5,850	6,223

SOURCE: G. Taylor, Connecticut Natural Gas

compound growth rate. During this same period, the size of families decreased from an average of 3.26 to an average of 2.95 persons per household. The 1985 population is projected to be 13.275 million, an increase of 949,000, or 7.7%. Family size is projected to decrease to an average of 2.69 persons per household.

The total residential consumption is also dependent on the residential consumption per household. Projections of this consumption are based on the 1970 and 1975 historical period and are adjusted to reflect normal weather conditions and the effect of the oil embargo of 1973 which resulted in a significant reduction in residential energy use. (It is not clear whether this energy reduction has been maintained. Some regions show increases in residential consumption. However, an analysis of 1977-1978 unit consumption in Connecticut indicates that average consumption was reduced by approximately 5 percent from the 1976-1977 period.) Table 2 shows household consumption through 1977 with and without the post-embargo conservation efforts, and it projects this consumption through the end of the century.

In multiplying the number of households by the residential consumption per household, a total consumption figure is reached. These numbers, also projected through 2000 are shown in Table 3. Table 4 displays both the residential energy consumption through 1985 and the fraction of that consumption that is electrical. (Data was not available on electrical consumption for all states.) Finally, Table 5 displays the rates of compound growth assumed for the various calculations.

Table 2:
Residential Consumption Per Household ($\times 10^6$ BTU)

	1978	1979	1980	1981	1982	1983	1984	1985	1990	1995	2000
Connecticut											
Normal Weather ¹	167.10	166.85	166.61	166.36	166.11	165.87	165.62	165.38	164.15	162.94	161.74
Adj. for Current Cons. ²	156.02	155.79	155.56	155.33	155.10	154.87	154.64	154.42	153.27	152.14	151.02
Maine											
Normal Weather Use	171.43	171.22	171.02	170.81	170.61	170.41	170.20	170.00	168.98	167.97	166.96
Adj. for Current Cons.	156.93	156.73	156.55	156.36	156.18	156.00	155.80	155.62	154.68	153.76	152.84
Massachusetts											
Normal Weather Use	167.01	166.69	166.36	166.04	165.72	165.40	165.08	164.77	163.18	161.61	160.06
Adj. for Current Cons.	162.57	162.26	161.93	161.62	161.31	161.00	160.69	160.39	158.84	157.31	155.80
New Hampshire											
Normal Weather Use	175.11	174.86	174.62	174.37	174.13	173.89	173.64	173.40	172.19	171.00	169.80
Adj. for Current Cons.	160.29	160.05	159.83	159.60	159.38	159.16	158.93	158.71	157.61	156.52	155.42
Rhode Island											
Normal Weather Use	170.16	169.71	169.27	168.82	168.38	167.94	167.50	167.06	164.89	162.74	160.62
Adj. for Current Cons.	156.46	156.05	155.64	155.23	154.83	154.42	154.02	153.61	151.61	149.64	147.69
Vermont											
Normal Weather Use	181.78	181.51	181.24	180.98	180.71	180.45	180.18	179.92	178.60	177.29	176.00
Adj. for Current Cons.	155.91	155.68	155.45	155.23	155.00	154.78	154.54	154.32	153.19	152.06	150.96

Notes:

- (1) Consumption trend for the period 1970-1973 adjusted to normal weather conditions.
 (2) Reflects the average reduction in consumption that occurred in 1974 from 1970-1973 projected levels.

SOURCE: G. Taylor, Connecticut Natural Gas

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Table 3:

**Residential Consumption Projected at
Current Conservation Trends (x10⁹ BTU)**

	1977	1978	1979	1980	1981	1982	1983
Connecticut	164.46	170.69	175.11	180.29	183.76	186.59	190.34
Maine	56.56	57.59	58.77	59.96	61.14	62.16	63.18
Massachusetts	324.13	334.41	342.21	348.96	355.56	362.30	370.78
New Hampshire	45.26	48.25	50.42	52.74	54.42	56.74	58.73
Rhode Island	50.04	51.63	52.59	53.70	55.57	56.20	57.29
Vermont	25.14	26.50	27.56	28.76	29.49	30.38	31.11
Total New England	<u>665.59</u>	<u>689.07</u>	<u>706.66</u>	<u>724.41</u>	<u>739.94</u>	<u>754.37</u>	<u>771.43</u>
	1984	1985			1990	1995	2000
Connecticut	193.30	197.19			207.53	219.54	231.51
Maine	64.19	65.36			68.37	71.34	74.43
Massachusetts	377.94	385.58			406.95	428.51	454.00
New Hampshire	61.03	63.17			71.24	80.14	89.83
Rhode Island	58.53	59.75			62.92	63.90	64.98
Vermont	31.99	33.02			35.39	38.02	40.91
Total New England	<u>786.98</u>	<u>804.07</u>			<u>852.40</u>	<u>901.45</u>	<u>955.66</u>

SOURCE: G. Taylor, Connecticut Natural Gas

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Table 4:
Residential Consumption (x10⁹ BTU)

	1977	1978	1979	1980	1981	1982	1983	1984	1985
Connecticut									
Households ¹	1061	1094	1124	1159	1183	1203	1229	1250	1277
Consumption per Household ²	167.35	167.10	166.85	166.61	166.36	166.11	165.87	165.62	165.38
Total Consumption ³	177.56	182.81	187.54	193.10	196.80	199.83	203.85	207.02	211.19
Electric Consumption ³	27.22	28.12	28.99	29.99	30.68	31.26	32.00	32.61	33.39
Maine									
Households ¹	360	367	375	383	391	398	405	412	420
Consumption per Household ²	171.64	171.43	171.22	171.02	170.81	170.61	170.41	170.20	170.00
Total Consumption ³	61.79	62.91	64.21	65.50	66.79	67.90	69.02	70.12	71.40
Electric Consumption ³	9.83	10.44	11.12	11.82	12.53	13.21	13.88	14.59	15.38
Massachusetts									
Households ¹	1990	2057	2109	2155	2200	2246	2303	2352	2404
Consumption per Household ²	167.33	167.01	166.69	166.36	166.04	165.72	165.40	165.08	164.77
Total Consumption ³	332.99	343.54	351.55	358.51	365.29	372.21	380.92	388.27	396.11
Electric Consumption ³									
New Hampshire									
Households ¹	282	301	315	330	341	356	369	384	398
Consumption per Household ²	175.36	175.11	174.86	174.62	174.37	174.13	173.89	173.64	173.40
Total Consumption ³	49.45	52.71	55.08	57.62	59.46	61.99	64.16	66.68	69.01
Electric Consumption ³	7.93	8.66	9.22	9.82	10.25	10.85	11.36	11.96	12.51
Rhode Island									
Households ¹	319	330	337	345	358	363	371	380	389
Consumption per Household ²	170.60	170.16	169.71	169.27	168.82	168.38	167.94	167.50	167.06
Total Consumption ³	54.42	56.15	57.19	58.40	60.44	61.12	62.31	63.65	64.99
Electric Consumption ³									
Vermont									
Households ¹	161	170	177	185	190	196	201	207	214
Consumption per Household ²	182.05	181.78	181.51	181.24	180.98	180.71	180.45	180.18	179.92
Total Consumption ³	29.31	30.90	32.13	33.53	34.39	35.42	36.27	37.30	38.50

Units

(1) Households - Thousands

(2) Consumption - Millions

(3) Total Consumption - x 10⁹ BTU

SOURCE: G. Taylor, Connecticut Natural Gas

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Table 5
Annual Compound Growth Rates - Percent

	Period				
	1970-1977 (7)	1970-1985 (4)	1977-1985 (1)	1977-2000 (0)	1985-2000 (8)
Population					
Connecticut	0.56	0.82	1.04	0.73	0.57
Maine	1.03	0.93	0.85	0.58	0.43
Massachusetts	0.33	0.50	0.66	0.54	0.48
New Hampshire	1.80	2.14	2.44	1.93	1.66
Rhode Island	(0.33)	0.31	0.57	0.46	0.41
Vermont	1.21	1.41	1.59	0.99	0.67
Total New England	0.53	0.74	0.93	0.72	0.60
Persons Per Household					
Connecticut	(1.27)	(1.27)	(1.27)	(0.86)	(0.65)
Maine	(1.10)	(1.09)	(1.09)	(0.74)	(0.56)
Massachusetts	(1.43)	(1.56)	(1.67)	(1.10)	(0.80)
New Hampshire	(1.45)	(1.68)	(1.88)	(1.20)	(0.83)
Rhode Island	(1.61)	(1.75)	(1.88)	(0.92)	(0.41)
Vermont	(1.64)	(1.81)	(1.96)	(1.28)	(0.91)
Total New England	(1.41)	(1.50)	(1.57)	(1.02)	(0.73)
Households					
Connecticut	1.85	2.11	2.34	1.61	1.23
Maine	2.49	1.03	2.25	1.32	0.83
Massachusetts	1.80	2.11	2.39	1.67	1.29
New Hampshire	3.28	3.88	4.40	3.17	2.52
Rhode Island	1.27	1.93	2.51	1.41	0.82
Vermont	2.88	3.27	3.62	2.29	1.59
Total New England	1.97	2.27	2.54	1.75	1.33
Consumption Per Household					
Connecticut	(1.44)	(0.70)	(0.05)	(0.11)	(0.15)
Maine	(1.46)	(0.75)	(0.12)	(0.12)	(0.12)
Massachusetts	(0.45)	(0.31)	(0.19)	(0.19)	(0.19)
New Hampshire	(1.39)	(0.72)	(0.14)	(0.14)	(0.14)
Rhode Island	(0.97)	(0.59)	(0.26)	(0.26)	(0.26)
Vermont	(2.31)	(1.16)	(0.15)	(0.15)	(0.15)
Total New England	(0.96)	(0.53)	(0.15)	(0.16)	(0.17)
Total Residential Consumption					
Connecticut	0.38	1.40	2.29	1.50	1.08
Maine	1.00	1.44	1.82	1.20	0.87
Massachusetts	1.35	1.80	2.19	1.48	1.09
New Hampshire	1.84	3.12	4.26	3.03	2.38
Rhode Island	0.29	1.33	2.24	1.14	0.56
Vermont	0.50	2.07	3.47	2.14	1.44
Total New England	0.99	1.74	2.39	1.58	1.16

Numbers in parenthesis indicate negative
SOURCE: G. Taylor, Connecticut Natural Gas

IV. Current Legislation

The following is a listing of both existing and pending legislation on the state and federal level which affects residential energy demand.

A. Connecticut

Existing Legislation

- 1) Property tax exemptions for solar and wind systems (until 1991).
- 2) Sales tax exemptions for solar energy systems (until 1982).
- 3) Thermal standards for all new and substantially renovated buildings (modified ASHRAE 90-75). Lighting standards are in draft form—Connecticut already has legislative authority to implement lighting standards.
- 4) Allowance made for municipalities to include energy considerations in zoning, subdivisions, and other local planning decisions. (Energy considerations include conservation, alternative energy, energy efficient settlement patterns.)

B. Maine

Existing Legislation

- 1) Property tax exemptions for solar heating equipment for five years after installation.
- 2) Sales tax exemptions for solar energy systems.
- 3) Establishment of a state solar hot water program (\$16,000 for 4400 grants).
- 4) Consumer protection legislation for insulation.
- 5) Sales tax exemption for the first 750 KW electricity used.
- 6) Lifeline electric service to older citizens.
- 7) Thermal and lighting standards for public buildings (ASHRAE 90-75).
- 8) Requirement that no public building or public school in excess of 5,000 square feet be built without first performing a life cycle cost analysis.

Pending Legislation

- 1) Thermal and lighting standards for buildings other than public buildings. There is presently no statewide code; of 156 municipalities that have some code or regulation, no city or town is known to have energy related standards incorporated into the code. The SEO is proposing ASHRAE 90-75 and HUD Minimum Property Standards for new and substantially renovated buildings.

C. Massachusetts

Existing Legislation

- 1) Property tax exemption for solar or wind energy devices.
- 2) Life cycle cost estimate for all new state and local building construction or additions which add 10% to the gross floor space and whose construction costs exceed \$25,000.
- 3) Requirement that state buildings maximize exposure to the sun.

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- 4) Authorization of state-chartered savings banks, co-operative banks, credit unions, and trust companies to make loans to finance the purchase and installation of solar or wind powered systems or heat pumps for up to ten years if the loan is secured by a mortgage on the subject real estate. Maximum loans are \$5,000 for a savings bank, \$12,000 for a co-operative bank, \$9,000 for a credit union and \$7,000 for a trust company, if, in all cases, at least \$2,000 of such loan is spent on the purchase or installation of the solar and wind system.
- 5) Sales tax exemptions on alternatives—solar, windpowered or heat pump systems—used as primary or auxiliary power system for heating or otherwise supplying the energy needs of an individual's principal residence.
- 6) Thermal standards for new and substantially renovated buildings (ASHRAE 90-75) and lighting standards for all new buildings except single family dwellings.
- 7) Establishment of the Massachusetts Home Mortgage Finance Agency which makes loans to mortgage lenders and banks to contract low and moderate income family rental housing. (Since this entity is a public corporation and receives state funding, it could be required to invest in alternative energy.)

Pending Legislation

- 1) Solar rights legislation—Would establish means to guarantee access to solar energy.

D. New Hampshire

Existing Legislation

- 1) Property tax exemptions for solar heating and cooling systems.
- 2) Requirement that New Hampshire utilities buy back excess power generated by small hydro.

Pending Legislation

- 1) Thermal and Lighting Standards. Presently there is no statewide building code.

E. Rhode Island

Existing Legislation

- 1) Property tax exemption for solar systems.
- 2) Requirement that oil produce deliveries be metered.
- 3) Thermal standards (ASHRAE 90-75) for all new and renovated buildings. Voluntary lighting standards for all buildings.
- 4) Sales tax exemption on personal property used in exploration for or production of offshore oil and gas.

Pending Legislation

- 1) Truth in Energy— Requires a statement of energy consumption patterns for real property to be provided by owners for prospective purchaser or leasee.
- 2) Used oil recycling.
- 3) Sales tax exemption for alternative energy systems.
- 4) Income tax exemptions for alternative energy systems.

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- 5) Solar rights and solar easements legislation.
- 6) Regulation in the insulation market.
- 7) Development of low-head hydroelectric facilities.
- 8) Nuclear facility siting legislation.

F. Vermont

Existing Legislation

- 1) Allowance for property tax exemptions for alternative energy systems to be adopted by cities or towns at the annual town meeting.
- 2) Income tax exemption for renewable energy systems—25% credit up to \$1,000 for residences on the installed cost of the system (until 1983).
- 3) Establishment of the Vermont Housing Finance Agency which provides low interest loans for energy-related improvements to low- and middle-income groups.
- 4) Allowance for cities and towns to appoint a town energy coordinator at the annual town meeting.
- 5) Allocation of \$124,000 to conduct an inventory of the state's forestlands.
- 6) Requirement of legislative approval for the construction of nuclear plants.

Pending Legislation

- 1) Thermal and Lighting Standards. Presently there is no statewide building code; those cities that have adopted local building codes have not incorporated energy standards into the code. SEO plans to recommend ASHRAE 90-75 for all new and substantially renovated nonresidential buildings including multifamily housing over three stories and Farmer's Home Thermal Performance Standards for all new and substantially renovated residential buildings.

G. Federal

Existing Legislation

- 1) Public Law 94-163 Energy Policy and Conservation Act. Provides money to each of the 50 states to develop and implement state energy conservation plans. Each state must: a) be designed to save an amount of energy equal to 5% or more of the state's projected 1980 demand; and b) contain programs to establish thermal and lighting standards for new and renovated buildings, right-turn-on-red legislation, energy procurement policies for state and local governments, and a car pooling-van pooling-mass transit program.
- 2) Public Law 94-385 Energy Conservation and Production Act. Amends previously enacted energy legislation, and provides money to states for implementation of Supplemental State Energy Conservation Plans.
- 3) H.R. 1466 (Cohen) Homeowner's Energy Conservation Act. Amends the Internal Revenue Code of 1954 to encourage greater conservation of energy in home heating and cooling by allowing individuals a credit of 25% of amounts paid or incurred for the installation of more effective insulation and heating equipment in existing residential structures. Introduced January 6, 1977.
- 4) H.R. 4757 (Reuss) Residential Energy Conservation Act. Provides for a federally

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financed low-interest loan program to save energy in residential dwellings. Introduced March 9, 1977.

- 5) S. 97 (Brooke, et al.) Energy Conservation Tax Credits for Residences and Small Business Amendment. Amends the Internal Revenue Code to provide tax credits for the installation of insulation and solar and wind energy equipment in residences and small businesses. Directs the Secretary of the Treasury to make a report to the Congress proposing an executive agency to evaluate new technologies and improvements in heating equipment. Disallows any investment credit for portable air conditioners or heating unit used primarily for human comfort. Provides an additional excise tax on gasoline sold between 1977 and 1981. Introduced January 10, 1977.
- 6) S. 198 (Griffin, et al.) Residential Insulation Credit Act. Amends the Internal Revenue Code of 1954 to allow a credit for expenditures for insulation of a taxpayer's own residence. Introduced January 12, 1977.
- 7) National Energy Act of 1978
 - a) Requires electric utilities to offer energy audits to their customers to identify appropriate energy conservation and alternative energy measures and to arrange the financing and installation of any such measures.
 - b) Extends through 1980 the Department of Energy (DOE) low income weatherization program.
 - c) Provides support for loans by the Government National Mortgage Association (GNMA) of up to \$8000 for the purchase and installation of solar heating and cooling equipment in residences.
 - d) Establishes federally-supported home improvement loans by GNMA for energy conservation measures aimed at elderly and moderate income families.
 - e) Mandates that DOE establish energy efficiency standards for 13 categories of major home appliances including refrigerators and air conditioning units.
 - f) Authorizes the Department of Housing and Urban Development (HUD) to establish grants and standards for energy conservation in federally-assisted housing.
 - g) Authorizes HUD to insure loans for conservation improvements in multi-family housing.
 - h) Establishes eleven standards on rate design including time-of-day rates and seasonal rates which must be considered by each state regulatory agency for their conservation potential and be adopted if the design induces conservation.
 - i) Establishes loan programs to aid development of small hydroelectric projects.
 - j) Provides for gradual deregulation of natural gas.
 - k) Gives a non-refundable income tax credit for residential insulation and energy conservation measures of up to \$300 or 15% of the first \$2000 expended.

- l) Gives a non-refundable income tax credit for residential installation of solar or wind equipment of up to a total credit of \$2200 covering \$10,000 of expenditures.

V. Energy Programs Affecting Energy Demand in the Low Income Sector

One of the greatest areas of energy waste is in the heating of buildings, which accounts for 25% of all the energy used in this country. This is one area in which the poor—often through no fault of their own—are wasting as much as anybody. Current studies show that the buildings we all inhabit are inadequately weatherized given the existing high prices of energy.

There are several programs that have been instituted to meet this crucial need of energy conservation, namely: weatherization, winterization, emergency energy assistance, rural home repairs, and farm home administration low interest energy loans.

An honest and genuine attempt has been made to evaluate these programs and determine the impact on the quantity and quality on conservation and energy reduction. The data, some of which is used here in its totality, comes from the specific groups involved in energy programs including the following reports: *Annual Report to the President and the Congress on the Weatherization Assistance Project* (prepared by Department of Energy, 3/78); *An Inventory of Federal Program Assistance Potentially Available to Help People With Inflated Energy Costs* (prepared by the Federal Executive Board, 1/78); telephone surveys and/or written communications with all the New England Energy Coordinators from the SEOO's and the CAA's; *Impact of Reduction in CETA Labor In Region 1 on Weatherization Assistance Program* (prepared by the Director of Solar and Resource Applications for DOE, 8/3/78); *Impact of the New England Regional Commissions's Low-Income Winterization Program* (prepared by Urban Systems Research and Engineering, Inc., for NERCOM, 8/4/78).

Available data from each corresponding agency involved in weatherization and/or related energy programs has not been compiled by the appropriate agencies to the degree necessary to provide accurate profiles of the various programs. Incompleteness and/or ambiguity of information reflects the limitations of an accurate evaluation of weatherization and related programs.

At a level which is difficult to determine with accuracy from available data, this means the amount of money available has always been inadequate to meet the need, and the availability of funding is not always timely.

Although, from the lack of a complete and accurate evaluation of the various energy programs in Region I, it is difficult to assess the total impact that such programs could have, a report is presented here of the findings, recommendations, and proposals and, where possible, an attempt has been made to quantify the benefits in terms of dollars. Among the various energy programs for the low-income community, winterization programs have in many ways been the most successful and had the greatest impact on energy conservation and demand reduction. The Community Service Administration, the Department of Energy, the New England Regional Commission, and several manpower training programs, including CETA, have provided 21.1 million dollars over the last three years to winterize the homes of low-income families. These funds are distributed by the six New England states to local Community Action Agencies which perform the actual Winterization. The agencies use the funds from CSA, DOE, and NERCOM to caulk and weatherstrip windows and doors; to install windows and doors; to install storm windows; to insulate ceilings, floors and walls; and to adjust furnaces. The result is reducing the cost of home heating for low-income families, conserving energy and to providing employment for those who perform the winterization work.

In addition, Winterization would produce other benefits, namely: increased comfort and improved health for winterization clients; improved training of CETA workers (one-third of whom

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have found jobs after winterization in construction-related activities; decreased dependence on foreign sources of energy through the conservation of 42 million gallons of fuel oil which would otherwise be imported; a shift of consumption from fuel to other goods and services which will cause an increase in economic activity in New England of \$700,000.

The homes of approximately 27,200 low-income families have been winterized in New England, and an additional 1000 oil burners adjusted over the last three years.

Fuel savings have averaged about 25% in the first heating season, which in the case of an oil-heated home amounts to 300 gallons. Allowing for the gradual loss of effectiveness over time, the energy equivalent of over 80 million gallons of fuel oil will be saved over the lifetime of the improvements. The fuel savings have a present value of \$45 million, compared with the \$21 million investment for all winterization activities. This represents an internal rate of return in real terms of 16%.

Because of a lack of flexibility these funds do not have the impact on the quantity and quality of weatherization that they would if the sources of funds were less restricted by regulation. If flexibility is allowed, program continuity could be maintained in the face of gaps between grant periods of different programs.

Changes are currently pending in DOE and CSA regulations which will have definite effects on the programs. The pace of winterization will certainly be slowed and the programs less effective if the regulations remain as they are now, impracticable.

If the programs continue with the same format as the last three years, the real rate of return on its investment will continue to be at least 16%. More than 300,000 eligible low-income homes remain to be winterized in New England, a backlog of 25 years at the current rate of activity. Continued funding would contribute to saving fuel and dollars. Because of the backlog, winterization programs can effectively continue to use funds at the current rate, or even a substantially higher allocation. If funding falls significantly below the current level local winterization programs may find their share too small a percentage of their total budget to have a significant impact.

The following appendices A and B contain data on the results and benefits of winterization programs. This information first appeared in *Impact of the New England Regional Commission's Low-Income Winterization Program* published by NERCOM. The results presented here in tabular and narrative form include: the outcome of winterization activities in terms of the number of homes winterized; the types of benefits that have resulted from the overall investments (DOE, CSA, NERCOM) in winterization, and estimates of their value; the potential future of winterization programs; rate of return of winterization; etc.

VI. Appendix A

Exhibit 1 provides a complete breakdown of the sources of funds for the weatherization programs during the past three years.

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Exhibit 1 Sources of Winterization Funds

FY 1976-1977 (\$ in Thousands)														
	CT		ME		MA		NH		RI		VT		N.E.	
	\$	%	\$	%	\$	%	\$	%	\$	%	\$	%	\$	%
NERCOM	325	34	340	13	412	22	317	24	308	21	317	25	2,019	21
CSA	145	15	1,516	57	500	26	645		614	43	542	43	3,962	42
State									350	25			350	4
CETA	200	21	500	19	980	52	361	27	151	11	406	32	2,104	27
Title II*	285	30											285	3
New Title XX			300	11									300	3
Total	955		2,656		1,892		1,325		1,425		1,267		9,520	

FY 1978 (\$ in Thousands)														
	CT		ME		MA		NH		RI		VT		N.E.	
	\$	%	\$	%	\$	%	\$	%	\$	%	\$	%	\$	%
NERCOM	81	5	85	4	103	2	74	12	77	9	79	4	500	4
CSA	196	11	730	39	1,500	32	76	13	406	47	1,120*	60	4,028	34
DOE	394	77	433	23	726	16	252	42	227	26	261	14	2,293	20
State			92	5									91	1
CETA			400	21	2,300	50	197	33	154	18	408	22	3,459	30
Title II*	1,123	62											1,123	10
New Title XX			150	8									150	1
Total	1,1794		1,890		14,629		599		864		1,868		11,644	

*Title II "Anti-Recessionary" grant funds run from April 1977 through April 1979. They have been allocated to fiscal years as if spent uniformly during the period.

**Includes more than \$700,000 in reprogrammed Special Crisis Intervention Program (SCIP) funds. Source: SEO Winterization staff; SFOO files.

Exhibit 2

Total Low-Income Housing Units Winterized

New England States

Through June, 1978

State	Total \$ Spent (in Thousands)	Units Weatherized	Expenditure Per House
Connecticut	2,700	3,300 (to 5/31/78)	\$830
Maine	4,500	5,900	\$760
Massachusetts	6,500	7,000 (est.)	\$930
New Hampshire	1,900	2,600*	\$730
Rhode Island	2,300	3,500	\$650
Vermont	3,100	4,900 (to 3/31/78)	\$640
NEW ENGLAND	21,100	27,300	\$780

*Does not include approximately 1,000 oil burners adjusted.

Pre-winterization average fuel use figures were obtained from State Energy Offices for the six New England states. The average of these estimates, 1200 gallons for oil-heated homes, was used as a baseline; to account for climatic variations among the states, the 1200 gallon New England average was adjusted according to the average number of degree days in each state. Comparable estimates were calculated for natural gas and electric heat.

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Combining these figures with the number of winterized homes as shown in Exhibit 2, the total amount of energy saved in the first year after winterization was calculated. The results, shown in Exhibit 3, are that 6.1 million gallons of oil 173 million cubic feet of gas and 35 million kilowatts of electricity were saved in the first year. As a point of reference, if all the winterized homes had used oil for heating, the fuel savings in the first year would have totalled 8.2 million gallons.

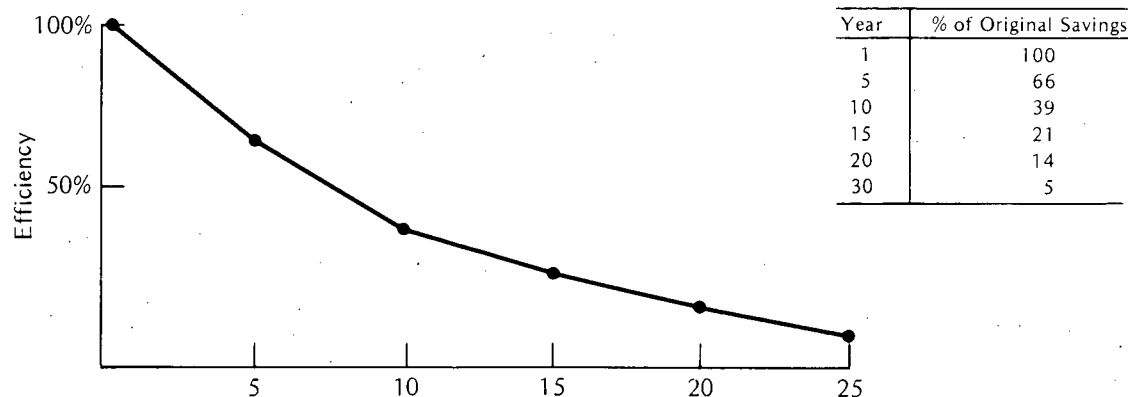
State	Degree Days	No. of Houses	BTUs Saved per house 10 ⁶ BTU	Total BTUs Saved 10 ¹² BTU	Oil 10 ⁶ Gal.	Gas 10 ⁶ cu. ft.	Electricity 10 ⁶ KWH
Connecticut	6,100	4,900	16	.12	.54	31.8	3.9
Maine	8,000	2,600	48	.28	1.78	5.5	9.1
Massachusetts	6,200	5,900	37	.26	1.23	68.3	5.3
New Hampshire	7,500	3,300	45	.12	.61	12.6	5.8
Rhode Island	5,900	3,500	35	.12	.56	38.9	2.2
Vermont	7,900	7,000	47	.23	1.34	15.7	8.1
NEW ENGLAND	7,000	27,300	42	1.13	6.06	173.	34.5

Two factors affect the reliability of these estimates: the uniformity of winterization techniques and the behavior of winterization clients.

Winterization improvements cannot be expected to last forever. Weather-stripping and caulk wear out in a few years, storm windows can lose their effectiveness suddenly through breakage, or more slowly as they become loose. Even insulation loses some of its effectiveness as it settles. Insulation, particularly cellulose insulation, can lose its effectiveness more rapidly if it gets wet. Improperly installed insulation may be subject to condensation of water vapor, which causes the insulation to compact.

The rate of decay of winterization fuel savings can be measured by keeping yearly records of fuel use and adjusting them for variations in the severity of winters. Winterization programs in New England have not kept these records on a systematic basis; nor do they have a long enough history to allow conclusions about the long-term effectiveness of the winterization improvements. Based on published analyses and interviews with weatherization officials, it is clear that there is considerable uncertainty about the life expectancy of these improvements. A pessimistic assumption, which is used in determining fuel savings, is that winterization improvements lose 10% of their present effectiveness each year. This is shown graphically in Exhibit 4.

Exhibit 4
Duration of Fuel Savings: Rate of Decline of Winterization Effectiveness



The 10% decay rate results in fuel savings over the life of winterization that are 10 times those experienced in the first year. The total savings of oil, natural gas and electricity, over the life of the winterization improvements are shown in Exhibit 5, which also shows that if all the winterized homes used oil heat, a total of 82 million gallons of oil would be saved.

Exhibit 5
Cumulative Energy Savings Over the Lifetime of Winterization Materials

State	Assuming All Energy is Consumed as Oil 10 ⁶ Gal.	Estimated Breakdown		
		Oil 10 ⁶ Gal.	Gas 10 ⁶ cu. ft.	Electricity 10 ⁶ KWH
Connecticut	8.7	5.4	320	39
Maine	20.4	17.8	55	91
Massachusetts	18.7	12.3	682	53
New Hampshire	8.5	6.1	126	58
Rhode Island	9.0	5.6	389	22
Vermont	16.6	13.4	157	81
NEW ENGLAND	81.9	60.6	1,728	345

Exhibit 6 presents the present value and internal rate of return for the overall weatherization program in the New England area. The internal rate of return.

Exhibit 6
Rate of Return of Winterization

State	Cost \$10 ⁶	Present Value \$10 ⁶	Internal Rate of Return %
Connecticut	2.7	5.1	13
Maine	4.5	10.8	19
Massachusetts	6.5	10.0	9
New Hampshire	1.9	5.9	24
Rhode Island	2.3	4.8	15
Vermont	3.1	9.2	25
NEW ENGLAND	\$21.1	\$45.5	16%

The results presented here clearly indicate that the winterization activities have resulted in benefits substantially greater than the costs of its investment. But these numbers do not tell the whole story. In addition to the amount of the benefits, one must also consider the distribution of the benefits. The direct beneficiaries of winterization programs are the needy, the old, and the cold. The program has enabled thousands of families to achieve the basic level of physical well-being that most of us take for granted.

In addition, the emphasis on supervisory personnel for winterization crew workers in the program benefits another group of low-income individuals. By improving the productivity of winterization labor, the program not only increases the efficiency of winterization, but the skills and effectiveness of the individual worker as well. The crew workers, formerly unemployed, are more likely to remain gainfully employed after their winterization training, and less likely to return to the unemployment rolls.

Cost savings by low-income households and improved job training result in indirect benefits to the taxpayers of New England and the country. The savings from winterization reduce the dependence of low-income households on state and federal income assistance programs. In most cases this impact is indirect, but in a few cases reported by winterization officials, there is a direct savings to state and local governments that were paying for fuel bills before winterization. The training of workers results in reduced welfare and unemployment compensation costs which are borne by taxpayers.

The future role that CSA, DOE and NERCOM will pursue in low-income home winterization is obvious upon examining the number of low-income homes that need to be winterized.

Estimates provided by the SEOOs in New England show that there is unfortunately no danger of running short of eligible houses. Exhibit 7 summarizes best available estimates of eligible houses remaining to be winterized. These figures should be compared with the approximately 27,000 houses that have been winterized by all six states combined through dates of their most recent calculations (see Exhibit 2).

Exhibit 7

Eligible Low-Income Dwellings Remaining to be Winterized, Estimates for New England States, July 1978

State	No. of Units
Connecticut	60,400
Maine	(greater than) 100,000
Massachusetts	(greater than) 100,000
New Hampshire	19,400
Rhode Island	25,500
Vermont	(greater than) 12,000
NEW ENGLAND	(greater than) 317,300

There are estimated to be about 12 times as many eligible dwellings remaining to be winterized as have already been completed—more than 25 years of work at current program levels. Given further deterioration of other housing units during this period, as well as possible increases in energy-efficiency standards, it is apparent that home winterization will not be a short-lived phenomenon.

In fact, because of the huge backlog of remaining work, an argument might be made for continuing immediately funding to speed up the task. This approach would result in larger amounts of fuel and dollars saved sooner; which means not only that savings would be achieved, but also that the present value of total savings over time would be increased.

While the intended purposes of these programs are immeasurably worthwhile, regulatory restrictions prohibit the successful implementation and the intended outcomes are slowed down and often cannot be reached.

Region I conducted a telephone survey of DOE grantees to determine the weatherization crew manpower status, as of June 30, 1978, for the Weatherization Programs being operated by the 68 Community Action Agencies (CAA) in the region. The areas of concern were: (a) the current level of crew manpower, including Title VI CETA slots; (b) the need for replacements as the CETA contracts for FY'78 expire; and (c) the optimal manpower levels to ensure that the DOE weatherization goals are met.

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The results of the survey clearly illustrate the potentially damaging impact that the impending CETA labor crisis can have on the DOE Weatherization Assistance Program in Region I. For example, as the CETA programs expire between June 30, 1978 and the end of FY'78, all but 179 of the 511 Title VI CETA workers currently on-board at CAAs in the region will have been terminated. Replacements for 332 expiring slots is imperative.

According to the telephone reports from grantees, the manpower status of Title VI slots on October 31, 1978 in each state will be as shown in the following table:

Grantee	Manpower Status as of June 30	Manpower Status as of October 31	Total Slots Needed to Achieve Goals
ME	55	25	89
NH	20	10	39
MA	218	87	320
VT	56	40	59
RI	44	0	72
CT	61	17	107
Region Total	454	179	686

While it is evident from the above figures that replacements for the expiring slots are imperative, the grantees estimate that an additional 354 slots will be needed over and above the 332 replacements in order for the CAAs to gear up their programs to a manpower level that will ensure that the regional weatherization goals are achieved. Given the present manpower level, along with the projected attrition rate, the subgrantees will simply not be able to reach the projected target of weatherizing 20,815 dwelling units through the first quarter of 1979. Preliminary reports for the period ending June 30, 1978 indicate that the six grantees in the region have weatherized approximately one-third of the units projected in the state plans for the period. Although the slow start-up in Region I has not been due solely to labor problems, the labor projections for the remainder of the fiscal year, as well as for FY'79 will certainly compound an already difficult situation.

The weatherization plan developed under the FEA guidelines provides an inadequate and inconsistent program for low-income people. In an attempt to establish a uniform national policy, the DOE regulations fail disastrously in their regional and state application. The FEA final rule (Fed.Reg.Vol.42, no. 105) removes state and local decisions, ignores the necessity of skilled labor and does not fulfill its stated objectives of concerning energy for those persons least able to afford higher energy costs.

Usually energy conservation measures are undertaken before cracks, broken windows, holes in floors and roofs, etc. are repaired. No combination of other more expensive home improvements can be effective until the rapid loss of heated air through these basic flaws is stopped.

Work accomplished by the various CAP agencies in the New England region as a result of weatherizing several hundred homes over the past two years, has clearly shown the areas where problems are likely to occur and what is necessary to bring these homes up to the point of "practical energy conservation". These items are barely included or totally dropped by the regulations.

Past experience has shown that no matter how well intentioned, unskilled volunteers or CETA workers, when they can be obtained, do not answer the skilled carpenters to determine materials, evaluate homes, supervise and coordinate winterization efforts on the hundreds of homes we have to work on.

CETA trainees do not reflect a commitment to do a quality job for poor people, for they often

are not trained properly because of time spent in training, and most of the times produce a hasty or slipshod job which does not produce significant savings in energy costs over a long period of time.

Use of volunteers can often provide good public relations and can contribute substantially to the development of community support, but it does not provide the varied experience and ability of skilled paid labor, and it therefore does not secure even with the stressed imagination a job done well.

Many of the homes are in rural areas, yet the allowance of transportation is minimal, barely any funds are permitted for tools for the application of materials and entire categories of essential work are virtually eliminated. Roofing, bulkheads, window replacement, doors, and minor furnace repairs are not cosmetic items, they are critical needs of families and they are only covered in a fifty dollar category.

The winterization program is crippled by the New England Regional Commission funds for labor cut by 75% and the severely reduced CSA funds.

The DOE's allocated funds cannot be a realistic effort to effectively continue a program and include skilled labor, supervision, training, transportation and tools. A review and revision of the DOE regulations are absolutely necessary, because the current DOE regulations dilute and remove the programs from the very people it is trying to assist and who most desperately need this work carried out on their homes.

It is important that legislation allowing sensitive regulation and implementation begin immediately so that we may begin to take advantage of the opportunities this challenge offers. Legislation should provide the Community Services Administration as well as HUD, and DOE through Community Action Agencies, CDC, SEOO's and other non-profit organizations serving the poor, a special opportunity to reassure a position of leadership in the meeting of a problem that will eventually be seen to be of vital interest to all. Agencies will be able to lead communities in the understanding and application of energy conservation techniques required in this time of scarcity and high price. Agencies will have the opportunity to foster training and employment opportunities in the field of weatherization that will have a real and growing future in a context of increasing awareness of the dimensions of the problem. Agencies will have the option of the home weatherization field, expanding the markets for services based on existing technology, and creating new markets out of developing technologies.

The old adage "Waste not, Want not" is taking on new meaning for growing numbers of people for whom waste has always been a way of life; as long as they had enough money, they could always buy the "Want not" part. In the face of depleted supplies, this practice cannot continue.

This is perhaps the only area where the poor, by eliminating waste, can cut down on their expenses. For a family living in an uninsulated home, relatively simple energy conserving home improvements can save up to 50% of their energy costs. At the same time that they are saving their precious dollars in their limited budget, they will be helping in the overall problem of conserving the decreasing supply.

And as programs such as the weatherization program pioneer in the application of optimal combinations of energy conservation techniques, the poor will have something to demonstrate to the rest of society; the non-poor will have to learn new ways from those who have never been able to afford to waste. And the better the job is done, the more there will be to go around and the more chance there will be for the poor to get their fair share.

In addition to existing programs, legislation must be introduced to provide for alternative residential energy conservation-related activities. The following deserve consideration, at least, as near-term alternatives:

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1) *Provide funds for practical research.*

For example, data collection and development of better techniques for measuring the results of winterization. Another example, research on installation of cellulose insulation with emphasis on moisture control.

2) *Provide a source of materials funds for clients with incomes 100-125 percent of poverty guidelines.*

An advantage of this is that households falling into the relevant income category can easily be identified from their applications, so that funds could be easily targeted.

3) *Provide funds for an expanded fuel burner test program.*

An oil burner program of some type instituted instead of, or in addition to, other types of winterization. Taking the New Hampshire program as a model with costs of \$25 per burner, average savings in the first year of about \$75, and an intended three year cycle. With such a low per-unit cost and a high, rapid payback, a burner test program seems to have many advantages.

4) *Provide funds for specified repairs.*

For example, funds to provide substantial home repairs before performing winterization, in order to make the winterization worthwhile.

5) *A multi-faceted energy consumer education program.*

For example, a program combining conventional winterization, consumer education, furnace repair and adjustment, household behavior patterns such as adjusting thermostats down at night, etc. Effective consumer education may prompt middle and upper income households to have, for example, their furnaces adjusted, thus achieving still greater fuel savings with little or no increase in public expense. For these higher-income households, awareness of energy-related savings through burner tune ups could also result in other more extensive energy conservation measures—all privately financed and all reducing fuel consumption in New England.

Everyone has a lot to learn about energy conservation in these times of high prices and dwindling supplies.

Optimal combination of energy home improvements should be set up by every homeowner of all socioeconomic backgrounds thus securing savings of energy. An unbalanced combination of improvements could be a waste of money.

Most of the 40 million owner occupied houses in this country could use additional insulation to offset sharply rising energy prices.

The higher the cost of energy, the greater will be the savings from increased conservation improvements, so that even in the same climate, houses with different energy sources require different levels of improvements.

The best combination of energy conservation improvements depends equally on climate and energy prices, so that when prices for home heating oil doubled in Washington, D.C., the effect on a homeowner's heating bill was the same as physically moving his house to Minnesota.

VII. Appendix B

Summary of Existing and Proposed Federal Weatherization Regulations

A. The CSA Weatherization Program

Since being signed into law in January, 1975, the CSA Emergency Energy Conservation Services Program has been governed by CSA Instruction 6142-1 (July 1976). Historically, winterization and crisis intervention have received overwhelming emphasis by CSA Energy grantees. Consequently, most of the revisions dealt directly with these two programs.

The first Instruction basically outlined program grantee eligibility, targeted the client population, defined program activities and program operators. Significant among these is the client eligibility limit, set at 125 percent of the national poverty guidelines. It also set budgetary requirements—at least 90 percent of weatherization funds to be used for materials costs, and a local matching share of program costs to be raised. Priorities for winterization activities were defined and per house materials cost limits were set at either \$250 or \$350 (\$350 applicable in New England).

Instruction 6143-1a was developed to clarify these regulations, providing more substance to the broad guidelines of its predecessor. The revised Instruction left unchanged the requirement that 90 percent of the allocation be used for the costs of materials; but in recognition of the problems experienced by many CAAs broadened the definition of materials to include the costs of transportation, tools and equipment. In situations where CAAs had documentation of unsuccessful attempts to obtain crew labor, supervisory labor or transportation costs from other sources, the Instruction made it possible to obtain waivers to use CSA funds. At the same time, however, CSA reaffirmed its requirements that only 10 percent of project funds be used for non-materials costs. For most agencies, the local matching share was increased from 20 to 40 percent for winterization activities.

At present, CSA's regulations with respect to funding labor are more flexible than they initially were; but crew labor is still considered an unusual expense, approvable only by waiver. Supervisory labor, not available through CETA, must be covered in many areas by CSA funds, thus reducing the CSA allocations available to support increasing DOE allocations for materials (see C.2, below). *In New England, however, NERCOM winterization funds have been available expressly to provide supervisory labor, thus also conserving CSA funds for other uses.*

B. Pending Changes to the CSA Program

Changes in the CSA Energy program have been pending since November 1977, as proposed Instruction 6143-1b. Intended to address specific problem areas, the primary impact on the winterization program would be a liberalization of current program provisions. Currently proposed changes include the following:

- 1) The minimum portion of winterization funds allocated to materials would be reduced from 90 to 60 percent. The cost of storing materials would be included as an allowable materials cost.
- 2) Materials cost limits per unit would be increased from \$250 to \$350 to \$800.
- 3) The routine non-federal share for winterization would be reduced from 40 percent to 20 percent.
- 4) Permanent supervisory staff for the Energy program could be paid directly with CSA grant funds. These expenditures would be considered to be program rather than administrative costs.
- 5) Repair and replacement of heating systems would be included as allowable winterization activities.

C. The DOE Winterization Program

The DOE winterization program, legislated in 1976, was originally intended to supplement the CSA program by providing additional material funds. Some of the principal differences from the CSA program include a household income eligibility ceiling of 100 percent of national poverty guidelines, instead of the \$350 CSA limit; and a statutory, rather than regulatory, maximum of 10 percent of winterization grants allowed for administration—which means that DOE cannot allow variations by waiver, as CSA can. The DOE program can fund no crew labor of any sort. On-site supervisors and administrative personnel may be paid with DOE funds; but these costs presently must be taken from the 10 percent of funds allocated to administration.

The net result of these requirements has been frequent criticisms from winterization agencies that the DOE program is unworkable as presently structured. Although intended to supplement the CSA program, it is common today for CSA to waive its own regulations, solely to properly support the plentiful but restricted DOE funds. As described more fully in Section 2.3, NERCOM winterization funds are perceived as necessary by the New England states to pay for costs that enable the winterization program as a whole to operate more effectively.

D. Pending Changes to the DOE Program

The Carter Administration has expressed the desire for all federal weatherization programs to operate from the Department of Energy. This implies that the DOE program must change from a supplementary to a primary program. To achieve this change, the legislative authority for DOE weatherization has been revised and included in the National Energy Bill (HR 8444). That Bill, however, gives little promise of passing Congress in the foreseeable future—because of other provisions having nothing to do with low-income weatherization. Consequently, DOE has prepared revised regulations based on its present legislation; these are expected to be released in the near future.

E. Pending Legislative Changes

Provisions the National Energy Bill being considered by Congress at this writing would render the DOE program more nearly identical to the CSA program as developed in Instruction 6143-1b—the most comprehensive and liberal of the CSA regulations. Under these provisions, income eligibility of participants would be increased to 125 percent of poverty guidelines; weatherization costs per house would be raised to \$800; and “materials” would be defined more broadly to include tools, certain specified energy-saving devices, transportation of labor and materials to job sites, on-site supervisory personnel costs and incidental repairs to heating systems costing no more than \$100.

F. Pending Regulatory Changes

The regulatory changes proposed by DOE are considered as a short-term alternative, to be used until new legislation is passed. Their importance to this discussion is to illustrate the flexibility that may soon be introduced into the DOE program regardless of the fate of the National Energy Bill.

The principal change would be in the interpretation of the term “materials.” As at present, a minimum of 90 percent of DOE weatherization funds would be spent for materials. However, the proposed regulations would allow up to 30 percent of the grant to any state to pay for transportation (mileage), purchase or lease of vehicles or equipment, operation and maintenance of vehicles, and *on-site supervisors*. Thus, supervisory labor costs may in the future be charged to the 90 percent materials portion, instead of the ten percent administration portion of a DOE grant. Alternatively,

purchases of vehicles and equipment could be approved by states. Currently, vehicle purchase or lease is prohibited, while equipment costs are limited to \$50 per item.

G. The Conservation Potential in the Residential Sector

A major requirement for estimating how much energy can be saved in the residential sector of New England is knowing the characteristics of houses in New England today. Such data simply does not exist. Some surveys have been taken to determine levels of insulation in houses and whether storm windows, storm doors, and weatherstripping have been installed. These include Project Conserve, sponsored by the federal government, and regional surveys by Northeast Utilities and the U. S. Census Bureau. Yet, such surveys are incomplete for several reasons. First, the survey limited geographical regions. Second, they are aimed at middle-and upper-income families living in single family homes, only a fraction of the actual housing stock. Third, the information gathered is overly optimistic because those answering the surveys often do not know the characteristics of their homes (e.g., how much insulation is in the walls) and because they do not want to appear energy wasteful.

Since no reliable surveys have been taken, models have been developed to estimate what New England's housing stock looks like. The most complete of these is the NEEMIS model developed by Richard Daifuku which is currently being used by the New England Regional Commission. Daifuku divides the current housing stock of New England into five categories; single family-detached houses, single family-attached houses, multi-family low-rise buildings, multi-family high-rise buildings, and mobile homes. He then estimates insulation, storm window, storm door, and weather-stripping levels in these buildings as a function of their age.

The Daifuku model appears reasonable in its assumptions about the age and distribution of the housing stock. However, after discussions with energy auditors, building contractors, and insulation installers throughout the region, it appears that the model is too optimistic in its estimates of weatherization levels. Therefore, the levels have been altered to what is believed to be more realistic ones. Two major differences exist between the Daifuku "base case" and the new "base case." First, Daifuku assumes that the majority of residences built before 1940, which make up the largest portion of the New England housing stock are insulated. The new base case assumes most of the pre-40 stock is uninsulated. Second, Daifuku's estimation of the general thermal performance of all New England housing stock is considerably higher than the performance assumed in the new base case. The new base case predicts increased fuel consumption as compared with the Daifuku base case.

Once the weatherization characteristics of the housing stock have been modeled, the question must be addressed regarding how much fuel can be save if weatherization levels of the existing stock are improved. Of course, fuel savings depend on the amount of weatherization. Five models were developed assuming varying degrees of weatherization improvement. The first four assumed that increasing amounts of capital were invested in improvements which have the highest rates of return. The fifth model assumes that all residences have been brought up to "ideal" standards. The relative energy savings between the base case and the five improved weatherization cases will then be determined. Preliminary runs indicate that insulating all homes to the ideal standard could cut the amount of fuel required for space heating in half. The total cost of each of the five improved weatherization programs has not yet been calculated, but will be in the future.

It is important to realize that the value of using the NEEMIS model to derive the energy savings is limited for two reasons. First, the NEEMIS model is only a model and not an accurate portrayal of what the housing stock actually looks like. Residences are assumed to be one of only five types and each type of house is assumed to have the same

dimensions and the same level of weatherization. Clearly these are oversimplifications. Second, there are still some errors in the program itself. The NEEMIS model falsely mandates the levels of insulation in the walls, ceiling, and basement floors in multi-family high-rise dwellings and mobile homes to be zero, thereby leading to an overestimate of the energy demand of these structures. (Since these structures do not make up the bulk of the housing stock, these errors are not glaring, however.) Also, an error exists in the program in calculating the temperatures of attics and basements, which leads to an underestimate of the energy demand of the structures. Yet the differences in fuel demand caused by these errors seem to be well within the uncertainty of the entire model. In fact, in correcting other errors in the model, it was noticed the corrected numbers never varied more than ten percent. The true value of the NEEMIS model is to demonstrate that there is a clear weatherization conservation potential in the residential sector, be it 40, 50 or 60 percent at its maximum, and that even a small capital investment can lead to a measurable energy savings.

Obviously, energy consumption in the residential sector can be reduced by means other than weatherization, and it is important to estimate the contribution to conservation these other methods make. The Residential Demand Subcommittee therefore will also estimate in the future the conservation potential by implementing the following:

- 1) Turning thermostats down, particularly during sleeping hours.
- 2) Improving the overall efficiencies of the heating systems in residences.
- 3) Converting from the use of highly wasteful conventional fuels for heat such as electricity to less wasteful ones.
- 4) Converting from the use of conventional fuels for heat to alternative fuels such as solar or wood.
- 5) Improving the efficiencies of such consumptive household appliances as refrigerators and air conditioning units.

Commercial Sector

The following seven recommendations were made by the Commercial Subcommittee and adopted by the full committee. The explanatory comments accompanying each recommendation were in some cases subjected neither to vote nor discussion by the committee.

I. RECOMMENDATIONS*

- 7) *There should be a locally-operated federally-supported review process which will insure that all new commercial buildings are designed and built to provide for cost-effective conservation, prudent fuel choice, and desirable operational flexibility, without imposing undue regulatory burdens.*

The Commercial Subcommittee felt that conventional thermal and lighting standards are not sufficient. They felt that both overall building performance standards and analysis of life cost of energy systems should be considered as possible regulatory tools. Both could be tested for effectiveness and efficiency in pilot programs on governmental buildings.

- 8) *A disproportionately large share of governmental efforts to promote or require energy conservation should be focused upon new construction in the commercial sector.*

*Recommendations are numbered as they appear in the Demand Committee's introductory section.

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The Commercial Subcommittee felt that the commercial sector is likely to continue to grow faster than the others. It also felt that the best time to make a building energy efficient is before it is completed. While new commercial buildings are only one part of New England's energy picture, they may present the single most important opportunity we have to help ourselves.

- 9) *More stringent regulatory requirements should be imposed upon larger new buildings than upon small.*

To do so would be to take advantage of economies of scale in both conservation and regulation.

- 10) *The design of new commercial buildings to foreclose as few retrofit options as possible should be encouraged or required. Many energy options which are now little used may play a major role in the future. Examples are roof-top solar collectors, electric heat pumps and district heating systems. Thoughtful design can insure that these options remain available, even if not utilized when a building is built.*

- 11) *Educational and technical assistance programs to benefit the commercial sector should be expanded.*

Owners of both new and existing buildings could benefit substantially. Aid to small businesses should be emphasized on the assumption that big businesses are more likely to have the resources necessary to help themselves.

- 12) *Any benefits, tax or otherwise, intended to promote conservation in the commercial sector should be available to lessees of real property on the same basis as owners.*

Commercial tenants are more likely to assume the attributes and attitudes of owners than their residential counterparts. Every effort should be made to give both owners and tenants reason to make energy-conserving improvements.

- 13) *Comparable incentives and penalties to encourage conservation should be applied throughout the commercial sector—to all entities, whether profit-making, not for profit, or governmental.*

Careful attention is necessary to insure that direct and indirect incentives created by governmental actions do not lead to artificial distortions.

II. CONSUMPTION PROJECTIONS

The following commercial consumption projections are included in this report to illustrate the type of forecast currently available. It must not be assumed to represent the point of view of either the Demand Committee or its Commercial Subcommittee. It has never been presented to the Commercial Subcommittee for adoption. If it were, it would in all probability be rejected.

The projections contain certain features which, on their face, are difficult to defend.

- 1) Projected differences among states in rates of growth, when extended indefinitely, would require extraordinary shifts in population and economic activity.
- 2) The historical growth in electricity's market share is projected to continue unabated in some states, but to be reversed suddenly in others with no explanation.
- 3) Reported reductions in commercial energy use between 1973 and 1975 are in some cases so large as to be improbable.

In spite of their shortcomings, these projections are the best turned up by the Commercial Subcommittee. The difficulties of this and other subcommittees in finding or producing a competent and widely acceptable demand forecast raise important questions about the role and

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usefulness of demand forecasting as a tool for planning and decision-making. While it is important to improve the quality of demand forecasting, it is even more important to recognize that demand forecasts cannot produce definite answers and that they are only one tool among many for planners and decision-makers.

Forecast Parameters*

- 1) Actual data adjusted for normal weather conditions. Assumed: 100% of oil use and 62% of natural gas use was for heating (based on an analysis of Connecticut gas companies data. No adjustment made for electric heat. Massachusetts data for 1977 indicate only 5% of the consumption is heat sensitive. This is partially offset by significant air conditioning consumption in summer periods.
- 2) Total consumption and electric consumption stated on a per capita basis.
- 3) The growth rate for the 1970-1973 period for both total and electric consumption was determined and projected through 1985.
- 4) The changing pattern of consumption following the oil embargo in 1973 was analyzed. The actual consumption for years available was compared to projected consumption at the 1970-73 growth rate. In 1974, per capita consumption by states was between 11% and 23% less than the projected data. In 1975, the per capita consumption was between 15% and 35% less than the projected levels. Data for Massachusetts and Connecticut for 1976 and 1977 indicate a continuing decline in per capita consumption. The decline, however, is at a significantly lower rate than realized during the first two years following the oil embargo. This implies that commercial users immediately took steps to reduce energy consumption and their results were impressive. It appears that further reductions in energy in existing structures will be more difficult to accomplish.

The trend in average reduction is projected to continue, but at much lower rates reflecting primarily energy conservation measures taken in new construction.

Factors developed from this analysis were applied to per capita consumption levels determined by projection of the 1970-73 growth rate to determine an adjusted per capita use which was multiplied by the projected population data to determine total annual consumption for the total and the electric use of the commercial sector. Consumption of other energy supplies was determined by subtracting the projected electric consumption from the total.

Consumption projections for the year 2000 were made by determining the compound growth rate of the adjusted per capita consumption for the period from 1975 to 1985 and projecting these data to the year 2000. These results were multiplied by the projected population to determine total and electric consumption.

*Supporting Material:

Federal Energy Data System Summary, February, 1978, DOE/EIA-0031/2 UG13
Connecticut Energy Advisory Board Annual Reports—Connecticut Energy Outlook
Commonwealth of Massachusetts—Energy in Massachusetts.

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**Energy Consumption — Commercial Sector
(10¹² BTU)**

	1970	1973	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	2000
Connecticut														
Electric	15.29	20.26	20.37	21.46	22.20	22.01	22.57	23.17	23.47	23.87	24.18	24.52	29.08	32.35
Other	62.99	74.37	67.47	68.00	70.48	73.95	76.53	79.58	82.22	85.38	88.92	93.46	98.54	171.24
Total	78.28	94.63	87.47	89.46	92.68	95.96	99.10	102.75	105.69	109.25	113.10	117.98	123.42	203.59
Maine														
Electric	4.07	5.20	5.39	5.52	5.56	5.68	5.80	5.92	6.02	6.11	6.22	6.32	6.42	7.93
Other	43.00	44.10	38.61	39.64	39.89	40.69	41.67	42.77	43.88	45.21	46.67	48.64	50.78	55.76
Total	47.07	49.30	44.00	45.16	45.45	46.37	47.47	48.69	49.90	51.32	52.89	54.96	57.20	73.69
Massachusetts														
Electric	26.80	35.37	37.36	39.00	36.71	38.18	39.72	41.29	42.90	44.58	46.32	48.13	47.96	86.80
Other	370.49	394.76	300.76	282.13	280.51	293.98	294.77	296.73	299.07	302.92	307.73	314.99	323.64	383.50
Total	397.29	430.14	338.12	321.13	317.22	332.16	334.99	338.02	341.97	347.50	354.05	363.12	373.60	470.30
New Hampshire														
Electric	2.45	3.03	3.16	3.29	3.48	3.71	3.96	4.21	4.46	4.72	4.98	5.27	5.57	16.32
Other	26.65	35.75	25.91	27.54	28.78	30.28	32.07	34.05	35.98	38.19	40.70	43.74	47.20	112.72
Total	24.10	38.78	29.07	30.83	32.26	33.99	36.03	38.26	40.44	42.91	45.68	49.01	52.77	129.04
Rhode Island														
Electric	5.65	5.16	5.31	5.47	5.65	5.84	6.03	6.24	6.45	6.67	6.91	7.15	11.57	
Other	38.84	49.23	36.22	33.16	34.05	35.11	36.31	37.79	39.43	41.34	43.47	46.00	48.91	102.68
Total	43.25	54.85	41.38	38.47	39.52	40.76	42.15	43.82	45.67	47.79	50.14	52.91	56.06	114.25
Vermont														
Electric	2.16	2.60	2.40	2.35	2.37	2.44	2.55	2.71	2.84	2.98	3.14	3.32	3.53	6.92
Other	17.80	18.12	12.98	13.79	14.04	14.42	14.84	15.31	15.57	15.96	16.33	16.86	17.46	23.31
Total	19.96	20.72	15.38	16.14	16.41	16.86	17.39	18.02	18.41	18.94	19.47	20.18	20.99	30.23
Total New England														
Electric	55.18	72.11	73.84	76.93	75.79	77.67	80.44	83.33	85.93	88.71	91.51	94.47	97.51	161.89
Other	359.77	616.33	481.58	464.26	467.75	488.43	496.19	506.23	516.15	529.00	543.82	563.69	586.53	859.21
Total	614.95	688.44	555.42	541.19	543.54	566.10	576.63	589.56	602.88	617.71	635.33	658.16	684.04	1021.10

**Energy Consumption - Commercial Sector
Compound Growth Rates - %**

	1970-1973	1970-1975	1975-1985	1975-2000	1985-2000
Connecticut					
Electric	9.83	5.90	2.02	1.87	1.77
Other	5.69	1.27	3.91	3.82	3.75
Total	6.53	2.24	3.50	3.44	3.39
Maine					
Electric	8.50	5.78	1.76	1.56	1.42
Other	0.85	(2.13)	2.77	2.15	1.74
Total	1.02	(1.34)	2.66	2.08	1.70
Mass.					
Electric	9.69	6.87	2.95	3.43	3.75
Other	2.13	(4.08)	0.74	0.98	1.14
Total	2.68	(3.17)	1.00	1.33	1.55
N.H.					
Electric	7.34	5.22	5.83	6.79	7.43
Other	10.29	(0.56)	6.18	6.06	5.97
Total	10.04	(0.02)	6.14	6.14	
R.I.					
Electric	8.61	3.19	3.32	3.28	3.26
Other	8.22	(1.39)	3.05	4.26	5.07
Total	8.26	(0.88)	3.08	4.15	4.86
VT.					
Electric	6.37	2.13	3.93	4.33	4.59
Other	0.60	(6.12)	3.01	2.37	1.45
Total	1.25	(5.08)	3.16	2.74	2.46
Total New England					
Electric	9.33	6.00	2.82	3.19	3.44
Other	3.26	(2.96)	1.99	2.34	2.58
Total	3.83	(2.02)	2.10	2.46	2.71

III. Existing Federal Programs In The Commercial Sector

A. Prior To The National Energy Act

1) State Energy Conservation Program (SECP)

Under the provisions of the Energy Policy and Conservation Act of 1975 (P.L. 94-163), the Department of Energy has given grants to states to implement State Energy Conservation Plans aimed at saving 5 percent of their energy consumption in 1980. The plans contain different program measures to reach this goal, but all must include the following:

- a) Mandatory lighting efficiency standards for public buildings,
- b) Mandatory standards and policies for improving energy efficiency through procurements practices for states and communities,
- c) Mandatory thermal efficiency standards for new and renovated buildings,
- d) Program to promote carpools, vanpools and public transportation,
- e) Traffic law or regulation allowing right turn on red light after stopping.

All New England states have had their plans funded, and will be eligible to apply for further funding in FY'78. The state shares of appropriated funds are:

	FY'77	FY'78	FY'79 (Tentative)
Connecticut	\$ 345,000	\$ 632,900	\$ 711,400
Maine	184,000	365,600	383,000
Massachusetts	153,000	1,156,700	1,146,200
New Hampshire	165,000	339,000	343,500
Rhode Island	179,000	341,000	361,200
Vermont	139,000	283,500	287,000
Region 1 Totals:	<u>\$1,576,000</u>	<u>\$3,118,700</u>	<u>\$3,232,300</u>

2) Energy Conservation and Production Act

The Energy Conservation and Production Act of 1976 (P.L. 94-385) provides for Supplemental State Energy Conservation Plans which must contain the following measures:

- a) Procedures for carrying out a continuing public education effort regarding:
 - i) Energy costs/savings from energy conservation and renewable resource measures
 - ii) Information and other assistance on planning, financing, installing and monitoring energy efficiency and related measures.
- b) Procedures for insuring effective intergovernmental coordination.
- c) Procedures for encouraging and carrying out energy audits for buildings and industrial plants.

Supplemental State Plans were funded with FY'77 funds and states are eligible to apply for FY'78 funds as follows:

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	FY'77	FY'78	FY'79 (Tentative)
Connecticut	\$ 183,000	\$ 359,000	\$ 151,400
Maine	99,000	193,400	81,500
Massachusetts	294,000	576,900	243,900
New Hampshire	88,000	173,300	73,100
Rhode Island	93,000	181,800	76,800
Vermont	74,000	145,300	61,100
Region 1 Totals:	<u>\$ 831,000</u>	<u>\$1,629,700</u>	<u>\$ 687,800</u>

In addition to program measures required to be implemented, the following are examples of activities underway in New England oriented toward the commercial sector: Technical Information Sharing Workshops (Connecticut); Computerized Energy Audits for Municipal Buildings (Maine); Energy Conservation Extension Service (Massachusetts); Institutional Conservation Program Utilizing Engineering Students (New Hampshire); Guidelines for Schools and Municipal Buildings (Rhode Island); Promotion of Wood-Burning (Vermont).

A complete descriptive inventory of SECP program measures affecting the commercial (and other) end-use sector(s) is being prepared for the Energy Congress by DOE, Region One.

3) *Voluntary Small Business Energy Conservation Program*

This technical assistance program originated with the Federal Energy Administration as one which could be administered via trade associations and utilizing the Service Corps of Retired Executives (SCORE—a joint SBA-VISTA program). Guidebooks for energy intensive small businesses (e.g., laundry and dry cleaning, printing, real estate management) have been developed, and training sessions conducted, but results to date (as determined by energy conservation actions taken) have been described as sporadic. One-to-one follow-up is said to be required, inasmuch as only generalized information can be presented in publications, workshops and the like. Trade associations or SCORE volunteers cannot be relied upon nor expected to provide the guidance necessary to produce the potential energy savings.

Working through state energy offices, tying in with their respective conservation plans, is believed to be a more coordinated, effective approach to this kind of program.

4) *Energy Extension Service*

Connecticut is one of ten states nationally participating in a pilot Energy Extension Service program. The Connecticut Department of Commerce has the largest role in the commercial sector with a program to train energy technicians who will assist small businesses with energy conservation information. Assistance is in the form of analysis of energy use, recommendations for operational modifications (such as thermostat control or other actions that can be taken at little or no cost) and suggestions for physical changes in the structure. About one half of the program recipients are said to have gone beyond the analysis and operational phase, although this proportion is expected to increase when tax credits are effective.

5) *Small Business Energy Conservation Loan Program*

Enacted in July and administered by the Small Business Administration, this

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program provides for direct funds and loan guarantees to firms engaged in the energy conservation business (products or services). (More specific information is forthcoming.)

B. National Energy Act

1) Energy Conservation

a) Federal Solar Energy Demonstration Program

The federal government is authorized to spend up to \$100 million to demonstrate solar technology by undertaking a 3-year program for installation of solar equipment in federal buildings. The program is designed to stimulate the manufacture of solar equipment, help lower its costs, and thereby make solar energy systems more attractive for widespread commercial use. In addition to this program, the federal government is authorized to spend \$98 million over three years to purchase photovoltaic energy devices for use in federal buildings. The purpose is to stimulate the development of a permanent low-cost private photovoltaic production capacity.

b) Energy Conservation in Federal Buildings

Energy audits are required of all existing federal buildings. Each federal agency must retrofit a certain percentage of its total square footage with energy conservation measures or solar energy systems so that by 1990 all federal buildings will be retrofitted to assure maximum efficiency. All new buildings must be designed to minimize their life cycle energy costs. These provisions will strengthen existing requirements for energy conservation in federal buildings.

c) Schools, Hospitals, and Public Buildings Grant Program

Grants to states of \$900 million over the next 3 years are authorized to assist schools and hospitals to pay for energy audits and installation of energy conservation and solar energy measures. These grants will generally cover up to 50 percent of the costs. Institutions eligible for grants to schools and hospitals include public and private non-profit elementary and secondary schools, colleges and universities, and hospitals.

In addition, \$65 million in grants are authorized over 2 years to conduct energy audits of public buildings. Institutions eligible for public buildings grants include buildings owned by units of local governments and non-profit nursing homes, community health centers, neighborhood health centers and orphanages.

Applications of schools, hospitals, local governments and public care institutions for grants must be made through the state energy agency.

2) Energy Tax Act: Business Energy Tax Credits

A variety of tax credits for investment by business is provided. An additional 10 percent of investment tax credit (non-refundable except for solar equipment) is provided for investment in:

a) Alternative Energy Property

This applies to boilers and other combustors which use coal or an alternative fuel, equipment to produce alternative fuels, pollution control equipment, equipment for handling and storage of alternate fuels, and

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geothermal equipment. This credit compliments and provides a major economic underpinning for the coal conversion regulatory program. The credit is not available to utilities.

b) Solar or Wind Energy Property

A refundable credit for investments in equipment to use renewable energy to generate electricity to heat or cool, or provide hot water. This credit is not available to utilities.

c) Specially Defined Energy Property

This applies to equipment to improve the heat efficiency of existing industrial processes, including heat exchangers and recuperators.

d) Shale Oil and Geopressurized Methane Equipment

This applies to equipment for the extraction and production of geopressurized methane and shale oil (but not for refining).

e) Recycling Equipment

This applies to equipment for the recycling of waste materials.

IV. Attributes Of The Commercial Sector

The commercial energy-using sector in New England has a number of distinct characteristics. These must be understood and taken into account, if we are to determine with any assurance what commercial demand for energy is likely to be and how that future demand can best be fulfilled or reduced.

1) *The commercial sector is the least understood and poorest defined of the four major sectors.*

It is in fact a dumping ground; the major common characteristic of its members is that they do not fit neatly into any of the other three sectors. There does not exist a generally accepted definition of the commercial sector.

2) *Energy-use data for the commercial sector is of poorer quality than that for the other sectors.*

The dividing lines between the commercial sector and each of the other three sectors are unclear. Existing historical data are of questionable value because the data base has varied significantly among fuel types, among states and utility service areas, and over time. For example, some electric utilities used to treat any apartment building with a master meter (a single meter for electricity used by all units) as commercial, but have discontinued the practice.

3) *It is more difficult to define how energy is used in the commercial sector.*

How much energy is used for what purposes is very well understood for the residential and transportation sectors. It is more difficult to find useful disaggregated data for, or to generalize about, the commercial sector.

4) *The commercial sector uses proportionately more energy in New England than in the rest of the country.*

There are two major reasons. First, our economy is geared more toward the provision of services than is the case in most other regions. Second, our cold climate requires more energy for the heating and cooling of commercial buildings than is the case with comparable structures in most other regions.

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- 5) *Energy use by the commercial sector in New England has been growing faster than energy use by the other three sectors.*

This conclusion can be made in spite of the questionable quality of available data. Service industries and government have been growing faster than the components of the other sectors. Replacement in the commercial sector as well as net growth has led to greater energy use; new commercial structures and practices have generally been more energy intensive than those which they replaced.

- 6) *Energy use by the commercial sector is more visible than that of any other sector.*

To the extent that overt wasting of energy, of conservation of energy, or use of novel technologies influences public attitudes and behavior, the energy-use practices of the commercial sector will have greater influence than those of any other sector.

- 7) *The commercial sector is indirectly responsible for a great deal of energy use.*

All resources consumed by the sector have an energy cost. Many actions by government influence energy consumption by the private sector. The mere location of a new commercial entity can significantly effect energy use for transportation.

- 8) *Competitive forces can lead to increased energy consumption in the commercial sector.*

Retail businesses may stay open longer hours and may heat or cool their buildings beyond levels essential for comfort, in pursuit of competitive advantage or in fear of competitive disadvantage. There are strong incentives to be as up to date as ones' competitors; being up to date has more often than not meant more energy.

- 9) *There has been excessive emphasis upon first cost in commercial investment decisions.*

Very often the person making a design or purchase decision will not be responsible for paying the resulting energy bills. Often, commercial enterprises require a higher rate of return for energy-saving (and other) investments than do industries or home owners. Established governmental procurement and construction practices have often ignored life cost.

- 10) *The commercial sector's energy use in New England is dominated by heating and, to a lesser extent, cooling.*

In spite of the difficulty with making generalizations mentioned above, some conclusions can be drawn. In addition to heating and cooling, lighting and ventilation are important both in using energy directly and in requiring the use of additional energy for cooling or heating.

- 11) *The commercial sector's use of electricity and natural gas in New England is highly temperature sensitive.*

Unlike the industrial sector and probably even more so than the residential sector, the commercial sector contributes disproportionately to winter and summer peak demands for electricity and to winter peak demand for natural gas. If utility rates do not take this factor into account fully, energy will be artificially cheap in the commercial sector and consequently more expensive for others. If rates within the commercial sector do not account adequately for peak use, those who contribute heavily to the peaks will be subsidized by those who do not.

- 12) *The commercial sector's energy use is likely to grow more quickly (or decline more slowly) than the other sectors in New England during the next few years.*

Indication is that the national shift from goods to services will continue and that New England's emphasis upon services will continue.

- 13) *The commercial sector is excessively vulnerable to supply interruptions.*

If there is in the near future a chronic or acute shortage of electricity, natural gas, or oil, political and economic forces will probably impose a disproportionate burden upon the commercial sector. Many commercial functions are felt to be less essential than

heating homes, fueling factories or maintaining transportation. The reputation of the commercial sector as a major energy waster may set it up as a scapegoat.

V. Reasons For Emphasis Upon The Commercial Sector

The commercial sector is particularly suitable for governmental programs intended to influence energy use for the following reasons:

- 1) *A large share of growth in the near future is expected to occur in the commercial sector.*

Recent electric utility forecasts indicate that the commercial sector, accounting for 30% of current sales, is expected to be responsible for 40% of anticipated growth. Conservation measures, new technologies, and fuel shifts can be implemented most easily in new construction; the commercial sector appears to be where a large share of new construction will occur, at least in New England.

- 2) *Much commercial property is subject to fairly frequent renovation.*

A major renovation is the best opportunity for retrofit measures.

- 3) *The commercial sector appears to be generally inefficient.*

This is not to say that it is the least efficient sector or that there are no exemplary commercial enterprises. It is to say that there exists major opportunities for improvement.

- 4) *The commercial sector is a major contributor to peaks for both the electric and gas utilities.*

At least for electric utilities, the commercial sector appears to have a relatively uneconomical load factor. Growth of the commercial sector could consequently mean poorer load factors overall.

- 5) *The commercial sector is a highly visible energy consumer.*

Waste in the commercial sector has a major detrimental effect upon public attitudes. Positive steps can have the opposite effect.

- 6) *Economic incentives in the commercial sector are often not sufficient to produce desirable changes in energy use.*

Rapid turnover, high rate of return requirements, and a bias in favor of first costs all reduce the likelihood that the invisible hand will maximize the national well being. Competitive forces may even lead to wasteful practices as businesses strive to maintain longer hours or more unseasonable interior temperatures than their competitors.

- 7) *New energy-use programs aimed largely or entirely at the commercial sector will in many cases be more cost effective than those aimed at other sectors.*

For a combination of the foregoing reasons, the commercial sector appears to be the best target for new governmental programs. This conclusion relates to the relative merits of programs focused upon the four sectors, regardless of whether a particular program is cost effective in any or every circumstance and regardless of whether a program is desirable or undesirable for reasons unrelated to cost. Cost could be defined in terms of private dollars expended, public subsidies required, or political capital expended.

Industrial Sector

I. Recommendations

A) Approved by the Demand Committee ¹

- 14) *Assess probable impact of cogeneration, in company with the Regulatory Committee which is assessing constitutional barriers to cogeneration.*
- 15) *Adoption of cost effective innovations in industrial energy-using equipment should be studied both in terms of its impact on regional energy usage and the improvement of the competitive position of regional industry.*

B) Lacking Approval by Demand Committee

- 1) *Regulatory reform to enable rapid and rational assessment of energy facility progress, so that reliability of supply, environmental, economic and other factors can be adequately assessed without introducing costly delay producing energy for the consumer.*

C) Tabled by the Committee

- 1) *Refine demand projections by sector, quantitatively versus time, for electrical and nonelectrical demand. Electrical demand should be projected to year 2000, nonelectric may need to be projected over a shorter time period, say 1985. Several demand projections may be appropriate such as those based on:*
 - a. *Unmodified extrapolation from past demand.*
 - b. *Extreme legislatively forced conservation and other demand modifications.*
 - c. *Some mean between (a) and (b) which is more probable of public (political) acceptance.*
- 2) *Collaborate with NEPOOL to use the Battelle-developed methodology to predict electrical demand, with such modifications as the Energy Congress may propose.*
- 3) *Establish means to reduce conflict and/or overlap between goals or applications of regulations issued by various federal and state agencies.*

D) Not yet reviewed by the Demand Committee.

- 1) *Provide assistance and create incentives needed to develop an infrastructure in New England to implement the use of coal for energy in a safe environmentally acceptable manner.*
- 2) *Recommended that the Demand Committee assure that recommendations from other Energy Congress Committees have considered impacts on demand issues as related to their respective areas of concern.*

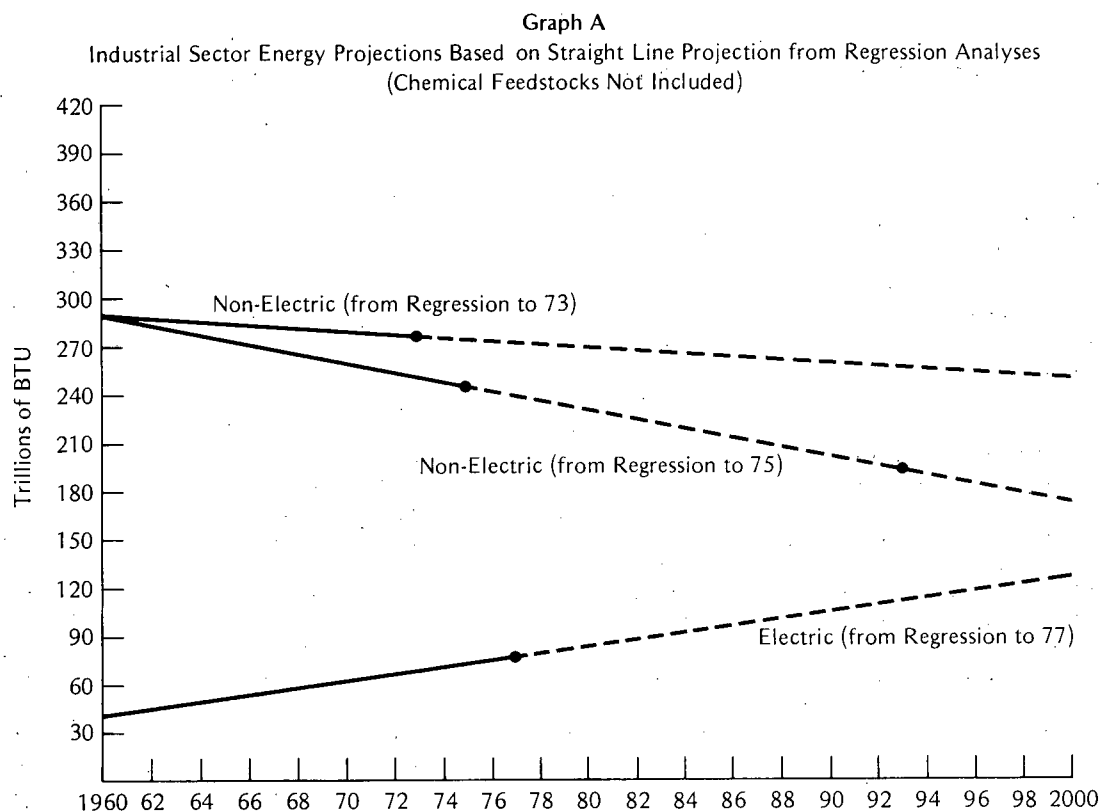
II. Projections

The attached Graph A shows electrical energy and nonelectric energy used in the industrial sector, based on FEDS data.² The FEDS data extends only to 1975, but electrical data for 1976 and 1977 have been added, and is taken from *Electric Power Statistics* DOE/EIA-00U34.

¹ The following two recommendations are numbered in which they appeared in the Recommendations Section of the Demand Committee report.

² Petrochemicals used for feedstock, averaging 35×10^{12} BTU per year, are not included.)

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Regression analysis was applied to electrical energy, using data from 1960 to 1976 and the plotted line extended to the year 2000 to represent future energy usage consistent with experienced relationships between electrical usage and industrial product. It is noted that the ratio of electrical energy to total energy has increased over time, and probably will continue to do so, since this form of energy seems closely related to industrial productivity.

The extended plot represents the extreme upper limit of future demand estimate; the effects of conservation and process efficiency would reduce the estimate.

Regression analysis was applied to nonelectrical energy, using data from 1960 to 1973, and again using data from 1960 to 1975, and these two plotted lines extended to the year 2000.

The upper line represents energy usage consistent with experience to 1973, whereas the lower line includes the effect of the significant energy reduction in 1974 and 1975. The upper line represents an extreme upper limit to future nonelectric demand estimates; the effects of conservation and process efficiency would reduce this estimate.

These *upper limit* estimates assume no cogeneration nor special attention to conservation and efficiency. Although cogeneration does not in itself alter the demand for electrical energy nor the demand for process or space heat, it does result in a total energy demand less than the sum of electrical and nonelectrical demand, (depending upon the degree of the cogeneration applied because it is more efficient).

As an independent check, the subcommittee examined relationships between electrical energy usage and economic activity for the period 1974 - 1976. Electrical and nonelectrical usage by Standard Industrial Classification (SIC code) is given in Table I. Value added is the measure of industrial activity; it is derived by subtracting the total cost of materials including supplies, fuel, electricity, cost of resales from the value of industrial shipments. These data are shown in Table II.

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Table 1:
Usage and Growth Rate by Standard Industrial Classification Code (SIC) - 1974-1975

Standard Industrial Classification Code by Industrial Group	Usage					
	1974		1975		1976	
	Electric 10 ⁶ KWH	Non-electric 10 ¹² BTUs	Electric 10 ⁶ KWH	Non-electric 10 ¹² BTUs	Electric 10 ⁶ KWH	Non-electric 10 ¹² BTUs
20 Food and Kindred Products	1068.	20.1308	1245.7	18.766	1007.2	18.1
22 Textile Mill Products	1197.1	25.59	1287.5	22.5192	1040.5	25.6
23 Apparel, Cloth, Textile Products	247.6	2.3884	325.	1.0236	289.5	1.6
24 Lumber and Wood Products	317.1	9.2124	368.3	5.118	344.2	5.
25 Furniture and Fixtures	140.1	2.0472	165.6	2.0472	129.4	1.9
26 Paper and Allied Products	3218.9	106.1132	2931.3	95.8772	2970.	99.6
27 Printing and Publishing	551.1	4.0944	637.4	3.412	581.9	3.5
28 Chemicals, Allied Products	1130.8	25.59	1035	21.1544	947.6	21.7
29 Petroleum and Coal Products	81.8	4.0944	92.6	3.412	62.9	3.
30 Rubber, Misc. Plastic Products	1645.8	13.048	1409.7	9.2124	1371.3	9.5
31 Leather, Leather Products	227.2	3.412	254.3	3.0708	192.9	3.2
32 Stone, Clay, Glass Products	702.4	19.1072	729.7	19.4484	712.7	19.2
33 Primary Metal Industries	1620.3	20.8132	1438.9	15.354	1363.4	14.5
34 Fabricated Metal Products	1474.8	19.4484	1502.	17.06	1363.	17.4
35 Machinery Except Electric	1716.3	15.0128	1911.1	12.6244	1591.	12.7
36 Electric, Electronic Equipment	1605.3	10.236	1594.7	8.53	1484.4	9.
37 Transportation Equipment	1194.4	11.6008	1260.5	10.5772	1280.3	11.6
38 Instruments, Related Products	625.1	6.1416	754.6	5.4592	753.6	6.2
39 Misc. Manufacturing Industries	703.8	5.8004	507.8	5.118	378.8	5.5
Total	20015.4	329.258	20147.5	284.902	18609.8	294.1

	Growth Rate					
	1974		1975		1976	
	Non-electric	Electric	Non-electric	Electric	Non-electric	Electric
20 Food and Kindred Products	-6.8	.18	-3.5	-19.1	5.2	-2.9
22 Textile Mill Products	-13.0	7.6	13.7	-19.2	0.0	-6.8
23 Apparel, Cloth, Textile Products	-57.3	31.1	75.8	-10.9	-13.2	8.0
24 Lumber and Wood Products	-44.4	15.5	-2.3	-6.0	-25.3	4.2
25 Furniture and Fixtures	0.0	17.7	-7.2	-21.9	-3.7	-4.1
26 Paper and Allied Products	69.6	07.4	3.9	-0.4	-63.1	-93.9
27 Printing and Publishing	-16.7	19.3	2.6	-63.4	-7.9	-8.5
28 Chemicals, Allied Products	-17.3	-8.5	2.6	-3.4	-7.9	-8.5
29 Petroleum and Coal Products	-16.7	18.2	-12.1	-32.1	-14.4	-12.9
30 Rubber, Misc. Plastic Products	-32.5	-10.7	3.1	-6.7	-16.6	88.7
31 Leather, Leather Products	-10.0	11.8	4.2	-24.1	-3.2	-7.9
32 Stone, Clay, Glass Products	1.8	3.9	-1.3	-2.3	0.2	0.7
33 Primary Metal Industries	-26.2	-11.2	-5.5	-5.1	-16.5	-9.3
34 Fabricated Metal Products	-12.3	1.8	2.0	-3	-5.4	-3.9
35 Machinery Except Electric	-15.9	11.8	0.6	-16.7	-8.0	-3.7
36 Electric, Electronic Equipment	-16.7	-0.7	5.5	-6.9	-6.2	-3.8
37 Transportation Equipment	-2.8	5.5	9.7	1.6	0.0	3.5
38 Instruments, Related Products	-11.3	28.7	13.6	-0.2	0.5	9.8
39 Misc. Manufacturing Industries	-11.8	-27.8	7.9	-25.4	-2.6	-26.6
Total	-13.5	0.7	3.2	-7.5	-5.5	-3.6

Compiled by: The New England Regional Energy Project, Burlington VT from the Census of Manufacturer's Data, U.S. Bureau of Census

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Table II: Value Added by SIC: 1974-1976

	1974	1975	1976
20 Food and Kindred Products	1378.8	1419.4	1573.
22 Textile Mill Products	2762.9	992.7	1143.8
23 Apparel, Cloth, Textile Products	747.1	752.8	846.9
24 Lumber and Wood Products	432.8	383.5	453.6
25 Furniture and Fixtures	396.4	311.1	359.6
26 Paper and Allied Products	1638.8	1566.7	1818.5
27 Printing and Publishing	1593.3	1018.5	1828.
28 Chemicals, Allied Products	1350.5	1402.7	1523.1
29 Petroleum and Coal Products	2.	2.	2.6
30 Rubber, Misc. Plastic Products	1271.9	1181.1	1281.9
31 Leather, Leather Products	646.4	662.9	798.7
32 Stone, Clay, Glass Products	645.7	651.5	744.
33 Primary Metal Industries	1335.2	970.3	1102.2
34 Fabricated Metal Products	2536.2	2496.1	2927.2
35 Machinery Except Electric	4273.9	3974.2	4716.2
36 Electric, Electronic Equipment	2975.1	2865.5	3329.3
37 Transportation Equipment	2306.	2519.	2852.7
38 Instruments, Related Products	1810.7	1958.3	2213.2
39 Misc. Manufacturing Industries	1310.7	1303.1	1579.1
*Total	28092.1	27481.1	31637.3

*Of value added of all SIC Classifications as reported by six New England States

The ratio of energy to value added is given by SIC in Table III for total industry in New England. For the period analyzed, virtually every industrial sector shows a declining ratio of energy used to value of production. This is even evident for electrical energy where the decline is not as striking as for nonelectrical, but, nevertheless, distinct.

Table III

	1974		1975		1976	
	Non-electric	Electric	Non-electric	Electric	Non-electric	Electric
20 Food and Kindred Products	1.450023209	0.774586597	1.322107933	0.877243483	1.146295123	0.6378720709
22 Textile Mill Products	0.9262007311	0.7332766296	2.268479903	1.297270072	2.2385449466	0.9098461
23 Apparel, Cloth, Textile Products	0.3196894659	0.3314148039	0.1399723893	0.4317215728	0.2125398512	0.3418349274
24 Lumber and Wood Products	2.128558226	0.7326709797	1.317374517	0.9428571429	1.102292769	0.7588183422
25 Furniture and Fixtures	0.5164480323	0.3549445008	0.6588052073	0.5323047252	0.5283648498	0.3598442714
26 Paper and Allied Products	6.475054918	1.964181108	6.11959107	1.902916959	5.477041518	1.633214188
27 Printing and Publishing	0.2569760874	0.3458858972	0.2108124807	0.4061785604	0.1914660832	0.3073851204
28 Chemicals, Allied Products	1.894853758	0.8373195113	1.508120054	0.7378626534	1.424725883	0.6221521896
29 Petroleum and Coal Products	204.72	40.9	170.6	46.3	15.3846154	24.19230769
30 Rubber, Misc. Plastic Products	1.073040333	1.293969652	0.77998473	1.244348489	0.7410874483	1.069740229
31 Leather, Leather Products	0.5278465347	0.3514851485	0.4632372907	0.383617439	0.400651053	0.2415174889
32 Stone, Clay, Glass Products	2.959145114	1.087811677	2.985172673	1.12030693	2.580645161	0.957930179
33 Primary Metal Industries	1.558807669	1.213526064	1.502397197	1.480862201	1.31550717	1.236980581
34 Fabricated Metal Products	0.7668322687	0.5814998817	0.6834662073	0.6017367124	0.5944247062	0.4656326815
35 Machinery Except Electric	0.2512669927	0.401577014	0.2176588999	0.4808766544	0.2692845939	0.3373478648
36 Electric, Electronic Equipment	0.344055662	0.5395785016	0.2976792881	0.5565171872	0.2703270958	0.4458949
37 Transportation Equipment	0.5030702515	0.5179531657	0.4198967844	0.5003969829	0.4066323132	0.4488028885
38 Instruments, Related Products	0.3391837411	0.3452256034	0.2787724046	0.3854363479	0.2801373577	0.3405024399
39 Misc. Manufacturing Industries	0.442542153	0.5367360952	0.3927557363	0.2896961331	0.3482996644	0.2398834779
Total	3.372066168	0.712492141	1.036719792	0.7331402309	0.9295989229	0.5882233945

Compiled by: The New England Regional Energy Project, Burlington, VT from the Census of Manufacturer's Data, U.S. Bureau of Census

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In order to project future demand, an independent projection of industrial earnings from the Bureau of Economic Analysis was used. Although industry earnings are not identical with value added statistics, for purposes of this study the two factors were assumed to vary together over time. These figures for all SIC groups by state are presented in Table IV.

For the period 1976 - 1985, industry earnings in New England grew at 1.01% for 1985 - 2000 earnings grew at 1.33%. For the projection given in Table V, it is assumed that energy use per unit of output remains constant. This assumption is obviously conservative in light of the rather steep decline indicated by data in Table III. These data from the three years were too limited to allow an interpretation in depth. Moreover the period contains effects from both the rapid price rise in energy and a business recession. For these reasons, (shortness of the period covered and the unusual one-time occurrences) these data were not considered complete for determination of reliable projections.

Table IV: Projected Growth in Industrial Earnings

	1976	1985	2000
Maine	735,435	914,230	1,255,087
N. H.	723,137	965,261	1,371,636
Vermont	347,917	447,538	616,216
Mass.	5,417,171	6,193,164	6,900,687
R.I.	930,855	1,164,160	1,601,500
Conn.	4,112,960	4,994,197	6,161,343
TOTAL	12,267,205	14,678,550	17,906,469
Compound Growth Rates:	1976-85 2.01%		
	1985-00 1.33%		

Source: Bureau of Economic Analysis projections

**Table V: New England Industries By Size and Energy Use
Compared
With Leading U.S. Energy Users - 1976**

(a) Rank	Sic Code	Employees (10 ³)	% National Employee	Employee Rank	Energy 10 ¹² BTU	Energy Rank
1	Chemical	856.5	3.7	10	25.1	3
2	Primary Metals	1102.0	4.8	7	19.1	6
3	Petroleum	143.8	1.6	19	3.3	16
4	Stone-Clay-Glass	580.5	4.3	14	21.5	5
5	Paper	615.2	10.3	13	109.8	1
6	Food	1480.5	3.7	4	21.5	5
7	Fabricated Metals	1442.1	7.9	5	22.0	4
8	Transp. Equip.	1679.2	6.3	2	16.0	8
9	Machinery	1990.7	8.1	1	18.4	7
10	Textile	884.5	7.1	9	29.2	2
	Tobacco	63.0	0.5	20	-	19
	Apparel	1323.5	4.8	6	3.0	17
	Lumber	632.5	4.2	12	6.1	13
	Furniture	435.3	4.3	16	2.2	18
	Printing	1082.1	7.1	8	5.5	14
	Rubber-Plastics	648.6	9.7	11	14.1	9
	Leather	253.5	23.5	18	5.0	15
	Electric Electronic	1610.2	8.5	3	14.0	10
	Instruments	522.5	14.5	15	8.7	11
	Miscellaneous	433.9	16.5	17	6.7	12

(a) First ten industries ranked as most energy intensive from among 50 most energy consumptive corporations in the industry.

III. Conservation

Increased energy prices provided incentive for conservation that has been lacking during the past several decades of cheap energy. Cost reduction efforts in industry generally has been directed to areas other than energy usage. It cannot be assumed that energy consumption is inelastic and will be reduced as price increases. To remain competitive, industry must consider other factors, chiefly productivity per man-hour, which is usually energy dependent. It is this need to increase productivity per man-hour in order to remain competitive that has been the prime reason for the increase in energy usage (especially electrical)

Although some reduction in the electrical energy usage relative to value added can be expected through non-technological conservation practices (shutting off unneeded machinery, etc.), it is expected that conservation will have its major impact on nonelectric energy demand—especially for space heating. This has been the most neglected area and the one most amenable to improvement both by capital expenditures and, in particular, operating procedures (reduced thermostat settings, better ventilation control, etc.).

Conservation, other than that voluntarily undertaken because of cost factors, may be encouraged by legislation and tax incentives. Legislation without tax incentives may have small impact, because it must not be allowed to create a regional cost disadvantage to industry. On the other hand, there is a possibility that new, more-efficient energy-using technologies could lower the cost of production and make regional industry more competitive.

IV. Cogeneration

As noted under Section II, *Projections*, the baseline projection assumes no decrease in the electricity use per dollar of value added, despite indications in recent years that this ratio may continue to decline. Graph A shows purchased electricity, and does not include that self-generated by industry (mainly the paper industry), and assumes no increase in self-generated electricity. It is generally accepted that efficiency improvements to existing processes, introduction of new, more efficient processes, and a shift to electric cogeneration and process heat could substantially reduce industrial purchased electricity below existing baseline levels.

To show what the impact of cogeneration or self-generation could be on purchased electricity demand, results of the Thermal Electron Corporation Reference Study of Cogeneration in New England were used to calculate the reduction of purchased electric demand and the use of non-electric energy. In making these calculations, plant boilers were assumed to normally operate at an 84% efficiency. This is consistent with the use of steam turbines which produce a relatively large amount of process steam per unit of input compared to gas turbines. If industries can sell energy to electric utility grids at higher prices than are currently attractive to utilities (designated rate reform in Table VI), then it is more likely that gas turbines would be used, since they have a relatively high ratio of electricity generated to steam produced.

Table VI summarizes the data from the Thermo-Electric report and shows the impacts on the amount of electricity purchased and the additional fuel required for the cogeneration equipment. At this time, the subcommittee offers no recommendations for legislation intended directly to reduce industrial demand. Industrial demand will, however, be indirectly influenced by the goods, services, and jobs required to support the other sectors and will be moderated indirectly by current and new legislation intended to reduce energy consumption in all sectors.

V. Nature of New England Industry

Over the past eight decades there has been a steady trend toward centralization of manufacturing and of energy production into capital intensive and highly efficient units. Although these have reduced the labor input per unit of produced output, other industries have been created (notably related to entertainment and recreation). Overall employment has not, therefore,

declined in relation to total production. However, the nature of industry today is such that the employment opportunities for the unskilled are few.

The philosophical question which was not formally addressed by the full committee relates to the question of either instituting changes in the industrial sector to provide more jobs for the unskilled by deliberately reducing productivity by decentralization, or continuing existing policies which emphasize highly centralized efficient capital intensive basic industries.

History suggests that the latter is the best course, if the objective is to increase the overall standard of living. Of course, it does not preclude the development of additional cottage industries for those who prefer to exercise craftsmanship.

New England uses about 23,200 BTUs per dollar of value added in manufacturing, versus 44,000 BTUs nationally. In New England, 21.6 percent of energy used in manufacturing is in the form of electricity which compares with 10% nationally (1971 data, Eisenmenger-Syron paper). This is attributed to the high technical sophistication which characterize much of the New England industry. The more energy intensive industries are commonly located elsewhere. Engineering and manufacturing skills somewhat moderate the regional disadvantage of high cost energy; at the same time this type of industry tends to depend more heavily on electric energy, which is used to enhance work's productivity. (see Table V)

VI. Discussion of Some Energy Constraints in Industrial Sector

Energy demand in the industrial sector of New England depends on many factors exclusive of regional population growth. One major consideration is that industries in New England as a group are not energy intensive. (Table V)

Increase in industrial energy demand would occur as a result of growing population. However, other factors exist which tend to exert a negative influence on industrial growth, such as local taxes, environmental regulatory and licensing activities, relative cost of regional energy vs. national costs and the region's public attitude in developing additional energy capacity—particularly electrical. It is possible that when considered together, these factors could create an investment climate detrimental to the production of the energy growth within the New England industrial sector.

Over the past decade, development of New England energy resources has progressed slowly. These developments have been evident in several ways, specifically in establishing new baseload electric generating power plants, building oil refineries, promotion of offshore oil production and in exploring indigenous energy resources including wood, other biomass and solar. This slow progress has resulted in a regional dependency on oil imports. To overcome this dependency, coal has been promoted by the DOE as a fuel replacement for oil throughout the country, including New England. Utilization of coal must meet strict air and water pollution regulations as directed by state and federal agencies. These regulations could restrict the wide use of coal within the New England industrial sector. In addition, the infrastructure for expansive regional coal utilization is not well developed. Transportation modes for handling vast quantities of coal and for disposing of ash are not established. Doubt may exist within the industrial sector concerning the establishment of an effective infrastructure in a manner which would provide as efficient, reliable supply of energy. The future energy posture of New England appears uncertain, and may both discourage new industries from locating in the region and encourage established firms to leave.

Part of the region's energy dilemma stems from regional state and federal energy policies and regulatory activities, especially those involving energy, economic and environmental issues. Generally problems arise not from the policies and regulations per se but usually from their implementation and management. Improvements in the regulatory process could be achieved at the state level. As an example, the work of the Massachusetts Facility Siting Council to integrate energy need, economic viability and environmental impact questions into one review process should be monitored and considered for implementation on a regional basis.

EPA's air regulations, especially recent amendments to the Clean Air Act, could create limitations on industrial growth. Of particular concern is the Prevention of Significant Deterioration concept (PSD) and attendant offset policy. Under these amendments a new industry must meet more rigid requirements before it can locate and operate in any area and particularly where air pollution standards are in violation. Since these regulations are designed to improve air quality, some industries might consider locating in areas in which they could meet air regulations more easily than in New England. Part of this difficulty arises from the fact that current air quality in many sections of New England are in violation of EPA and state standards and therefore will require more pollution control equipment than in some other regions.

Many factors affect industrial energy demand. It is important to recognize that demand projections capture only a few of these. Other factors not included can affect the overall level of industrial activity and, thereby, industrial energy usage. Among such factors are energy costs, availability of labor force, markets for goods and services, taxes, and oil and gas deregulation. Although current status and interrelations among these factors might be known, their projections to the year 2,000 may be so doubtful as to be of little value for estimating future industrial growth. However, their potential influence on industry could be significant. Efforts to monitor these should be undertaken on a continuous basis to insure future industrial growth in conformity with established environmental standards and socio-economic needs for employment.

Appendix

The following tables are taken from:
Eric Hirst (Oak Ridge National Laboratory)
Energy Intensiveness of Passenger and Freight Transport
Modes 1950-1970.
April 1973 ORNL-NSF-EP-44

From: Energy Primer:
Selected Transportation Topics
Office of the Secretary
United States Department of Transportation

Table 1
Automobile Traffic and Energy Consumption

	IC		Urban		Total		Average EI BTU/PM
	Traffic 10 ⁹ PM	EI BTU/PM	Traffic 10 ⁹ PM	EI BTU/PM	Traffic 10 ⁹ PM	Energy 10 ¹² BTU	
1950	430	3200e	260	7600e	690	3300	4800
1955	630	3300e	310	7900e	950	4600	4800
1960	730	3300e	400	8000e	1130	5600	5000
1965	800	3300e	530	7900e	1330	6800	5200
1970	970	3400e	690	8100e	1670	8900	5400

Table 2
Truck Traffic and Energy Consumption

	IC Freight			Other		Total	
	Traffic 10 ⁹ TM	EI BTU/TM	Energy 10 ¹² BTU	Traffic 10 ⁹ VM	Energy 10 ¹² BTU	Traffic 10 ⁹ VM	Energy 10 ¹² BTU
1950	170	2400e	410e	76	1000e	91	1400
1955	220	2400e	530e	93	1300e	110	1800
1960	290	2900e	820e	98	1300e	130	2200
1965	360	2400	870	140	1800	170	2700
1970	410	2800	1140	180	2300	220	3500

Demand Committee

Table 3
Domestic Aircraft Traffic and Energy Consumption

	IC Passenger		IC Freight		Subtotal Energy (a) 10 ¹² BTU	Domestic Military Energy 10 ¹² BTU	General Aviation Energy 10 ¹² BTU	Total Energy 10 ¹² BTU
	Traffic 10 ⁹ PM	EI BTU/PM	Traffic 10 ⁹ TM	EI BTU/TM				
1950	9.3	4500e	0.30	23000e	49e	87e	12e	150e
1955	21.	4800	0.49	24000	110	380e	23	490e
1960	32.	6900	0.89	35000	250	540	29	820
1965	54.	8200	1.9	41000	520	640	43	1200
1970	110.	9400	3.4	42000	1000	620	96	1800e

(a) Subtotal Energy is the sum of commercial passenger and freight energy.

Table 4
Railroad Traffic and Energy Consumption

	IC Freight		IC Passenger		Total Energy 10 ¹² BTU
	Traffic 10 ⁹ TM	EI BTU/TM	Traffic 10 ⁹ PM	EI BTU/PM	
1950	630	3100	33	7400	2200
1955	660	1200	29	3700	890
1960	600	790	22	2900	540
1965	720	720	18	2700	570
1970	770	670	11	2900	550

Table 5
Bus Traffic and Energy Consumption

	IC		Urban		School		Total	
	Traffic 10 ⁹ PM	EI BTU/PM	Traffic 10 ⁹ PM	EI BTU/PM	Traffic 10 ⁹ PM	EI 10 ⁹ PM	Traffic BTU/PM	Energy 10 ¹² BTU
1950	26	640e	24	3100	14e	760e	64e	100
1955	26	1100e	18	3400				110
1960	19	1500	16	3400	25e	1200e	60e	110
1965	24	1600	15	3500				120
1970	25	1600	13	3700	38e	1100e	78e	130

Table 6
Urban Mass Transit Traffic and
Energy Consumption

	Electric		Bus (a)		Total		Average EI BTU/PM
	Traffic 10 ⁹ PM	EI BTU/PM	Traffic 10 ⁹ PM	EI BTU/PM	Traffic 10 ⁹ PM	Energy 10 ¹² BTU	
1950	22.	3900	24	3100	48	160	3500
1955	13.	3800	18	3400	31	110	3500
1960	8.9	3900	16	3400	25	89	3600
1965	8.9	3900	15	3500	22	81	3700
1970	7.2	4100	13	3700	20	76	3800

(a) Data for urban bases also included in Table 5.

Table VI

Base-Line Low Electricity Projection

	1976 ¹		1985 ²		2000 ²	
	10 ⁶ KWH	10 ⁹ BTU	10 ⁶ KWH	10 ⁹ BTU	10 ⁶ KWH	10 ⁹ BTU
Purchased	18610	63.5	22268	76	27165	(92.7)
Self-Gener.	3769	12.9	4510	15.4	5502	(18.8)
TOTAL	22379	76.4	26778	91.4	32667	(111.54)

Economically Feasible Cogeneration of Electricity by 1985³

	No Rate Reform	Rate Reform
Cogeneration	5710	16,320
Additional Fuel (10 ¹² BTU)	5	63
Adjusted Purchased Electricity (10 ⁶ KWH)	21068	10458
Percent Decrease in Purchased Electricity	5.4%	53%

¹Annual Survey of Manufacturers²Based on growth at BEA earnings rate. See Table IV.³Bases on Thermo-Electron Report. A Study Inplant Electric Power Generation in the Chemical, Petroleum Refining, and Pulp and Paper Industries. TE-5429-97-76

Table VII

Cogeneration Versus Separate Generation Of Electricity and Steam For A Large Industrial Plant

Separate Generation Mode

Energy Resources		Useful Energy	Energy Efficiency (%)
50 Btu	→ Central Station → electricity	19 Btu	37
100 Btu	→ Plant Boilers → steam	84 Btu	84
Total	150 Btu	103 Btu	69

Cogeneration Mode

125 Btu	→ Cogenerating Industrial Power Plant →	electricity	19 Btu	82
		steam	84 Btu	
Total	125 Btu		103 Btu	82

Source: Bernow, S.S., *Industrial Cogeneration in NY State*, Energy Systems Research Group, Inc., Proposed for New York State Energy Office.

Transportation Subcommittee

The Transportation Subcommittee was not able to submit their report before the publishing deadline. An expanded transportation report evaluating the existing transportation demand projections will be submitted at a later date. The committee did present a number of recommendations which were considered by the full Demand Committee. A summary of these recommendations follows:

A) Approved by the Full Committee

- 1) The Federal Government should substantially increase research and development of new gasoline products such as gasohol.
- 2) The use of commuter car and van pooling and of express buses from commuter lots should be promoted.
- 3) Rail service should be routed along areas of greatest population. For example, there should be an increase in service along the inland route from New Haven to Boston which passes through more major cities than the shoreline route.
- 4) Congress should perform energy impact analyses in connection with bills funding various types of transportation.
- 5) The New England states should require energy impact statements for all government-funded transportation projects.

B) Approval Lacking Full Committee

- 6) The Federal Government should announce a policy and draw up contingency plans to institute gasoline rationing if gasoline consumption is not reduced by 1985.

C) Tabled by the Committee

- 7) Utilize express buses for other transportation purposes when not in use during morning and evening commuter rush hours.
- 8) The Federal and State Governments should subsidize economic and attractive passenger rail service.

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Committee Overview

Reducing New England's overwhelming dependence on oil and on other fossil fuels is a common goal of the six committees of the Energy Congress. Consistent with this goal, the Conservation Committee has concentrated its efforts on framing specific action recommendations which would either reduce consumption of fossil fuels or increase the efficiency of their use.

Nonetheless, the committee wishes to acknowledge the direct interrelationship between conservation and the development of alternative energy sources. Given the goal of reducing fossil fuel consumption, alternative energy sources can be viewed as conservation measures and conservation can be viewed as alternative sources of supply. Accordingly, the committee endorses

Conservation Committee

the efforts of the Supply Committee and the Alternative Energy Committee to address the common goal of reducing the region's overwhelming dependence on oil and on other scarce fossil fuels.

The benefits of conservation are many; it can be viewed as the equivalent of an energy source as well as a potential means to offset increasing energy costs. With the region's demanding winters and high fuel prices, conservation measures are particularly cost-effective. Significant gains in reducing consumption will not only result in important savings for individuals but will assist industry and business and improve New England's competitive economic position.

The development of a viable conservation industry to meet the region's needs for conservation goods and services would impact favorably on economic development and community revitalization. Any reduction in the consumption of energy reduces the flow of dollars to non New England producers and reduces the need for expanded capital investment in expensive technologies. Conservation, by almost any standard, is often the lowest cost source which will be needed to meet energy demand over the next few decades, and should make the supply of energy more abundant by reducing waste and demand via education, improved housing and appliances, and more efficient industrial usage of energy. Such improved energy efficiency can become the basis for economic competition.

The Conservation Committee has concluded that conservation need not inherently imply sacrifice and major lifestyle changes: waste can be trimmed before any essential usage is cut. However, it is also recognized that the low-income community, whose energy expenditures meet only the essentials, lack the resources to implement necessary housing improvements, and their needs must be given additional consideration.

In structuring its work, the Conservation Committee approached the development of energy conservation measures by establishing subcommittees to address conservation issues specific to the residential, industrial/commercial, and transportation sectors. The subcommittees have been meeting monthly since May, and have discussed a large number of issues impacting on conservation. In addition, the full committee has regularly reviewed the work of the subcommittees and discussed the preliminary findings of each subcommittee.

Potential conservation measures are numerous, and the committee has established a *means* test by which to evaluate and limit their preliminary recommendations. The *means* test evaluates proposals by examining their legislative need, feasibility, potential for passage, time frame, and balance of regional interests. Using these criteria as guidelines, the Conservation Committee has developed the proposals listed below; several recommend Congressional action, while others call for administrative changes in existing programs and regulations to facilitate greater energy conservation.

Recommendations

I. Residential

- 1) *To overcome the financial barriers of residential energy conservation, expanded programs of grants, low-interest loans, and tax credits are recommended.*

The financing of conservation measures presents a particular burden to the individual consumer, and programs should include support and incentives for all income groups. Congress should study various monetary and non-monetary mechanisms for funding energy conservation programs.

- 2) *Congress should study the regional impacts of energy policies, the elasticity of energy pricing, energy price structures, and the end uses of energy.*

Conservation Committee

Accurate understanding of how energy policies affect consumers is needed in order to develop equitable programs dealing with all aspects of energy. Artificial pricing does not necessarily enhance conservation; rather, end users should be charged for their contributions to the cost of energy production. If, however, national policies result in energy prices set above market or result in excess profits, such revenues should be used for conservation programs, including development of alternative technologies, technologies for increased production, and for minimizing the effect on low-income consumers.

- 3) *The National Weatherization Program is recognized as a major, long-term low-income energy project, and Congress should continue funding and give priority to its implementation.*

At the present rate of activity, it would take a minimum of 25 years to retrofit the approximately 340,000 low-income housing units in need of weatherization in New England. Therefore, funding should be increased to expand the per unit limit and the retrofit services provided, allow for integration with basic housing rehabilitation; and expand administrative services. Different labor force arrangements should be examined; the present program suffers from reliance on temporary and unskilled CETA labor.

- 4) *Congressionally mandated energy education programs should continue, with the State Energy Offices responsible for their coordination and implementation. Such programs should be designed to reflect the needs of specific population groups within each state.*

Lack of relevant information is a barrier to energy conservation, and effective educational programs must be developed and coupled with financial incentives for conservation. At the state level, programs can be targeted to specific population groups, such as rural single family homes, or urban multi-unit complexes.

- 5) *The use of complete home energy audits should be continued and their availability increased. To protect consumers, Congress should require audit firms or persons performing audits to make certain disclosures as to the interest the firm or person might have in the resulting recommendations. Further, all heating suppliers should participate in any mandatory audit programs.*
- 6) *The federal government should be responsible for establishing product standards and workmanship guidelines for energy conservation materials, and the present efforts to determine such standards are endorsed.*
- 7) *As mandated in the National Energy Act, Congress should establish mandatory appliance efficiency standards. Additionally, prominent labeling of appliances with information pertaining to energy consumption should be required.*

When establishing efficiency standards, the federal government would do well to follow the model of several state programs, which establish mandatory minimum performance standards for each type of appliance, and require that all appliances for sale after a certain date meet that minimum level.

- 8) *The impact on job creation of various conservation measures should be considered when evaluating conservation programs.*

The resulting jobs due to production of conservation materials, installation, distribution and sales can help stimulate the local economy. Findings from the hearings held by the Alternatives Committee support the theory of job creation through conservation and alternatives.

II. Industrial/Commercial

- 9) *To facilitate the sharing of ideas regarding energy conservation in business and industry, an "energy clearing house" should be established as a source of reliable, decision-relevant information that identifies appropriate improvements and the best alternatives for making those improvements.*

Small businesses often don't have the financial or technical ability to lower their energy use, while larger businesses are conducting similar product and service evaluations, and both could benefit from information sharing. To assure that businesses can make cost-effective decisions, such information should include referral on services, product evaluation, and networking so that businesses can share their knowledge.

- 10) *Building energy conservation is one of the most comprehensive approaches to conservation available to all commercial and industrial buildings. Energy conservation programs, including government research efforts, energy performance standards, and financial incentives, should address existing buildings with an emphasis equal to that presently applied to new structures.*

The rate of replacement of the New England building stock is relatively low; thus over the near-term (25 years), existing, less energy-efficient structures will continue to dominate the building stock. In addition, the problems of improving the existing building inventory are more complex and difficult than the problems of constructing better new buildings, emphasizing the need to specifically address the retrofit of existing buildings.

III. Transportation

- 11) *Congress should not authorize any deficit spending of the Highway Trust Fund. Such spending runs counter to the principles of energy conservation.*
- 12) *All highway categories incorporated in the Federal-Aid Highways Act and the Urban Mass Transit Act (FAHA & UMTA) should be opened up to allow funding alternative transportation modes. This funding should come directly from the Highway Trust Fund.*
- 13) *Highway money should be allowed for use in transit operating assistance as well as capital (construction) costs under the same restrictions that now apply to UMTA.*
- 14) *When a locality decides to replace a planned interstate highway segment with a mass transit project, it should be funded with interstate highway monies, not with UMTA appropriations or general revenues.*
- 15) *In planning highway transportation projects, analysis of energy consumption should be a criterion in evaluation of the project, much the same as environmental impact, social and aesthetic values are protected.*

- 16) *The Northeast Corridor Improvement Project (NECIP) must be continued, and every effort should be made to achieve the original goals of the project.*

NECIP has been the crucial legislative issue regarding intercity rail passenger service affecting the New England region, and it is essential that the project be completed.

- 17) *Restrictions on truckers' use of piggyback service should be lifted.*
- 18) *The Interstate Commerce Commission should be given specific authorization to give a higher priority to energy conservation.*

Conservation Committee

- 19) *Unnecessary competition between rail and truck transportation service modes should be corrected through regulatory reform.*

Inessential circuitry routing, the arbitrary 20% mileage figure applied to trucks use of gateways, piggyback and superhighways, intercorporate transportation, and exempt commodities regulations should be reevaluated and possibly removed.

- 20) *Federal research into improved efficiency in trucks should be increased.*

Fuel-saving improvements through technological development, such as aerodynamic design changes and engine modification, should continue, and results of such research should be available to truck operators, both large and small, through the Department of Transportation.

- 21) *Driver education programs should incorporate energy conservation instruction in addition to safety training. Federal assistance in developing such materials for school and private instruction is recommended.*

Instruction should include gas-saving techniques in driving, trip cost information, transportation costs (both in dollars and petroleum), and an overall awareness to limit driving. The opportunities for the use of alternative modes of transportation should be explained and encouraged.

- 22) *The present Bikeways program should be expanded to include development of intercity bicycle paths. In addition, strategically located and secure storage racks should be provided.*

- 23) *Enforcement of the 55 MPH speed limit must become more stringent.*

IV. General

- 24) *The Conservation Committee strongly recommends the restoration of the Crisis Intervention Program funding to prevent a recurrence of winter fuel emergencies.*

When examining specific measures to encourage energy conservation, the committee also recognizes that rising energy costs impact more severely on low-income consumers. Low-income people spend a disproportionately high percent of their income on energy; such expenditures are almost entirely for essentials, and the low-income household has little opportunity to reduce consumption. The repercussions of not being able to meet ever higher winter heating bills, such as shut-offs and refusal of delivery, pose a real threat to life, especially to the elderly. The Crisis Intervention Program is a short-term approach to the energy problem. However, it is necessary until low-income housing is sufficiently weatherized, and substantial public assistance and utility rate reform is enacted.

Substantiating Papers

In a number of cases the Conservation Committee or individual Delegates to the committee developed papers discussing the action recommendations noted above. These papers follow.

I. Financial Barriers

Financial assistance for energy conservation measures is especially needed in the residential sector, where homeowners and renters often lack the capital to make necessary improvements to save energy. A variety of financial incentives are needed to encourage conservation among low, middle, and upper income groups.

Conservation Committee

Tax credits, such as those recently passed in the 1978 National Energy Act, are supported by the Conservation Committee. They stimulate those who can afford the upfront cost to make the investment in conservation measures, and reduce the payback period for such an investment.

Low-interest loans enable more middle income homeowners to finance home energy improvements. Federal or state guarantees for long-term loans for insulation and other improvements should be adopted. The Farmers Home Administration and the Veteran's Administration already provide such guarantees, and there is no reason why guaranteed loans should not be available for everyone.

Grants are extremely important in meeting home improvement needs of low-income households. Such housing is often in critical need of insulation, and a disproportionately high percent of the low-income person's earnings is already going for basic energy needs. Grant programs such as the weatherization program discussed later, should be expanded and vigorously implemented.

Funding for these incentives should be more thoroughly examined so that equitable measures can be devised to raise needed revenues. Conservation measures should be, in part, aimed at higher income consumers, who can reduce excess consumption, but should not result in higher energy prices for low income persons. Possible sources for such funding, as discussed by the committee, include: bank and/or utility involvement, utility rate restructuring, transfer of funds from other federal programs, income and/or energy taxes, or general revenue.

II. Energy Pricing Policies

Congress should study the regional impacts of energy policies, elasticity of energy pricing, energy price structures, and the end uses of energy. Accurate understanding of how energy policies affect consumers is needed in order to develop equitable programs dealing with all aspects of energy.

Artificial pricing of energy is not seen as encouraging conservation and should not be implemented, especially in view of the lack of evidence regarding the elasticity of energy pricing. Until there is greater understanding of the regional impacts of energy policy, price structures and elasticity, energy rates should reflect their replacement costs.

If, however, national policies do result in artificially high energy prices, such revenues should be distributed for conservation programs, development of alternative technologies, and for minimizing the impact on those who can least afford higher energy prices: the elderly and the low-income consumers.

Energy rates should reflect the cost to the consumer equal to the burden placed on the system. Utility rate reform is long overdue and the committee supports the intent of the National Energy Act to encourage states to review: declining block rates, which may promote wasteful energy consumption; peak load pricing, to discourage unnecessary use and spread the usage out; lifeline rates, so that peak load pricing does not over-burden elderly and low income households; and load management, which spreads out use and reduces the need for new plant construction.

III. National Weatherization Program (Submitted by Judith Mauzaka)

The National Weatherization Program is recognized as a major, long-term low-income energy project, and Congress should continue funding and give priority to its implementation. The

Conservation Committee

central arguments supporting this recommendation and a variety of points concerning program design are noted below.*

- 1) There are approximately 340,997 low-income housing units in need of weatherization in New England (102,566 owner occupied, 238,431 rentals). As of June 1978, only 27,000 homes have been weatherized. At the present rate of funding and activity, it will take approximately 25 years to complete the balance (not to mention work which will be required due to deterioration and partial weatherization efforts due to limited expenditures per unit).
- 2) Fuel savings have averaged about 25 percent in the first heating season, which in the case of an oil-heated home amounts to 300 gallons. Allowing for the gradual loss of effectiveness over time, the energy equivalent of over 80 million gallons of fuel will be saved over the lifetime of improvements. The fuel savings have a present value of 45 million dollars, compared with the 21 million dollar investment for all New England weatherization activities in the past three years.
- 3) Weatherization benefits New England in two ways:
 - a) Directly, by reducing the need for reliance on imported fuels and decreasing demand;
 - b) Indirectly, by generating weatherization funds for local labor and material (nearly 100 percent of New England weatherization purchases are made in the region) and by shifting expenditures by recipients of weatherization from fuel to other goods and services.
- 4) Nationwide, two fifths or less of the homes of the poor have insulation, storm windows and doors. As homeowners, this material is not affordable; as renters, low-income residents cannot demand such housing improvements.
- 5) Weatherization is the most effective conservation method for the low-income community. It effectively contributes to the growth of the economy while assisting low income individuals, and in particular the elderly, in meeting the goals of energy conservation. Failure to provide these services to those who cannot afford it will continue unnecessary waste of energy and increase transfer payments and crisis funding. Weatherizing low-income households will conserve energy (thus reducing the need for capital investment in expensive energy technologies), save low-income persons money, and relieve the demand on general revenues for emergency assistance.
- 6) As evidence of an effective home retrofit program with solid government support, Canada's recent activities stand out. In 1977, Nova Scotia set a two-year limit to weatherize 75 percent of its residential housing stock and completed one half of the total units in its first year. The rest of the country has set a 10-year limit for its goal of retrofitting the entire housing stock.
- 7) It is useless to speak of weatherizing homes which have rotting foundations or siding with holes. Also, insulation cannot be installed in old homes with 20 amp wiring. Therefore, the weatherization project needs to work in conjunction with a major program in housing rehabilitation. Maine has such a pilot project underway which successfully utilizes the resources of the Farmers' Home Loan Administration.

*References: *Impact of the New England Regional Commission's Low Income Winterization Project*, Urban Systems Research & Engineering, Inc., August, 1978; *GAO Report on the Effectiveness of the CSA Weatherization Program*, August, 1978; Testimony before the Department of Energy Hearing on the Federal Weatherization Program, September, 1978; *Position Paper on the Proposed Transfer of CSA's Energy Budget to DOE*, Ad Hoc Committee to Maintain CSA's Energy Program for the Poor, February, 1978.

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- 8) Fuel burner retrofit (as rigorously practiced by New Hampshire — 1,000 burner adjustments during the last three years) reflects a very short payback period and should become standard weatherization practice. Savings (approximately 75 dollars per average house in the first year) typically exceed the 25 dollar adjustment fee.
- 9) Total reliance on temporary and unskilled CETA labor, in addition to a predetermined time frame and completion schedule, place the Weatherization Program on a quality versus quantity seesaw. It can either maximize production or maximize training opportunities, but rarely both. CETA should be seen as supplemental labor, not a primary source. The only way that the Weatherization Program will ever reach its goals is through provision of a mix of trainees and permanent community action agency work crews and staff and by an extension of present regulations.

Due to serious labor problems, many weatherization programs are closing down throughout the country. Unless a significant portion of the \$200 million appropriated nationwide for the next year's budget is set aside for more than just supervisory labor, many more programs will collapse.

Both CETA and non-CETA workers can also be provided by a Congressional mandate to the Department of Labor. The Department of Labor may bypass local CETA prime sponsors by funding weatherization program operators directly. It can also set aside a certain number of CETA workers strictly for weatherization and remove the current one-year employment stipulation.

- 10) The existing weatherization program has suffered from an inability to maintain an effective balance among money for materials, labor and tools. There have been funding delays and per unit cost limitations. These will be chronic problems unless a secure and steady funding source is developed.

Although the Department of Energy has apparently become the primary funding source for weatherization, there are grounds upon which to advocate returning control of the program to the Community Services Administration:

- a) CSA is flexible—allowances are made for emergency repairs and the unanticipated and often extensive needs of substandard housing;
- b) CSA is diverse—allowances are made for job training, education and information, alternative technology installments, advocacy, and innovative research and development components;
- c) CSA deals with a total poverty approach—allowances are made for housing, counselling, food and unemployment, and recognizes that the needs of its targeted audience extend into other areas of basic necessities, especially major housing rehabilitation;
- d) CSA has experience with its constituency—both clients and local project operators, and has proved to be responsive to their needs.

However, if the Department of Energy is to remain the primary and not supplementary funding source of the program, major changes in format must be adopted in order not to inhibit optimum program operation, including:

- a) DOE must recognize the inherent poverty and social service function of the program, thereby acknowledging that by definition low-income people normally live in substandard housing;
- b) DOE must allow more money for personnel (both for supervisors and for some crew members). Rather than the present funding blend of 90% materials and 10% administration, a more realistic administration allocation of 20-30% should be

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considered. This is especially important if DOE is no longer involved in a supplemental capacity;

- c) Allowable expenditures for home repairs, vehicles, and tools must rise (especially to allow for the purchase of insulation blowing machines) and a major redefinition of eligible materials is needed.

CSA's approach has been to reduce the impact of high energy costs on the poor through a variety of measures, including conservation. DOE's approach is to conserve energy through higher prices. Congress can show its support of CSA's weatherization involvement in March, 1979, when supplementary HEW and Department of Labor appropriations will be considered.

IV. Energy Audits

Home energy audits are seen as an integral part of any comprehensive energy program, and their availability should be increased. The National Energy Act requires utilities to offer to inspect a home and recommend and arrange for installation of conservation measures; the Conservation Committee recommends that all heating fuel suppliers should participate in any mandatory audit program. Also, to protect consumers, audit firms or persons performing audits should be required to make certain disclosures as to the interest the firm or person might have in the resulting recommendations.

With the passage of the National Energy Act, a large number of utility audit programs will be starting soon, and there is a clear need to determine an optimal structure for these programs. The type of information that is really useful to a homeowner, the potential savings of conservation measures, and the methodology of audits must be established.

Utility audit programs in many cases do not strongly promote retrofit.¹ A typical result of an audit is a set of recommendations and a sheet of paper listing contractors whom the homeowner may contact. Much better results from these programs could be obtained if retrofit were made more integral to the program. Also, there is some doubt regarding the interests of utilities in energy conservation. These doubts could be alleviated through vigorous audit implementation and follow-up. These problems must be recognized and addressed by the emerging audit programs.

V. Appliance Efficiency Standards

Under the 1978 National Energy Act, the federal government is responsible for establishing mandatory efficiency standards for appliances (such as refrigerators, water heaters, air conditioners, televisions, kitchen ranges and ovens). Appliance improvements would result in savings of energy and savings of dollars to the customer over the life of the appliance.

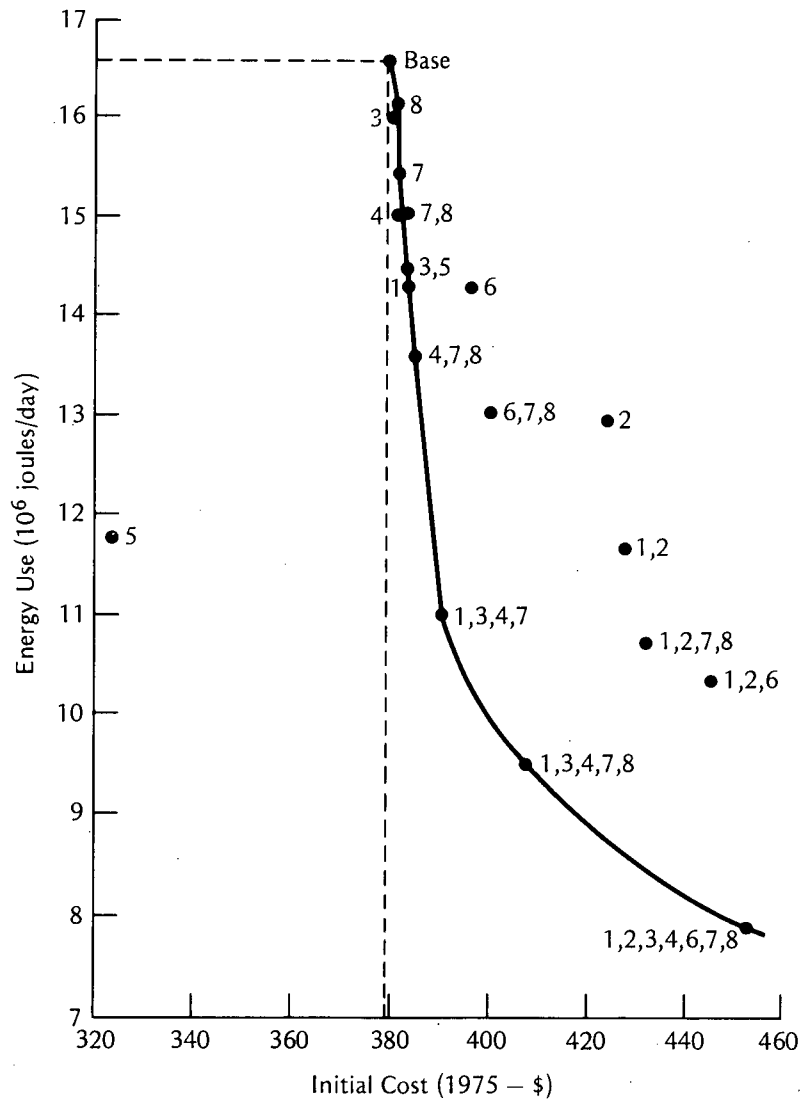
The technology of appliance efficiency improvement is known today, and many energy-saving design changes can be made with only a small increase in the initial cost of the appliance. Hoskins and Hirst, for example, in *Energy and Cost Analysis of Residential Refrigerators*², compared energy use vs. retail price for a variety of design changes in a model refrigerator-freezer. As shown in Figure 1, a substantial reduction in energy use can be achieved with a few basic changes and at a minimal cost increase.

Federal guidelines were first outlined under Title III of the Energy Policy and Conservation Act (P.L. 94-163) which established an energy conservation program for consumer products other

¹ Peter Hogarth, *Survey and Analysis of Residential Energy Audit Activities in the US*, Prepared for the Office of Technology Assessment, by Technology and Economics, Inc., May, 1978.

² Oak Ridge National Labs, January, 1977.

Figure 1
Energy Use vs. Retail Price for Various Design Changes for a
0.45 m³ (16 ft³) Top-freezer Refrigerator



Source: Hoskins, Robert A., and Hirst, Eric., "Energy Cost and Analysis of Residential Refrigerators," Oak Ridge National Labs, Jan., 1977.

1. Increase insulation thickness	5. Eliminate frost-free and forced air systems
2. Improve insulation thermal conductivity	6. Improve compressor efficiency
3. Remove fan from cooled area	7. Increase condenser surface area
4. Add anti-sweat heater switch	8. Increase evaporator surface area

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than automobiles. Under the Act, the Department of Energy prescribed energy efficiency improvement targets for each category of appliance. For example:

- a) The energy efficiency improvement target for refrigerators and refrigerator-freezers shall be a 39 percent increase in the energy efficiency of the total number of refrigerators and refrigerator-freezers manufactured by all manufacturers in calendar year 1980 when compared with the energy efficiency of the total number of refrigerators and refrigerator-freezers manufactured by all manufacturers in calendar year 1972.

These federal standards, however, are proving difficult to implement, and it is unlikely the present deadline of 1980 will be met. The primary problem with the guidelines is the comparison of appliance efficiencies with the base consumption levels of 1972, which prove to be almost impossible to calculate. While debate over the calculations of those base consumption levels continues, manufacturers will be unable to determine if they have met the percent increase in efficiency targeted by the DOE guidelines.

Several states have established their own appliance efficiency standards, and some of these state guidelines provide a better model for a mandatory federal program. In California, the Appliance Efficiency Standards apply to the sale of new appliances within the state. The standards set specific formulae for determining the energy consumption levels that must be met by all appliances of a certain category. (See Tbl. 1.)

Table 1

California Efficiency Standards

Refrigerators and Freezers. The energy consumption of all new refrigerators, refrigerator-freezers and freezers, sold or offered for sale in California on or after the date specified in this table shall be certified not to exceed the values derived from the appropriate formulae where V is the total refrigerated volume (cubic feet) and EC is the energy consumption (kWh per month):

Effective Date	Appliance	Formula
November 3, 1977	Refrigerators	$EC = 40 + 2.5W$
	Refrigerator-freezers and freezers with automatic defrost system	$EC = 40 + 7V$
	all others	
October 1, 1978	Upright freezers with automatic defrost system	$EC = 38 + 6.6V$
	all others	$EC = + 4.7V$
	Other freezers with automatic defrost system	$EC = 31 + 5.4V$
	all others	$EC = 31 + 3.9V$
November 3, 1979	Refrigerators	$EC = 40 + 2.5V$
	Refrigerators-freezers with automatic defrost system	$EC = 40 + 5V$
	all others	$EC = 40 + 4V$
	Upright freezers with automatic defrost system	$EC = 38 + 4.7V$
	all others	$EC = 38 + 3.8V$
	Other freezers	$EC = 31 + 3.1V$

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Like the federal guidelines, the state standards describe uniform test methods for measuring the energy consumption of each type of appliance. The federal government is encouraged to establish *mandatory minimum performance standards* for appliances. The present reliance on the 1972 base consumption levels is unworkable. Instead, minimum energy efficiency levels should be set, and all appliances on the market must meet those levels.

Further, the federal government should require prominent labeling of appliances with information pertaining to energy consumption. Such labeling should include the minimum efficiency level established for the appliance, as well as the consumption level of that particular model. In addition, labeling should show the range of efficiency achieved for the appliance so that the consumer can determine where that particular model's performance falls within the range.

VI. Conservation and Job Creation

The impact on job creation of various conservation measures should be considered when evaluating conservation programs. The development of a viable conservation industry to meet the region's needs for conservation goods and services is supportive of regional economic development. Such development could create employment opportunities, stimulate the local economy, and reduce the out-flow of dollars to non New England suppliers.

The Conservation Committee recognizes the work of the Jobs Subcommittee of Alternatives as directly related to the interests of conservation. Of special relevance are two studies, the Franklin County, Massachusetts and the Long Island Jobs studies, which deal specifically with job creation in energy conservation programs.

VII. Business and Industry Energy Clearing House

There is a need among industries to share information and ideas regarding energy conservation. Hundreds of different measures affect energy use in commercial and industrial businesses, and identifying the most appropriate energy conservation projects is beyond the capabilities of many businesses. This need is acute among small industries, as these businesses usually have financial restrictions that prevent them from hiring expertise, and the current "free" information is too generic to have impact. Much of New England's commerce consists of small industries which are extremely diversified, and which employ a significant portion of the population. Savings accrued through energy conservation could strengthen the Northeast's economy, stimulate development, and create an escalating job market.

An *energy clearing house* would meet this need by providing industries with decision-relevant information on process or building improvements and evaluation of equipment and/or installation of such measures. Presently, information available from marketers of goods and services is sometimes biased, and the task of judging claims or comparing among competitive products and services is complex and time-consuming. By creating a mechanism for industrial users of energy conserving measures to share their experiences with potential users, the *clearing house* would function as a cross between *Consumer Reports* and the Better Business Bureau. Product profiles, operational procedures, evaluation techniques, and other services would be available, allowing potential customers to evaluate appropriate energy saving measures before a capital investment is made, thus improving cost-effectiveness. Businesses promoting legitimate energy saving services would also benefit, as their products or services would be presented with documented performance data.

Ideally, information from the *clearing house* would be made available at little or no cost. Congress should consider creation of such a resource for business, and the Conservation Committee is examining the development of a specific delivery system. Whether the *clearing house* is attached to an existing institution or established as a non-federal, independent source, it should identify the energy needs of the region's businesses, and any government or private

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programs presently addressing industrial energy conservation. Whatever mechanism is chosen, the *clearing house* must remain independent and impartial so that its information obtains maximum credibility.

VIII. Retrofit of Existing Commercial and Industrial Buildings

One pervasive problem for business interests is the cost of heating and cooling industrial and commercial buildings. Thus building energy conservation is one of the most comprehensive approaches available to benefit all businesses. In New England, a large segment of the building stock is comprised of existing structures. With a replacement rate of approximately 2% a year, the mix will continue to be predominantly existing structures for a number of years, making it essential to address the problems of retrofitting older buildings.

Energy conservation programs addressing existing buildings should be given equal emphasis as programs for new buildings, including government research efforts, the development of performance standards, and financial incentive programs. Current and past government programs focus attention on new buildings. Federal research efforts predominantly address energy conserving technology that is most easily applied to new construction. Similarly, major federal government initiatives are under way in the development and implementation of standards for new construction.

The current emphasis on new construction is misdirected for two reasons: first, the problem of improving the existing building inventory is more complex and difficult than the problem of constructing better new buildings; and second, the rate of replacement of the New England building stock is such that buildings constructed under today's and future standards will represent a small percentage of the region's building stock over the near term (25 years), and will consume even a smaller percentage of the energy used in buildings.

Therefore, Congress should allocate at least one half of federal research resources in building energy conservation to research on the problems of existing structures. Standards are needed for the upgrading of existing buildings, as are programs to address cost-effective improvements in the energy efficiency of such structures.

The importance of such programs to New England is evident. The region's building stock is being replaced at a lower rate than the national replacement rate. Additionally, due to the colder climate, energy consumption in buildings is a more significant portion of the cost of doing business in the region. Finally, as newly constructed facilities become relatively more attractive than existing facilities, the probability of businesses relocating outside of New England increases. The retrofit and increased energy efficiency of all buildings is important to the overall reduction of the nation's energy needs, and should be a major part of any conservation program.

IX. Highway Trust Fund/Mass Transit (Submitted by Ann Roosevelt and Sylvia Field)

The Highway Trust Fund was established in 1956 to provide funds for the construction of the Interstate Highway System and to accelerate the expansion of existing neglected rural roads. In large measure, these purposes have been achieved. Recognizing the critical liquid fuel situation, we must now question whether expansion of the Highway Trust Fund, above and beyond maintenance costs, and the placing of restrictions on the use of such monies to designated highway categories runs against the grain of our urgent need to conserve energy. More appropriate action, in our judgement, would entail increased revitalization of mass transit systems in New England, while discouraging inessential automobile use.

The 95th Congress, in its final days, passed the 1978 Highway Transportation Act which authorizes the following expenditures on highways:

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Fiscal Year	Billions of Dollars
1979	8.40
1980	8.90
1981	8.90
1981	9.40
1982	8.15
Total Fiscal Years 1979-1982	34.85

Two points regarding this authorization deserve mention. First, while most of this money is allocated from anticipated Highway Trust Fund revenues, a small portion has been allocated from other sources. This will only serve to perpetuate a trend toward federal, state, and local subsidies for highway costs that clearly contradicts the goal of energy conservation.

The Federal Highway Administration's 1974 *Highway Statistics* indicates that a large disparity exists between direct expenditures on highway construction, maintenance, and administration, on the one hand, and revenues raised through user taxes and tolls on the other. In 1973, New England spent \$1.43 billion on highway construction, rehabilitation and maintenance while fees for the use of these roads covered only \$0.93 billion of this expense, a 35% disparity. The remaining one-half billion dollars came from general funds, property taxes, bond proceeds, and miscellaneous sources.

This disparity between revenue and expenditure leads to the other concern implied in the \$34.85 billion authorization, that is, deficit spending. No deficit spending was authorized in the 1978 Highway Transportation Act, a policy we support. Deficit spending discourages the use of mass transit by:

- 1) Increasing financial support of less energy efficient vehicular traffic over more energy efficient transportation modes competing for the same federal funding,
- 2) Further weakening the link which ties road user payments to the full costs of highway rehabilitation, and
- 3) Providing money for new road construction which will perpetuate the attractiveness and convenience of the automobile as the chief transportation choice.

Another way to promote mass transit is to create more flexibility in the use of highway money so it can fund public transportation. Currently, funds for most categories in the *urban highway* system under the Federal-Aid Highways Act can be used for mass transit *capital assistance*. But even more flexibility is needed to promote the use of mass transit and discourage the use of the automobile. Providing the states with Highway Trust Fund money which must be restricted to highway expenditure guarantees that a state or locality will spend this money on highway projects, even if more desirable energy conserving transportation options are available. A consistent Federal policy would require states and localities to choose from a variety of alternative transportation modes rather than limiting such choices to highway construction and improvement.

Similarly, Highway Trust Fund money now available for capital costs should be made available for transit operating assistance. In nearly all instances, New England states and localities would better serve the region by revitalizing and improving existing mass transit systems rather than purchasing and constructing new ones. Existing systems could be improved through expansion of feeder lines, satellite parking, and shuttle service, where appropriate.

Decision makers ought to be able to choose among project alternatives based on the merits of the project rather than committing themselves to restricted options because of federal funding constraints. Such shared funding could be modeled after the Urban Mass Transit Act restrictions.

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These allow 50% of UMTA grants for use toward operating assistance. Included in such operation changes should be the establishment of no fare, low fare, and off-peak fares to attract riders.

Lastly, energy analyses will and must continue to play a most significant role for choices between transportation projects. Therefore, it is imperative that such analyses accompany any project plan before funding is allotted for that project. These analyses would be similar to environmental impact statements. They should compare the energy efficiency of the transportation project to all other means for performing the same transportation task.

X. Intercity Rail Passenger Service (Submitted by Ann Roosevelt and Sylvia Field)

Time and cost constraints have placed considerable pressure on Northeast Corridor Improvement Project (NECIP) planners. It is now questionable whether they will meet their revised goals with the funding authorized by Congress and within the allotted time. There are several ways that this project might go forward more efficiently.

If feasible, a return to the original work plan, as originally specified by Congress, should occur. Estimates showed that it would cost \$4.3 billion to renovate the Northeast Corridor System. This renovation would cut the trip time between Washington and New York to 2 1/2 hours. It would cut the time between New York and Boston to three hours. The system envisioned would provide service for thirty million passengers annually, an increase from the 1975 level of 9.6 million passengers.

The Railroad Revitalization and Regulatory Reform Act of 1976 revised these proposals downward. Congress authorized only \$1.6 billion, and the consequent improvement goals were more modest as well. The Act relaxed the trip-time goals to 2 hours and 40 minutes between Washington and New York, and 3 hours and 40 minutes between New York and Boston. Passenger load estimates have been eased to only 21.8 million passengers, a drop of 30%.

The Act stipulated that NECIP improvements should be completed by 1981. However, the changes will make this extremely difficult. James Cagwood*, NECIP director for DeLeuw, Cather/Parsons, the designers of the project, testified before Congress that the result of design change has led to a condition known as *fast-tracking*: substantial planning concurrent with design and construction.

Fast-tracking involves many risks that further threaten cost constraints and the quality of the work on the project. Those that Cagwood enumerated were:

- 1) Redundant design efforts,
- 2) Wasteful expenditures on construction activity,
- 3) Increase of project costs because of:
 - a) Reduced productivity that results from track use constraints.
 - b) Other productivity shortfalls,
 - c) Escalating signal and electrical equipment and material costs,
 - d) Revised forecasts of program management costs, and
 - e) Increased labor costs (because of time losses).

*Statement of James A. Cagwood, Project Director for NECIP, DeLeuw, Cather/Parsons, before the subcommittee on Government Activities & Transportation of the House Government Operations Committee, June, 1978.

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This has created a dismal situation for the project, because improvements have now been "reduced to the bare minimum" necessary to meet trip-time goals. Also, there will not be any major expansion of system capacity along the Corridor.

These problems could be rectified by a return to the original project plan. In the interest of energy conservation, this return would make rail service along the Corridor far more attractive. It would also enable rail passenger service to compete more effectively with other passenger transportation modes.

If NECIP must continue under such severe constraints, then expenditures on improvements of dubious value should be reconsidered. One such improvement is electrification. Seventeen percent of the current trimmed NECIP budget — \$305 million — is set aside for electrifying the remaining non-electrical portion of track between New Haven, Connecticut and Boston, Massachusetts.

In the NECIP Final Programmatic Environmental Impact Statement, Published in June 1978, the advantages that electrification offers were cited. They are:

- 1) Environmental advantages,
- 2) Excellent acceleration/deceleration characteristics,
- 3) Independence from a single fuel source (diesel),
- 4) A savings of 176,000 barrels of oil annually, and
- 5) Eliminating the locomotive change at New Haven.

According to numerous studies, each of these points are questionable. The Massachusetts Executive Office of Environmental Affairs¹ (Mass. EOE) criticized the electrification plan for a variety of reasons, not the least of which is its environmental disadvantages. The Massachusetts EOE claims that the only advantage would be the consequent savings of petroleum. However, this savings in oil must be balanced against the increased air pollution and public safety implications of relying on more coal-fired and nuclear generated electricity. Moreover, according to Battelle Columbus Laboratories, which prepared an environmental assessment of the NECIP plan, it will be necessary to expand present generating facilities or construct new ones in order to electrify the rail line.

A study by Peat, Marwick, and Mitchell² finds yet further fault with electrifying the rail system. This study suggests that the total energy savings is not clear-cut (the Mass. EOE predicts a 3% increase in total use), while the escalating costs of electric power make it less attractive economically. Moreover, it suggests that the petroleum savings would be relatively minor, since all diesel fuel used in rail transportation accounts for less than 4% of the petroleum used in the transportation sector.

Sufficient debate about the environmental effects and fuel savings of electrification exists to consider less expensive alternatives for accomplishing similar goals. Since the acceleration and deceleration between New Haven and Boston could not account for that much time, improving it somewhat at such a great expense may not be necessary.

If it is absolutely impossible to return to the original trip time goals and schedule, then Congress should consider authorizing a Government Accounting Office (GAO) investigation into the effectiveness of improvements within the limits of its restricted budget. The GAO could

¹ Statement of the Secretary of Environmental Affairs on the Draft Environmental Impact Report regarding NECIP, Massachusetts Executive Office of Environmental Affairs, December, 1977.

² Peat, Marwick, Mitchell, *Energy & Economic Impacts of Projected Freight Transportation Improvements*, November, 1976.

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examine why estimates on Corridor improvement have varied so greatly over the last decade. They could determine whether electrification is really a significant advantage and whether its benefits are worth such a large share of such a limited budget. Numerous possibilities exist. The Massachusetts EOE has suggested one possible alternative to complete electrification of the line that was not even mentioned in the final environmental impact statement. The EOE proposal recommends a combination of diesel/electric and electric locomotives. These locomotives would run on diesel electric engines until they reach the electrified portion of the line when their catenaries would be raised and a switch would be made to electric power. This would entirely negate the loss in time which results from locomotive changes.

In the interest of energy conservation, it is essential to provide public transportation systems that the public will use and that will contribute substantially to lowering the region's demand for energy.

XI. Rail and Truck Freight (Submitted by Ann Roosevelt and Sylvia Field)

While the nation has witnessed a severe decline in rail traffic over the last thirty years, the Northeast Region has lost rail service at an even greater rate than the national average. Carloadings for the Northeast dropped 4.3% in 1977, compared to a 0.7% decline for the entire nation.

The railroad decline has been attributed to the inability of rail to serve its customers as well as trucks can. There are certain improvements that could be made through Congressional legislation and regulatory reform that would somewhat ameliorate that situation. Because of its energy savings potential, it is essential to retain rail freight service in New England as a link of a vital national rail network.

Rail freight is much more energy efficient than truck freight for transporting bulk goods over long distances. Per net ton-mile, rail freight consumes only 687 BTU, compared to 2343 BTU for trucks. Furthermore, truck freight accounted for 23.87% of all transportation energy consumed in the U.S. in 1976. This contrasts to only 2.76% for rail freight.

Congressional action must center on three strategies:

- 1) Promote cooperation between truck and rail, to allow each to perform its best services most effectively;
- 2) Eliminate unnecessary competition between rail and truck freight service which only results in energy waste;
- 3) Bring regulatory procedures into line with energy conservation objectives.

Removing restrictions on trucker's use of piggyback service would meet all three strategy criteria. Piggyback service -Truck on Freight Car (TOFC) and Container on Freight Car (COFO)-combines the advantages of truck freight service with those of rail. For the short haul, goods would travel on highway. For the long haul, they would travel by rail. This service would use two to three times less energy than conventional truck service by substituting more energy efficient rail mileage for less energy efficient truck mileage.

Other advantages of piggyback, according to the Council on Wage and Price Stability, include:

- 1) More direct shipments of goods;
- 2) Improved service;
- 3) Reduced highway congestion, air pollution, and maintenance costs;
- 4) Eventual lower shipping rates.

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In 1976, however, only 5.9% of all domestic rail freight carloadings were piggybacks. Among many factors responsible for this are existing Interstate Commerce Commission regulations that restrict truckers' use of piggyback. ICC regulations currently forbid regulated truckers from travelling to a city to use a piggyback service unless the trucker has already been granted an ICC operating authority for that city.

Moreover, if the piggyback mileage is not at least 80% of the mileage the truck would travel via its authorized route, the ICC forbids truckers from using that service. This 80% figure was scaled downward from an original 85% figure in 1976. It was modeled after the 20% mileage rule, established by the ICC in 1974.

Over 17,000 trucking companies are subject to ICC regulation. The ICC gives top priority to maintaining competition in the trucking industry, even if such competition interferes with other national objectives, i.e., energy conservation, and even if the regulations lead to inefficient operations. Its discouragement of piggyback service is merely one example of these regulations.

Intercompany transportation is another example of ICC regulation. The ICC prohibits one company from transporting the goods of another when returning to its original location. This results in undue empty mileage. Similarly, the ICC prohibits unregulated (exempt) carriers from transporting goods of regulated carriers. This also results in substantial empty mileage.

A whole series of regulations affecting piggyback, gateway passage, and superhighway travel are all based on the arbitrary figure of 20%; exceeding this level supposedly adversely affects competition, although this has never been shown, nor has it even been tested.

The 20% figure was set for removing gateway restrictions in 1974. The previous year a group of truckers petitioned for its removal. They claimed that eliminating the circuitous routing of gateways could save each year:

- 1) 100 Billion Vehicle Miles;
- 2) 200 Million gallons of fuel;
- 3) \$1 billion in operating expenses;
- 4) 100,000 tons of pollutants from diesel emissions.

The ICC responded by forbidding truckers from using gateways if the gateway mileage exceeded the authorized route mileage by 20%. This restriction does not apply to shipments under 300 miles.

Regarding superhighway travel, in 1975 the ICC used the 20% criterion to restrict truck travel on superhighways if the mileage reduction from the authorized route remained below that figure.

Without congressional action to stimulate reform of ICC regulations which presently encourage energy waste, there is little likelihood of near term solution of these problems.

XII. Crisis Intervention (Submitted by Judith Mauzaka)

The Conservation Committee strongly recommends the restoration of the Crisis Intervention Program funding through the Community Services Administration to prevent a recurrence of winter fuel emergencies. While such a program is recognized as a short term approach to the energy problem, it is a necessary interim program which must continue until such time that low-income housing is sufficiently weatherized and substantial public assistance and utility rate reform is enacted.

While examining specific measures to encourage energy conservation, the committee also recognizes that rising energy costs impact more severely on low-income consumers. Low-income people spend a disproportionately high percent of their income on energy, and such expenditures

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are almost entirely for essentials. Consequently, the low-income household has little opportunity to reduce consumption.

Major arguments supporting this recommendation are enumerated below.*

- 1) The cost of the four basis necessities (energy, food, medical care, and housing) rose at a rate of 15%, more than one third faster than the government's Consumer Price Index of 11.2% for the period of March through June, 1978.

Breakdown	Annual rate for 3 mo. ending Mar. '78	Annual rate for 3 mo. ending June '78	Annual rate for 6 mo. ending June '78
Energy	5.4	12.3	8.8
Food	15.7	20.9	18.3
Shelter	11.4	12.8	12.1
Medical	8.7	7.5	8.1
TOTAL	11.4	15.0	13.2

- 2) In general, New England energy costs have risen four times faster than welfare payments since 1973. Even before 1976-1977, many poor and elderly paid 60-80% of their incomes for shelter and heat.
- 3) Energy costs are disproportionately high for low-income consumers who face the fewest options and the most burdens as reflected in income inelasticity, lack of choice in housing, etc.
- 4) In Connecticut alone, where 1970 housing stock figures show 44% of the homes built before 1940 and 34% built before 1960, attesting to the need for adequate insulation and infiltration measures, there is a \$5.7 million estimated need for crisis intervention this winter. Currently, only \$1.3 million has been allocated.
- 5) Although low-income household energy use is almost entirely for essentials (i.e. space and water heating, cooking, food refrigeration, lighting), and studies show that a low income also corresponds with low energy usage, the percentage of income spent on energy for the poor is in marked contrast to that of the well off:

	Home Energy Consumption	Gasoline Consumption	Total
First Decile (less than \$3,000 yearly)	20.2%	9.6%	29.8%
Tenth Decile (above \$30,000 yearly)	2.0%	2.2%	4.2%

Any excess usage among low-income consumers is normally the result of poorly insulated homes and inefficient appliances. Therefore, any increase in the price of energy will cause a reduction in real living standards that is seven times as large for the poorest decile as for the richest decile.

- 6) Rising energy prices lead to winter heating bills higher than what a growing number of people with limited means can afford to pay. Resulting shut-offs, refusal of delivery combined with recent colder than normal winters pose a real threat to life, especially to the elderly. However, the poor don't need aid just during shortages and severe winters. Their energy costs plague them whether the winter is severe or mild.

*References: National Center for Economic Alternatives, Washington D.C., August, 1978; Thomas Fitzpatrick, *Connecticut's Crisis Intervention Programs, Coordinating Diversity* April, 1978; Newman, Dorothy, *The American Energy Consumer*, Ballenger Publishing Co., Cambridge, MA. 1975; Urban Institute, *Evaluation of the 1977 Summer CSA Crisis Intervention Program*, April, 1978; Charles Burkhardt, New England Fuel Institute, Watertown, MA.

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- 7) Heating oil bills for an average household in New England have increased from \$340 per year at the end of 1971 to \$810 at the end of 1977. A 10% increase per year (due to inflation, the price of domestic crude and OPEC crude) will bring the average heating oil bill to about \$1,030 a year within less than a two-year period.
- 8) Such an increase does not take into account non-product costs such as insurance, real estate taxes, labor, vehicle replacement, deliveries, equipment replacement, etc. In general, indirect energy costs and usage, (i.e., products which require energy to produce, transport, store and sell) are considerable and will substantially add to the financial burdens of the poor and middle income.
- 9) The increasing number of uncollectable accounts has resulted in numerous independent heating oil distributors going out of business and regulated utilities attempting to recover their losses by passing these costs on to other customers.
- 10) In order to avoid such problems as administrative lag, inadequate training and poor communication, the program must provide reasonable workable and uniform program requirements, time and eligibility limits along with adequate levels of support for administration and technical assistance. The elderly, who comprise the target audience of the program, must not be hurt by no-escrow clauses.
- 11) To shift the program from a band-aid approach of simple income maintenance and direct subsidy to utility companies, crisis intervention can easily expand to become a more encompassing "crisis systems" program. Local administering agencies have effectively established an outreach system which will allow workers to administer immediate relief (i.e. wrapping hot water heaters, fixing frozen pipes) and assessing the need for blankets, clothing, and food. This expansion of the program, coupled with rigorous counselling and self-advocacy training will provide more mileage for the invested money and act as a bridge to long-term weatherization. Indeed, crisis intervention clients, wherever applicable, should receive priority as weatherization clients despite the recognition that the funds presently available cannot possibly meet the demand.

XIII. Continuing Work

The Conservation Committee is continuing its work on a variety of topics. Some aspects of this work will focus on further substantiating committee recommendations while other efforts involve new proposals and issues which may lead to additional committee recommendations. These topics include:

- 1) Accelerated depreciation for capital investment in energy conserving replacement equipment;
- 2) Alternative fuels, i.e. alcohols;
- 3) Weatherization;
- 4) Crisis Intervention;
- 5) Income and energy use;
- 6) Conservation financing.

REGULATORY AND INSTITUTIONAL PROCESSES COMMITTEE

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OVERVIEW OF COMMITTEE ACTIONS

In keeping with its charge to achieve consensus recommendations, the Regulatory and Institutional Processes Committee has concentrated on topics where agreement could be reached. More controversial topics have also been discussed, some in considerable detail, but recommendations on such topics are few since consensus was an overriding goal.

It is clear that a "best energy strategy" must be modified to become an optimal energy strategy given institutional constraints in New England. To begin with, this region is defined as six states. The very existence of those states places legal and institutional barriers in the path of any attempt to apply energy-related policies or actions to the region as a whole.

The problem is not merely legal or jurisdictional. Political climates and the energy policies shaped by those climates vary from state to state. Private-sector efforts to regionalize (e.g. The New England Power Pool) have sometimes run ahead of public-sector efforts to fulfill regional regulatory obligations. Expansion of the regional concept to include eastern Canada and inexpensive hydro power capacity is discouraged by the existence of national boundaries.*

The committee spent considerable time discussing but not acting upon controversial energy topics such as facility siting, nuclear waste disposal, nuclear construction, nuclear licensing, and oil

* However, the committee notes that contractual reliance on Quebec hydro may be a wiser policy than reliance on OPEC oil.

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and gas pricing. Action on these topics was avoided because the committee saw limited opportunities for consensus within the time available and viewed potential results of detailed consideration as providing little more than reiteration of perspectives already known to the Congress. It should also be noted that other committees of the Energy Congress considered some of these topics. Indeed certain less controversial issues such as transportation/energy problems and fuel mix have not been considered in detail by this committee because it was known that other committees were dealing with those topics. Subsequent to the preparation of this report and in response to public comment on the report, the Regulatory and Institutional Processes Committee may consider and act upon some of the controversial topics as well as upon those aspects of other topics not fully considered by other committees.

Topics considered and acted upon by the committee were as follows.

- 1) Decentralized Sources: Energy Conservation/Solar Energy Package.
- 2) Decentralized Sources: Cogeneration/Small Scale Hydropower.
- 3) Interstate Regulation.
- 4) Public Awareness.
- 5) Low-Income Intervention
- 6) Uniform Taxation of Utilities.
- 7) Foreign Tax Credits.

SUMMARY OF RECOMMENDATIONS

I. Decentralized Sources: Energy Conservation/Solar Energy Package

- 1) *Promising, nonconventional energy technologies using renewable resources should be encouraged in order to reduce New England's heavy dependence on resources with finite, depletable reserves.*
- 2) *Of the two options available for federal action, increased subsidy of alternatives is preferred to reduced subsidy of conventional energy technologies for two reasons:*
 - a) *Federal subsidy can reduce prices by encouraging commercialization and mass production; and*
 - b) *It is politically unrealistic to expect the federal government to significantly reduce the existing subsidies given to conventional technologies.*
- 3) *While the Energy Tax Act of 1978 and the Energy Conservation Act of 1978 contain considerable subsidies of the type recommended here, further federal action is recommended:*
 - a) *To augment subsidization of passive solar systems, and*
 - b) *To add grants for installation of solar and other alternative energy devices (including retrofit components) in homes owned by persons with incomes so low that they pay little or no income tax (and will not, therefore, benefit from tax credits).*

II. Decentralized Sources: Cogeneration/Small Scale Hydropower

- 4) *The productive use of otherwise wasted heat should be encouraged regionally, as should the use of other site-specific resources such as the energy latent in falling water.*

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- 5) Governmental policy should be directed toward maximization of decentralized sources of power where this is consistent with cost effectiveness to consumers and will not increase New England's dependence on oil.
- 6) The committee recommends favorable administrative action to encourage decentralized power under recent federal actions:
 - a) Sections 202, 203, 204, and 210 of the Public Utility Regulatory Policies Act of 1978 encouraging cogeneration, its interconnection with existing electric power grids, the wheeling of power, and the encouragement of cogenerated power and other small power production facilities through sales of excess power to an existing grid; and
 - b) FERC's promulgation as of September 5, 1978 of a short-form licensing procedure for small scale hydropower facilities.
- 7) The New England states should consider the regional importance of encouraging sales at retail of cogenerated and small scale hydro power in order to maximize site-specific advantages and minimize transmission losses. Wherever feasible, cogenerated and small scale hydro power should be used on site or near site.
- 8) There should be created a New England regional technical committee of the type recommended by the Massachusetts Governor's Commission on Cogeneration to encourage cogenerators and to serve as an information center on small, decentralized energy technologies.

III. Interstate Regulation

- 9) Sections 141 and 142 of the recently enacted Public Utility Regulatory Policies Act of 1978 should be amended to earmark a portion of the funds for state utility regulatory assistance to interstate utility regulatory assistance.
- 10) Other actions to strengthen interstate regulatory capability should be undertaken because the private sector has taken advantage of interstate interconnection opportunities to realize important economies of scale while regulation continues to be pursued largely at the state level.

IV. Public Awareness

- 11) The committee believes that voluntary action to improve New England's energy situation is preferable to legal or political pressure, and that public awareness of energy facts, estimates, and prospects is the critical variable needed to make voluntary action become a useful contribution to solving energy problems. A regional organization with permanent staff and with advisors, similar to the New England Energy Congress, should be created to communicate energy facts, estimates, and options for the future to the public at large.
- 12) This organization should not be connected to an existing government. It should be as free as possible from policy constraints imposed by governments. Its only obligation should be to make the public aware of energy facts and responsible energy estimates.
- 13) This organization should be funded by sources which will not influence the organizations' choice of ways to proceed. Multiple source funding is one means for reducing opportunities for any single source to influence policy.

V. Low-Income Intervention

- 14) Congress should consider legislation which goes beyond present consumer laws to make low-income consumers a separate and distinct category of consumer advocacy.
- 15) Congress could partially accomplish this objective by enacting legislation which makes grants to states contingent upon states creating an agency or agencies capable of adequately representing low-income interests in utility rate cases.
- 16) Two such agencies are suggested:
 - a) A Low-Income Consumer Council funded by state and federal sources, but with the federal funds contingent upon state satisfaction of federal guidelines relative to low-income representation, and
 - b) A Low-Income Funding Committee at the state level which would make grants to applicant organizations wishing to intervene in rate cases on behalf of low income interests, such committee to be authorized to obtain funds for awarding grants from private, state, and federal sources and from a minimal percentage of the gross revenues of regulated utilities.
- 17) If only one type of agency were authorized by federal legislation, 16(a) above is recommended to provide maximum continuity for low-income interest and to separate the special problems of low-income utility customers from those of other consumers (whose interests may be quite different and whose ability to represent those interests is not hampered by inability to pay for expert testimony).

VI. Uniform Taxation of Utilities

The committee explored the implications of (1) replacing the income tax on electric utilities with a use tax and (2) allowing privately owned electric utilities to issue tax exempt securities. The first issue arose out of the concern that investment tax credits and accelerated depreciation are inappropriate for regulated utilities. Allowing privately owned utilities to issue tax exempt securities places them on a more equal footing with municipals. Comments were received from a variety of sources. In general, there was not widespread support for either part of the proposal, so the committee made no recommendation.

VII. Foreign Tax Credits

By vote of the committee, the Issue Background Paper on foreign tax credits prepared by committee staff was made an addendum to the Energy Conservation/Solar Energy Package.

SUBCOMMITTEE REPORTS

Energy Conservation/Solar Energy Subsidy Package

I. Federal Government Energy Development Spending Policies

Research and development has established the potential ability of solar and other alternative energy technologies to make a significant contribution to New England's production of energy. However, current construction and installation costs of alternative systems are high relative to established systems using oil, coal, gas, and nuclear-derived energy sources. These higher costs are due, in large part at least, to the fact that solar and alternative technologies do not compete on an equal basis with conventional systems which have been, and are, heavily subsidized by the federal

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government.* In order for costs of alternative renewable systems to achieve economic parity with established systems either (1) federal subsidy of conventional sources could be decreased (thus permitting "true" cost to dictate choices of an energy system) or (2) federal subsidy of renewable sources could be increased.

Elimination of all governmental subsidies might be an effective strategy. However, for the near term, reduction of existing federal subsidies and other incentives currently used to stimulate traditional fossil fuel and nuclear resources is considered to be politically unattractive and unlikely to occur until depletion of such sources more closely approaches actual exhaustion.

For alternative, renewable systems to gain a significant foothold among near-term energy options, therefore, this committee firmly believes that costs of such systems must be reduced by mass marketing and commercialization of existing and developing solar and other renewable technologies. A first step toward such cost reduction should be increased federal subsidy to give such technologies an opportunity to compete with our traditional, subsidized energy production and consumption system.

The following recommendations provide details for application of federal incentives to stimulate competitive manufacture, installation, and use of solar and other alternative energy systems.

II. Solar Subsidy Package

The following packages of solar industry and market subsidies are focused on the residential, commercial/industrial, and governmental sectors which will have the greatest impact on expanding the use of solar energy with the least cost to government and least regulatory burden. The incentives will also apply to energy conservation devices as the structure must be energy efficient and well-insulated in order for a solar energy system to be cost effective.

A. Residential Sector

1. Income tax credit for energy conservation and alternate energy equipment.
2. Minimum warranty requirements for equipment eligible for the income tax credit.
3. Minimum collector and system product standards for equipment eligible for the tax credit.
4. Certification of these products or systems to the standards.
5. Federal backup of insurance or warranties given by manufacturers to consumers.
6. Federal loan guarantees for banks loaning money for such equipment.
7. Low income and urban programs.
8. Inclusion of passive design systems and on-site constructed systems for eligibility for tax credits and inclusion within warranties and system standards.

B. Governmental Sector

1. Schools, hospitals, local public building energy conservation and solar energy retrofit program.
2. Federal solar heating and cooling demonstrations program.

*For an estimate of the magnitude of federal incentives given to conventional sources, see Battelle Pacific Northwest Laboratories, *An Analysis of Federal Incentives Used to Stimulate Energy Production*, Report to DOE, March, 1978.

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3. Minimum solar requirements for federally funded housing construction and rehabilitation.
4. Federal facilities photovoltaic program.
5. Utilities program.

C. Commercial/Industrial Sector

1. Accelerated depreciation for energy conservation equipment and solar energy systems.
2. Federal loan guarantees to banks lending money to commercial/industrial establishments.
3. Bonus depreciation.
4. Special investment tax credit.
5. Deferral of taxes used to purchase major commercial or industrial systems.
6. Tax free alternate energy equipment banks.
7. Inclusion of passive design systems and on-site construction within eligibility requirements.

III. Elaboration Of Solar Package

A. Residential Sector Incentive Package

This package of subsidies for the solar industry and market focuses on providing an income tax credit to homeowners to purchase energy conservation, solar and other alternate energy equipment. It is important that passively designed systems and systems constructed on-site are included within the definition of eligible systems.

As the quid pro quo for receiving this solar income tax credit, the equipment eligible for the credit must meet minimum product standards for design, output, reliability, and cost-effectiveness, and the system must be certified by an independent testing laboratory to meet these standards. Eligible systems must also provide a warranty on system components that will meet these standards for at least five years, and the warranty will provide that the systems will be repaired without cost for the duration of the warranty.

To further increase consumer confidence that systems eligible for the federal tax credit will perform as warranted, and that the warranties will be honored, the federal government should provide an insurance program for the solar industry to guaranty that all warranties on solar equipment will be met even if the company should go out of business or drop its solar equipment line.

Additional residential sector incentives would include federal guarantees of loans to homeowners to buy solar equipment at subsidized interest rates. This would help alleviate the high front-end cost barrier to homeowners for purchasing solar systems by ensuring that low cost credit to purchase the systems is available, and this would also remove hesitation bankers might have about loaning money for such systems. Moreover, the federal government can subsidize the interest costs for these systems by paying the bank the difference between the lower consumer interest rate and the higher commercial rate. Precedents for this type of federal government secondary financing guarantees are found in the activity of FHA, FHMA and GNMA, and they have been shown to be effective and low cost interventions. These programs are basically adopted

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within Section 141-167 of Title I HR-8444, the National Energy Act, and should be promptly administered.

There must also be a series of incentives focused on introducing use of energy conservation and alternate energy sources in the low income and urban market. Installation of energy conservation equipment would be the first priority in this sector, because it is energy and cost efficient, and is a necessary first step before any solar energy equipment could be installed. The low income weatherization program of the Community Services Administration and the Department of Energy to install energy conservation improvements can later be used as a potential vehicle to retrofit urban low income dwellings with passive or active solar devices. Tenant and other local community organizations can also be used to retrofit solar energy systems in urban areas with substantial governmental assistance and funding. These programs, along with installation and maintenance training efforts, would provide a number of urban unemployed the skills to compete for the jobs that will be created by the incipient solar market, while rehabilitating many new living units in currently uninhabited inner city buildings.

A refundable tax credit for low income individuals can provide a financial incentive to install energy conservation and alternate energy devices. The refundable feature would give money back to people who did not have sufficient income tax liability to take advantage of a regular income tax credit, and give them sufficient supplementary funds to make energy conservation or solar energy purchases. Low interest, long term loans guaranteed by the federal government or made directly by federal agencies to low income people should also be implemented for this sector.

It is believed that this residential sector package will provide effective financial incentives to homeowners to purchase such systems, and will develop consumer confidence in these systems as they will be warranted and meet minimum design and reliability standards. They will aid the solar industry itself by guaranteeing that all warranties will be carried out, and ensuring that only high quality products will be put on the market.

Finally, it is suggested that this incentive package will be effective, yet will cost the government relatively little money as it would not require significant appropriations. This is because much of the subsidy comes from tax credits and federal loan or warranty guarantees. This fits into current trends of fiscal responsibility by government and minimum federal intervention in the industry.

B. Governmental Sector Incentive Package

A program encouraging retrofit of energy conservation and solar energy equipment in schools, hospitals and state and local public buildings will not only achieve the objective of insuring the maximum number of installations installed in these types of buildings, but will provide a great market stimulus to the solar industry, as well as providing an example by government for the public and private industry in general to install such systems. The schools, hospitals and local public buildings program could be patterned after Title I of HR-8444, the National Energy Act, Sections 301-323, which provides \$900 million over three years for energy audits and actual retrofit of energy conservation and solar energy equipment.

Another important governmental sector program would be to convert a substantial number of federal buildings and facilities to use solar heating and cooling equipment such as is found in Title I, HR-8444, of the National Energy Act, Sections 721-752. This program would provide \$100 million over three years to demonstrate solar heating and cooling in federal buildings, require a life cycle cost analysis of all federal buildings, and require minimum percentages of buildings owned by each federal agency to be

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retrofitted yearly, with all federal buildings to be retrofitted by January 1, 1990. The money for retrofit would be included in the budgets of each requesting federal agency.

In addition, it should be required that all publicly funded housing construction or rehabilitation funded through federal agencies include as the quid pro quo for receiving the federal money a minimum number of units to be heated, cooled or supplied with hot water from solar units. There are many tens of thousands of units of low and moderate income housing rehabilitated yearly with federal money, and this can be an effective method of implementing a federal policy of subsidizing alternate energy resources within a residential context, particularly in urban and low income areas. This will also provide a tremendous demonstration as well as market stimulation device.

The governmental sector series of subsidies should include a program for purchase and utilization of photovoltaic energy devices in federal facilities, as included in Title I of HR-8444, Sections 761-769, authorizing \$98 million over three years for the procurement of photovoltaic systems to be used by federal agencies. This, of course, would be a significant incentive to the photovoltaic industry to develop mass production techniques (and thereby bring costs down) and would also give photovoltaics a massive real life test of their reliability and ability to supply electric energy for essential uses.

Finally, a utilities program could be implemented to have public utility companies offer to install energy conservation and solar energy devices in customers' homes, and allow them to pay back through the utilities' periodic billing systems. This would alleviate the high initial cost problem, and relieve consumers from being concerned about selecting and installing equipment, maintenance, enforcing warranties, or finding financing. This would utilize the utilities' expertise in the energy area and established relations with every energy user, and would stimulate the mass production of equipment, reducing costs. This program is similar to the utility residential energy conservation program in Title I of the National Energy Act.

C. Commercial/Industrial Sector Incentive Package

This package would provide incentives to commercial and industrial establishments to install solar energy and energy conservation devices, somewhat similar to the package of incentives for the residential sector. Initially, the federal government would guarantee loans made by banking and other private lending institutions for the purchase and installation of energy conservation and solar energy systems, with the interest charges subsidized by the federal government. This will help not only to overcome the initial high capital cost problem, but will also help to make available credit to purchase and install such systems, credit that might not otherwise have been offered by conservative lenders in a tight credit market. Again, the systems purchased through such federal financial guarantees should meet minimum product system standards and should offer minimum warranties, although they would differ somewhat from the residential standards and warranty requirements. Moreover, a federal warranty guarantee program as was suggested for the residential sector would be available for a period of time to assure the buyers of this equipment that the warranties will be implemented.

In addition, these business organizations can take advantage of a number of traditional financial incentives given by the federal government to business and industry primarily through the tax code. These focused incentives would include accelerated depreciation of solar and energy conservation systems; increased investment tax credits for purchase of solar energy and energy conservation systems; modification of the class life asset depreciation range system to favor depreciation times for solar energy equipment; and provision for solar energy development bonds which would be tax free and would be similar to industrial development or air pollution control facilities bonding which also receive tax free treatment within the Internal Revenue Code.

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This series of subsidies, including loan guarantees to make credit more available and tax benefits to induce commercial and industrial establishments to purchase and install solar energy equipment, can open up a large new market for the solar energy industry and make substantial gains in promoting the widespread use and development of alternate energy equipment in the industrial and commercial sector.

Again, it must be cautioned that it is essential that passively designed equipment and on-site constructed systems must be eligible for these subsidies.

The foregoing incentives concentrate on the residential, governmental and commercial/industrial sectors where it is felt that an impact can be made in the shortest time with a moderate amount of federal subsidy. These programs are suggested as a result of the analysis in Section I of the federal patterns of spending and energy subsidies which indicate that if this country really wants an alternate energy industry, it must take decisive and forthright steps to provide the incentives necessary to create that industry in the minimum period of time. Because the alternate energy industry is, in fact, competing against oil, coal, natural gas and nuclear power industries, which are extremely heavily subsidized by the federal government, the federal subsidies will have to be effective and powerful enough to meet this stiff but subsidized competition. It is possible, however, that subsidies may be removed from all non-renewable and nuclear sources and that they be allowed to compete on an equal basis with unsubsidized alternate energy sources. However, this seems politically and practically unfeasible, as it would be extremely difficult to divorce these major nonrenewable energy industries from their historical and extremely profitable federal energy subsidies.

There are a number of other possible subsidies which have not been mentioned here, partly because they are not as powerful as the ones mentioned above, and partly because they apply primarily to state level action and cannot easily be implemented on the federal level, where the decisions of the New England Congressional Delegation will be most effective, and where they have the best opportunity to take action.

IV. Addendum: An Example of Indirect Federal Subsidy of a Conventional Energy Source

A. Background

Multi-national corporations are permitted to reduce their 48% corporate tax liability by an amount equivalent to taxes paid a foreign country on business conducted overseas. Recently, two congressional committees have held hearings on the operations of this credit as it affects oil companies specifically. A Senate Subcommittee (the Church Committee) on multinationals held hearings in 1975, and the House Subcommittee on Government Operations held hearings in Fall, 1977.

B. Issues

At face value, the foreign tax credit appears to be an equitable instrument for making foreign investment a viable undertaking. Were it not for the credit, corporations might avoid international development because of a double tax burden. Like reciprocal trade agreements, it discourages isolation and supports a policy of encouraging U.S. business abroad.

There are, however, two issues which are currently debated between experts and government. They are as follows.

- 1) Certain oil companies argue that the credit, while equitable, puts them at a competitive disadvantage with certain foreign oil companies, which are not taxed domestically at all on income earned overseas (e.g., France). Some countries (e.g., Japan and Germany) offer positive incentives to overseas investment. That is, they

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give interest-free loans for exploration and the loans are excused if exploration results in a "dry hole". The U.S. should consider incentives to give domestic oil companies parity with these foreign oil companies on exploration. Over the long term, ability to meet our oil demands with foreign production will "stock-pile" our domestic reserves for use in any future emergency.

- 2) Certain tax experts claim that domestic oil companies use any cost of obtaining oil at a foreign well-head as a foreign "tax" and write it off as a tax credit rather than using it as a business deduction. Royalties are the most flagrant example. Companies cannot (for obvious reasons) call royalties paid to a domestic property owner "taxes". Yet overseas, such royalties are treated as taxes or (at oil company insistence) are called "taxes" by the country imposing the royalty.

An import/export specialist estimates that this accounting practice saves American oil companies between \$1 and \$2 billion in tax payments to the IRS. Since their total profits annually are about \$7 billion, domestic oil companies receive a 15 to 20% subsidy through use of this tax write-off. The specialist is less concerned with the subsidy per se than with the fact that the system does not encourage arms-length bargaining, and he feels that in a period of oil glut, our companies could force OPEC to lower prices. As it is, the oil interests and the foreign governments cooperate to serve their own interests. The tax system distorts the economics of arms-length bargaining and links OPEC to multinational corporations.

This implication is only "buried by logical extension" in congressional testimony.

Consolidated Reports on Cogeneration and Small Scale Hydropower

I. Advantages of Cogeneration and Small Scale Hydro

- 1) Utilization of decentralized energy sources with attendant independence.
- 2) Possibility of lower costs of power generation.
- 3) Production of energy where needed thereby diminishing transmission losses.
- 4) Opportunity to reduce construction programs.

II. Disadvantages of Cogeneration and Small Scale Hydro

- 1) Power produced may be more expensive than utility generated power.
- 2) Additional cost of protective devices.
- 3) May require construction of additional transmission facilities.
- 4) May exacerbate need for utility backup.
- 5) In present economic climate, it is difficult to assess future development of cogeneration and its effect on utility system capacity construction and service reliability.

III. Regulatory Implications

- 1) Cogeneration and small scale hydro may be promoted on social and political grounds even if, in the short term, they are not economically justified. Yet any extra cost must somehow be covered.
- 2) Decentralized energy sources may require the development of new administrative and legal proceedings to address government regulation, price setting, and economic and personal liability doctrines.
- 3) In those instances where cogenerated and small scale hydro power is utilized instead of utility-generated power, utility fixed costs must still be covered over a smaller amount of energy output.
- 4) Long range planning must coherently address the contribution of decentralized power and the attendant need for construction of backup/standby equipment.

IV. Regulatory Obstacles

- 1) Difficulty in allocating costs or cost benefits to the decentralized power source and/or other utility consumers where costs of power factors can change instantly.
- 2) Allocation of cost burden on noncogenerating consumers to cover utility fixed costs.
- 3) Allocation of additional transmission construction and/or wheeling costs.
- 4) Lengthy and complex administrative requirements for cost/price determinations (which presently don't acknowledge cogenerators and small scale hydro).
- 5) Extensive and complex legal proceedings for various licenses and permits to construct and operate many types of facilities.
- 6) Difficulty of attracting cogeneration and small scale hydro facility financing in cases where there is no demonstrated likelihood of return.
- 7) Installation of some types of cogeneration facilities may be in opposition to other social policies such as reducing oil dependence.

V. Cogeneration Utilization Scenarios

A. Scenario 1—Minimization of Cost to Consumer

- 1) Purchase power only when less expensive than all other available alternative source. It would be required that power be purchased on a hierarchical cost basis.
- 2) Cogenerated energy costs must include appropriate allocation for costs of the facility, including depreciation, and necessary transmission and wheeling costs.
- 3) Cogeneration financing will be more difficult where the return on investment is speculative (as is often the case).
- 4) Adoption of this scenario would be most appropriate where a power pool exists to accurately assess costs of alternate sources of generation. The difficulty, of course, is with cost fluctuations as major units go on and off line. (Obviously this assumes that power pool cost assessment assumptions and calculations are appropriate and accurate.)

B. Scenario 2—Minimization of Oil Dependence

- 1) The crucial issue is the development of political and financial incentives to promote nonpetroleum based cogeneration. At present, nonpetroleum based cogeneration, other than at existing hydroelectric facilities, would likely be more expensive than utility generated power. To the extent that this is true, financial incentives are needed because of the higher costs and somewhat speculative operating characteristics and operating life of new types of nonpetroleum energy sources. Political incentives are needed to adopt a regulatory climate which would foster the development of nonpetroleum based sources and to convince the public, where higher-cost alternatives are advocated, that they should pay more for power than they would otherwise have to, in order to realize the goal of decreasing oil dependence.
- 2) Recognizing that cost will always be of regulatory concern to some degree, it may be appropriate to put some type of ceiling price on cogenerated power, establish a ratio between cogenerated costs and alternative source costs, or adopt some other pricing mechanism so that completely uneconomic cogeneration will not be uncritically subsidized through rates.
- 3) As an alternative, cogeneration utilizing petroleum or petroleum derivatives could be prohibited thereby forcing anyone desiring to put in a cogeneration facility to use a nonpetroleum energy source.

C. Scenario 3—Maximization of Decentralized Sources of Energy

- 1) This scenario requires a positive, clear and comprehensive articulation of the desirability of decentralized energy sources. This can be accomplished again through political and financial incentives or, in the extreme, through the prohibition of the operation of nondecentralized sources.
- 2) An important adjunct is the allocation of any additional transmission and/or wheeling costs among appropriate customers.
- 3) A direct incentive would be to allow decentralized sources to transmit and sell power to ultimate retail consumers at whatever costs and under whatever conditions might be negotiated between the cogenerator and the consumer.
- 4) Regulatory processes would have to be simplified and streamlined. State or federal agencies are in a much better position to assess environmental effects and carry out ongoing monitoring activities. Licensing, permitting and financing regulations of the many amorphous acronymic agencies of federal and state government would be a major administrative and economic hindrance.
- 5) The rights of access and sale given to cogenerators must be as equally binding on municipal systems as on private or public utility systems, including the right to allocate increased cost of cogeneration. Some administrative process for price regulation would have to be developed to insure that there is a reasonable relationship between the cost to consumers of cogenerated power and the cost of production of that power.

Implicit in all these scenarios is a determination of what characteristics of a cogenerator will be chosen to distinguish it from a utility facility as necessary so that incentive and disincentive programs have the desired effect. It is likely that the optimum strategy (which coincidentally may be the one most likely to be approved) would be seen as a marriage of all three scenarios—the maximization of decentralization to the extent it can yield lower energy costs while reducing oil dependence.

VI. Cogeneration Issues Prominent in Report of Massachusetts Governor's Commission on Cogeneration

- 1) According to this report, cogeneration can provide 1,700 MW in replaced electric generating capacity in New England. However, since capacity to meet increased demand must be built in advance, utilities and regulators alike are reluctant to depend on uncertain prospects for increased cogenerated power. Therefore, if cogeneration does in fact come on line rapidly while utility expansion occurs at a rate deemed adequate without cogeneration, short-term overcapacity is certain. Furthermore, utility policy to date has treated cogenerated power as unreliable, and utility expansion plans assume 100% back-up for cogenerating customers. Such a policy is tantamount to ignoring cogenerated capacity altogether.
- 2) Since most cogeneration in New England requires use of oil, any delay in utility non-oil capacity expansion caused by increased cogeneration will save expansion capital but increase (or at least not replace) New England's oil consumption.
- 3) Because, historically, expansion has decreased average costs per kW of electricity produced, a policy of advocating stagnation to avoid costs of expansion does not appear to make sense (or is at least economically unorthodox). But marginal costs are now so high that each expansion increases average costs and depreciation of old capacity cannot produce revenue sufficient to fund expansion. Since cogeneration is produced at historical costs, it tends to be economically sound for utilities to replace new construction plans with anticipated cogenerated power, provided the cogenerated power is firm and can be used on peak.
- 4) Fuel saved by itself is almost never enough to amortize capital installation of a cogenerating system but
 - a) Dispersed generation reduces transmission losses,
 - b) Reliability in numbers is an advantage, and
 - c) Cogenerated power can replace new centralized power and thus eliminate capital costs for the central utility.
- 5) Because of this generally pessimistic economic prognosis, cogenerators are reluctant to make the necessary capital outlay. This tendency would rob New England of an important source of interim power, and therefore appears to justify financial incentives such as those contained in the National Energy Act. There should also be state-by-state encouragement plans which would help potential cogenerators over the planning uncertainties.
- 6) The economics of cogeneration is heavily dependent on power planning decisions. Inappropriate definitions of need or incorrect estimates of workability of new technologies can make real savings appear to be potential losses, or vice versa.
- 7) Except for the possibility of near-term overcapacity, every impact of increased cogeneration on existing utilities could or should be either neutral or beneficial given proper cogeneration incentives and regulations.
- 8) A workable cogeneration system must include time-of-day metering and the resultant incentive to produce cogenerated power on peak and to use back-up utility power only at off-peak intervals. Yet time-of-day metering is expensive.
- 9) The Public Utility Regulatory Policies Act of 1978 allows FERC to order interconnection, purchases, and sales for any cogenerator with excess power to be sold at wholesale to an interstate-connected grid.

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- 10) However, an important residue (in New England especially) of potential cogenerators may wish to sell at retail by contract. This would require important policy decisions by state regulators, and much of the Governor's Commission report deals at length with these policy issues.
- 11) The Report also deals with other legal changes which could encourage cogeneration including:
 - a) Amendment of Federal Power Act Sections 824 a (b) and 824 (b) to clarify right of cogenerator to interconnect,
 - b) Amendment of the NEPOOL Agreement, Section 1.2 which excludes participation in NEPOOL by cogenerators, and Section 10.1 which disqualifies use of cogenerated power as part of a participant's capability responsibility,
 - c) Amendment of Mass. G. L. Chapter 164A, Section 3 which appears to limit NEPOOL purchases to purchases from generating units producing 25 mW or more,
 - d) Amendment of Mass. G. L. Chapter 164, Sections 1, 2, and 3 to indicate if cogenerators may be called "electric companies,"
 - e) Amendment of Mass. G. L. Chapter 164, Section 92 to mandate backup power at a fair price,
 - f) Amendment of Mass. G. L. Chapter 164, Section 94A to include availability of cogenerated power in rate cases, and to enforce DPU Order 18810 requiring utilities to consider all possible sources for peaking,
 - g) Encourage DPU to indirectly require acceptance of excess cogenerated power and utility interconnection through liberal interpretation of Mass. G. L. 164, Section 94G and Order 18810,
 - h) Encourage basic policy change at the state level to amend traditional monopoly-franchise approach by permitting limited competition where the public interest (defined to include conservation and cost-effectiveness) warrants it, and
 - i) Make appropriate changes in Siting Council and SEC regulations.
- 12) To be optimally efficient cogenerated power should be sold at retail near the generating site or be used directly by the cogenerator. Wholesale sales to a grid of small amounts of power are inefficient because of the transmission losses and uselessness of such power during periods of overcapacity (i.e., off-peak).
- 13) Since states have general control of sales at retail, present federal legislation will have limited impact on retail sales.
- 14) FERC may order interconnection where sale is at wholesale and grid is interstate.
- 15) States may indirectly require interconnection through siting, fuel adjustment regulations, and load management regulations.
- 16) The Report recommends mandatory purchase of excess cogenerated power by utilities where such power is reliable and more economical than conventional sources.
- 17) The Report does not deal with the possibility that cogenerators may be willing to sell excess at a loss because any market is better than none. This would imply mandatory purchase by the utility at a reasonable price even if not economical to the cogenerator.

- 18) The Report deals with many other problems including air pollution (which is responsible for a major share of the high capital cost attributed to cogenerated power), regulation of construction as limited by building codes, siting powers, SEC jurisdictional problems, franchise-monopoly implications, and precise economic elaboration.
- 19) The Report deals with Massachusetts almost exclusively although it cites Connecticut PUCA Dockets 770319 and 770320 which direct HELCO and CL&P to design rates for purchase of excess cogenerated power, and New Hampshire's Chapter 362:5 allowing PUC to exempt cogenerators from rate and service regulations applicable to utilities.
- 20) The Report does not deal with nonelectrical cogeneration (e.g., heating).

Proposal for a New England Council for Energy Awareness

I. Introduction

The energy crisis has caused widespread concern among people from all sectors and has given rise to a special and probably unique set of problems. Because energy affects our economic, political, business, social and environmental institutions, ramifications of energy usage have wide ranging impacts throughout our society. Various interest groups have examined various aspects of the problem, i.e., technical, institutional, economic, environmental, sociological and political. These examinations have been conducted by individuals representative of industry, government, environmental, public interest and academic organizations. It is reasonable to expect that almost every facet of the problem has been addressed by one group or another. It is also reasonable to expect that solutions to the energy problem involve participation by virtually every segment of our society, e.g., financial, consumer, legal, academic, business, industrial, technological and public interest groups.

The federal government is presently attempting to lessen future adversities by stimulating the development and commercialization of new energy technologies, energy conservation, and intelligent energy planning before problems become acute. It is evident that the *development* of technologies and strategies may be easier to achieve than their *acceptance* and their *utilization*.

The solution to today's energy problem obviously does not lie *solely* in technological innovation and development. In the past, most of the federal government's successful experience in technology development has been in cases where the government was not only the developer but the user. The user of future solutions to today's energy problem are the members of the pluralistic society in which we live. Thus the viability of any solution rests not only upon its technological but also its environmental, institutional, political, sociological and economic "realities". These "realities" are not well known to the general public. In addition, the establishment of what is "reality" is prone to subjective decision and data inaccuracies. These "realities" also have regional characteristics.

New England is a region with specific characteristics. It has a high dependence on oil and it has high energy prices. It has no developed indigenous fossil fuel supplies. In the event of an embargo, New England could be forced into a crisis situation with unforeseen environmental consequences. It has a strong tradition of political independence and participation. It is highly urbanized and industrialized, but also contains scenic areas of unsurpassed beauty which are of key recreational importance to not only its own urban centers but also those of its populous neighbors, New York and New Jersey. New England contains many of the most prestigious universities and academic institutions in the nation, and is home base for many leading special interest groups.

New England's unique set of energy problems and opportunities has been recognized and a variety of organizations have been addressing various aspects of the problem. While these activities

are evidence of a desire to solve the regional energy problem, they are not individually an adequate means of achieving a solution.

One way to expedite a solution is to create an informed public (businesses, environmental organizations, "public interest" groups, utilities, etc.) such that intelligent choices may be expressed. The identification of consensus and divergence among these groups should be more easily identified. What is needed then is an organization which can increase public awareness and focus concerns within the region.

II. Objectives

It is proposed that there be established within New England a Council for Energy Awareness. The Council should possess the following *characteristics*:

- 1) Be realistic and workable, serving a useful function for both the public and private sectors;
- 2) Be interactive with the public and private sectors and include all regional interests, especially those which do not have formal responsibility for energy policy formulation.

The *goal* of the Council should be to develop and communicate energy alternatives. In pursuit of this goal, the Council should accomplish the following *general tasks*:

- 1) Identify the present New England situation (Where We Are),
- 2) Identify alternative New England energy futures (Where We Want to Go),
- 3) Identify possible strategies for effecting needed change (How We Get There), and
- 4) Communicate the results of these tasks.

III. Structure

In order to achieve the objectives outlined in Section II, it is proposed that a New England Council for Energy Awareness be established. The Council should be structured in a manner similar to that shown in Figure 1 with the following element functions.

A. Host Organization

It is proposed that a Council be established under the auspices of a regional non-profit or academic institution.

Function

The Host Organization would be responsible for fiscal, contractual and administrative arrangements necessary for the conduct of the Council.

B. Operations

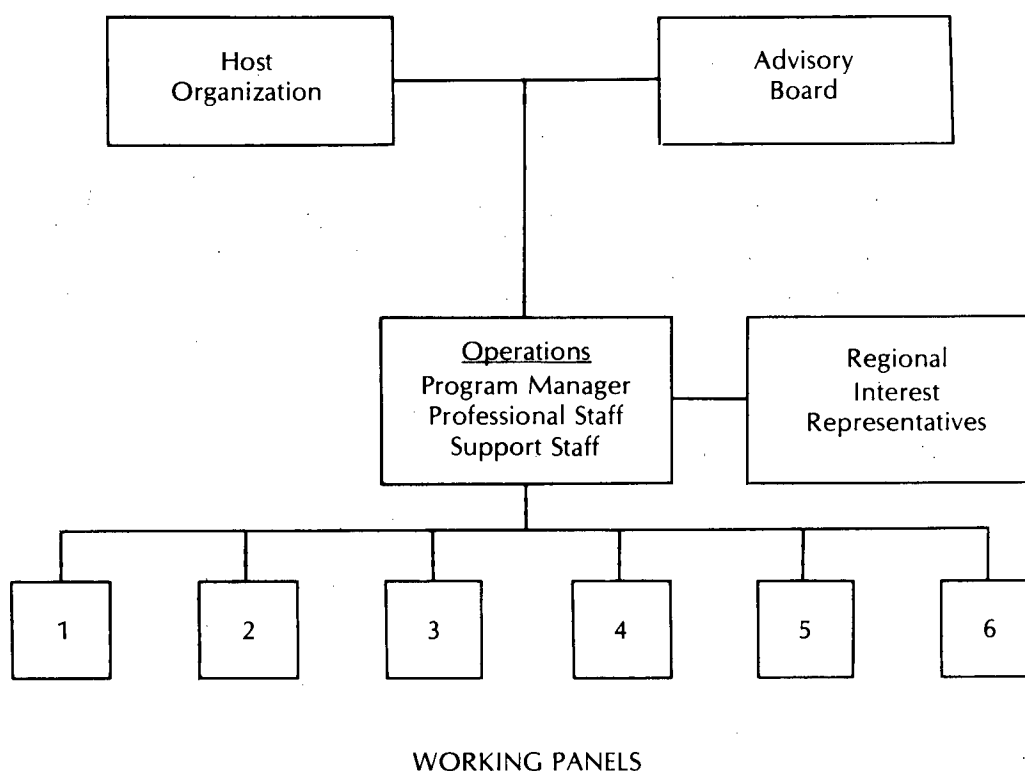
The Council would be under the overall direction of a program manager, who should be assisted by professional and support staff. The staff should be chosen such that it would possess a cross-section of technical, environmental, institutional and economic skills with out-reach experience in the region.

Function

The program manager would oversee the selection of topics, nominate and

oversee the working panels, select the panel chairmen, hire and manage any required consultants, coordinate activities with appropriate private and public sector organizations, and prepare necessary administrative and directive materials such that day-to-day council business is handled in an organized and business-like manner. The staff should support the program manager in the accomplishment of these tasks.

Figure 1. Council Structure



C. Advisory Board

Policy guidance and direction of the Council would be provided by an Advisory Board. The board would consist of representation such that a balanced viewpoint of the various interests of the region would be provided.

Function

The Advisory Board would provide guidance for the activities of the Council. It should approve topics selected for consideration, the membership of work panels, and outputs of the Council. It should assure the appropriate means for providing both private and public interactions with the Council.

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D. Regional Interest Representatives

The Regional Interest Representatives would be a group of key persons who should be representatives of the various interests and states within the region. It is proposed that they be constituted from the present delegates to the New England Energy Congress. They would include environmental interests, the energy industry, the business sector, labor, public interests and others.

Function

The Regional Interest Representatives would review working panel outputs, would deliberate in order to develop consensus from divergence and would then direct operations staff to produce a sense-of-the-meeting paper outlining areas of agreement and divergence for public awareness.

E. Working Panels

Each Working Panel would have a chairman. Representatives of labor, environmental, financial, consumer, governmental, university, industrial and commercial interests would be recruited as panelists so that each panel possessed expertise on its subject matter and represented all significant regional viewpoints. It is suggested that panel members be nominated by present delegates to the New England Energy Congress. Panels would be assisted by Council staff.

Function

Working Panels would identify the assumptions of each interest group; assemble the most up-to-date data; analyze such data for completeness, accuracy and bias; synthesize the data into a readable form; and seek agreement and recommendations. These Work Panels would then focus and communicate results including areas of consensus and divergence.

IV. Process

There are currently great differences of opinion and levels of awareness among the various New England interest groups. In order to narrow these differences and increase public awareness, it is necessary to understand their basis. Among the elements contributing to divisiveness between groups are: (1) different fundamental values, (2) different data bases, (3) different visions of the future consequences of today's energy choices, and (4) different self-interests and interpersonal conflicts.

The Council outlined in this proposal attempts to increase the level of public awareness and to ameliorate this divisiveness through the operation of a carefully defined process.

The process itself would: (1) identify issues of broad regional concern; (2) establish Work Panels whose work can be understood and accepted by regional interests; (3) develop interactions between Council members which would hopefully be carried on beyond the Council process itself; and (4) develop interactions between the Council and the private and public sectors. The following is an example of how the Council might operate on a given issue:

- 1) The program manager and staff oversee the issue selection process and nominate Working Panel members.
- 2) The Advisory Board after receiving input from the program manager, staff and regional interest representatives, approves the issues to be addressed by the Working Panels.

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- 3) The Advisory Board after receiving input from the program manager, staff and Council, approves the Work Panel members.
- 4) The Working Panel will then meet and produce draft recommendations with assistance of the staff. They will:
 - a) Draw on existing data and expertise, and assemble and analyze relevant data for accuracy, completeness and bias.
 - b) If needed, they will collect additional data, either internally or by contract with approval of the program manager. With board approval, the Working Panels may further refine or expand their general scope of work.
 - c) They will deliberate and identify areas of consensus and divergence for public awareness.
 - d) They would seek public input through public hearings or other means as they deem appropriate.
 - e) They will report to the project Advisory manager and Board for review.
- 5) The report will be submitted to the Regional Interest Representatives by the program manager and staff.
- 6) The Regional Interest Representatives will meet to review the report of the Working Panel and, with staff assistance, produce a "sense of the meeting" paper on the report.
- 7) The "sense-of-the-meeting" paper will then be sent to the Advisory Board.
- 8) The Advisory Board will advise on a course of dissemination for the Working Panel's report. The Advisory Board will also determine the appropriate methods for maximizing awareness of final recommendations.

V. Products

Products of the proposed Council would range from those that are highly visible to those that are truly of an amorphous nature. Products would include:

- 1) Energy data from which informed, intelligent decisions may be made.
- 2) Articulation of a series of regional needs which might be used as one of the guides to establish priorities.
- 3) The establishment of better interactive communications between various interest groups within the region.
- 4) The establishment of a focal point for debate of regional issues by responsible and representative organizations within the New England community.
- 5) The sharing of information by bringing together regional representatives and organizations.
- 6) The sensitizing of regional participants to other regional viewpoints.

Proposal For Development Of Funding For Low-Income Intervenors

I. Introduction

The public utility regulatory process involves an adversary proceeding in which the regulating agency balances the interests of the utility companies against those of the various classes of consumers.

Current administrative practices in public utility regulation fail adequately to protect the interests of the low-income residential utility consumer since no state has an institution with sufficient expertise in the field of utility regulation which is devoted solely to the representation of such consumer interests. In nearly all cases where there is an office of consumer counsel (or its equivalent) that office is charged with representation of all consumer classes — industrial, commercial and residential. Often, interests of these classes will conflict and the low-income residential consumers' interests will be ignored or compromised. The regulatory agency's staff are also in the position of being unable adequately to represent each discrete interest and therefore are forced to ignore or aggregate interests. Thus, the regulating agency cannot define and protect the interests of the consumers without the routine intervention of knowledgeable and representative consumers of all classes to balance the case presentation of the utility companies.

While commercial and industrial consumers can pass increased costs of utility service on to the consumers of their products or service, residential consumers have no such option. However, middle and upper income residential consumers have the income flexibility to expend resources to react to rate increases by conserving (e.g. weatherizing, purchasing timers to take advantage of time-of-day rate structures, etc.) and could conceivably pool resources to advocate for their interests. Low income residential consumers lack the resources to react to increases by conserving, and they lack the resources to advocate on their behalf before regulatory agencies. An effective affirmative or defensive presentation in a utility case can require considerable financial outlay where experts and/or studies may be necessary such as in generic rate structure cases or rate increase cases. Additionally, while all other consumers have the flexibility to maintain utility service where rates increase (though they may suffer economic harm or inconvenience), low-income consumers are exposed to potential life-threatening harm where rates increase beyond what those consumers can pay.

As a method to begin dealing with these problems, we propose development of advance funding drawn from federal and/or state sources and a minimal percentage of gross revenues of regulated utilities for intervenors acting on behalf of low income consumers.

II. Funded Entities

Funding of two separate entities is proposed. Federal legislation creating this program could allow states to choose between the two proposed entities, mandate development of only one entity, or mandate development of both. The proposed entities are described below.

A. An Office of Low-income Consumer Counsel.*

The existence of such an office would help guarantee continuity and competent representation of low-income interests in energy matters. Such an office would not necessarily overlap an existing office of consumer counsel (or equivalent). It would represent exclusively low-income residential consumers whose interests may conflict with the interests of consumers generally, or, where there is no conflict, the low-income

*If only one entity is chosen for funding, it is our recommendation that it be an "Office of Low-income Consumer Council" which will allow for development of expertise and provide continuity of representation.

counsel could choose to join with the consumer counsel in the burden of preparation and presentation of a case, or decide not to participate at all, conserving minimal resources for cases of greater importance to low-income consumers. Additionally, the low-income consumer counsel's office should be funded to handle all energy related matters, not just regulated utilities, which would allow for representation of low-income consumers, for example, to obtain oil and bottled gas, to obtain increases in weatherization programs, to obtain increases in available subsidies for energy bills, or to intervene on a federal level.

The low-income consumer counsel needs to be independent to avoid being compromised. Therefore, wherever such an office may be physically located or through whatever agency its funding may be handled, it alone should determine its budget expenditures (within federal and state law) and its positions and activities. Hiring of the counsel should be by appointment of the governor for a fixed term, with removal between terms only permitted for cause. Limiting the ability of those outside of the low-income consumer counsel to make budget expenditure determinations or to remove counsel severely limits potential interference, political or otherwise, with the activities of the counsel.

- B. *A committee in each state, created to distribute funds to intervenors who represent low-income consumer interests in whole or in part, and whose presence would contribute to a full and fair consideration of the issues.*

Often, individuals and groups outside those normally intervening have taken on an issue which has not received adequate consideration previously and which should be presented. Lack of resources could prevent such an individual or group from putting on an effective case.

III. Funding Sources

The proposed funding sources for both entities include monies appropriated on the federal and state levels, private contributions and a minimal percentage of gross revenues of regulated utilities. Receipt of federal funds would be contingent upon state by state development of a program and funding mechanism for low-income intervenors consistent with the enabling federal legislation. Federal funding levels could be determined by the number of low-income persons in the state, balanced by the impact of the potential loss of service.* Grant administration and development of federal regulations would be handled through the Department of Energy (DOE) which presently has similar responsibilities with federal money granted to states to establish or expand electric utility consumer counsel offices under Section 205 of the Energy Conservation and Production Act of 1976. Significant freedom would be allowed within which each state could experiment in its program so long as the broad parameters of the federal legislation were met.

Funding would be somewhat different for the low-income consumer counsel's office and for other funded groups:

- A. The low-income consumer counsel's office would receive funds by the same method as the state commission or regulating agency and some federal funds.
- B. A statewide funding committee would be responsible for making grants to applicant organizations other than the office of low-income consumer counsel. This committee would need at least \$100,000 annually for funding of low-income intervention. Such funds could be obtained by a combination of federal funds, state funds, and/or a minimal percentage of gross revenues of the regulated utilities, and it would be

*Thus, states with colder climates, where a loss of utilities can be life-threatening, would receive a large grant. The administering federal agency would determine by regulation what formula would be employed to effectuate the balance.

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empowered to receive funds from other sources including private contributions. The committee would consist of at least the following individuals (or his/her designee where a state agency is involved):

1. The head of the agency regulating activities of the utilities;
2. The head of the agency or sub-agency responsible for activities concerning consumer protection;
3. The head of the agency or sub-agency administering federal welfare programs such as Aid to Families with Dependent Children;
4. A representative, appointed for a fixed term by the governor, of an organization which has consumer rights as one of its primary concerns; and
5. A representative, appointed for a fixed term by the governor, of an organization which is primarily concerned with the needs and rights of low-income consumers.

To the extent that an individual or group funded through the committee receives funds derived from a percentage of gross revenues of regulated utilities, its use of this funding would be restricted to activities involving regulation.

In determining which applicant organizations to fund, the committee would set its own criteria. However, the committee could only fund activities designed to present a low-income perspective or meet a low-income consumer need, and additionally would be bound to consider at least the following:

1. Whether activities proposed by the applicant would be likely to contribute to a full and fair consideration of the issues to be covered;
2. The chance for impact on low-income residential consumers of utility service;
3. Whether any impact of the proposed activities is likely to have state-wide or local impact;
4. The importance of the issues around which activities are proposed;
5. The availability of alternative or supplemental funding for the proposed activities;
6. Whether or not the proposed activities are duplicative of other activities which have been or will be carried out; and
7. The "track record" or the applicant group or individual.

IV. Timing of Funding

Any office of low-income consumer counsel would need to be funded at a minimum per fiscal year to provide continuity of representation. Any funding left from one year should remain in the office's budget to avoid encouraging the office to engage in unnecessary activities or activities of limited value just to expend the balance of the budget. Such flexibility in the budget would allow the office to cope effectively with periods of relative inactivity and periods of great activity, which do not necessarily occur in times coinciding with the funding years.

Funding or funding guarantees of applicant organizations must be available before activity is required. Several insoluble problems arise if it is not available until after activity occurs:

- A. It may be impossible to hire experts and conduct studies which are important to effective case presentation without at least a funding guarantee which will cover any fee;

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- B. If an attorney is involved, she/he may not ethically hire experts and make fee payment contingent on the outcome of the case or on the potential receipt of money which is contingent on that attorney's case presentation.

As in the case of the funding of the office of low-income consumer counsel, any funding left from one year should remain in the committee's budget for fund disbursement in the future for the same reasons as stated above.

V. Summary

Low-income residential consumers are in the unique position of lacking the income flexibility to effectively deal with increasing utility costs or to represent their special needs. As a result their position often receives less than adequate consideration. Therefore, federal legislation must be developed which encourages the state by state development of independent offices of low-income consumer counsel and/or a funding mechanism for other groups representing low-income interests, and provides federal funding for this purpose. Receipt of federal funds would be contingent upon each state devising a program within the broad parameters of the federal legislation with supplemental funding becoming available through state appropriation and/or a minimal percentage of gross revenues of regulated utilities. All funding or funding guarantees must be provided in advance to permit development of the most effective case possible. In this way, the positions of low-income residential consumers, the most vulnerable segment of utility consumers, would receive consideration necessary to avoid potential tragedy.

Federal Taxation of Electric Utilities: Issue Background Paper

I. Background

Utilities (like other corporations) are mandated by Congress to collect, through rates charged, amounts sufficient to cover corporate tax liability at the corporate income tax rate of 48%. Because of the 10% investment tax credit and accelerated depreciation, the major portion of these taxes are never paid by utilities which are expanding capital plant almost continuously to serve expanding markets for electric energy. It is estimated that approximately \$3.1 billion was collected for federal income taxes in 1976 by investor-owned utilities, but only \$542 million was paid in federal taxes that year.* The unpaid balance is usually kept in reserve and used per se or as collateral to fund capital expansion.

Whether or not tax reserves become appreciable amounts depends somewhat on state regulatory policy. Section 167-(1) of the 1969 Internal Revenue Code permits state regulation to exclude all of the benefits from capital base upon which ratepayers pay a return under accelerated depreciation. However, under Section 46-(f) of the 1971 Code covering normalization for the investment tax credit, companies are given 2 options: (1) to allow a return on the unamortized ITC benefits or (2) allow both full use of ITC funds by companies and claims for a depreciation allowance on the entire value of an asset purchased only partially with ITC funds.

Generally New England states attempt to adjust their ratemaking calculations to account for deferred or excused taxes in the tax reserves of the companies they regulate. Connecticut, New Hampshire, Maine, and Vermont are considered "flow-through" states. Massachusetts and Rhode Island policies are not known. However, Massachusetts appears to permit normalizing in certain

*Edison Electric Institute as quoted in Batinovich testimony before House Ways and Means Committee, 3/8/78.

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circumstances. In a presentation on deferred taxes in June 1978, Gene Gaber of the University of Vermont tried to show that tax reserves are dramatically higher in normalizing jurisdictions. He contrasts "normalizing companies" such as AT&T, Central Telephone and Utilities, and Boston Edison whose deferred taxes as a percentage of invested capital were 11.9, 15.5, and 11.0 respectively with "flow-through" companies like Niagara Mohawk, Northeast Utilities, and Public Service of New Hampshire, whose like percentages were 1.9, 2.4, and 4.7 respectively.

The California Commission advocates a usage tax rate of .0004 per KWH to replace the present 48% income tax on regulated utilities. A bill, H.R. 8897, was filed by Congressman Stark in the First Session of the 95th Congress incorporating the California recommendation. Many state PUC's support the California position, and the number supporting appears to be growing. However, many states oppose this position, as does the National Association of Regulatory Utility Commissioners.

A delegate has suggested that the mere change from income to usage taxation is too shallow a focus; that electric utility management in general is a problem of wider concern. The delegate suggests that equal regulatory treatment of all utilities giving electric service should be the goal of tax reform.

This delegate therefore suggests consideration by this committee of an additional proposal to exempt the interest on utility bonds and the dividends on utility stock from taxation to make investor-owned utilities more comparable to municipal electrics and cooperatives in terms of their treatment under tax law.

II. Major Points For and Against H.R. 8897

PRO

1. Removal of present limitations on regulatory procedures through income tax law would return to states their full powers and duties to regulate consistent with optimum service to utility users, especially as regards the power of regulators to limit capital expansion in a period when such limits are called for by energy conservation policy.
2. Taxation would be simplified by a usage tax.
3. Public credibility would be enhanced by removal of a confusing tax system used for purposes other than revenue collection alone.
4. A tax on use would discourage non-essential use in conformance with national conservation policy.
5. Incentives for capital formation are not only inappropriate in a period of moderating demand, utilities are a special case in the private sector. Because they are regulated

CON

1. A change from income to usage taxation would increase regulatory power and responsibility at the state level. Whether this is good or bad depends on one's view of the qualifications of regulators and the adequacy of their regulatory procedures.
2. Greater simplicity should be achieved by degrees. To revolutionize a taxing system at one stroke is to invite equity suits and inadequate coordination of tax policy.
3. Public credibility is not an issue because the public is unaware of the tax issue.
4. Conservation benefits of a usage tax are not significantly different from present tax policy. As bills go up, incremental conservation will occur regardless of the factors causing electric bills to rise.
5. Investor-owned utilities are not inherently different from other private corporations as regards their needs to cover debt for capital costs. Congressional intent

PRO

they serve, in effect, as tax collectors. Present law permits collection of taxes which are not in fact passed on to the government. They are collected under "false pretenses".

6. In states where regulation is lax, IRS rules encourage utilities to exacerbate these "false pretenses" by "normalizing" instead of "flowing through" tax benefits to ratepayers (who make the tax payments). This is probably illegal on fifth amendment grounds.

7. A tax at the rate of 20¢ for 500 KWH would not be a heavy burden on electricity users. Yet it would provide IRS with revenue at least equal to revenue from the present "phantom" tax.

CON

through AD and ITC was to improve capital formation throughout the private sector. At least some capital expansion will be required even in a period of moderating growth in demand. The burden of taxes on all corporations is unclear, and a substantial amount is paid by consumers.

6. Without reserve accounts, income would have to be raised to provide equivalent coverage. This would reduce any benefits to ratepayers. It is alleged by both sides that regulators who wish to "flow-through" benefits to ratepayers do so notwithstanding IRS rules. Lax regulation is a separate issue.

7. Several advantages of the income tax as a taxing mode have been elaborated. Corporate tax deferrals and exemptions as currently authorized reduce cost of capital and ultimately, therefore, cost of electricity to consumers.

III. Tax Exempt Bonds and Stock

PRO

1. Municipals and coops now enjoy tax exempt status. This gives ratepayers served by such utilities an unfair advantage over ratepayers served by investor-owned and taxed utilities.

2. Making investor-owned utility bonds and stock tax exempt would lower cost of electricity to consumers.

3. A special subsidy for electricity users is justified by the substantial universality of electric usage. It is now a "necessity".

4. If private and public utilities are treated more uniformly under tax law, the process of regulation will be easier and more equitable.

5. Rates to ratepayers would be lower, and, since electricity is used universally, the proportionate benefit to the poor would be greater than to the well-off.

6. Any stimulus to expansion of investor-owned utilities would not in fact result in unwarranted expansion because expansion is regulated in any case.

CON

1. Ratepayers served by investor-owned utilities enjoy the progressive management innovations which publicly-managed utilities have difficulty adopting because decisions are often based on political factors remote from "good" management considerations.

2. The cost of electricity would be reduced only at the expense of higher cost for something else since revenue "lost" through tax exemption would have to be replaced by other taxes.

3. One might say that automotive use is also substantially universal. Would an automaker be less qualified for exempt status?

4. To open up a Pandora's Box of legal questions about private rights to tax-exempt status seems a heavy price to pay for easier regulation of utilities.

5. Lower rates would not encourage conservation.

6. The stimulus to expansion would in fact result in expansion where regulation is lax.

ENERGY ECONOMICS AND FINANCING COMMITTEE

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COMMITTEE OVERVIEW

The Energy Economics and Financing Committee is charged with the responsibility of developing concrete, realistic recommendations to address three basic areas of concern:

- 1) Attracting the requisite capital to New England in order to finance necessary energy projects on a least cost basis.
- 2) Exploring the costs and benefits of New England energy options.
- 3) Energy specific tax, fiscal, and credit policy.

To achieve this goal with meaningful results, the committee chose to view these problems through the organization of three subcommittees. The subcommittees were:

- 1) Financing Mechanisms
- 2) Government Policies
- 3) Cost/Benefit

Each subcommittee was given a directive by the full committee to study its area of concern and develop specific recommendations for full committee review. In addition, the full committee directed each subcommittee to consider the impact of their recommendations on the economically disadvantaged.

Since May 20, the committee and its subcommittees have met several times each month. A broad spectrum of economic and financial topics relating to New England's energy situation were discussed and assessed within the three subcommittees. Reports and position papers were drafted to address this situation and the energy problems in the New England region. After these initial investigations, the subcommittees drafted recommendations within their jurisdictions. The majority of the committee's work in recent months has been the review and discussion of these recommendations.

The process of proposal review took place at both the full committee and subcommittee level. The committee based its decisions on a consensus system. It utilized the subcommittee reports as the basis for discussion. Straw-polls were conducted in order to arrive at the sense of the committee. At times, some recommendations would not be considered further, while at other times a recommendation would be accepted outright. In most instances realization of the complexity involved in an issue would dictate further study. Although the committee was unable to reach consensus on a number of issues, the discussion of the proposals provided an insight into the complexities of energy decision-making.

The final report of the committee will include all proposals that have gained full committee support through this process. Other proposals that fail to gain full support will be included in this report if there is sufficient support among the members (i.e. more than 2/3 of the members are in favor), but will not be given the status of committee findings and recommendations. Rather, alternative positions will be noted and the names of those delegates subscribing to each will be given.

In this preliminary report, brief background information is provided for each of the consensus recommendations. Non-consensus proposals are listed without reference to the divergent opinions. In the final report, indepth and researched reports will be provided for both the consensus recommendations and non-consensus proposals.

New England's overwhelming dependence on imported oil was identified by the committee in its initial deliberations as the region's major energy problem. In its efforts to find consensus on the means to alleviate this dependency, broad support was demonstrated for encouraging the development of New England's indigenous energy resources and alternate fuel technologies. The committee's recommendations reflect this dual concern.

The following is the format chosen by the Economics and Financing Committee in presenting its preliminary findings and recommendations:

- 1) Overview—Description of the process through which the committee developed its recommendations.
- 2) Consensus Recommendations—The results of the committee's deliberations.
- 3) Non-Consensus Proposals—Although not accorded full support, these proposals received the support of 2/3 of the committee.
- 4) Rationale and Documentation of Consensus Recommendations—Description of the committee's reasons and thinking on consensus recommendations.
- 5) The NEA and Committee Recommendations—Delineation and discussion of committee recommendations which were incorporated in the NEA.
- 6) Proposals Discussed, But Not Recommended—List of proposals which did not receive adequate support to warrant further investigation.
- 7) Note on the Report on Financing Mechanisms.

CONSENSUS RECOMMENDATIONS

- 1) *Emphasize continued DOE funding of research on coal technologies, e.g. conversion and cleaning. These research and development efforts should include solvent refined coal, fluidized-bed combustion, coal liquefaction, coal gasification.*

Economics and Financing Committee

- 2) *Emphasize increased DOE support for research, development and demonstration of wood and peat as viable energy sources.*
- 3) *The New England Congressional Delegation should support the development of the Cobscook Bay Tidal Project in Eastern Maine if it is proven economically feasible using life-cycle costing techniques. This life-cycle cost analysis should account for the inevitable increases in the real cost of electricity in the future.*
- 4) *State utility regulatory agencies should consider rates based upon the cost of service of back-up energy for users of renewable energy sources at the same proceedings and following the same timetable suggested by the National Energy Act for utility rate reform.*
- 5) *Require that life-cycle cost analysis on buildings' energy systems be conducted on federally financed multi-family housing projects.*
- 6) *Investment tax credits and accelerated amortization be extended to industrial and commercial businesses that install alternative energy or conservation equipment. Accelerated amortization is defined as the rapid write-off of an investment over a five-year period.*
- 7) *Federal and state governments should provide information to lending institutions regarding successful bank programs for financing energy conservation projects.*
- 8) *Tax credits established in the National Energy Act for the residential sector to encourage the use of non-conventional energy sources and energy conservation equipment should be refundable as well as retroactive to April 20, 1977.*
- 9) *The proposed legislation that established a State Energy Management Plan to coordinate the development of state energy programs should provide a level of funding which is at least equal to current levels for these programs.*
- 10) *Solar training programs and courses need to be set up for city planners, architects, labor unions, etc. such as the training course, "Solar Heating and Cooling of Residential Buildings: Sizing, Installation, and Operation of Systems", U.S. Dept. of Commerce, Oct. 1977. Programs are needed for labor unions on solar job opportunities. Courses should be designed to train and update workers on solar technology. State and local officials should be made aware of the merits of solar technologies and encouraged to use them. Classes and workshops should also be aimed at educating the general public so they can construct and install active and passive solar systems.*
- 11) *We recommend that DOE investigate and identify other non-profit groups who have not been covered under present incentives for the usage of conservation measures and alternative energy to non-profit groups.*
- 12) *Congress should direct the GAO to study energy cost problems of persons of less than median income with the goal of developing recommendations to alleviate negative impacts.*

Non-Consensus Proposals

- 1) *The FERC should be directed to use rolled-in pricing in cost-of-service rate setting procedures in cases involving LNG.*
- 2) *Low-income families should be assisted in coping with rising energy costs through a direct rebate program based on an objective formula.*
- 3) *Increased amounts of money need to be diverted from the Highway Trust Fund into the financing of public transportation systems, especially bus and light rail.*

- 4) *The Small Business Energy Loan Act of 1978 should be interpreted, or amended, to provide loans to solar equipment leasing companies.*
- 5) *Congress should avoid laws which would restrict horizontal investment within the energy industry.*

DISCUSSION OF RECOMMENDATIONS

- 1) *Emphasize continued DOE funding of research on coal technologies, e.g. conversion and cleaning. These research and development efforts should include solvent refined coal, fluidized-bed combustion, coal liquefaction, and coal gasification.*

Creation of a synthetic fuels industry based on our nation's abundant coal resource is essential to offset the scarcity and cost of imported oil.

Maximizing DOE funding of research on coal technologies will shorten the lead time for the commercialization of conversion processes. These processes will greatly reduce the environmental problems which would result from the direct burning of that coal.

Conversion of coal to high-BTU pipeline quality gas is an efficient way to utilize coal. It is efficient because this gas, which is interchangeable with natural gas, can be delivered through existing pipeline and distribution systems. Moreover, this high-BTU gas can be utilized in the New England region to offset reliance on imported fuels.

Research and development funds spent on direct combustion of coal with stack-gas clean-up and the use of sulfur-removing fluidized-bed combustion systems will make the pollution control methods more feasible. Solvent-refined coal may offer a viable alternative for pollution control. Commensurate funds are required for research on the disposal of the residual by-products of these pollution control technologies, i.e. ash, sludge.

Research funding is also necessary to develop efficient and environmentally acceptable processes for the conversion of coal to liquid fuels which can be used as transportation fuel.

The end result of these research and development efforts will be the efficient and environmentally sound utilization of the nation's largest energy resource, coal.

- 2) *Emphasize increased DOE support for research, development, and demonstration of wood and peat as viable energy sources.*

The availability of wood in the New England states (especially the Northern Tier) could be the basis of providing a significant portion of the regional energy mix. Without government support for research, development, and demonstration, this renewable, indigenous source of energy might not be fully utilized. For example, over 75% of the land mass of Maine, Vermont and New Hampshire is commercial forest land and appears to have the potential of supplying the development of large-scale electric generation, home heating and other uses in both the long and short run.* It is the sense of the committee that, in order to aid in the capital formation necessary for the development of this industry, DOE's research activity and expenditures must be increased.

*USDA Forest Service Resource Bulletins NE-26, NE-36, NE-43, NE-46.

Due to the abundant reserves of peat in the region, peat emerges as a possible alternative source of energy. In a region that is primarily dependent on oil and is coal deficient, it would be highly desirable to look at peat resources which are abundant. The economics and the state of the art of peat energy development are quite well-known in Ireland and in the Soviet Union. In these countries peat energy is utilized to fuel electric generating facilities and heat homes and industry. It is cheaper than imported petroleum. The New England region, too, could benefit from peat as an energy resource. In Maine alone, the reserves are estimated to be 21 quadrillion BTUs. However, as is the case with wood, government funding is needed. Research and development should serve as the catalyst for infusing the necessary capital.

- 3) *The New England Congressional Delegation should support the development of the Cobscook Bay Tidal Project in Eastern Maine if it is proven economically feasible using life-cycle costing techniques. This life-cycle analysis should account for the inevitable increases in the real cost of electricity in the future.*

The Passamaquoddy and Cobscook tidal projects have already undergone comprehensive study and investigation dating back to 1930 and are undergoing further research at the present time by the Army Corps of Engineers. The project could provide as much as 500 MW of capacity to the region. Tidal power, a form of renewable energy, fits the objectives of the National Energy Plan in that regard. The project could serve as an important demonstration of the feasibility of tidal power in the United States.

To determine whether this project is economic, a detailed life-cycle cost analysis will have to be made. This analysis, however, should not contain the limiting assumption that fuel costs will remain constant in the future. It is unrealistic to believe that the cost of capital operations, and more specifically, the cost of fuels, will remain constant in the future. The experience of the past several years should highlight the extent of variation that fuel prices can take.

We should give consideration to a capital-intensive renewable energy project such as the Cobscook Bay tidal project.

- 4) *State utility regulatory agencies in considering utility rate structures should include rates based upon the cost of service of back-up energy for users of renewable energy sources at the same proceedings and following the same timetable suggested by the National Energy Act for utility rate reform.*

Those customers utilizing renewable forms of energy for heating and other functions present potential problems to utilities and their customers. The potential problems range from negative impacts on load factors to the charges of discrimination or unequal distribution of total costs among ratepayers.

The committee wishes to emphasize that the thrust of this recommendation is not to alter a state commission's mandate in setting fair and reasonable rates, but to urge commissions to study the problems on a meaningful and timely basis.

A number of New England public utility commissions are looking at or have enacted requirements for rate structures based on peak load and time of service pricing. The National Energy Act has provisions which urge state commissions to consider such rates and allows the Department of Energy to intervene in proceedings to argue on behalf of such structures.* The Act incorporates a timetable for the scheduling of such hearings. It is at these hearings and within this required timetable that the committee strongly urges the New England state utility commissioners to address the issue of rates

*Title I of H.R. 4018, The Public Utility Regulatory Policies Act of 1978.

based upon "back-up" cost of service. The resultant rates for renewable energy use would thereby be set on an objective basis.

- 5) *Require that life-cycle cost analysis on buildings' energy systems be conducted on federally financed multi-family housing projects.*

The National Energy Act of 1978 requires that federal buildings apply life-cycle cost analysis to all existing federal buildings with regards to retrofitting and apply such analysis to newly built federal buildings.* In addition, several states such as Massachusetts have legislation that requires state and local governments to consider using alternative energy systems, including solar and wind powered energy systems in the design of all new state funded buildings.

Yet no legislation requires that life-cycle cost analysis be conducted for federally funded multi-family housing projects. The Economics and Finance Committee therefore recommends that the National Energy Act be extended to include federally financed multi-family housing projects.

Current funding mechanisms often encourage the installation of the lowest initial cost heating systems, and ignore the higher operating costs that are subsequently passed on to residents. These regulations are counter-productive if subsidized housing passes on heating costs that are higher than those in private housing. A life-cycle cost analysis of space heating and cooling and hot water heating equipment that considered the available conventional and alternative energy systems would reduce the total costs of energy in these facilities. Moreover, it would alleviate the economic burden that is currently being passed on to consumers with the least ability to meet those costs.

These analyses would also serve as models for the private sector in selecting the most appropriate system for use in local and specific conditions, and thereby encourage consumer awareness regarding the trade-offs between initial versus life-cycle costs of energy systems.

- 6) *Investment tax credits and accelerated amortization should be extended to industrial and commercial businesses that install alternative energy or conservation equipment. Accelerated amortization is defined as the write-off of an investment over a five year period.*

The intent of this proposal is to encourage energy conservation in the commercial/industrial sector by stimulating capital spending on energy saving measures and renewable energy resources. The concept of investing capital to more efficiently utilize resources is not new. In fact, when "cheap energy" abounded, many of the increases in productivity were accomplished through investment in energy consuming machinery. Efficient use of energy was not as important as it is today because of its low cost. With the current trend of higher energy costs and the ultimate exhaustion of non-renewable energy sources, efforts to increase capital investment in more efficient processes is essential. This is especially true for those processes which convert primary fuels to provide space heating and cooling and for processing energy for business and industrial needs. These efforts will not only decrease growing demands on limited energy resources, but will also improve the economic viability of business and industry in regions such as New England which have a heavy preponderance of older facilities.

Investment in alternate energy and conservation equipment can take many forms. Installation of solar or wind energy systems for heating, cooling, or generation of electricity; conversion or replacement of existing boilers that use oil or gas with more

*Title V, Part 3 of H.R. 5037, The National Energy Conservation Policy Act of 1978.

efficient units or with those that utilize alternate fuels; and the insulation of building to reduce heating and cooling requirements are just a few of the many options available.

Unfortunately, widespread investment in energy and conservation will require the commitment of substantial amounts of capital, and lack of capital resources and/or long payback periods could restrict investment decisions. Most businessmen generally look for a fifteen percent return on investment in their product lines, but they typically demand a return on thirty percent or more on discretionary investment, including those on energy saving equipment.* The double incentive of the investment tax credit and accelerated amortization will make energy saving equipment investments more attractive, and will result in higher energy savings.

Although conversion of older equipment using oil and gas to alternate sources is encouraged in the National Energy Act, the substitution of more efficient oil and gas units, when such conversion is not appropriate, must also be encouraged. This conversion should be limited, however, to those installations which show at least a 10 year payback when energy savings are compared to the investment.

- 7) *Federal and state governments should provide information to lending institutions regarding successful bank programs for financing energy conservation projects.*

The experience of a number of innovative banking institutions indicates that conservation programs can be greatly enhanced when special discounts and conservation education for homeowners are combined in a concerted marketing effort. The government should encourage lending institutions to expand this effort and to explore and develop other possibilities for increasing consumer interest in conservation investments. Government sponsored educational programs that outline some of the initiatives that have proven successful would increase lending institution participation.

Examples of the successful bank energy conservation programs are instructive. For instance, some lenders have offered lower down payments and reduced interest rates on mortgages for the purchase or refinancing of homes meeting certain energy efficiency standards. Others have developed coordinated marketing strategies with utilities, insulation contractors, and hardware outlets, thereby providing the consumer with "one stop shopping" that includes financing. The provision of direct line of credit to conservation and solar contractors and the development of common financing packages with forms geared to particular kinds and sizes of energy projects is another approach. Some are thinking of working with large employers to develop financing packages for conservation/solar options for their employees, perhaps including payroll deduction plans and other mechanisms designed to reduce administrative costs to the lender.

Probably the most successful energy conservation program by a financial institution is the program conducted by Seattle Trust and Savings Bank. Their success results from their incorporation of the various essential characteristics of successful energy conservation programs into a single aggressive program.*

- 8) *Tax credits established in the National Energy Act for the residential sector to encourage the use of non-conventional energy sources and energy conservation equipment should be refundable as well as retroactive to April 20, 1977.*

The Energy Committee is highly satisfied that the final version of the National Energy Act includes substantial programs of tax credits for the purchase of energy

*Business Week article cited in Steven Schneider's "Common-sense about Energy, Part II", *Working Papers* March/April 1978, p. 50; this tendency is also documented in G. N. Hatsopoulos, et al, "Capital Investment to Save Energy", *Harvard Business Review*, March/April 1978, p. 111.

*Further information about this program is available in *Innovative Financing: Banks and Energy Conservation*, prepared for DOE, May 1978, Contract No. EY-76-C-03-1201.

conservation, solar, and wind energy.* However, we believe that the credits as passed would be further improved if they could be made refundable, and thus available to home-owning low-income families. Therefore, we recommend that legislation so amending the credits be enacted during the 96th Congress.

Under the version of the legislation originally passed by the Senate, both the conservation and solar credits would have been refundable; that is, home-owners with little or no taxable income and who therefore pay little or no tax would still have received the credit in the form of a cash disbursement from the treasury. This would have insured that such low income persons were not disadvantaged by what in lieu of such provision constitutes a regressive tax program. The importance of rendering the credits refundable is based in part on the desirability of making these tax incentives available to retired families who have low and/or fixed incomes, a substantial portion of which incomes are nontaxable (e.g., Social Security income). In addition, such retired families are apt to be occupying older housing stock which is either uninsulated or not insulated to current standards, and are therefore very much in need of activities within the scope of the conservation credit. The limited financial resources of such families constitutes a constraint on such activities, and in addition many families in this category may not take advantage of low income weatherization programs. We therefore believe that it is important that the tax credit should operate to provide these citizens with an incentive at least equal to that accorded more affluent homeowners.

At the same time, however, the refundable nature of the credit could create possible abuse. Affluent homeowners, whose tax liability is small enough, would be eligible to take advantage of the refund. Since this recommendation benefits low and fixed income homeowners, the use of the credit by affluent taxpayers would be detrimental to the intent of the committee. Therefore, there should be a statutory income limit on the refundable credit.

- 9) *The proposed legislation that established a State Energy Management Plan to coordinate the development of state energy programs should provide a level of funding which is at least equal to current levels for these programs.*

The proposed State Energy Management Plan (SEMP) legislation would coordinate existing Federal programs that provide funds to state energy offices, and allow the states more flexibility in planning and conducting timely and relevant energy programs. While this legislation is in itself an acknowledgement of the important role that the states must play in any national energy program, the committee is concerned that present funding levels will not be adequate to provide the necessary resources.

The committee agrees with the appropriation levels developed by the National Governors Association SEMP Task Force, which call for \$120 million in FY 1979, \$140 million in FY 1980, and \$160 million in FY 1981-83. This level of funding would allow the states to continue many of their successful conservation programs and establish the new programs required by the act. Without this support it seems inevitable that many state conservation programs would have to be eliminated in order to concentrate on new responsibilities.

- 10) *Solar training programs and courses need to be set up for city planners, architects, labor unions, etc. such as the training course, "Solar Heating and Cooling of Residential Buildings: Sizing, Installation, and Operation of Systems", U.S. Dept. of Commerce, Oct. 1977. Programs are needed for labor unions on solar job opportunities. Courses should be designed to train and update workers on solar technology. State and local officials should be made aware of the merits of solar technologies and encouraged to use them.*

*Title III of H.R. 5037, The National Energy Conservation Policy Act of 1978.

Classes and workshops should also be aimed at educating the general public so they can construct and install active and passive solar systems.

There are a number of educational activities that are needed to increase knowledge about solar technologies. Educational workshops aimed at the general public as well as specific special interest groups, who would be responsible for the design, installation, or maintenance of solar heating and cooling systems, must be initiated to promote and encourage this energy source. The residential, commercial, and industrial sectors are the specific markets where this activity should be directed. State and local officials, including city planners, when instituting a new project or evaluating an old one, should consider solar as an alternative. Project planners, architects, engineers as well as the investors in new or remodeled facilities must become aware of the advantages and limitations of solar technology so that it may be compared with conventional systems.

In anticipation of increasing market demand for solar systems, and in order not to deter acceptance, consideration must also be given to educating and training both professional and tradesman in its application. Information must not only be provided on solar hardware, but programs must be developed to demonstrate how conventional skills apply to solar technologies. It is anticipated that the skills required for solar installations would be similar to those traditional construction skills now required for the installation of conventional systems. Workers would thus only need simple retraining or training in special applications in most instances. Such training should not only include installing solar devices, but consider the problems associated with retrofitting existing structures, conducting energy audits, and implementing conservation and weatherization measures. These activities are often essential to the operation of a solar heating or cooling system. In addition to the training and retraining programs, community energy programs should be set up that would generate jobs by hiring and training the unemployed.

The training course, "Solar Heating and Cooling of Residential Buildings: Sizing, Installation, and Operation of Systems", conducted by the Dept. of Commerce provides a more indepth investigation of solar. This course acquaints the participant with many of the technical and economic considerations concerning solar energy. A course of this type is invaluable for public officials and individuals who need extensive knowledge about solar technologies.

- 11) *We recommend that DOE investigate and identify other non-profit groups who have not been covered under present incentives for the usage of conservation measures and alternative energy to non-profit groups.*

Due to Congress' reliance on tax-related devices to provide incentives for the installation of energy conservation measures and renewable energy systems, non-profit institutions are at a relative disadvantage. Section 501(c)(3) of the Internal Revenue Code exempts non-profit groups from income taxation. As a result of this tax-exempt status, however, these non-profit institutions do not have the same incentive to purchase energy-saving technologies. Although these technologies would lower their increasing fuel costs, non-profit institutions do not have the working capital available to undertake high initial cost, energy-saving expenditures.

The National Energy Act attempts to alleviate this problem by providing for a three phase program of energy audits and matching grants.* Specifically, schools and hospitals qualify for initial preliminary energy audits. If there is an evident potential for energy savings, the qualifying building would receive technical assistance audits. After these audits have determined the need for energy saving technologies, a program of 50%

*Title I of H.R. 5203, The Energy Tax Act of 1978.

federal funds—50% state or private sources would be provided. This 50-50 split provides needed funds, but also provides an inducement for the institution to participate fully because of the significant expenditure of its own funds.

Nevertheless, there are non-profit institutions who do not benefit from these federal programs. These institutions include churches, museums, veteran's halls, granges, and other non-profit groups who own their own facilities. The federal government should identify and investigate the existence and the extent of the energy needs of these institutions. If the energy needs of these institutions are serious enough, possible action similar to those provided for schools and hospitals could be undertaken.

- 12) *Congress should direct the GAO to study energy cost problems of persons of less than median income with the goal of developing recommendations to alleviate negative impacts.*

The energy costs for persons of less than median income who live in the New England region present problems which may cause deterioration in their living standards to unacceptable levels. These potential negative impacts on the quality of life demand meaningful action on the part of the government. It is the position of this committee that there exists no reliable body of data from which the Congress can base a sound judgement as to whether remedial action is necessary. What exists at the present time are general figures and conclusions for the entire United States, not New England specific data. Separate analysis is essential on New England because of its adverse climate and its greater dependence on petroleum. The combination of the long heating season and relatively expensive energy necessitates a large expenditure on heating bills. These expenditures are regressive for the part of the population below the median income. With this in mind, the committee strongly suggests that the GAO be directed to compile and develop recommendations sufficient to alleviate any negative impacts.

Throughout our deliberations, questions of energy cost impacts have frequently surfaced. The lack of reliable data precluded more specific recommendations and it is for this reason we request the Congress to direct the GAO to perform the required task.

NEA RECOMMENDATIONS

Due to the uncertainty about the passage of key portions of the National Energy Act, the Economics and Financing Committee proposed several recommendations which were parallel to NEA provisions. When Congress passed the entire legislation, the committee removed most of these proposals. The committee would like to strongly commend Congress on the passage of these timely proposals.

The topics that were contained in both the NEA and the committee's work were:

- 1) Installation of alternative energy and conservation in government buildings if economically feasible in terms of life-cycle costing
- 2) Encourage spending of Federal research and development funds on photovoltaics.
- 3) Empower the secondary mortgage market entities (GNMA, FNMA, and FHLMC) to purchase solar energy loans. Increase the FHA loan limit to cover solar system costs.
- 4) Increase the general loan limit for Low-Income Weatherization programs.

- 5) Ensure that utilities offer equitable rates for the purchase of surplus power from those who generate their own electricity.
- 6) Public Utility Commissions should require utilities to adopt energy conserving rates for electricity.

OTHER PROPOSALS DISCUSSED

The following topics received considerable attention from the Committee, but specific courses of action were not taken:

- 1) Creation of a central clearing house for coordinating and expediting the approval process for energy projects.
- 2) Authorization for states and/or local governments to use bonding authority and provide loan guarantees for energy projects.
- 3) Establishment of a no-return on equity, government-sponsored finance agency.
- 4) Avoidance of laws which restrict voluntary movement of capital within the energy industry.
- 5) Efforts be made to achieve uniform legislation in New England to deal with industrial development or revenue bonds.
- 6) Direct DOE and IRS to develop legislation that would encourage the financing of new energy projects.
- 7) Environmental regulations affecting an energy project should be specified in advance.
- 8) Property tax exemption on energy related equipment be legislated at state and local levels.
- 9) Small solar companies be provided with access to and assistance in obtaining capital for investment.
- 10) Subsidies for R & D of renewable energy sources be equitable to those provided for R & D of non-renewable sources.
- 11) Subsidization of renewable energy production facilities which are in the national interest.
- 12) Direct the use of rolled in pricing and an all-events tariff in the investment in a coal gasification plant.
- 13) Recommend to DOI a timetable for lease sales and environmental input to accelerate offshore development.
- 14) Recommend that Congress price natural gas and new oil at prices that fully recognize the replacement cost of these sources.
- 15) Reinstitution of the percentage depletion allowance for tertiary recovery, shale oil, heavy oils, and tar sands.

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- 16) Empower municipal governments to use tax-exempt bonds to assist citizens in utilizing conservation and solar energy.
- 17) Extend existing financial incentives for solar to solar leasing companies.
- 18) Institution of a gas-guzzler tax for all the New England states.
- 19) Development of financing packages for conservation/solar projects for federal, state, and local government employees.

NOTE ON THE REPORT ON FINANCING MECHANISMS

A report by the Financing Mechanisms subcommittee is in draft form and is not available for inclusion in this preliminary report. This report delineates the financing mechanisms available for large-scale, community-scale, and consumer, end-use energy projects.