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AN ASSESSMENT OF ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION PRIORITIES FOR NEW YORK STATE

Interim Report

Volume I

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November 1977

POLICY ANALYSIS DIVISION
NATIONAL CENTER FOR ANALYSIS
OF ENERGY SYSTEMS
BROOKHAVEN NATIONAL LABORATORY

DONOVAN, HAMESTER AND RATTIEN
WASHINGTON, DC

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STATE UNIVERSITY OF NEW YORK
AT STONY BROOK

prepared for the
NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

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AN ASSESSMENT OF ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION PRIORITIES FOR NEW YORK STATE

Interim Report

Volume I

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November, 1977

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Abstract

In compliance with its mandate to accelerate the development and use of energy technologies in furtherance of the state's economic growth and the best interests of its population the New York State Energy Research and Development Authority (NYSERDA) initiated, in March 1977, an assessment of energy research and development priorities. This project was undertaken as a collaboration between the Authority, Brookhaven National Laboratory, the State University of New York at Stony Brook and the firm of Donovan, Hamester and Rattien.

The report, presents a view of the energy supply-demand future of the state, and the ways in which this future can be affected by external contingencies and concerted policies. That view takes into consideration energy supplies that may be available to the state as well as energy demands as they are affected by demographic and economic changes within the state. Also included are the effects of national energy policies and technological developments as they modify both supplies and demands in New York State. Finally this report proceeds to identify those general technological areas in which the Authority's program can be of greatest potential benefit to the state's social and economic well being. This effort is preliminary to the work of subsequent phases of the project which will aim at a cost-benefit analysis determination of RD&D priorities.

The preliminary analysis conducted in the study thus far indicates the following RD&D areas as being of highest priority: energy conservation in buildings (promotion and execution of RD&D) and industry; district heating; fuel cell demonstration; solar heating and cooling (analysis, demonstration and information dissemination); energy-environment interaction (analysis); energy information services; and, in general, the attraction of federal RD&D programs to the state.

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I. EXECUTIVE SUMMARY

A. AIMS AND APPROACH OF THE STUDY

In March of 1977 the New York State Energy Research and Development Authority (NYSERDA) initiated a systematic assessment of energy research and development priorities in New York State. The project is a collaboration between the Authority, the Brookhaven National Laboratory, the State University of New York at Stony Brook and the firm of Donovan, Hamester and Rattien. The project was designed as an 18 month effort. It was decided to draw upon the interim results of the analysis to develop at this point a document that would be useful for the Authority's process of planning its fiscal 1978-79 activities.

To determine energy R&D priorities for New York one must construct a view of the energy supply-demand future of the state, and the ways in which that future can be affected by external contingencies and concerted policies. That view must include a consideration of energy supplies that may be available to the state as well as the technological changes that can come about through actions taken outside the state. From that analysis one can then identify those particular issues or problems that may confront the state in the future that can be affected by technological change resulting from research, development or demonstration (RD&D) activities. If one then analyzes the degree to which federal and other existing RD&D activities address these problems, one has a basis for establishing priorities in the state energy RD&D program. These, in broad outline, are the steps followed in this report.

The aim of the present report is to identify those general technological areas in which NYSERDA's program can be of greatest potential benefit to the economic and social welfare of the state. Subsequent analysis in this project will deal with a wider range of possible energy futures for the state in which the effects of price elasticities are explicitly included. It will also deal with RD&D projects on a more specific basis, considering both their costs and their benefits.

In what follows we first summarize the salient features of the national and international energy picture laying particular emphasis on those elements which relate to the New York State situation. The next section focuses on a more detailed presentation of state energy supplies and demands through the year 2000. These are based on a "surprise free" scenario described in detail in Chapter IV and Volume II of this report. The potential RD&D roles for NYSERDA which can influence the future supply-demand situation form the subject of discussion in the next section. This is followed by a summary of ongoing and projected RD&D activities that relate to New York State's energy situation. All of these threads are brought together in the next section which deals with the establishment of priorities for NYSERDA RD&D activities. In addition to itemizing the separate considerations affecting selection of priority areas this section identifies a series of priority areas for NYSERDA RD&D activities. The executive summary concludes with a final discussion of "preliminary priority predictions" for NYSERDA.

B. CRITICAL ELEMENTS IN THE NATIONAL AND INTERNATIONAL ENERGY PICTURE

The technical options open to New York State in coping with its energy problems are now and will continue to be bounded by the national and international energy situation, and by policies initiated and goals set at those levels. These elements define the background context within which appropriate activities for NYSERDA must be identified and priorities established.

1. U.S. domestic oil production peaked in 1970 at 11.3 million barrels per day and is currently less than 10 million barrels per day.
2. The imported fraction of U.S. oil consumption continues to increase - even after the 1973-74 oil embargo - and now stands at 42% of total use. These imports now cost the U.S. some \$35 billion per year, compared with \$3 billion in 1970. The fraction of imported oil coming from Arab OPEC countries has also increased since 1973 and now stands roughly at 50% of total imports.
3. U.S. oil production is not expected to increase between now and 1985, and is expected to decrease substantially thereafter.

4. Production limits within OPEC have been estimated to range from 35 to 45 million barrels per day, levels which would satisfy an increasing world demand for OPEC oil only up to 1985-1990.

Of almost equal relevance to the national energy situation is our dependence on natural gas production, which is also declining. This resource accounts for 30% of the nation's total energy consumption. While federal regulation of interstate gas, or total deregulation, is likely to produce some changes in the allocation of domestically produced gas among different regions of the country, its effectiveness in stimulating increased domestic production is unknown.

The major policy initiatives of the Federal Government in coping with these impending shortages of oil and natural gas are common to all recent national energy plans. There are two basic elements. Coal and nuclear power are to replace oil and natural gas to the greatest extent possible and energy conservation and efficiency improvement is to be effected as soon as possible throughout the economy. In terms of its relevance to New York State, five particular targets of the current National Energy Plan are worth noting.

By 1985:

1. Half of the targeted savings of imported oil (some 2.4 million barrels/day) will come from the switching of oil and gas to coal in industry and utility uses.
2. Nuclear power will provide as much as 20% of the nation's electricity supply.
3. On a sales weighted basis, automobile efficiencies will reach 27.5 miles per gallon.
4. Improvements in insulation for new and existing building structures will have resulted in a drop of 5% in national heating and cooling demands from an extrapolation of current trends.
5. Solar heating and cooling installation will account for 2% of space heating demands in 2000 and heat pumps for 20%.

C. THE NEW YORK STATE ENERGY SITUATION

Figures I-1 and I-2 summarize the energy supply and demand situation in the state. As shown in Figure I-1, 82 percent of the state's energy is consumed in the form of oil and natural gas. Virtually all of the oil and gas used by the state is produced elsewhere, with 63% of the oil imported from foreign sources. Energy prices are generally higher in the state than elsewhere, with electricity prices in some of the more densely populated parts of the state being more than 100% higher than the national average. As shown in Figure I-2, per capita energy consumption in the state is lower than the national average, primarily because of low industrial energy consumption and lower use of fuels for transportation than is typical of the nation as a whole. The presence of large population centers in and adjacent to the state, exacerbates the environmental consequences of energy production and utilization.

In terms of generating workable energy RD&D strategies to cope with this situation, it is well to recognize the relatively static features of the state system of energy production, distribution and consumption. In part, this arises out of the patterns of land use throughout the state. These are characterized by the concentration of a large fraction of the state's population in a few large urban centers. New York City accounts for approximately 40% of the state's total energy consumption, the surrounding suburbs another 20%, with the remaining 40% going to meet up-state demands.

As a basis for making RD&D decisions, we have developed a "reference case" projection of the future supply-demand situation in the state. This scenario is not to be construed as a prediction of the future but rather as an example of how the state's energy system might develop over the next 25 years, assuming relatively surprise-free conditions. This scenario was prepared with the use of the Brookhaven Reference Energy System model. This model serves the function of providing an integrated framework for balancing energy supplies and demands according to fuel forms, end use utilizing devices and intermediate conversion technologies. The model is driven by energy demands which are exogenously set. Assumptions used in establishing

Figure I-1. Primary energy sources - 1974 (Btu x 10¹²).

Figure I-2. Per capita energy consumption - 1974.

energy demands and supply/demand matching include 1) the extrapolation of past growth in individual end-use sectors 2) the adoption of the National Energy Plan features for increase in end-use efficiencies and the switching from oil to coal or nuclear in the production of electricity 3) continued allocation of existing domestic supplies of natural gas and oil to the state on the same basis as now exist and 4) no curtailment of coal or nuclear-based electricity generation. As noted above, the model takes into account only indirectly the effects of price; on final demand or on the use of particular fuels or technologies.

The reference scenario, together with the accompanying sensitivity analyses, allow a number of major conclusions to be drawn. Assuming full implementation of current national energy targets.

1. Overall demand for energy in the state would grow 10% between 1974 and 1985, and an additional 10% between 1985 and 2000. These figures are approximately one third of equivalent national values.
2. Energy resource use would shift to coal. Coal's fractional share of total energy demand would increase from 11% in 1974 to 20% in 1985 to 36% in 2000. This represents a 400% increase in coal use between 1974 and 2000. For nuclear power the equivalent value is 1000%.
3. Total oil requirements for the state would show an increase of 10 times the national figure between 1974 and 1985 (12% compared to 1.2%) and a factor of 4 between 1985 and 2000 (16% compared to 4%). This would mean a continued high reliance on imported oil, from 63% in 1974 to 67% in 1985 to 60% in the year 2000.
4. Natural gas consumption would show an increase of 17% by 1985 and drop of 18% between 1985 and 2000. Assuming the state receives its historical share of domestic gas production (3%) and if the production targets in the National Energy Plan (NEP) are met, these state demands for natural gas could be satisfied.
5. State fuel demands noted above are based on the attainment of energy conservation targets noted in the NEP. If the 1985 NEP targets are not met, oil demands would rise by 29%, and natural gas 12%. By the year 2000, the equivalent incremental increase for oil is 75%, and natural gas 46%.

6. The effects of accelerating the switch to the use of new energy technologies could result in substantial reductions of the state demand for oil. Examples include higher implementation targets for solar heating and cooling, use of waste heat and waste materials, and higher efficiencies in the utilities area through the use of fuel cells. The total oil equivalent savings from all of these new technologies by the year 2000 total 133×10^6 bbl, or 32% of total state demand.

There are additional factors, not directly evident in the analysis of energy supplies and demand that will influence New York State RD&D choices. The environmental effects produced from increased coal utilization in nearby states is an example. Barriers toward commercial utilization of the new technologies, noted above, would be more quickly overcome if shortages of oil and natural gas, now being predicted by the Federal Government, come to pass. Growing Northeast regional cooperation on planning energy supply systems could enhance the impact that the region has on federal energy policies, thereby obviating the need to regard those policies as immutable. But, even if we recognize these uncertainties, it is clear that all strategies to effect a transition to a lowered dependency on oil and natural gas will contain the following elements.

- an expansion in the use of electricity in every major energy end-use sector except transportation.
- the substitution of coal and/or nuclear power for oil in the production of electricity.
- large scale retrofitting of existing structures.
- a major increase in the diversity of energy technologies that are being utilized in the residential, commercial and industrial sectors.

It is within the context of these characteristics of an energy technology "solution" that the functions of NYSERDA have been examined and criteria established for RD&D support activities.

D. THE ROLE OF THE NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

The programs and roles of NYSERDA must be derived on the basis of its particular responsibilities and functions relative to other state and national agencies. On the federal scene, it is, of course, the new Department of

Energy which has the most important institutional relationship to NYSERDA. At the state level the State Energy Office is, in effect, the parent agency of NYSERDA, and the energy RD&D policies of NYSERDA derive from overall state energy policy for which that office has responsibility.

Both the Power Authority of the State of New York (PASNY) and the Public Service Commission carry out duties within the state which are related to the activities of NYSERDA, in both cases legislative provisions make it clear that they are not to carry out the kind of RD&D that is the prime responsibility of NYSERDA. The Empire State Electric Energy Research Corporation (ESEERCO), on the other hand, does perform R&D in the electric area and the two institutions are in regular contact to avoid duplication of effort; they have, in fact, joined in the sponsorship of several research projects.

The basic issue, however, is this: given the overwhelming expenditure of federal funds for the development of new energy technologies (on the order of \$3 billion) why is it necessary at all for New York State to support energy RD&D? The two basic answers to this question are these: First, the mere development of a technology is not sufficient. Once a technology has been developed it must be adapted to local conditions, accepted by critical decision makers and actually implemented into the energy system before its benefits can be captured. These steps are particularly relevant to so called "end use" technologies, such as solar space and water heating and heat pumps, where many local decision makers, including private citizens, must be involved in implementation. Second, the energy situation in New York State has certain unique features (such as those related to its particular housing stock and population densities) which are not adequately reflected in a national RD&D program.

From these two basic rationales for a state based energy RD&D activity derive the following specific NYSERDA functions:

- Encourage, develop and manage ("promote" and "execute") programs of research, development and demonstration of innovative energy producing and using technologies which can relieve the pressures of uncertain energy supplies, environmental costs and constantly rising prices;

- Attract federal energy RD&D funding to New York in projects with direct economic or social benefit to the state, using state co-funding for those collaborative projects which are in the long term energy interests of the state.
- Analyse the economic factors, technological features and institutional elements of the state's energy system in order to evaluate the potential viability of proposals to solve a wide range of the state's energy problems;
- Disseminate technical information concerning energy RD&D results obtained by USERDA, NYSERDA, and other organizations to assure the widest possible application of relevant energy technologies.
- Establish and maintain close policy and program relationships with the Department of Energy and other energy-related federal and state agencies.

E. FEDERAL, UTILITY, PRIVATE SECTOR, AND REGIONAL ENERGY RD&D PROGRAMS

NYSERDA's final list of priorities for its investments of funds and effort will be most cost-effective if they take full advantage of similar on-going and projected activities coming under other jurisdictions. The largest of these are those of DOE which now provides 85% of total federal funding to energy RD&D. DOE's mandate, based on national energy RD&D plans, covers every major technological area involving energy supply. It also includes conservation and environmental control technologies. An increasing fraction of DOE's budget is going to conservation, solar, and geothermal relative to supply enhancement from coal, nuclear and fusion. Near and mid-term results are also receiving increased priority relative to long term programs. Conservation, synthetic fuels development, and geothermal utilization techniques account for 2/3 of the total 1977 budget of \$600 million allocated to high priority near and mid-term technologies. DOE's long term priorities are based on obtaining energy from "inexhaustible" technologies-breeder and fusion reactors and solar energy. The breeder program accounts for 60% of the total \$1.2 billion budget for the ~~inexhaustible~~ energy sources: fusion 32%; and 8% goes to solar-electricity.

These figures make it evident that DOE is now putting a high priority on achieving inexhaustible sources for generating electricity. The near and mid-term emphases are on reducing oil and natural gas demands through the use of conservation technologies, of solar heating and cooling technologies, and the substitution of coal.

Information on RD&D programs in the utilities is comparatively meager. Areas of RD&D interests by the utilities are confined to transmission and distribution of electricity, fossil and light water reactor power generation, and accompanying air and water pollution problems. While investment in these areas by individual utilities is extensive, much of the RD&D affecting the utilities as a group is carried out by major equipment manufacturers such as Westinghouse and General Electric and by the Electric Power Research Institute (EPRI). EPRI is supported by monies from most of the country's utilities. Its budget of \$150-\$180 million for 1977 is 90% allocated to near and mid-term RD&D. ESEERCO, a coordinating group for New York electric utility systems, also funds RD&D in areas of interest to its members. ESEERCO's RD&D budget for 1977 is approximately \$6.5 million. It also functions as a means of interfacing between the New York State electric utilities and DOE and NYSERDA. The ESEERCO expenditures represent only 12% of the total spent on RD&D per year by its eight members. About 50% of the \$53 million expended annually is spent on internally managed projects; 25% goes to EPRI; the remainder is split among a number of recipients.

For proprietary reasons most companies expending monies on energy-related RD&D do not make this information available in sufficiently detailed form to allow analysis. A National Science Foundation study covering the years 1974-1976 indicated that in 1976 roughly 80% of private sector investments went to the nuclear and fossil fuel areas. Between 1974 and 1976, however, the largest increases were for solar and energy conservation.

Regional and state energy programs involving aspects of energy RD&D are expanding. These expenditures in most cases go to producing material on energy support systems and energy conservation for the public and to analyzing state energy policy issues. A few states: New Mexico, Ohio, California, and New York have, however, gone further and financed energy RD&D. California is the only other state, besides New York, which supports these activities out of utility taxes.

F. PRIORITIES FOR NYSERDA RD&D ACTIVITIES

Establishing RD&D priorities for NYSERDA has involved several separate considerations:

- The potential contribution of such efforts to the state's energy supply-demand situation as projected in a range of scenario situations.
- The significance of non-technological factors/barriers which may prevent maximum utilization of technology-derived products and processes.
- Estimates of the marginal impact of NYSERDA efforts in the face of on-going and projected federal, utility and private sector efforts.
- The delineation of an appropriate role for NYSERDA that falls within the mandate of its authority.

The conclusions drawn in this interim report based on these considerations should be treated as tentative in view of the incompleteness of the data base and the limited scenarios which have been explored. For example, we have not as yet treated specific technologies on an individual basis. Nor have we analyzed detailed socioeconomic impacts in separate geographic areas of the state. Correcting these and other deficiencies will form the primary tasks during the remaining months of the study.

Five areas of high priority for RD&D efforts (at both the federal and the state level) have been identified on the basis of their ability to reduce demands on oil imports and at the same time limit environmental impacts.

1. End use conservation in buildings is rated high primarily because of the substantial energy benefits of such programs. Attaining the changes in efficiency as targeted in the NEP would produce decrease of 50 to 75% in space heating requirements by the year 2000.
2. Industrial end use conservation is judged to be of high importance even though improving energy use efficiencies may involve a number of diverse technologies.
3. Transportation conservation derives its overall importance from the sectors higher demand on oil and its generation of substantial pollution.

4. Nuclear waste management is rated high because of the likely increased use of nuclear power in the generation of electricity.
5. Pollution control technology is accorded a high priority because of the likely increase in the use of coal in the state.

Two additional areas--environmental impact assessment and information dissemination services--have been tentatively identified for high priorities on the basis of a consideration of the barriers to implementation of the products derived from activities in the technological areas noted above. Environmental impact assessment, which involves the developing of data to allow comparison of the system-wide environmental effects of various technologies, is clearly needed to establish a more rational public discussion of energy alternatives. Information services, aimed at disseminating to purchasers independent performance and cost data on a variety of competing technologies appears to be critical to accelerating the commercialization of solar energy and other new support systems.

The substantial federal utility and private sector RD&D programs summarized in Section E above leads to the conclusion that the marginal impacts of NYSERDA RD&D activities will be highest in five areas:

1. Solar heating and cooling: The rather modest objectives of federal and private sector programs are not likely to permit the development and demonstration of devices satisfying local variations in climatic conditions.
2. Building end use conservation: Federal funding in the retrofitting of existing structures is likely to have only a very small impact on urban areas in the state.
3. Pollution control technology: The problems in this area are so pervasive that NYSERDA activities specific to increased coal useage in the state are likely to result in high marginal benefits.
- 4,5. Manpower education and information services: Non-NYSERDA efforts in these areas are small. On a per capita basis NYSERDA activities could produce significant changes in the rate of commercialization of new technologies.

It is noteworthy that a low marginal impact rating has been assigned to two of the RD&D areas otherwise accorded a high priority, because of large non-NYSERDA activities and the lack of relatively few technical problems that are regionally unique. These are transportation conservation and nuclear waste management.

A medium rating is assigned to industrial end use conservation in recognition of the active private sector RD&D efforts involving specific energy intensive industries.

The final factor considered in judging priority activities for NYSEDA deals with the appropriateness of the Authority's role. Based on the discussion of NYSEDA's possible roles, noted earlier, it appears that the Authority should give high priority to the following:

- Encouraging and promoting the conduct of federal, utility and private sector RD&D efforts which will produce results of direct use to the state. This role is seen as being particularly applicable in the areas of building conservation, transportation, electricity generation, coal utilization, and nuclear waste management.
- Conducting and executing in part or totally, of RD&D by NYSEDA in areas where the Authority can design and manage the program. Specific areas of applicability of this role for NYSEDA are solar energy, building conservation, and pollution control technology.
- Technical, economic, and social analyses in areas where such analyses could aid in internal NYSEDA decisions or decisions effecting the use of energy technologies made elsewhere in the state government. This role is seen as being needed in the areas of solar heating and cooling, industrial end use conservation and pollution control technologies.
- Information services, and technology transfer in connection with the areas of solar energy, industrial conservation, building conservation, and environmental impact assessments.
- Attraction to the state of major federal energy RD&D activities which would have beneficial economic impacts on the state.

G. CONCLUSIONS AND RECOMMENDATIONS

Until further analysis can establish the relative and absolute costs attached to the list of priority activities discussed above, it is not possible to draw conclusions on expenditure priorities, "preliminary priority predictions" based on the material analyzed so far have been identified, however, and are summarized below:

- High priority RD&D areas for NYSERDA are assigned to the following major categories: solar energy, energy conservation, energy environment-interaction. A low priority is given to the fossil and nuclear energy categories with some exceptions. In the case of coal, for example, control technology RD&D has received a high priority.
- High priority roles are accorded to building and industrial conservation. In the buildings area, the most appropriate roles are promotion and execution; in the industrial area, the most appropriate role is an analytical one to establish specific areas of concentration. A low priority is assigned to electricity generation/distribution, with the exception of fuel cells which are given a high priority.
- NYSERDA has high priority roles in executing, analyzing and disseminating information in the areas of solar heating and cooling and in environmental impact assessments. Medium priority roles are given to solar industrial process heat and biomass fuels. Wind generated electricity is assigned a low priority.

As a final conclusion we would note that, despite the preliminary nature of our work so far, it has become clear that NYSERDA can make an important contribution to achieving a viable energy system for New York State. Indeed, our analysis of the energy transition problems that will face the state over the next ten to twenty years indicates an increasingly important role for the types of activities for which NYSERDA has been given responsibility.

II. INTRODUCTION

A. BACKGROUND

Although the roots of our current energy problems go far back in history public and political awareness of the role of energy in our society dates from the period in 1973 and 1974 when the Organization of Petroleum Exporting Countries tripled oil prices and imposed an oil embargo on the United States. It was widely recognized at that point that energy is a ubiquitous necessity for national economic and social welfare. It therefore came as a shock that we are dependent for our energy supply on countries and institutions over which we have little direct control.

Governmental attention to the "energy problem" which had gradually increased in the early 1970's⁽¹⁾ entered a period of significantly greater activity in 1974. At that time there was a widely recognized need for institutional change in the energy field and one element of that change was the creation of the U.S. Energy Research and Development Administration (USERDA) by the Energy Reorganization Act of 1974 as a successor to the Atomic Energy Commission. There was also a recognition of the need to formulate national energy policy on the basis of much better information and analysis than available at that time. As a result substantial data and analysis activities were created within the newly formed Federal Energy Administration (focused initially on the "Project Independence" analysis). Within USERDA a major analytical effort was initiated to guide the development of a national energy R&D policy.

Such activities notwithstanding, there has been a growing recognition that "national energy problems" manifest themselves, at the state level, in ways that cannot be fully appreciated on a national scale. Fuel shortages, environmental impacts of energy use, economic and social impacts of increased energy prices, the equity problems of increased energy taxes--all of these issues are state problems as well as national problems. In fact many of these issues can be resolved only through actions taken jointly at the federal and the state level.

It is not surprising, therefore, that the response to the "energy crisis" at the state level has been similar to that in Washington. In September of 1975 the New York State Energy Research and Development Authority (NYSERDA) was established as a successor to the Atomic and Space Development Authority. Its mandate was to accelerate the "development and use of new energy technologies to supplement energy derived from existing sources which will promote the State's economic growth, protect its environmental values and be in the best interests of the health and welfare of the State's population."⁽²⁾

The formulation of state energy policies is as urgent a need as the formulation of national energy policies. The economic and social welfare of the state and its population depends upon energy policies formulated at the national level. Energy policy analysis at the state level, the responsibility of the State Energy Office, must not only form a basis of developing state authorized policies and programs, but also must form a basis for identifying state interests as they are affected by federal policies. The determination of state energy policies must be based on a firm foundation of information and upon careful analysis of the implications of alternative actions.

In the particular case of research and development policies the state, in this case NYSERDA, must determine that mix of R&D activities which will be of greatest benefit to the state over its long term future, in the context of related activities in nearby states and at the federal level. This is a central component of NYSERDA's planning function. It is particularly important that opportunities for mutually advantageous cooperative programs between NYSERDA and other energy research agencies in the region and at the federal level be considered.

B. PURPOSE OF THIS REPORT

In March of 1977 the New York State Energy Research and Development Authority initiated a systematic assessment of energy research and development priorities in New York State. The project is a collaboration between the Authority, Brookhaven National Laboratory, the State University of New York at Stony Brook and the firm of Donovan, Hamester and Rattien. The

project was designed as an 18 month effort. It was considered useful to draw upon the interim results of the analysis to develop at this point a document that would be useful for the Authority's process of planning its fiscal 1978-79 activities.

To determine energy R&D priorities for New York one must construct scenarios of the energy supply-demand future of the state, and the ways in which these scenarios can be affected by external contingencies and concerted policies. These views must include a consideration of energy supplies that may be available to the state as well as the technological changes that can come about through actions taken outside the state. From such analyses one can then identify those particular issues or problems that may confront the state in the future that can be affected by technological change resulting from state-initiated research, development or demonstration (RD&D) activities. This then provides a basis for establishing priorities in the state energy RD&D program. These, in broad outline, are the steps that are followed in this study.

The aim of the report is to identify those general technological areas in which NYSERDA's program can be of greatest potential benefit to the economic and social health of the state.

Since only one third of the overall project has been completed, this report must be considered to be preliminary. In subsequent phases of the project the work reported here will be extended in two significant areas. Firstly, the "reference case" projection of the state's energy future will be complemented by a consideration of other possible futures. Some of these will include conditions in which major changes occur in the price of basic energy fuels. RD&D planning must take into account, and prepare for the possibility of, a wide variety of possible future conditions even though some of them may not be highly probable. Secondly, extensions of this work will deal with RD&D programs at a greater level of detail and specificity than has been possible heretofore. The aim will be to develop a cost-benefit analysis which will arrive at RD&D priorities on the basis of the benefits to the state from the differential implementation of various technologies, compared to the cost to the state for achieving that result.

C. OUTLINE OF REPORT

As discussed above, the energy options available to the State of New York will continue to be strongly bounded by the national energy situation and national energy policies. The next chapter presents a brief summary of national energy problems and issues. Chapter IV then focuses on the situation in New York State against that background. The current supply-demand situation is analyzed and the probable directions of evolution of the system in the future are described. This analysis is based on one example of a detailed "surprise-free" future energy scenario developed for this study. The reference scenario, which is detailed in Volume II of this report, is used in Chapter IV to identify major state energy issues and concerns and their implications for possible state actions--including technological change influenced by RD&D activities.

To identify appropriate state energy RD&D programs it is important to clarify the relationship between actions taken at the state and federal levels. In Chapter V we discuss the role of New York State Government in determining its energy future and, in particular, the role of NYSERDA. More specific background information on energy RD&D activities currently being supported by NYSERDA and by other agencies, particularly USERDA, is given in the next chapter.⁽³⁾ The final chapter then draws on all of this information and analysis to identify priority areas for NYSERDA programs.

It should be emphasized that the assessment contained in this report is preliminary. The stress has been placed on providing a firm basis for RD&D policy formulation and on the identification of broad areas of programmatic concentration. A summary and prospectus of the work in progress toward a more detailed establishment of RD&D priorities is contained in Volume III of this report.

NOTES AND REFERENCES

CHAPTER II

1. The first Presidential message on energy was delivered in June of 1971. That message mentioned for the first time the need for institutional change and emphasized these elements of technology development: the fast breeder reactor, coal gasification and stack gas removal of sulfur oxides. It also requested the first integrated assessment of energy research and development priorities, a study which is an early prototype of that discussed in this report. See, Office of Science and Technology, Executive Office of the President, "An Assessment of New Options in Energy Research and Development," AET-9 (Nov. 1973), Associated Universities, Inc., Upton, New York.
2. See New York Energy Research and Development Authority, "Energy for New York's Future." Details of NYSERDA's programs are contained in Quarterly Reports to the Director of the Budget.
3. The functions of the Energy Research and Development Administration have been absorbed by the New Department of Energy and carried out under more than one Assistant Secretary. With this in mind, in this report we will generally refer to federal energy RD&D activities as being the program of USERDA.

III. THE NATIONAL ENERGY SITUATION

A. INTRODUCTION

In this chapter we outline very briefly the national energy situation. There is no intention to recapitulate here all aspects of this picture but rather to point out those aspects which are important in creating an understanding of the energy problems of New York State. ⁽¹⁾

New York's energy problems are similar to those of other states in the Northeast. In many instances an understanding of the New York energy situation can best be achieved through an analysis of the energy situation of the Northeast. Furthermore, increased regional coordination of energy policies based on a regional view could be of significant benefit to the states of the region. For these reasons, in this chapter we develop the relationship of the national energy picture to that in the Northeast as a bridge to the more specific consideration of New York's energy situation discussed in the next chapter.

The essential structure of the current U.S. energy situation is portrayed in Figure III-1. On the right-hand side of the figure are indicated the final uses of energy and the amounts of energy (in 10^{15} or quadrillion Btu) going to each use in 1975. The numbers in parentheses in the figures refer to the efficiency (or more precisely the "relative effectiveness") of the various processes of energy conversion incorporated in the system. In tracing back (to the left in the figure) one gets to the amount of primary resources required to supply the demand for energy with the current system.

Table III-1 presents a summary of the data of the figure. In the Table the amount of each fuel used by each consuming sector is indicated. Note that electricity (at 3413 Btu/Kwh) is included as a "fuel" under each sector. Fuels going to produce electricity are indicated in the "Utility" column. The total resource consumption indicated in the Table, 66.09×10^{15} Btu, is lower than that indicated in Figure III-1 because it is measured at the point of consumption. Taking all system inefficiencies into account the total resource consumption in 1975 was 70.67×10^{15} Btu.

Table III-1
U.S. Energy Consumption in 1975
(Btu x 10¹⁵)

	<u>Resid.</u>	<u>Comm.</u>	<u>Ind.</u>	<u>Trans.</u>	<u>Utility</u>	<u>Total</u>
Electricity	2.02	1.42	2.46	.02	-	5.92*
Petroleum Products	2.94	1.75	5.30	17.70	3.15	30.84
Natural Gas	5.24	2.14	6.84	-	3.14	17.36
Coal	-	0.12	3.75	-	8.93	12.80
Nuclear	-	-	-	-	1.89	1.89
Hydro	-	-	-	-	3.20	3.20
Total	10.20	5.43	18.35	17.72	20.31	66.09*

* Electricity not included in column total to avoid double counting. Fuels used to produce electricity are shown under column labeled "Utility".

Another set of data that will be referred to in our discussion of the natural energy picture is the price of different fuels in different regions of the country. This information is shown in Table III-2. As is evident from this Table there are substantial differences in the prices of electricity, natural gas, and coal between the Northeast and other parts of the country. These differences account for the wide range in the average price for energy in the industrial sector around the country.

B. Basic National Energy Goals

As suggested in the introduction, our society is now aware of the critical role that energy plays in economic and social well-being. When faced with the task of creating a satisfactory energy system, however, we are confronted with a set of diverse, and often conflicting, requirements. In particular:

- The consumer, the industrial energy user and their political representatives consider that energy should be cheap and readily available. This attitude has been a powerful political force and has led to strong federal regulation of energy prices, particularly for natural gas.

Table III-2
1975 Regional Retail Energy Prices
(\$/10⁶ Btu)

<u>Fuel (Sector)</u>	<u>NW-Eng.</u>	<u>NY/NJ</u>	<u>MID-ATL</u>	<u>S.-ATL</u>	<u>Midwest</u>	<u>S.-West</u>	<u>Central</u>	<u>N-Cntrl</u>	<u>West</u>	<u>N.-West</u>	<u>U.S.</u>
Electricity											
Residential Sector	13.21	14.85	11.14	8.19	9.70	7.91	9.98	8.20	9.80	4.25	9.47
Commercial Sector	12.87	14.93	10.35	8.59	9.49	6.91	8.65	6.90	8.30	4.44	9.27
Industrial Sector *	9.36	8.04	7.26	5.25	5.84	4.22	5.84	3.71	6.30	1.64	5.60
Natural Gas											
Residential Sector	3.06	2.50	1.93	1.49	1.53	1.35	1.65	1.17	1.53	2.09	1.69
Commercial Sector	2.54	2.03	1.65	1.18	1.29	.91	1.31	.98	1.25	1.57	1.34
Industrial Sector *	2.15	1.51	1.08	.83	1.07	.71	.75	.60	.99	1.03	.88
Distillate											
Residential Sector	3.13	2.85	2.78	2.80	2.64	2.72	1.81	2.80	2.99	2.93	2.79
Commercial Sector	2.77	2.59	2.58	2.57	2.49	2.49	1.96	2.68	2.74	2.68	2.58
Industrial Sector *	2.77	2.58	2.56	2.56	2.48	2.48	2.26	2.68	2.75	2.67	2.56
Residual											
Commercial Sector	2.13	2.07	2.06	1.84	2.22	1.92	1.21	2.55	2.64	2.57	2.10
Industrial Sector *	2.13	2.07	2.03	1.86	22.21	1.98	1.48	2.50	2.63	2.59	2.10
Liquid Gas											
Residential Sector	3.54	2.93	2.64	2.49	2.36	2.43	3.63	2.61	2.79	2.70	2.64
Industrial Sector *	3.04	2.55	2.47	2.31	2.22	2.26	2.44	2.44	2.56	2.47	2.38
Coal											
Industrial Sector *	1.18	1.01	.78	.87	.89	1.46	.47	.75	1.03	.77	.86
Transportation Sector											
Gasoline	4.53	4.64	4.46	4.48	4.68	4.41	4.62	4.65	4.69	4.55	4.57
Jet Fuel	3.38	3.06	3.02	2.99	2.83	2.93	2.84	2.92	2.90	2.97	2.98
Distillate	3.74	3.55	3.53	3.53	3.45	3.44	3.23	3.65	3.70	3.64	3.51
Residual	2.13	2.07	2.03	1.86	2.21	1.98	1.48	2.50	2.65	2.59	2.13
Average Sector Prices											
Residential Sector	4.56	4.17	4.07	4.56	2.93	3.29	3.32	2.48	3.27	3.26	3.58
Commercial Sector	3.97	4.64	4.27	4.43	3.21	3.31	3.07	2.63	4.26	2.92	3.78
Industrial Sector *	3.97	3.54	2.50	2.28	2.02	1.11	1.68	1.34	2.16	1.49	1.90
Transportation Sector	4.32	4.20	4.09	4.16	4.38	3.85	4.28	4.27	4.14	4.08	4.17

*Industrial Sector does not include refineries.

- The economist and planner feel that for the sake of the overall efficiency of the economic system energy should be priced at levels that reflect its cost of replacement.
- The environmental impact of energy systems should be minimized. This generally leads to higher prices. Energy related activities account for some 85 percent of total pollutant emissions from all economic activity.
- Energy availability and prices should not favor one region of the country over another, or one income group over another. This is a relatively new policy goal; in the past low energy costs have been an acceptable mechanism to develop "backward" regions, such as the TVA region. This new policy goal is endorsed by high energy cost regions and resisted by low energy cost regions.
- We should preserve our national endowment of natural resources.
- We should not be dependent on insecure foreign sources of energy. This goal was most sharply defined by President Nixon in 1974 as requiring "energy independence" by 1980. That goal was soon realized to be attainable only at an unacceptably high national cost.

Many of these goals are clearly in tension and their resolution is the central task of national energy policy formulation. In formulating policy these goals must be translated into specific policy issues. It is these policy issues that will be discussed in the next sections.

C. ENERGY RELIABILITY AND OIL IMPORTS

A central issue in our national energy situation is our dependence on petroleum, the depletion of domestic petroleum resources and our consequent increased reliance on petroleum imports.

In 1974, 46 percent of total energy resource consumption was petroleum. Petroleum's fractional share has been increasing steadily; it was only 19 percent of consumption in 1960. This increase, of about 4.6 percent per year between 1960 and the early 70's, was due in part to low prices, the growth of automobile and air travel, and environmental constraints on the use of coal.

During this period the increasing costs of domestic production and the availability of cheap imports served as a disincentive to domestic production, which peaked at 11.3 million barrels per day in 1970. Production in 1976 fell to about 9.7 million barrels per day. This has resulted in an ever increasing fraction of our oil being imported; and an increasing fraction of that comes from the countries which belong to the Organization of Petroleum Exporting Countries (OPEC). OPEC now supplies roughly 50% of our imported crude oil. This trend is shown in Table III-3.

Table III-3
Trends in U.S. Oil Production
and Consumption
(Million Barrels/day)

<u>Year</u>	<u>Domestic Production*</u>	<u>Foreign Imports</u>	<u>Total</u>	<u>Imports %</u>
1968	10.6	2.8	13.4	21
1970	11.3	3.4	14.7	23
1972	11.2	4.7	15.9	30
1973	10.9	6.2	17.1	36
1974	10.5	6.3	16.8	37
1975	10.0	6.1	16.1	38
1976	10.0	7.3	17.4	42

*Includes natural gas liquids.

The four-fold increase in the world price of oil in 1973-74 and the oil embargo raised major economic concerns about the continued high levels of oil imports. There is concern, first of all, about the direct economic impact of higher energy costs and secondly about the huge balance of payments burden that these imports represent. The current oil import bill is approximately \$35 billion per year (or \$125 per person)- compared to \$3 billion in 1970.

A third impact of concern is the possibility of another cut-off of oil supply induced by political motivations. The embargo of 1973-74 which

affected 14 percent of U.S. petroleum consumption caused an additional 500,000 unemployed at its peak.

It will not be easy to reverse the trend of increasing imports to the U.S. In fact, since 1973 the oil import fraction has increased substantially. Moreover, projections in the National Energy Plan⁽²⁾ (NEP) and elsewhere do not indicate significant increases in domestic oil production between now and 1985 even with Alaskan production, increased offshore production and tertiary onshore recovery. Thus it is anticipated that even under optimistic assumptions the absolute level of imports will increase and will probably fall in the range of 12 to 16 million barrels per day, corresponding to total consumption of 23 (with implementation of NEP initiatives) to 25 million barrels per day (with no new policy initiatives). The world demand for oil also has and will continue to increase because of the economic growth of industrialized as well as developing countries. In 1976, thirteen OPEC countries exported 29 million barrels of oil per day. Under current world demand trends, by 1985 this number could exceed 50 million barrels per day. If production could actually keep up with the growth rate, and if annual world demand increased by only 3 percent per year, the world's currently estimated "recoverable" oil would be depleted by the year 2020. If one considers the alternative resource strategies that OPEC, and particularly Saudi Arabia might follow, a divergence between desired demand and willingness-to-supply could appear well before that time--in fact in the period between 1985 and 1995.⁽³⁾

The Northeast finds itself in an even more precarious situation relative to oil than the nation as a whole. Not only does the Northeast depend on oil for a larger fraction of its total resource consumption - 63% compared to the national figure of 46% - but also a larger fraction of that oil is imported - 63% compared to 42%.⁽⁴⁾ Historically, the Northeast has also paid higher prices for its oil than many other regions of the country; in recent years, however, that difference has essentially disappeared as shown in Table III-2. This has been due primarily to the FEA entitlements program which was designed to equalize the price of crude oil, whatever its source, to all refiners independent of their location or size.^(5,6) Under current legislation the wellhead oil tax is designed to replace the entitlements program but is expected to have the equivalent effect in terms of regional

equity.* Thus, although there may be some oil price differences resulting from specific contract provisions, large regional oil price differences are not expected to exist in the future.

D. NATURAL GAS - PRICE AND AVAILABILITY

Consumer-oriented policies have, in recent years, maintained ceilings on the wellhead price of natural gas shipped in interstate markets. This resulted in a rapidly increasing demand for this clean fuel in the period since the end of World War II. Between 1960 and 1970 gas consumption grew by about 5.7 percent per year. Since 1970, however, consumption has declined, not for any lack of demand, but because of declining production. Natural gas now accounts for 30 percent of the nation's energy resource consumption with 20 trillion cubic feet (tcf) being consumed last year. (Of this, domestic production accounted for 19 tcf.)

The prices at which natural gas has been regulated in interstate markets has been about one quarter of the price of imported oil on the basis of equivalent energy content. The price of new gas in the intrastate market, however, is comparable to that for imported oil. The result has been that a large fraction of new production is dedicated for consumption in the state in which it is produced. This trend is shown in Figure III-2 which compares the annual additions to dedicated reserves for the interstate and intrastate markets in two time periods on either side of 1970.

Despite this trend, and the higher prices on the intrastate market for new gas, the average price paid for gas in producing states is considerably below that in the Northeast, as shown in Table III-2. For this reason natural gas is used much less in the Northeast (16 percent of resource use) than on a national average basis (27 percent of resource use). As was evident last winter, higher prices are not the only adverse result of the geographical situation of the Northeast relative to gas supplies. During that period the Northeast received an undue share of natural gas curtailments, a situation that was remedied in large part by the Emergency Natural Gas Act of 1977 which finally gave the FPC power to equalize curtailments among pipeline companies.⁽⁹⁾

*Indeed some disadvantageous regional market distortions which occurred due to the "reverse entitlements" program should disappear with the new policy.⁽⁵⁾

Figure III-2. Comparison of interstate and intrastate average annual additions to dedicated reserves.

Source: Reference 8.

A key provision of the National Energy Plan relative to natural gas is the extension of federal price regulation to gas sold intrastate. This is intended to reverse the trend shown in Figure III-2 and will thereby be of benefit to the Northeast. Nonetheless, the prognosis for future natural gas supplies is rather dismal. Various estimates differ on specific magnitudes,^(7,8) but there is general agreement that U.S. production will continue to decrease in the future,⁽¹⁰⁾ and it is likely that significant price increases will be forthcoming.

E. THE USE OF COAL - ENVIRONMENTAL CONCERNS AND CONSTRAINTS

The basic challenge to energy change should now be clear. Behind the issues discussed in the previous sections is the fact that oil and gas, on which we depend for three quarters of our energy needs, represent only seven percent of our basic energy resources. Coal, on the other hand, which is currently being produced at the rate of 660 million tons per year, supplies only 18 percent of energy demand although it represents 90 percent of our energy resources. (The total recoverable coal reserves in the United States are estimated at 427 billion tons).

A common thread through U.S. energy policy statements over the last six years has been the necessity of shifting our energy system away from natural gas and oil to coal. A typical policy target is to double our use of coal over the next ten years. But this shift has been particularly difficult to initiate. The major users of coal, the utilities and industry, have been reluctant to switch to coal at a time of increasing coal prices, uncertain environmental regulation and unproved environmental control technology. Coal producers, on the other hand, have been inhibited by decreases in productivity due to (much needed) health and safety regulations and are reluctant to invest in new mines without an assurance of a growing demand.

Technological innovation is a key, particularly in achieving environmentally and economically acceptable coal combustion. But if the increased use of coal is to solve the long term problems of oil and natural gas depletion it must substitute not only the production of electricity and industrial process heat, which account for only one third of oil and gas use, but in the transportation, residential and commercial sectors as well. This, of course, implies the conversion of coal to liquid and gaseous fuels. Technologies to accomplish those conversions are now the subject of extensive research and development

programs (see Chapter VI). Thus far, however, liquid and gaseous fuels from coal are far more expensive than their natural counterparts.

The switching from oil and gas to coal for industrial and utility uses accounts for more than half of the saving in imported oil by 1985 (some 2.4 million barrels per day) in the NEP. These policies follow those contained in the Energy Supply and Environmental Coordination Act (ESECA). Unfortunately, in the Northeast there has been little success in implementing the conversions called for in ESECA and some analyses consider that the NEP conversion targets are optimistic.⁽¹¹⁾

Increased coal use in the Northeast can manifest itself directly and indirectly.⁽¹²⁾ The direct means of increasing coal use in the future is through conversion of oil (or gas) fired electric capacity to coal, and construction of new coal-fired capacity. Another direct means would be the increased use of coal by industry, replacing oil and gas, possibly through conversion to low-Btu gas. The Northeast may in the future also use coal indirectly, through the conversion of coal to liquid and gaseous fuels outside of the region. These indirect supplies are not expected to be significant by 1985, but could provide from 5 to 10 percent of the supply by 2000.⁽¹³⁾

A major constraint on the increased use of coal nationally is the environmental impacts of coal combustion. These are particularly critical in the Northeast whose geographical location and population densities exacerbate the problems of health impacts. Of more concern are the sulfur oxides produced in coal combustion. Current regulations apply to SO_2 in ambient air and as emitted at a power plant stack, but recent concern seems to focus more on sulfates (or more precisely, acid aerosols), the reaction products of SO_2 created during atmospheric transport. The scale of that transport is such that a significant fraction of the sulfate concentration in the Northeast is due to sulfur emissions in the Midwest and the TVA Region. Thus, if a national air quality standard is promulgated for sulfates, the constraint on sulfur emissions will be more severe in the Northeast than elsewhere, with possible impacts on energy costs to industry and utilities.

The national administration has taken the position that all new facilities, including those that burn low sulfur coal, should be required to use the best available control technology. Although there is now considerable

uncertainty regarding how that policy will manifest itself and what the implications will be for the Northeast,⁽¹⁴⁾ there is general consensus that it will result in greater production of Appalachian coal (possibly not from Pennsylvania) and some doubt whether it will, in fact, improve air quality in the region.⁽⁴⁾

We should mention another possible constraint on planned increases in coal use that could have a particularly severe impact on the Northeast--the inadequacies of the coal transportation network. Although national studies⁽¹⁵⁾ indicate that, with proper planning, such bottlenecks and capacity constraints that do exist can be overcome without undue difficulty, in view of the obsolescence and widespread bankruptcy of Northeast railroads, such optimism should be tempered with some doubt and concern in this region.⁽¹⁶⁾

F. NUCLEAR POWER

Another common feature of all recent national energy plans, borne from a concern over oil and gas depletion has been support for increases in the use of nuclear power. This strategy is also an element in the current administration's National Energy Plan, but is tempered by a moratorium on the use of plutonium as a fuel, and therefore on the need for fuel reprocessing. This new policy is based on three considerations: new estimates of the availability of uranium, increasing estimates of the cost of fuel reprocessing and, more basically, a concern for the possibility of plutonium being clandestinely diverted (nationally and internationally) for use in nuclear weapons.⁽¹⁷⁾ This policy has introduced a new element into one of the basic public concerns about nuclear power: radioactive waste disposal. Official policy on disposal has not yet been settled, a situation which has resulted in the necessity of increased storage of spent fuel elements at reactor sites.

Currently, nuclear power supplies about 10 percent of U.S. electricity. That fraction is somewhat higher in the Northeast where the cost of competing technologies is higher than the national average. The future implementation of nuclear power has been uncertain in recent years because of uncertainties on economics, public attitudes (which affect licensing times), fuel supplies (including enrichment capacity) and the regulatory situation. Current administration policy is to "ensure that risks from nuclear power are kept as low as possible, and --(to) resolve problems and unnecessary delays

in the nuclear licensing process." The administration target for 1985 is that nuclear power provide "as much as 20 percent of electricity supply." It is expected that, with the current economic and regulatory situation, over the next 25 years, approximately one half of the new base-load electrical capacity in the Northeast will be nuclear, the other half being coal.

G. ENERGY CONSERVATION

Over the past several years there has been an increasing emphasis on the role of energy conservation--or increased energy efficiency--in national energy policy.⁽¹⁹⁾ This has been due to an increasing realization of the difficulties and costs of augmenting energy supplies at the rate of historical growth of energy demand and an increasing appreciation of the cost effectiveness of efficiency improvements relative to supply enhancement.

The automobile, symbolic of so many aspects of American life, is fittingly enough the central target of conservation policies. This is because of its role in oil consumption, however, rather than its symbolic role; transportation accounts for about one quarter of U.S. energy consumption, with the automobile responsible for one half that or about 5 million barrels of oil per day. Currently contemplated excise taxes on energy inefficient cars are designed to assure that the legislated requirement of 27.5 miles per gallon on a sales-weighted basis is met by 1985. This policy is aimed at reducing gasoline requirements between the present and 1985 by 10 percent.

An analysis of the situation in the Northeast indicates that gasoline consumption in 1985 should be roughly equal to current consumption. Other transportation modes in the region--air, truck and water--are all expected to grow more rapidly.⁽²⁰⁾

Heating and cooling of buildings (and water heating) account for almost 20 percent of total U.S. energy use. In the residential sector, current policy initiatives concentrate on tax credits for adding insulation and solar equipment for space and water heating. It is also intended that public utility commissions be required to direct utilities to offer residential customers "turnkey" conservation services, financed by loans repaid through monthly bills.

In the industrial sector, which accounts for 37 percent of the nation's energy consumption, there have been more directly perceived economic incentives for energy conservation. These incentives are augmented in current proposals by a number of programs including the oil and gas pricing provisions, and taxes on industrial and utility use of oil and gas. The tax on natural gas, for example, would be an amount equal to the difference between the cost of gas and a price target keyed to distillate oil.

The goal of the administration's energy conservation programs is to reduce the annual growth of energy demand to below 2 percent, compared to the 3.5 percent typical of recent history. There are differences of opinion as to whether the specific programs advocated by the Administration will actually achieve the required reduction in growth.⁽²¹⁾ In the Northeast, however, it appears that a future energy growth rate of close to 2 percent is not unreasonable given the pricing and other proposals in the NEP.⁽⁴⁾ The possibility of achieving lower energy growth rates in the Northeast results from a number of factors. Some of these are the lack of energy-intensive industrial growth, relatively low population growth and conservation possibilities in the transportation and residential sectors.

H. NEW TECHNOLOGIES

In the preceding discussion we have alluded to a number of technological changes that will be required in reducing energy demand growth and in shifting our energy system from its dependence on oil and gas. Some of these, such as fluidized bed coal combustion, are designed to facilitate the substitution of coal for oil and gas; others, such as solar space and water heaters, are designed to reduce our long term dependence on fossil fuels. In the next chapter we examine the energy situation in New York State more explicitly and identify general technological areas that appear to afford promise for the state's energy future. In Chapter VI we present a survey of the technologies currently under development along with a specification of state and national RD&D programs. It is clear from the discussion above, however, that central to the resolution of the long term problems of energy supply are large shifts in resource use and in the technical structure of our energy system. Such changes do not take place quickly or easily. As suggested by Figure III-3, time scales on the order of 50 years have characterized major shifts in resource consumption in the past. Furthermore, in the future

such changes are not apt to occur as quickly or as easily as they have in the past. Newly perceived (and newly important) environmental restrictions, massive existing capital investment (and relatively low future demand growth), the lack of an easily exploited new resource--all of these factors contribute to the difficulty of change. The facilitation of change thus becomes a major goal of energy policy at the federal and at the state level.

Figure III-3. U.S. energy consumption patterns.

Source: Energy Research and Development Administration, "A National Plan for Energy Research Development and Demonstration" ERDA-48, based on data of U.S. Bureau of Mines, U.S. Census.

NOTES AND REFERENCES

Chapter III

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8. R. Langlois, "Future Natural Gas Supplies to the Northeast," BNL-50558 (April 1976), Brookhaven National Laboratory, Upton, New York.
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14. For a discussion of the implications of proposed Clean Air Act Amendments on the Northeast see DHR, Inc., "Discussion Paper: Implications of Clean Air Act Proposals for Coal Conversion in the Northeast," Draft Report to the Coalition of Northeastern Governor's Coal Subcommittee, May 1977. For a Discussion of environmental aspects of the implications of the National Energy Plan on the Northeast, see P. M. Meier, op.cit., Section 4.4.
15. See, for example, Manalytics Inc., "Coal Transportation Capability of the Existing Rail and Barge Network, 1985 and Beyond," (Sept. 1976); and FEA, Office of Coal, "Coal Rail Transportation Outlook," (May 1976).
16. Of particular concern in the Northeast is the issue of railroad abandonment. At the time of the Con Rail takeover of the bankrupt Northeastern railroads some 5700 miles of track were not accepted. Some 3000 miles are expected to be abandoned. See FEA, Office of Coal, op.cit. and Reference (4), p. 41.
17. These policy rationales are expressed most clearly, if unofficially, in the Report of the Ford Foundation, Mitre Corporation, Nuclear Energy Policy Study Group, Nuclear Power: Issues and Choices, (Ballinger, Cambridge, 1977).
18. Executive Office of the President, op.cit., p. 31, 69ff.
19. Despite its many proclaimed flaws, the Ford Energy Policy Project of 1974 had a critical impact on national thinking regarding the potential for energy conservation. See Energy Policy Project, A Time to Choose: America's Energy Future, (Ballinger, New York, 1974).
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IV. THE ENERGY SITUATION IN NEW YORK STATE

A. INTRODUCTION: GENERAL APPROACH

The basic justification for an energy RD&D program in New York State must derive from a careful appraisal of the state's current and future energy situation. In this chapter we assess this situation in terms that bear on the rationale for such a program and in a way which will eventually lead to the establishment of technical priorities within that program. We examine first the current and future supply-demand situation in the state, against the back-drop of the national and world energy situation described in the previous chapter. We then identify certain key energy issues in the state related to the future supply-demand situation. We finally discuss some technical implications of these issues which bear upon the question of RD&D priorities.

The basic analytical approach we have used in this project is as follows: First we assemble a detailed set of data on how energy is used in the state and how that energy is supplied. A projection is then made of the underlying factors which will determine future energy use such as the number and kind of houses to be built, the number of vehicle-miles to be travelled by various kinds of vehicles, etc. We then make technical assumptions regarding the types and efficiencies of the technologies to be used in the system, for example, the burner efficiencies and amount of insulation in new housing (or retrofit installations). Assumptions are also made regarding the mix of energy forms (oil, gas, electricity, etc.) used for specific purposes (heating, electricity production, etc). We then have one scenario of the energy supply-demand future of the state,⁽¹⁾

A scenario constructed in this manner accomplishes two purposes. First, it provides a means of drawing aggregate conclusions from detailed sectoral analyses. One can determine, for example, the future state oil import requirements that follow from specific energy demand and fuel mix assumptions. Secondly, it provides a framework by which one can evaluate the impact of individual changes in the assumptions. Of particular importance in the current analysis are the impacts that result from changes in the rate of introduction of new technologies that could result from NYSERDA RD&D programs.

The particular scenario used for this study is described briefly in part D of this chapter and is described in detail in Volume II. In general the scenario is designed to correspond to a future which is consistent with all currently anticipated developments and policies at the state and federal level.

B. OVERVIEW OF THE CURRENT SITUATION

Along with the other heavily populated states of the Northeast, New York State's concern with energy derives from five basic considerations.

- To a larger extent than many states in other sections of the country, New York's energy supplies are derived from the two fuels for which the uncertainty in future supply and price is greatest--oil and natural gas. As shown in Figure IV-1, in 1974 66% of New York's total primary energy supply was derived from oil and 16% from natural gas. Figure IV-2 shows the breakdown of final energy consumption in the major consuming sectors.
- Virtually all of the oil and gas used by the State is imported, with 63% of the oil coming from foreign sources.⁽¹⁾ The state is thus vulnerable to supply disruptions both domestically and internationally. Unless prescribed by Federal legislation, the energy producing regions of the country furthermore can be expected to use their energy resources to capture related manufacturing activity away from those states which import fuels.
- Energy prices in the Northeast, and in New York in particular, tend to be higher in general than most other regions of the country.⁽²⁾ This is particularly true of electricity prices. In some of the most populated parts of the state these were more than 100% higher than the national average. This is due in part to the mix of fuels used to produce electricity and in part on the prices of those fuels. These factors add to other elements in the state such as higher labor costs to reduce the states' relative economic competitiveness. Table IV-1 summarizes some recent state energy prices and the corresponding US average prices. As discussed in Chapter III prices are expected to equalize somewhat in the future.

- The presence of large population centers within the state and adjacent to it complicates the problem of effecting major technological changes in the state's energy supply system, and at the same time exacerbates the environmental consequences of any energy use. For example, it may become increasingly difficult to site the large number of electricity

TABLE IV-1

REPRESENTATIVE ENERGY PRICES IN NEW YORK STATE

1976

	N.Y. State <u>(\$/10⁶Btu)</u>	U.S. Average <u>(\$/10⁶Btu)</u>	Ratio <u>N.Y./U.S.</u>
Electricity - Residential		10.8	
New York City	23.7		2.19
Buffalo	15.3		1.42
Natural Gas - Residential		1.79	
New York City	3.02		1.69
Buffalo	1.95		1.09
Oil - Residential		2.88	
New York City	3.05		1.06
Buffalo	3.06		1.06
Oil to Utilities	2.08	1.94	1.07
Con Edison	2.29		1.18
Niagara-Mohawk	1.76		0.91
Coal to Utilities	1.16	0.85	1.36
Rochester Gas and Electric	1.35		1.59
N.Y. State Elec. and Gas	1.00		1.18

Figure IV-1. Primary energy sources - 1974 (Btu x 10¹²).

Figure IV-2. Per capita energy consumption - 1974.

generating plants that may have to be built between now and the year 2000 in the urban regions of the state in which roughly 60% of the population resides.

While there are parallels to each of these elements to be found in the nation's energy problem, before one can understand the full importance of these considerations it is necessary to spell out the special factors which have influenced energy patterns in the state.

Out of such an understanding it will become evident that 1) certain technological options which are available to the country as a whole may not be suitable for the state; 2) state problems in contending with the trends in federal energy policies may require special attention by way of requiring technological innovations to be introduced in the state before other parts of the country; and 3) the environmental and safety problems arising out of the state impacts of federal strategies to replace oil and gas may require action at the state level.

C. FACTORS INFLUENCING ENERGY PATTERNS IN NEW YORK STATE

There are several sets of factors which have influence on the final form of the network of energy supply and demand in New York State. The first, which has affected the energy demand sector more than any other, relates to the patterns of land use throughout the state, the overall make-up of its economic base and the composition of the state's population. These structural and developmental components set the basic patterns for the state's energy growth. They have derived from historical trends and state and local preferences--none of which has been affected strongly by energy considerations.

For example, the concentration of a large fraction of the state's population in a relatively few large urban centers is a basic determinant of the composition of final energy demand. The massive growth of the suburbs ringing older inner cities in each of these areas is another major contributor to the structure of energy use in the state. Finally, the long standing steady shift in the state from manufacturing to service activities accounts for another basic element in the composition of energy demand.

To illustrate this point, we display in Figure IV-3 a plot of the division of end use energy consumption in New York City, the Nassau-Suffolk region (a more or less prototypical suburban region), New York State, the Northeast, and the U.S. as a whole. We note that industry, which in

Figure IV-3. Divisional energy demand by sector.

the suburban counties accounts for only 10% of total energy demand, accounts for 21% in NYC, 21% for the total state, 45% for the Northeast, and 40% for the nation. Energy demand in the commercial sector on the other hand goes from a high of 29% in the suburbs to 27% in the city, 19% in the state, 13% in the Northeast and 11% for the U.S. Transportation accounts for 20% of total energy demand in the suburbs but only 13-14% in the city, state, region and 30% in the country. Finally, residential demands fall slowly from a high of 43% in the city to 20% in the U.S. as a whole. In absolute terms in 1974, New York City consumed approximately 40% of the state's final energy consumption, the suburbs around the city accounted for another 20%, with the remaining 40% going upstate.

Higher energy prices, fuel shortages, and changes in energy technologies will undoubtedly play a role in modifying the relative percentages of the energy consumed in each of the demand sectors in each of these geographic areas. But, barring unforeseen circumstances, the time element in effecting major changes in these percentages will be decades, not years. Moreover, such considerations are important in evaluating the potential for utilization of new energy production and end use energy technologies, in that technologies coinciding with these relatively static structural components are likely to find easier acceptability.

A second set of factors influencing the state energy system relates to the make-up of the energy carrier subsystems which have already been set in place. It is this carrier system which links primary energy fuels to the individual end-use sector energy demand. Included in the carrier system are the different components in the energy conversion-distribution network and the mix of end-use sector energy demand. The state's electrical generating stations and its grid networks is an example of the latter. Figure IV-4 is a summary representation of the flow of energy to various specific end uses in the state. In that figure, the number over each arrow indicates a flow of energy, in 10^{12} (trillion) Btu. The numbers in parentheses indicate the efficiency of conversion of one energy form to another (e.g., oil to electricity) or the relative efficiencies with which various energy forms satisfy end uses such as space heating. It is important to understand (in viewing the introduction of new technologies) that over an extended period of time, the characteristics of the energy conversion subsystems and the mix of end-use technologies must grow to accommodate one another. For example, the rapid growth in the use of air conditioners in the late 60's and early 70's goes hand in hand with increased

Figure IV-4. N.Y.S. reference energy system, year 1974.

demands for electrical systems which can accommodate summer peaks. Increased oil refining is directly tied to increased automobile use. Altering the energy carrier system in New York State will therefore require a considerable degree of coordination if the process is not to become inefficient and wasteful.

In New York State, the energy carrier system is based primarily on the use of oil as the dominant fuel. In 1974, oil accounted for 66% of primary energy consumption (including its use as petrochemical feedstocks). Of this, 20% is used to supply oil fired electric generating stations, 33% goes for space and water heating in the residential and consumer sectors, 11% for producing process heat and feedstock in industry and almost all of the remaining 36% for transportation. Natural gas, the other basic fuel used in the state (16% of the total) is used as follows: 6% to produce electricity, 19% to process heat, and 75% is used in the residential and commercial sectors. Electricity as an intermediate energy carrier accounts for 11% of primary energy consumption. Its use is divided among end uses as follows: 66% to the residential and commercial sectors, 30% to process heat in industry and the remaining 3% to transportation. Energy uses by sectors are summarized in Table IV-2. In that table the amount of each fuel used by each consuming sector is indicated. Note that electricity (at 3413 Btu/kwh) is included as a "fuel" under each sector. Fuels going to produce electricity are indicated in the "utility" column.

A third set of factors on which New York State's energy system depends are the price and availability of its fuel imports. Because it lacks indigenous conventional energy resources, New York State, like most of the other states of the Northeast, is almost totally dependent on importing its primary energy. The almost total dependence of the state on imports in contrast to states in the Southern and Western parts of the country make evident that in the near future, the state, like much of the Northeast and North Central Region, will be highly sensitive to decisions made by the Federal Government, by other energy exporting states and by foreign governments. For example, it was noted in Chapter III that federal policies bringing the pricing of intrastate natural gas under federal regulation will affect the availability of future gas supplies to the state. The same applies, with even greater force, to

Table IV- 2

N.Y. ENERGY CONSUMPTION IN 1974
(10^{12} Btu)

<u>Fuel</u>	<u>Res.</u>	<u>Com.</u>	<u>Ind.</u>	<u>Tran.</u>	<u>Agric.</u>	<u>Utility</u>	<u>Total</u>
Electricity	114.6	131.3	113.8	11.0	1.5	.0	372.2
Petroleum	550.5	363.4	291.5	986.7	9.4	540.0	2741.5
Nat. Gas	371.4	112.6	124.2			37.7	645.9
Coal			173.6	.0	.0	196.5	370.1
Nuclear	.0	.0	.0	.0	.0	108.0	108.0
Hydro	.0	.0	.0	.0	.0	283.0	283.0
Total	1036.5	607.3	703.1	997.7	10.9	1165.2	4148.4*

* Electricity omitted to avoid double counting. Note that the fuels used to produce electricity are shown under "utility" and total 1165.2×10^{12} Btu. The total amount of electricity consumed is 372.2×10^{12} Btu; the overall efficiency of electricity production and transmission is thus $372.2/1165.2 = 31.9\%$

OPEC decisions on oil prices and restrictions on production.

New York State is also highly dependent on energy imports in the form of energy embodied in the materials and goods flowing into (and out of) the state. Because a significant fraction of industry in New York depends on labor intensive manufacturing activities which require energy intensive materials, it is important to understand that energy exporting states and countries may move to exploit their resources through policies seeking to modify energy flows both in the form of primary and processed energy and embodied energy as well. It is natural for an energy producing region or country to use its energy resources to feed local energy intensive industry rather than exporting the raw materials to competing regions. Over an extended period of time, policies directed principally toward affecting inter-regional energy flows could alter the competitive position of the industrial base in New York State. In assessing state energy R&D strategies it is important to recognize this high degree of dependence on imports. Initiatives designed to reduce uncertainty should receive major attention.

Policies and actions external to the state not only affect the price and availability of fuels and alternative supply technologies, they exert a substantial influence on the technologies employed in energy utilization. The improvement of automobile efficiencies, the introduction of electric cars, and ambient environmental standards all depend in large part on federal initiatives. Many of these elements are captured in the National Energy Plan (NEP) now being considered by Congress. The effects of the NEP on the Northeast states discussed in Chapter III document this influence.

It is evident from the above discussion that the major outlines of the options available to the state for modifying its energy system, which will in turn define the roles of state sponsored RD&D, will be constrained by the broad energy strategies being implemented at the federal level. It must also take into account the probable actions of its traditional suppliers of fuels and energy-intensive materials, both within the U.S. and overseas. It does not follow, however, that the role for the state can only be an inconsequential one. Rather, as the next section of this chapter will show, it means that state strategies must exploit the special relationships between New York State and the effects of actions taken elsewhere.

D. THE FUTURE SITUATION--REFERENCE CASE

Research, Development, and Demonstration (RD&D) activities should be designed to ameliorate the future energy problems of the state. Thus, establishing RD&D priorities requires a view of possible future energy supply and demand in the state and an identification of the major energy issues of concern. As noted earlier, in order to provide a quantitative basis for analysis we have constructed a "reference case" scenario of the future energy supply-demand situation in the state. The reference case is not intended to be a prediction of the future, but rather to provide a basis for discussing impending energy problems in the state and for judging the impacts of new technologies. It is basically a surprise-free scenario which incorporates reasonable assumptions in each sector about the determinants of energy demand--such as population trends, new residential, construction, industrial growth, automobile travel, etc. Most of these assumptions derive from estimates made within the State Government.

In addition to constructing a scenario, a number of assumptions have to be made regarding energy policy as promulgated primarily at the national level. These policies will determine, in large part, the changes in fuels and technologies used in the energy system of the state between the present and some time in the future. In order to create a self-consistent picture, we have assumed that the policies contained in the National Energy Plan⁽⁴⁾ will be implemented. Thus it assumes that the trends in fuel shifts, growth of electricity with respect to other fuels, introduction of new technologies and improvements in energy utilization efficiencies described in Chapter III for the U.S. as a whole, also apply to New York, with appropriate corrections being made for local conditions. It further retains the effects of current utility plans regarding the discussion between nuclear powered and coal-fired electricity generating stations. A tabulation of some of the basic assumptions made in constructing the reference case scenario is presented in Table IV-3.

The reference case scenario used in this analysis represents, of course, only one of many surprise-free futures for the state supply-demand system. But it is quite adequate for our purposes at this stage. Because of the inertia of the system, it is very unlikely that the situation in 1985 will be very different from our projection. By the year 2000 a number of factors other than the scenario are highly uncertain. Furthermore, the purpose of this

Table IV-3
SELECTED BASIC ASSUMPTIONS FOR REFERENCE CASE

Variable	Values			Sources (Volume II references)
	1974	1985	2000	
State Population, 10 ⁶	18.25	18.63	19.46	NYS Economic Development Board (NYSEDB)
Households, 10 ⁶	6.13	6.88	7.75	NYSEDB
Housing Stock Mix, %				1970 Census of Housing ¹ Project Independence Task Force Report ²
Single Family	38	41	38	
Low Density	24	21	20	
Low Rise	13	15	15	
High Rise	25	23	21	
Commercial Floorspace, sq. ft. x 10 ⁶				
School	574.0	574.0	514.0	NYS Education Dept. (modified) ^{7,8,11}
Hospital	208.7	208.7	208.7	NYS Dept. of Health (modified) ¹²
Office	456.2	501.8	552.0	Regional Plan Association (modified) ⁹
Retail	510.0	588.5	683.9	1972 OBERS Projection/NYSEDB ¹⁰
Services	780.0	900.1	1045.9	1972 OBERS Projection/NYSEDB ¹⁰
Industrial Value added, \$ x 10 ⁶				
Chemical & Allied Prod.	2368.	3501.	5681.	1972 OBERS Projection ¹⁰
Primary Metal Indus.	1818.	1953.	1991.	Economic Activity in U.S. (1974)
Stone, Clay & Glass	924.	1355.	2065.	(modified by private communication with U.S. Dept. of Commerce)
Paper & Allied Prod.	1090.	1530.	2170.	
Food & Kindred Prod.	2600.	2908.	3656.	
Transportation				
Air passengers, 10 ⁶ pass. miles	8376	12895	23223	Systems Design Inc. and BNL ¹⁷
Auto, 10 ⁶ pass. miles	85460	125750	165778	Dept. of Taxation & Finance
Truck, 10 ⁶ ton-miles	28045	31972	412275	Highway Statistics 1974
Agriculture				
Farms, 10 ³	48	38	38	Cornell University, July 1976 and BNL ²³
Efficiencies in End Use				National Energy Plan (BNL Analysis) "Sourcebook for Energy Assessment," BNL-50483 ³
Residential/Commercial				
Space heating				
oil	.45	.52	.69	
gas	.49	.58	.75	
Water heating				
oil	.55	.63	.63	
gas	.56	.61	.63	
Transportation (mpg)				
automobiles	16	19	26	
Fuel Supplies, Btu x 10 ¹²				
oil	2746	3075	2598	6% of domestic production (historical allocation) & imports
Natural Gas	647	534	437	3% of domestic production (historical allocation)
Coal	370	769	1511	Total demanded is supplied
Nuclear	108	383	1035	Total demanded is supplied
Electric Generation, GWH x 10 ³				
Oil	47.5	66.2	3.0	NYPP 149-b Report for 1977 ³¹ expansion plan modified to include conversion of certain existing oil plants to coal
Gas	3.0	0	0	
Coal	16.7	57.1	124.5	
Nuclear	9.6	37.0	100.0	
Hydro	28.3	24.7	25.2	

stage of the assessment is to identify general areas for RD&D concentration rather than specific programs. The next phase will consider specific programs and will require the development of a longer set of scenarios.

The model used to link energy supplies to end use demands is the regional version of the Reference Energy System. This model was developed at Brookhaven National Laboratory as a means of allowing decision-makers to understand the interactions between technical elements making up the different potential paths between supply resources and levels of final service demand in different end use sectors.⁽¹⁾ It employs exogenously derived energy demands to drive possible future versions of the energy production-distribution system. A single path through the energy system network reflects the application of a specific energy resource to specific end use. More elaborate decision tools will be used in the next phases of the study when an improved specification of the state RD&D programs has been arrived at.

The major conclusions that follow from developing this reference case are presented below and in the accompanying graphs and tables. Details of the reference case are given in Volume II.

- 1) Overall demand for energy in the state continues to grow during the remaining years of this century even if the energy conservation targets of the National Energy Plan are met. In New York State, as shown in Figure IV-5, this means a 10% increase between 1974 and 1985 and an additional 10% between 1985 and 2000. Expressed in terms of annual growth, the New York figures are 0.8% and 0.6% compared to equivalent national values which range between 2.3% and 1.9%. Reasons for the lower growth in New York are anticipated low state population and economic growth rates, and the relative absence of agglomerations of energy-intensive industries.
2. Energy source use will shift increasingly to coal, particularly in producing electricity and in producing process heat for industry. Coal's fractional share of total state energy demand goes from 11% in 1974 to 20% in 1985 to 36% in 2000. This corresponds to an increase of 400% in coal use between 1974 and the year 2000 as a result of the increase in total energy consumption. This is shown in Figure IV-6. The role of nuclear powered electric generation is required to increase by a factor of 1000% to accommodate increased demands for electricity.

Figure IV-5. Energy demand by sector.

*PCFS = Petrochemical feedstocks.

Figure IV-6. N.Y.S. base case fuels at end use.

- 3) Even so, total oil requirements for New York State increase by 12% between 1974 and 1985. Between 1985 and 2000, they decrease by 16%. These figures are to be compared with equivalent nation-wide increases of 1.2% and 4.0%. To keep the increase in oil requirements in the state down to these levels requires that the fractional share of oil in the residential sector drop from 52% in 1974 to 42% in 1985, to 32% in the year 2000. This is shown in Figure IV-7. The equivalent figures for the commercial sector, shown in Figure IV-8, are: 57% (1974), 51% (1985), 42% (2000); the industrial sector (Figure IV-9); 19% (1974), 17% (1985), 13% (2000). Percentages for the industrial sector exclude petrochemical feedstocks.
- 4) By 1985, natural gas requirements for the state show decreases of 12% and by the year 2000 this has decreased by an additional 18%. Its share in the residential sector decreases from 35% in 1974 to 30% by the year 1985 and to 25% by the year 2000. The equivalent figures for the commercial and industrial sectors, shown in Figures IV-8 and IV-9 are 18% (1974); 15% (1985); 13% (2000) and 18% (1974), 16% (1985), and 12% (2000), respectively.
- 5) Should New York continue to receive its historical share of national natural gas production (about 3%) and if the natural gas production targets in the National Energy Plan are met (15 trillion cubic ft. in 2000), its projected gas requirements can be satisfied. Such is not the case for oil. On the basis of projections in the NEP and New York's historical share, the state can expect to obtain about 1.1×10^{15} Btu of domestic oil in 1985 which will require increasing the fraction of imported oil from 63% in 1974 to 67% in 1985. The levels of imports are expected to remain high (about 60%) even by the year 2000.
- 6) Electricity produced from a combination of hydro, coal and nuclear resources is assigned an increasing contribution in all end use sectors except transportation as shown in Figure IV-10. In the residential sector, its fractional share goes from 11% in 1974 to 25% in 1985 to 40% in 2000. Similar anticipations in the commercial and industrial sectors are shown in Figures IV-8 and 9. In the residential and commercial sectors, electricity goes primarily to space and water heating and in the industrial sector to process heat. This assumes

that much of the new construction in the interim period will employ heat pumps and resistance heating.

- 7) Two new technologies were considered in the reference projection-- heat pumps and solar energy for space and water heating on the basis of market penetrations calculated from National Energy Plan targets. By 1985, heat pumps are assumed to provide 3% of space heating demands in the residential sector and solar energy 1% of the total demand for water heating. By the year 2000, heat pump contributions have increased to 9% and solar water heating to 5%. Solar energy also supplies 2% of space heating by the year 2000. In the commercial sector, heat pumps provide 2% of space heating demand in 1985 and 4% by 2000. Solar energy is used to fill 1% of water heating demand in 1985 and 5% in 2000. These values in no way represent upper limits. Accelerated state programs, considered below, going beyond the national goals would lead to higher values.
- 8) The environmental implications of the reference case scenario have not been analyzed in any detail. Nevertheless we have calculated changes in pollutant emissions of various kinds by sector over the period of analysis. In the 1974-1985 period all emissions increase, with particulates and nitrogen oxides growing at about 2.5% per year. This is due to the increased coal use in industries and utilities and growth in the transportation sector. Between 1985 and 2000 many pollutant emission levels are steady or decreasing, the exception being particulates which increase due to increased use of coal in manufacturing.

E. ALTERNATIVES TO THE REFERENCE CASE

The characteristics of the state's future energy supply-demand picture as summarized above from the reference case give little indication of their sensitivity to the many assumptions that have gone into their estimation. Targeted goals for supply substitutions may not be met, nor may increases in end-use efficiencies of energy use. On the other hand in certain areas, such as the introduction of new solar energy-based technologies, a more rapid rate of implementation may be achieved. Information on how the reference case energy supply-demand picture may change with these developments is also

helpful in understanding the energy system effects of introducing or not introducing new energy technologies. In Vol. II, a number of alternative cases are considered. The conclusions reached from these sensitivity analyses are presented below:

Figure IV-7. N.Y.S. base case residential.

Figure IV-8. N.Y.S. base case commercial.

Figure IV-9. N.Y.S. base case industrial fuel demands.

* ACTUAL GENERATION IS ABOUT 8% HIGHER BECAUSE OF EFFICIENCY LOSSES IN TRANSMISSION.

Figure IV-10. Electricity production and use in New York State.

PERCENTAGES DO NOT ADD TO 1 BECAUSE GOVERNMENT AND AGRICULTURE ARE NOT INCLUDED. TOTAL USE BY THESE TWO SECTORS OF EITHER FUEL IS LESS THAN 1% FOR ANY REFERENCE YEAR.

Figure IV-11. Use of oil and natural gas in three reference years. Percentage and (Btu x 10¹²).

- 7) Two new technologies were considered in the reference projection-- heat pumps and solar energy for space and water heating on the basis of market penetrations calculated from National Energy Plan targets. By 1985, heat pumps are assumed to provide 3% of space heating demands in the residential sector and solar energy 1% of the total demand for water heating. By the year 2000, heat pump contributions have increased to 9% and solar water heating to 5%. Solar energy also supplies 2% of space heating by the year 2000. In the commercial sector, heat pumps provide 2% of space heating demand in 1985 and 4% by 2000. Solar energy is used to fill 1% of water heating demand in 1985 and 5% in 2000. These values in no way represent upper limits. Accelerated state programs, considered below, going beyond the national goals would lead to higher values.
- 8) The environmental implications of the reference case scenario have not been analyzed in any detail. Nevertheless we have calculated changes in pollutant emissions of various kinds by sector over the period of analysis. In the 1974-1985 period all emissions increase, with particulates and nitrogen oxides growing at about 2.5% per year. This is due to the increased coal use in industries and utilities and growth in the transportation sector. Between 1985 and 2000 many pollutant emission levels are steady or decreasing, the exception being particulates which increase due to increased use of coal in manufacturing.

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- 1) The effect of introducing alternative energy supply assumptions on the reference case can be significant. We offer three examples:
 - a) The reference case assumed that substantial oil coming into the state would come from shale by the year 2000. If such is not the case the estimated oil from domestic sources would be reduced by 16%.
 - b) Availability of oil from the Outer Continental Shelf was not considered in the Reference Case: Intermediate range estimates of OCS oil production by the year 2000 give values in the vicinity of 200,000 bbl/day. Assuming New York State receives 30% of this amount, it would represent an addition of only 2% to state imports from domestic sources.
 - c) The reference case indicated that the New York State short-fall in natural gas would be 19 bcf which corresponded to 3% of the total state demand for natural gas. It would be possible to make up for this deficiency with the use of high Btu synthetic gas (SNG) by the construction of commercial scale SNG plants.
- 2) State demands projected for oil, natural gas and electricity are, of course, dependent on the fulfillment of the energy end-use efficiency goals in the NEP. To reveal the sensitivity of the reference case results variations were run for the residential/commercial, transportation and manufacturing sectors in which 1) no increase in end-use efficiencies in the residential and commercial sectors were included, 2) the NEP 1985 targets given in Table IV-3 were moved forward to the year 2000. The distribution of demands among these three fuels was assumed to remain constant.
 - a) For the former case oil demands in the residential/commercial sectors increased by 13% in 1985 over the reference case results, and by 48% for the year 2000. Natural gas percentage increases were 11% for 1985 and 32% for the year 2000. Electricity showed only small increases of 3% and 4%. In the latter case, the equivalent increases in the year 2000 are 30% for oil, 19% for gas, and 1% for electricity. In the reference case, electricity is partially substituted for direct usage

of oil and natural gas in space and water heating in these sectors. Assuming such electricity were to be fueled by sources other than oil and natural gas, the percentage noted above for oil and natural gas would be substantially reduced. For electricity, on the other hand, the differences would increase substantially. This demonstrates the interactions between policies designed to replace scarce supplies in the production of electricity with those aimed at achieving increases in end-use efficiencies.

- b) By the year 1985, the reference case shows that 33% of total state demand for energy emanates from the transportation sector. This increases to 34% by the year 2000. Most of this energy will continue to come from petroleum. These values, large as they are, are predicated on the NEP targeted increases in transportation efficiencies as shown in Vol. II. If such increased efficiencies are not attained it would result in a 33% increase in transportation sector energy demands by 1985 and a 60% increase in the year 2000. If, however, the 1985 targets were attained in the year 2000 only a 35% increase in the transportation sector energy demand would result.
- c) In the manufacturing sector the NEP calls for both end-use efficiency increases and the substitution of direct coal use to replace oil and natural gas to produce process heat. The changes in the percentage increases of fuels in the manufacturing sector for the two conditions described above are summarized as follows. Non-attainment of NEP goals would result in an increase of 20% in oil demands (other than feedstock) in 1985 over the reference case; gas 13% and electricity less than 1%. In 2000 oil demands increase by 60%, gas 56%, electricity 2%. Here again the sensitivity analyses assume no major substitution of electricity or other fuels for oil and natural gas.

In summary, if NEP targets are not met, the total oil demand for New York State could show an increase of up to 112 million barrels of oil in 1985. This would represent an increase of 29% in the total state oil demand in 1985. For natural gas the added requirements are 64 bcf which represent a percentage increment of 12%. By the year 2000 the extra fuel demands imposed by NEP non-attainment are considerably larger. For oil it is 285 million barrels or a 75% increment. For natural gas it is 200 bcf or a 46% increase. The

differences for electricity are much less significant given our assumption of not including the effects of fuel switching to electricity.

- 3) As noted above, the effects of introducing new energy technologies at the rates anticipated in the NEP on the state's future energy supply-demand picture (as portrayed in the reference case scenario) is not significant. On the other hand the earlier implementation of the number of innovations not specifically identified as targets in the plan, could affect the reference case results significantly. In what follows we briefly summarize the conclusions reached in Vol. II where the effects of introducing a number of innovations are reported.

- a) Should NEP targets for the year 2000 with respect to solar energy space and hot water heating devices be achieved by 1985, and a tripling in the implementation levels be achieved by the year 2000, by 1985 3.6×10^6 bbl oil equivalent of the state's energy demand could come from solar (1% of the total state energy demand) and by 2000 12.5×10^6 bbl oil equivalent (3% of total).
- b) The use of waste heat corresponding to 50% of that available from the additional coal based electric generating stations called for in the reference case, for residential/commercial structures would result in a savings of 13×10^6 bbl by 1985 (3.4% of the reference case total), and 63×10^6 bbl 2000 or 15% of the reference case total.
- c) The increased use of fuel cells fueled by hydrogen or hydrogen-rich fuels to displace steam turbine capacity as spinning reserve to produce electricity for base and peak load operation, and as a means of reducing transmission losses, have the potential by the year 2000 of resulting in a oil savings of $45. \times 10^6$ bbl of oil equivalent or 11% of the reference case total.
- d) Making use of the energy contained in solid waste as a boiler fuel augmenting coal has the potential of saving energy corresponding to 10×10^6 bbl of oil by the year

2000 or 2.5% of the reference case total for the state.

- e) A one per cent improvement in transmission and distribution efficiency by the year 2000 would save the oil equivalent of 3×10^6 bbl or 0.7% of the state total demand in the year 2000.

Taken together the total oil equivalent savings by the year 2000 from these innovations total 133×10^6 bbl or 32% of the state total demand as projected in the reference case. While these results do indeed demonstrate the substantial sensitivity of our reference case results, they should not be interpreted as necessary outcomes. No doubt, new state and federal initiatives would be forthcoming were there strong indications that state oil and natural gas demands were moving up at excessive rates.

- 4) As noted above, in the reference case electricity produced from a combination of hydro, coal, and nuclear resources is assigned an increasing contribution in all end-use sectors except transportation. Were restrictions placed on the use of nuclear fuels or on coal to generate electricity in central stations, they could affect the state's ability to expand its electric generating capacities. Environmental considerations, for example, could restrict the use of coal. Expanding nuclear power might become unacceptable to the public. To determine the sensitivity of the electric capacity expansion proscribed in the reference case scenario to such developments, we have considered several cases in which varying kinds of restrictions are placed on utility capacity expansion.

Reference Case: As described above.

Case I: No growth in nuclear capacity; No oil-fired base load capacity by 2000; No restrictions on coal expansion.

Compared to the reference case, by 1985 the 15% cut-back in nuclear power is taken up by a 20% increase in coal use and a 4% increase in oil usage. By the year 2000, however, this policy has reduced the reference case nuclear generation

of electricity to 1/3 of the reference case at the cost of increasing coal usage by 60%.

Case II: No growth in coal capacity: no limits on oil-fired generation until 1985 and then a phase out of oil-fired base load generation by 2000; no limits on nuclear expansion.

By 1985 this restriction on coal utilization already leads to a 40% increase in oil requirements for generating electricity. This increase, on an annual basis, corresponds to 45×10^6 bbl of oil or 12% of the total state consumption of oil in 1985 projected in the reference case. The continuation of the restrictions on the use of coal to produce electricity to the year 2000, when accompanied by the phase out in oil use, results, of course, in a major expansion of nuclear powered generation capacity. This amounts to almost a doubling of nuclear installed capacity over the base case. In absolute terms this would call for the production of an additional 30 1000 MW nuclear installations.

Case III: No growth in coal capacity; no growth in nuclear capacity; no limits on oil-fired generation.

Although the realization of these conditions are unlikely, this case was run to obtain some ideas of the additional requirements for oil. By 1985 the increase is only slightly larger than for the conditions given in Case II. By the year 2000 however, oil demands for generating electricity have increased 63% over what is indicated in 1985. The total annual oil demand for generating electricity is now 275×10^6 bbl which corresponds to 53% of the total used in the state in 1974.

F. STATE ENERGY ISSUES AND THEIR IMPLICATIONS

In considering the issues arising out of these conclusions and their implications, it is important to keep in mind the commentary in Chapter III with respect to the energy situation of the Northeast region as a whole. Most of these states (and those of the North-Central region as well) have historically relied on energy imports from other parts of the country and overseas. As a result they have been and will continue to be strongly affected by uncertainties in future supplies of oil and natural gas. None, however, is likely to be more adversely impacted than those which, like New York, had already experienced downturns in their economic growth even before the energy

"crisis". As noted earlier, the question the state faces is not only whether it can assure itself of adequate sources of energy supplies to meet its needs at "affordable" prices; also entering are the relative competitive positions of the state vis-a-vis energy exporting regions of the country and other states seeking to adopt energy self-sufficiency policies.

Although, as noted in Chapter III, prices for petroleum and natural gas will, almost certainly, be moving upward to reflect their marginal costs of replacement, it is highly unlikely that the higher prices will increase domestic production to the point where supplies come near meeting demand for these fuels. Certainly the chances of returning to the situation of a few years ago with ample supplies of fuels is so small that it offers no basis for policy. All of this implies that the state will have to undertake a vigorous policy to first supplement and later totally replace these scarce fuels by other sources--preferably those over which the state is likely to have greater control. In the interim it must act to reduce energy demands through promoting increases in efficiencies in energy production, distribution, and utilization.

The time scale for effecting their replacement will be highly dependent on events and policies taking place outside the state. The more pessimistic forecasts of limits on non-Communist world oil production noted in Chapter III would allow only 30 years before oil in effect disappears as a basic energy fuel (either through restrictions on exports or very large price increases). More optimistic projections suggest a period of 40-50 years will be available which would make the transition times compatible with those of the past. But independent of these forecasts, New York State's major energy problem over the next several decades will be to effect this transition in a manner that, on the one hand, is compatible with the direction of similar federal initiatives, while, at the same time, insuring equitable access to energy by all segments of the state's population.

Entering into the choices of how this transition is to be accomplished are many elements--the strategy the state intends to employ in coping with oil and natural gas shortages in the intervening years, and the influence of non-technical, non-economic, social factors. Each will have an impact on the criteria for evaluating technology-related policies options. These, in turn,

will influence the state's RD&D priorities. To reflect these non-technical considerations in more concrete form we list below a number of "state concerns" which will bear on state energy technology choices and decisions.

- a) The avoidance of the economic and social disruptions brought about by sudden interruptions in imported petroleum and natural gas supplies during the period of transition.
- b) The assurance that the alternative fuels employed in place of oil and natural gas will be secure against sudden changes in price and availability.
- c) The need for assurance that mandatory energy conservation measures imposed by the Federal Government will not lead to results inimical to the interest of the state vis-a-vis those of other regions of the country.
- d) The requirement that added costs of protecting citizen health and physical environmental from energy production and distribution in areas of the state where population densities are high not make the cost of energy to lower income groups prohibitive.
- e) The possibility that public attitudes within the state will develop to a point where any of several large technological options will have to be removed from consideration.
- f) The principle that maximum advantage be taken of collaborative actions with other states in the region that could ease New York's problems in moving to reduce its dependence on oil and natural gas.
- g) The recognition by the Federal Government of the special energy situation of New York and other states in the Northeast and the developments of Federal R&D programs more specifically directed to their needs.

Although this list is in no way complete, it demonstrates the sensitivity of the issues that are likely to be encountered in attempting to formulate a precise set of energy RD&D priorities or a ranking of criteria for judging the value of such investments to the state. Furthermore, it substantiates a theme, developed throughout this report, (that while the state must acknowledge its limited ability to sustain an independent approach to energy alternatives, in the absence of a strong program of its own (or in cooperation with nearby states) programs constructed on a national basis may very well not meet state needs.

G. CHARACTERIZING STATE ENERGY TECHNOLOGY "SOLUTIONS"

The reference case conclusions together with those based on the sensitivity analyses described in Vol. II have ignored the discussion of a wide variety of developments which could affect the overall situation. Some of the most important are listed below.

- 1) A clear interaction exists between New York State strategies for reducing its dependence on oil and natural gas and the kind of policies adopted in other nearby states. Competition for Pennsylvania coal, for example, will increase its price. Increased coal utilization in states adjacent to New York will lower prevailing air and water quality. Differences in enforcement of state-imposed conservation actions can lead to movement of industry across state lines with adverse employment effects.
- 2) The market penetration of heat pumps and solar energy devices could take place at a much faster rate if technological advances continue to be made and if competition among commercial firms selling these devices continues to result in lower prices. In addition, other energy conversion systems using waste heat, such as direct heating and cogenerated electricity, may be introduced more quickly than has been anticipated in our reference case and its alternative scenarios. The introduction of these conversion systems and others is likely to be particularly enhanced if the public comes to perceive that the shortages of oil and natural gas predicted for the 80's will indeed come about.
- 3) It is not at all clear that the level of oil imports to the state assumed in the reference case in 1985 (1 million barrels/day) and, the year 2000 (0.7 million barrels/day) is feasible. In 1985, for example, New York State, under those assumptions would require 15% of total national oil imports (while receiving 6% of domestic production). As noted in Chapter III, recent studies have raised considerable doubt on the ability or willingness of the oil producing countries to meet prospective world demand beyond the 1985-1990 time period. Moreover even if no oil export restrictions take place the implication of continued high levels of imports for U.S. balance of payments may also lead to more vigorous U.S. policies to reduce imports. Such eventualities could force the rates for conversion from oil to coal and

nuclear-based electricity to proceed much faster than indicated above. Such developments would also lead to forced reductions in oil usage in the transportation sector.

But, regardless of the exact conditions under which the state effects a transition away from oil and natural gas it is evident from our discussions of the state's energy supply-demand dynamics that all the strategies to effect a transition to a dependence on alternative fuels will contain components of each of the following elements independent of the specific technologies employed. Each in turn has its own set of implications which must be considered before an appropriate list for RD&D programs for NYSERDA can be assessed.

1) An Expansion in the Use of Electricity in Every Major End Use Sector Except Transportation:

Although there are a number of alternatives to the use of oil and natural gas for space conditioning and water heating in residential and commercial structures, an increase in the use of electricity for these purposes is almost sure to develop. In part, this is due to the overall flexibility of electricity as an energy carrier. Although electricity lacks the ability to be stored, on-site schemes for storing energy in the form of heat make up for this deficiency. The increased use of electricity is also suggested by its adaptability to both electrical resistance devices and heat pumps as means of producing the heat needed. It is essential to note that this expanded use of electricity need not be satisfied exclusively through the construction of additional numbers of large central stations. Greater use of cogenerated electricity, advanced utility systems, small hydro-systems, and wind mills all have the potential for contributing to the increased generation of electricity.

If government policies move in the direction of favoring the increased use of electricity the following situations could be produced:

- In older building stock, replacement of current heating and hot water systems with electric resistance systems may take place without accompanying improvements in building insulation. From the overall system perspective, this means a drop in overall systems efficiency.

- The expanded use of solar heating and cooling systems with electrical back up, rather than on-site storage, could be tolerated thereby reducing the cost of installation for such systems.
- Cogenerated electricity may, if permitted, compete in certain geographic areas with utility generated electricity. This may require new legislation dealing with jurisdictional problems which may result.

2) The Substitution of Coal and/or Nuclear Power for Oil in the Production of Electricity:

In the long run the most flexible sector in the state's existing energy carrier system with respect to oil and natural gas substitution is in the production of electricity. By the year 2000 neither oil nor natural gas is likely to be used to any significant extent in the generation of electricity. This means that coal and/or nuclear power will have become the dominant fuels. Of the two, coal offers greater flexibility in how it can be used. It may be used in small fluidized bed coal systems, or as an alternative fuel in refuse burning energy systems. Coal may also be converted to low Btu gas. Nuclear fuels will almost certainly be confined to central stations of at least several hundred megawatts in power. In either case, the increased use of these fuels will have a number of consequences:

- coal burning activities (size, location, pollutant emissions, etc.) throughout the state will have to be coordinated with similar activities in adjacent states to minimize environmental damage.
- the waste disposal of the residuals of either fuel will likely entail new state obligations.
- systems combining electricity production with the production of district hot water and/or steam are likely to receive increased attention.

3) Large Scale Retrofitting of Existing Structures:

In other areas of the country experiencing increases in population and higher rates of economic growth, the current anticipated levels of increased end use energy efficiency targeted in the National Energy Plan can be achieved by enforcing higher efficiency standards on new construction. In New York, however, even if all newly constructed structures were to be

built using higher efficiency standards, substantial retrofitting of existing buildings will be required to bring up the state average to NEP targets for energy end use efficiencies.

For New York this means that technical innovations aimed at achieving improvements in insulation in existing structures and conversions in their heating and cooling systems must receive special attention. The construction of inexpensive on-site energy storage offers one possibility. Widespread installation of heat pumps using electricity, solar hot water heaters, and passive solar systems is still another possibility. To reduce heat wastage new more efficient replacement windows may be required as well as sprayed types of wall and ceiling insulation. Should the state undertake to mandate such a retrofit program it will have a number of implications:

- standards may have to be set to establish performance of retrofitted systems.
- the state may have to support the development of special processes for retrofitting older buildings in the inner city areas.
- restrictions may be necessary to eliminate commercial systems which minimize capital outlays but increase operating costs.
- certain industries may require special support and technical aid in reducing their energy consumption.

4) Major Changes in the Diversity of Energy Support Systems

We have already alluded to the increased diversity of energy supply systems (type, scale, service targets, etc.) and energy end-use devices (solar heating/cooling, heat pump, resistance heating, diesels, fuel cells, etc.). In essence the current relative homogeneity of energy production and consumption within the state (and the region) will no longer hold. This will not only complicate planning for allowing the state to meet its energy needs; it will also require much more systematic integration of the technical requirements that accompany these diverse systems. Under such conditions the role of the utility as a supplier-distributor of electricity from large stations may have to change. Also likely to change are the current commitments of the utilities and other energy suppliers to guarantee deliveries sufficient to meet all "reasonable" demands.

Finally the role of the state in promoting the health and welfare of its citizens may require it to become a regulator of last resort should the

distributive energy support systems serving individual communities or building complexes fail. This changing nature of the state's energy system bears directly and indirectly on a number of aspects related to assessment of state RD&D programs.

- Insuring overall state energy efficiencies may require collaborations between local authorities and industry to preserve waste heat from industrial processing for the heating of residential and commercial structures.
- Utilities responsible for satisfying electric demands of communities may have to exert authority over the communities choice of on-site systems and indeed may end up owning them.
- Back-up responsibilities for publicly regulated energy delivery companies may have to be weakened as the number of off-grid systems increases.
- Standards of reliability and stability for systems of on-site energy may be reduced to lower the initial capital costs. Should this occur it may make tie-ins with centralized systems more difficult.
- Setting rates for electricity from central stations will be very much complicated by the presence of these alternative systems.

NOTES AND REFERENCES

Chapter IV

1. This analytical approach was just developed for national energy RD&D assessment. See Associated Universities, Inc., "Reference Energy Systems and Resources Data for Use in the Assessment of Energy Technologies" AET-8, April 1972. See also M. Beller, Ed., "Sourcebook for Energy Assessment" BNL-50483, Brookhaven National Laboratory, December, 1975.
2. About 5×10^{12} Btu of oil was produced in the State in 1975 corresponding to less than 0.2% of consumption. Gas production (6.8×10^{12} Btu) corresponded to about 1% of consumption.
3. Although some natural gas prices have been maintained relatively low (somewhat of an anomaly in the Northeast), policies to normalize interstate and intrastate gas rates promise to eliminate that advantage in the future. Oil prices, under current regulatory policy show little interregional variations. See discussion of energy prices in Chapter III.
4. Executive Office of the President Energy Policy and Planning, "The National Energy Plan" April 29, 1977, U.S. Government Printing Office.

V. THE ROLE OF NEW YORK STATE GOVERNMENT

A. DIFFERENCES BETWEEN NEW YORK STATE AND FEDERAL ROLES

The New York State government can have a major impact upon the production, distribution and use of energy within the state. The impact differs from that which the federal government has upon energy production and use. The following discussion illustrates that NYSERDA performs a series of functions different from other major RD&D supporters and which are particularly important to realizing state energy goals.

The role of the New York State government in energy matters differs from that of the federal government for both fundamental structural as well as practical reasons. For example, New York State cannot change supply costs and availability of basic fuels such as natural gas or oil because it produces very little of these energy sources. New York, in common with other Northeastern states, finds itself particularly vulnerable to unpredictable foreign supply actions because a high proportion of its oil supply comes from foreign countries. As the discussion in Chapter IV indicates, 63 percent of the oil used in New York State comes to the state from foreign sources. The state produces virtually no natural gas, a fuel which accounts for 16 percent of the total energy consumed within the state.

Measured purely in dollar terms there are many organizations which have a more significant RD&D role. The federal government is the most important public agency supporting energy RD&D with expenditures of approximately \$3.5 billion per year. The majority of this will be spent by the newly created Department of Energy (DOE), although other agencies do undertake energy RD&D programs which are large compared with NYSERDA. Private industry spends approximately \$1.5 billion per year on energy RD&D either directly or through industrial research groups such as the Electric Power Research Institute (EPRI). Funded by the electrical utility industry, EPRI spends approximately \$180 million annually for RD&D on the electrical portion of the nation's energy systems. Recently the American Gas Association formed a similar research organization with an estimated budget that is scheduled to grow to about \$100 million per year. In New York, the Empire State Electric Energy Research Corporation (ESEERCO) undertakes the support of energy RD&D

on behalf of the state's electric utility companies. Thus there is a broad range of participants who either support or undertake energy RD&D and a wide range of objectives and goals which these RD&D efforts are meant to serve. A further, more detailed discussion of the RD&D activities of these organizations is to be found in Chapter VI.

In addition to this national RD&D activity, a number of state governments support energy RD&D efforts. California, New Mexico and Ohio all have substantial RD&D programs (see Chapter VI). These efforts are necessitated to some extent by differences between regions but also by a shared need to effect state energy goals through RD&D activities which cannot be achieved by any other RD&D funder or performer.

B. POWERS AND AUTHORITIES OF NEW YORK STATE PUBLIC AND PRIVATE ENERGY-RELATED AGENCIES

Whereas the federal government can, through its broad array of direct and indirect regulatory, taxing and economic powers, sharply influence all aspects of the production, distribution and use of energy, the state government is very much more constrained in its ability to affect the energy system. The state can change only slightly the energy system's reliability (through public investment and regulation), the allocation system for energy (through regulation and taxes), and federal energy policies (via its representation in Congress and its participation in policy making with federal agencies like DOE).

However, New York State government can significantly modify other factors such as:

- the character of state energy demand (through investment, regulation, and conservation incentives);
- the location and operation of major electric energy production and distribution facilities;
- the distribution of electric energy throughout the state;
- the New York public's perception of energy problems;
- the environmental impacts of energy use;

- the distribution of impacts of some federal energy tax policies (via redistributive state taxation practices);
- the priorities of some federal expenditure programs (via analysis, cost-sharing, etc.); and
- local institutional barriers to behavioral and technological change.

In order to realize New York State's potential influence on the energy system, there have been created over many years such commissions and authorities as the Public Service Commission (PSC), the New York State Energy Research and Development Authority (NYSERDA), and the Power Authority of the State of New York (PASNY), in addition to the State Energy Office. Obviously many other agencies have major impact in the energy area. Most notable are the Departments of Environmental Conservation and Transportation.

The Energy Law gives the State Energy Office broad power to assist the governor and the legislature in the development of state energy policies and to implement such policies through the promulgation of statewide, broadly applicable rules and regulations. The Energy Law also provides that the Energy Office has the power to conduct research and contract with the federal government for grants and other funds; Subdivision 17 of Section 5-106 of the Energy Law empowers the Energy Office "to cooperate with and supplement the work of the New York State Energy Research and Development Authority, and undertake studies in energy and energy related areas." The passage of an amendment to NYSERDA's statute in 1977 has altered the precise interpretation of the relationship between the State Energy Office and NYSERDA, by designating a single individual to be the head of both agencies.

Section 5-109 of the State Energy Law, as amended in the 1977 legislative session, requires the Commissioner of the State Energy Office to:

Prepare and distribute at the earliest feasible date an index of functions and responsibilities of state agencies relating to energy and energy resources in sufficient detail to guide the public and serve as a basis for such further steps as may be deemed necessary to assure full coordination without duplication of the energy related activities of such agencies.

An indication of the relationship among NYSERDA, PSC and PASNY and their respective duties, responsibilities, and power can be gained from a review of the statutes and practices of the agencies.

The Power Authority Act (Public Authorities Law §§1000-1015) establishes PASNY as a generator of electric power. A specific relationship between PASNY and NYSERDA is set forth at Subdivision 9 of Section 1005 of the Act which provides that PASNY is authorized and directed:

to cooperate with....and....to enter into contractual agreements with (NYSERDA) in connection with the planning, siting, and development, construction, operation and maintenance of generating facilities of (PASNY) utilizing new energy technologies to the extent such action is consistent with the purposes and powers granted by law to (NYSERDA).

The Public Service Commission has broad regulatory powers with respect to the manufacture, transportation, sale and distribution of gas, electricity, and steam to the producing utilities (among numerous other subjects of regulation). The principal regulatory power of the PSC is, of course, in fixing of utility rates (Section 66(12) of the Public Service Law), but the PSC also has extensive powers to conduct investigations into quality, methods, standards, and efficiency relating to utility operations, the energy supplied by the utilities and methods of distribution of energy. These powers appear to authorize the PSC to conduct a broad range of research programs. However, in recognition of the inherent conflict between the conduct of a research program by the regulatory agency which could eventually be required to rule on a number of issues relating to the results of such research (i.e., Do utility contributions to a specific program constitute an allowable "research" expense on the books of a utility? Has a particular technology reached a level of reliability to justify major modifications to a utility system? etc.) the Safe Energy Act of 1975 (Chapter 864 of the Laws of 1975) amended Section 18-a of the Public Service Law to provide that:

In the case of research, development and demonstration of new energy technologies, the director of the budget may enter into contracts....with (NYSERDA) for the costs of such research, development and demonstration.....

Although this provision basically establishes a research funding mechanism, it may also establish a policy with respect to possible ambiguities in the relationship between NYSERDA and PSC: that is, that research, development and demonstration of new energy technologies are to be conducted not by the PSC but by the Authority.

In addition to the entities described in this section, the Empire State Electric Energy Research Corporation (ESEERCO), a corporation formed by the New York utility companies "to develop a coordinated research effort that involved all aspects of power systems,⁽¹⁾ closely complements the Authority in its research function. ESEERCO "is empowered to sponsor and support research and development programs in the technical and the environmental aspects of generation, transmission, distribution and conservation of energy." The Authority's research program is shaped by a statutory statement of public policy (Section 1850-a of the Public Authorities Law) while "the R&D goals of ESEERCO reflect the goals of the electric systems." Of course, there is a considerable overlap in the goals of the two organizations and the two agencies are in regular contact to avoid duplication of effort and have, in fact, joined in the sponsorship of several research projects. In addition, since the utility company members of ESEERCO also conduct research on an individual basis, "ESEERCO must therefore act as a link between its member systems and,...the Authority...."

C. NYSERDA'S ROLE AND FUNCTION

The New York State government can strongly impact the use of conventional energy sources (particularly electrical energy). Prior to the creation of NYSERDA, New York could only establish preconditions for the development and use of new, alternative or unconventional energy sources such as solar and conservation technologies which could ease the energy situation in the state,

The creation of NYSERDA in 1975 gave the New York State government another tool to assist the government and the private sector in dealing with energy problems. The objectives set forth in NYSERDA's enabling legislation direct the Authority to address "the need for obtaining and maintaining an adequate and continuous supply of safe, dependable and economic power and energy" and to accelerate the "development and use within the state of new energy technologies to supplement energy derived from existing sources" so as to "promote the state's economic growth, protect its environmental values and be in the best interests of the health and welfare of the state's population". NYSERDA's primary objective, then, is "the development and utilization

of safe, dependable, renewable, and economic energy sources and the conservation of energy and energy resources."

The Authority is able to perform a number of functions which can help the state and its citizens deal with the energy problems they face. In general terms, the Authority can:

- Encourage, develop and manage programs of research, development and demonstration of innovative energy producing and using technologies which can relieve the pressures of uncertain energy supplies, environmental costs and constantly rising prices;
- Attract federal energy RD&D funding to New York in projects with direct economic or social benefit to the state, using state co-funding for those collaborative projects which are in the long term energy interests of the state.
- Analyze the economic factors, technological features, and institutional elements of the state's energy system in order to evaluate the potential viability of proposals to solve a wide range of the state's energy problems;
- Disseminate technical information concerning energy RD&D results obtained by USERDA, NYSERDA, and other organizations to assure the widest possible application of relevant energy technologies; and
- Establish and maintain close policy and program relationships with the Department of Energy and other energy-related federal and state agencies.

In addition to these energy roles, NYSERDA like any other state government entity has several broader roles which derive from its inherent responsibility to promote, in every way possible, the health, well being, and prosperity of the State of New York. These broader roles involve taking actions which will add to or insure current employment, increase commerce, attract federal grants, and increase federal revenue sharing. In the energy area where the federal government is spending billions annually there may be many opportunities.

More specifically, the Authority can and does serve in the energy roles and performs the functions outlined below:

- Act as a catalyst and manager by bringing together public and private groups to undertake energy RD&D.
- Act as an energy RD&D supporter and project manager for new energy technologies.
- Act as a source of information and analysis for the making of energy policy decision on state, regional or national levels.
- Act as the developer of new technologies which can assist the state or its citizens.
- Act as a financing source for energy or environmental projects which can benefit the state.

The following brief descriptions of current NYSERDA projects exemplify these roles and functions in an especially clear manner:

- Fuel Cell Demonstration--
The Authority, in cooperation with Con Edison, ESEERCO, Northeast Utilities Corporation and Niagara Mohawk Power Corporation has been successful in attracting this major federal demonstration project to New York State. The demonstration of this new technology promises: a return to the decentralized power plant concept; elimination of transmission and distribution losses owing to the capability of siting near or within the high load centers; substantial reduction of environmental impact due to atmospheric and thermal pollution associated with conventional power generation systems. The project costs are now estimated at \$8 million, equally cost-shared between NYERDA and the New York participants.
- Westchester Solar Hot Water Demonstration--
The Authority, in cooperation with Con Edison, is conducting this demonstration project in order to determine the potential impact of solar hot water systems market penetration within a gas/electric utility service area. Effects on load distribution, permitting possible deferral of new power plant requirements, will be evaluated and system cost/performance of solar hot water systems will be characterized.

- Solar Heating and Cooling Demonstrations--

The Authority, in cooperation with various representatives of the commercial and public sector, has been successful in attracting several USERDA demonstration projects to New York State. Authority participation is based upon the desire to promote solar technology applications especially in those instances where successful demonstration offers the opportunity for substantial application throughout the state. The ability to cost share with the public and private sector is a key element in attracting large scale solar projects and the federal funding that accompanies such awards. The Authority has been directly responsible for obtaining \$470,000 of USERDA support of the solar heating demonstration at Ballston Spa Central School District. The total worth of the project is in excess of \$1 million including a \$200,000 commitment from NYSERDA. Further, the Authority is presently negotiating with USERDA and representatives from the private sector giving consideration to additional funding support to ensure the timely installation of reliable solar systems selected for demonstration in New York. Among these are installations at the Carey Arboretum in Millbrook, New York, the New Rochelle Public Library and commercial installations in Bohemia, New York and Troy, New York.

- Add-On Devices/Gas Fired Systems--

The Authority, in cooperation with the New York Gas Association and the Public Service Commission, is addressing the safety issues associated with the installation of energy conserving devices to gas-fired heating plants. The absence of safety and installation standards has forestalled the application of such devices, to date. The project permits laboratory evaluations of various systems and their associated installation procedures, establishes safety and installation standards and provides for field testing of selected systems as installed throughout the gas utility service areas in New York State. The New York Gas Association will contribute \$150,000 (to a project valued at approximately \$300,000) directed toward the field test aspects of the project.

- HUD Solar Hot Water Grant--

The Authority has contracted for engineering services to provide technical support to ten states participating in this federal program. Nine thousand solar domestic hot water systems will be installed at federal expense in New England and the Middle Atlantic States. The consulting services include system analysis, system qualification and certification to ensure a high level of performance as well as consumer protection. The installed value of these systems is estimated at approximately \$25 million. The Authority is acting as coordinator and contract manager between the states and the Polytechnic Institute of New York.

- Solar Heliostats--

The Authority funds and manages the development efforts associated with low cost heliostats. These systems are sun-seeking focusing solar collectors that permit the generation of substantially higher temperatures than other collectors. High temperature collectors are suited to the requirements associated with industrial needs for process heat and/or steam supplements to commercial heating and cooling systems. The Authority is now in the midst of negotiations to further advance the design of the "Rogers Focusing Solar Collector" with federal funds. The total value of these efforts to date is approximately \$405,000, including \$89,000 applied to the "Rogers" system and \$115,000 contributed toward R&D at Brookhaven National Laboratories. Future funding of the "Rogers" system will derive primarily from federal sources.

All of the activities described above must be carried out in the context of the very large federal, private and quasi-public current energy RD&D activities. NYSERDA's function is unique. NYSERDA serves as a leader, advocate and catalyst in order to shape the RD&D programs, priorities and projects of other organizations. Furthermore, NYSERDA acts as a "balance wheel" by supporting energy RD&D which can be of great importance to New York State but which may be of lower priority to other potential funding sources.

NOTES

Chapter V

1. All quotations with respect to ESEERCO are from the "Report of the ESEERCO R&D Goals Task Force to the Board of Directors of ESEERCO", July, 1976.

VI. ENERGY RD&D PROGRAMS

A. INTRODUCTION

New York State's research, development and demonstration (RD&D) program must be arrived at in the context of the RD&D programs being carried out by the Federal Government, the private sector, utilities and other states.

The purpose of this chapter is to present an overview of the energy RD&D activities currently being funded by those other sources. It is meant to provide a detailed enough view of RD&D activities to allow identification of major complementarities and similarities between NYSERDA's potential programs and those of RD&D performers elsewhere. As a consequence, this overview focuses in more detail on areas determined to be of special interest in setting NYSERDA RD&D priorities as described here and in Chapter VII.⁽¹⁾

The remainder of this chapter is organized into the following four sections:

- B. Federal RD&D
- C. Utility RD&D
- D. Private Sector RD&D
- E. Regional/State RD&D (Including NYSERDA)

In each of the categories of RD&D, there is information (where available) regarding current levels of funding, recent time trends in funding, projected funding, program objectives, and program milestones.

One of the starkest contrasts that comes out of compiling such a comprehensive overview is the range in project detail available: the Federal Government's richly detailed description of planned efforts contrasts with the private sector program descriptions with very little detail. The analysis in this chapter, necessarily reliant on existing information, has not been able to remedy this imbalance.

B. FEDERAL RD&D PROGRAMS

1. The Energy Research and Development Administration

The Energy Research and Development Administration (ERDA) was established in January 1975 to be the major federal agency for the conduct of energy research and development. The programs of ERDA are now contained within the Department of Energy. In addition to being the principal RD&D sponsor,

ERDA also had the responsibility to coordinate the entire federal energy RD&D effort through interagency agreements, and to provide national leadership through the development of a National Energy RD&D Plan.

In fiscal year (FY) 1977 ERDA provided 85 percent of the total federal funding⁽²⁾ for energy RD&D. Table VI-1 shows the ERDA energy RD&D budget by major program for the fiscal years 1975, 1976, and 1977. These figures are shown in percentage terms in Table VI-2. The major programs in energy RD&D and their emphasis are outlined below:

- Fossil Energy Development

Emphasis in these programs lies in substitution of domestic coal resources for increasingly scarce supplies of oil and natural gas; increased efficiency of the use of fossil fuels through advanced power conversion systems, and increased oil and natural gas recovery in the United States.

- Solar Energy Development

Goals in this area include increased development and demonstration of solar energy technology applications to provide process heat, space heat, electricity and fuels (from biomass).

- Geothermal Energy Development

The programs for geothermal RD&D are aimed at the utilization of geothermal resources through conduct of more extensive resource assessment, development of more advanced engineering techniques, and construction of pilot plants. There is a provision for \$50 million in FY 1977 for loan guarantees to enable industry to proceed with geothermal production demonstration projects.

- Conservation RD&D

The conservation RD&D efforts are oriented toward developing technologies with increased efficiency, providing additional options to substitute other fuels for oil and gas, and improving methods of electricity distribution and storage.

- Fission

The goal of the fission program is to develop a nuclear reactor system which generates more fuel than it uses thereby greatly expanding the resource base of nuclear

Table VI-1
ERDA Energy Related Budget FY 75-76-77
(Authority in \$ Millions)

	<u>FY 75</u>	<u>FY 76</u>	<u>FY 77</u>
<u>Energy RD&D Programs</u>			
Nuclear Fuel Cycle and Safeguards	\$ 118	\$ 173	\$ 347
Conservation	36	75	120
Geothermal	28	31	100**
Fusion	183	250	392
Fission	567	602	823
Solar	42	115	160
Fossil	335	398	477
Environmental Control Technologies	<u>8</u>	<u>13</u>	<u>16</u>
Subtotal	\$1,317	\$1,657	\$2,435
 <u>Supporting Research</u>			
Basic Energy Sciences	191	210	227
Environmental Research	<u>171</u>	<u>193</u>	<u>203</u>
Subtotal	362	403	430
 TOTAL ERDA ENERGY RD&D	<u>\$1,679</u>	<u>\$2,060</u>	<u>\$2,865</u>

*1976 dollars do not include transition quarter.

**Includes \$50 million for Geothermal Loan Guarantee Program.

Source: Reference (4).

Table VI-2

Distribution of ERDA Energy RD&D Budget
(Authority in %)

	<u>FY 75</u>	<u>FY 76*</u>	<u>FY 77</u>	<u>FY 76 - FY 77 Percent Change</u>
<u>Energy RD&D Program</u>				
Nuclear Fuel Cycle and Safeguards	7	8	12	101
Conservation	2	4	4	60
Geothermal**	2	2	3	223
Fusion	11	12	14	57
Fission	34	29	29	37
Solar	2.5	6	5	39
Fossil	20	19	17	20
Environmental Control Technology	.5	1	1	23
<u>Supporting Research</u>				
Basic Energy Sciences	11	10	8	8
Environmental Research	<u>10</u>	<u>9</u>	<u>7</u>	5
	100.0	100	100	

* 1976 figures do not include transition quarter figures.

** The sharp increase in the Geothermal program is due to the addition in FY 1977 of \$50 million for the Loan Guarantee program.

energy. The program consists of five major program activities: the Liquid Metal Fast Breeder Reactor (LMFBR), Water-Cooled Breeder Reactor, Gas-Cooled Breeder Reactor, Light Water Reactor Technology and Reactor Safety Facilities. The main emphasis is the LMFBR Program including government/industry cooperative management. The planned LMFBR demonstration reactor is now under intensive review and likely to be delayed or cancelled.

- Nuclear Fuel Cycle and Safeguards

A major goal of these programs is to improve the use of current commercial nuclear reactors by developing more acceptable commercial waste management procedures, nuclear fuel reprocessing techniques, and safeguards for preventing theft of nuclear materials.

- Fusion

Research in this area is aimed at determining the scientific feasibility and demonstrating the technical and commercial feasibility of obtaining nearly unlimited electric power for the long-term (beyond 2000) from the controlled thermonuclear fusion reaction.

- Environmental Control Technology

Efforts in this area are primarily directed toward investigating technologies for the control of emissions and discharges and ultimate waste disposal.

- Supporting Energy RD&D

Programs include assessment of biomedical and environmental effects of energy sources and also solutions of fundamental scientific and engineering problems.

Tables VI-1 and VI-2 lead to several broad conclusions: In recent years, the federal energy RD&D budget has grown very rapidly in every major program area. The 1977 budget represents a 39 percent increase in budget authority over the previous year. As seen from Table VI-1, conservation received a substantial increase in funding over the past few years (a 60 percent increase in budget authority from FY 1976 to FY 1977). The main thrust of this increase is directed toward development and demonstration of energy efficient technologies for industry, buildings, transportation and electric energy systems. The solar and geothermal programs also have increased substantially in importance (39 percent increase in solar and a 223 percent increase in geothermal.) The other major increase deals with the nuclear fuel cycle and safeguards (a 101

percent increase in budget authority from FY 1976 to FY 1977). Programs in this area include management of nuclear wastes and nuclear fuel reprocessing and safeguarding nuclear materials against theft.

The distribution of funding among programs reflects historical accident (changes in disparate programs prior to their consolidation in ERDA), the stage of program development and the frequently disparate views of the large number of budgetary decisionmakers (ERDA management, OMB, eleven congressional subcommittees). For these reasons there is no simple explanation for ERDA funding patterns. In order to assist in developing priorities ERDA has put significant resources into developing program planning, budgeting and monitoring systems in the context of developing a National Plan for Energy RD&D. In their most recently published plan ERDA lists eight national energy technology goals⁽⁴⁾ it plans to pursue:

- I. Expand the domestic supply and economically recoverable energy producing raw materials.
- II. Increase the use of essentially inexhaustible domestic energy resources.
- III. Efficiently transform fuel resources into more desirable forms.
- IV. Increase the efficiency and reliability of the process used in energy conversion and delivery systems.
- VV. Transform consumption patterns to improve energy use.
- VI. Increase end-use efficiency.
- VII. Protect and enhance the general health, safety, welfare and environment related to energy.
- VIII. Perform basic and supporting research and technical services related to energy.

The ERDA strategy for attaining these goals covers all time periods:⁽⁵⁾

NEAR TERM
(Now to 1985 and beyond)

Increase the efficiency of energy used in all sectors of the economy and extract more useable energy from waste materials.

Preserve and expand major domestic energy systems: coal, light water reactors, and gas and oil from new sources and by enhanced recovery techniques.

MID TERM
(1985 to 2000 and beyond)

Accelerate the development of new processes for producing synthetic fuels from coal and extracting oil from shale.

Increase the use of fuel forms such as geothermal energy, solar energy for heating and cooling, and extraction of more usable energy from waste heat.

LONG TERM
(Beyond 2000)

Permit the use of the essentially inexhaustible resources: nuclear breeders; fusion; and solar electric energy from a variety of options including wind power, thermal and photovoltaic approaches, and ocean thermal gradients.

Provide the technologies to use the new sources of energy, which may be distributed as electricity, hydrogen, or other forms throughout all sectors of the economy.

On the basis of this strategy ERDA has identified seven high priority technologies for the near- and mid-term: ⁽⁶⁾

<u>Technology</u>	<u>Total Federal FY 1977 Budget (Authority in \$ Millions)</u>
Conservation	121
Light Water Reactors	82
Enhanced Oil and Gas Recovery	35
Direct Coal Utilization	52
Synthetic Fuels (including shale, biomass)	180
Geothermal	106
Solar Heating and Cooling	45

The long-term high priority programs which involve inexhaustible energy sources include: ⁽⁷⁾

<u>Technology</u>	<u>Total Federal FY 1977 Budget (Authority in \$ Millions)</u>
Breeder Reactors	750
Fusion Electric	392
Solar Electric	76

Table VI-3 indicates in more detail by generic technology or research area the 1975, 1976 and 1977 funding for ERDA's (as well as total federal) RD&D budget. This detailed table and the above summary make it clear that

Table VI-3
Federal Energy RD&D Budget
(Authority in \$ Millions)

<u>Technology</u>	<u>FY 75</u>	<u>FY 76*</u>	<u>FY 77</u>
<u>FOSSIL ENERGY</u>			
<u>Coal</u>			
Liquefaction	94.7	89.9	73.9
High-Btu Gasification	59.8	53.4	45.2
Low-Btu Gasification	50.0	24.6	33.1
Advanced Power Systems	4.1	10.0	22.5
Direct Combustion	35.9	38.1	52.4
Advanced Research and Supporting Technology	23.3	35.4	37.1
Demonstration Plants	13.0	51.9	107.2
Magnetohydrodynamics	14.3	29.6	37.6
<u>Petroleum and Natural Gas</u>			
Gas and Oil Extraction	26.4	41.5	35.2
Supporting Research	1.8	1.8	1.8
<u>In-Situ Technology</u>			
Oil Shale	3.8	14.0	23.4**
In-Situ Coal Gasification	6.6	6.1	8.2
Supporting Research (In-Situ)	1.0	1.3	1.4
Extraction Technologies	52.2**	61.8**	65.6**
Resource Appraisal	17.4**	18.2**	17.2**
Federal Subtotal	404.3	477.6	561.8
ERDA Subtotal	334.7	397.6	477.1
<u>SOLAR ENERGY</u>			
<u>Thermal Applications</u>			
Solar Heating & Cooling of Buildings	13.1	35.1	45.3
Agricultural & Industrial Process Heat	0.7	1.0	1.5
<u>Technology Support and Utilization</u>			
Environmental & Resource Assessments	0.5	4.8	3.9
Solar Energy Research Institute	0.0	2.2	1.5
Information Dissemina- tion and Commercialization	0.7	2.2	1.0
<u>Solar Energy Applications</u>			
Solar Thermal Energy	13.2	19.3	43.4
Photovoltaic Energy	5.2	22.4	32.8
Wind Energy	5.7	15.1	17.1
Ocean Thermal Energy	1.9	8.1	9.2
Fuels from Biomass	0.9	4.5	4.3
Federal Subtotal	41.9	114.7	160.0
ERDA Subtotal	41.9	114.7	160.0

*Does not include funds for FY 1976 Transition Quarter.

**Projects with other than ERDA funding (i.e., other federal agencies).

Table VI-3 (continued)
Federal Energy RD&D Budget
(Authority in \$ Millions)

<u>Technology</u>	<u>FY 75</u>	<u>FY 76*</u>	<u>FY 77</u>
<u>GEOTHERMAL ENERGY</u>			
Environmental Control & Institutional Studies	0.5	3.9	4.8
Resource Exploration & Assessment	13.2**	15.3**	15.5**
Hydrothermal Technology Applications	6.6	5.8	12.9
Demonstration Projects [‡]	--	--	--
Advanced Technology Applications	4.8	7.1	10.6
Engineering R&D	13.8**	11.3**	12.2**
Geothermal Resources Development	0	<u>0</u>	<u>50.0</u> ^{##}
Federal Subtotal	38.9	43.4	106.0
ERDA Subtotal	20.0	31.2	100.1
<u>CONSERVATION</u>			
<u>Electric Energy Systems and Storage</u>			
Electrical Energy Storage	20.3**	24.9**	25.4**
Energy Storage Systems	7.4	16.3	22.3
<u>Technologies to Improve Efficiency and End Use Conservation</u>			
Industry Conservation	0	4.2	12.4
Buildings Conservation	2.4	12.5	21.6
Transportation Energy Conservation	8.1	12.9	23.7
Energy Conversion	<u>2.4**</u>	<u>9.5**</u>	<u>15.8**</u>
Federal Subtotal	40.6	80.3	121.2
ERDA Subtotal	36.5	74.6	120.0
<u>FUSION POWER</u>			
<u>Magnetic Fusion</u>			
Confinement Systems	51.7	76.9	88.8
Reactor Projects	0	17.3	91.8
Development Technology	33.0	41.5	67.5
Applied Plasma Physics	33.5	31.0	43.0
<u>Laser Fusion</u>	<u>65.1</u>	<u>83.6</u>	<u>101.0</u>
Federal Subtotal	183.3	250.3	392.1
ERDA Subtotal	183.3	250.3	392.1

*Does not include funds for FY 1976 Transition Quarter.

**Projects with other than ERDA funding.

[‡]Studies and projects leading to actual demonstration plants are not funded under this category.

^{##}Includes \$50 million for Geothermal Loan Guarantee Program.

Table VI-3 (continued)

Federal Energy RD&D Budget
(Authority in \$ Millions)

<u>Technology</u>	<u>FY 75</u>	<u>FY 76*</u>	<u>FY 77</u>
<u>NUCLEAR FUEL CYCLE R&D AND SAFEGUARDS</u>			
Uranium Resource Assessments	12.3**	24.5**	42.5**
Support of Nuclear Fuel Cycle	17.9	39.3**	69.5**
Waste Management (Commercial)	11.0	14.8**	82.3**
Nuclear Materials Security and Safeguards	11.7**	21.3**	37.6**
Uranium Enrichment Process Development	47.1	54.8	95.9
Advanced Isotope Separation Technology	<u>24.0</u>	<u>32.6</u>	<u>43.8</u>
Federal Subtotal	124.0	187.3	371.6
ERDA Subtotal	117.4	172.9	346.6
<u>FISSION POWER</u>			
<u>Liquid Metal Fast Breeder Reactor</u>			
LMFBR Base Program R&D	356.8	313.3	343.3
Clinch River Breeder Reactor Plant Project	62.8	107.0	237.6
LMFBR Reactor Safety	47.4**	55.0**	70.2**
Advanced Fuels	17.8	15.1	16.2
<u>Water Cooled Breeder Reactor</u>	36.3	42.1	48.8
<u>Gas-Cooled Reactors</u>			
Thermal Reactors (HTGR & VHTR)	14.2	15.3	16.2
Fast Breeder Reactor (GCFR)	6.8	6.3	8.1
Gas Cooled Reactor Safety	6.5**	8.1**	9.3**
<u>Light Water Technology</u>	51.4**	73.4**	82.1**
<u>Supporting Activities</u>	13.2	17.4	20.1
<u>Reactor Safety Facilities</u>	22.3	22.3	33.3
Other Capital Equipment [‡]	4.3	24.4	27.7
Molten Salt Breeder Reactor ^{‡‡}	<u>7.2</u>	<u>3.6</u>	<u>0</u>
Federal Subtotal	647.0	703.3	912.9
ERDA Subtotal	567.1	602.3	827.4

*Does not include funds for FY 1976 Transition Quarter.

**Projects with other than ERDA funding.

[‡]These items are not associated with any specific technology within the Fission Program.

^{‡‡}This program is being terminated, and no funds have been requested for FY 1977.

Table VI-3 (continued)
Federal Energy RD&D Budget
(Authority in \$ Millions)

<u>Technology</u>	<u>FY 75</u>	<u>FY 76*</u>	<u>FY 77</u>
<u>ENVIRONMENTAL CONTROL TECHNOLOGY</u>			
Environmental Control Technology	89.1**	70.3**	72.0**
<u>BIOMEDICAL AND ENVIRONMENTAL RESEARCH</u>			
Health Studies	81.4**	85.0**	83.6**
Biological Studies	46.5**	50.9**	52.1**
Environmental Studies	102.9**	132.6**	141.4**
Physical & Technological Studies	29.6**	31.2**	31.3**
Assessments	<u>14.4**</u>	<u>18.9**</u>	<u>26.4**</u>
Federal Subtotal	274.8	318.6	334.8
ERDA Subtotal	167.5	188.0	199.3
<u>BASIC ENERGY SCIENCES</u>			
Materials Sciences	69.6**	76.0	104.3
Molecular, Mathematical and Geo-sciences	103.0**	118.2	127.7
Nuclear Sciences	<u>102.0**</u>	<u>110.0</u>	<u>95.8</u>
Federal Subtotal	274.6	304.2	327.8
ERDA Subtotal	149.4	163.1	173.7
<u>ENERGY-RELATED SUPPORTING ACTIVITIES</u>			
<u>Information Services</u>			
Public Awareness	2.6	2.8	3.2
Technical Information Services	6.3	7.6	8.6
<u>General Systems Studies</u>	6.4**	10.7**	11.0
<u>General Technology Transfers</u>	4.1**	6.0**	2.0
<u>Manpower</u>			
Manpower Development	5.3**	4.3**	4.9**
Education and Training	<u>3.2</u>	<u>4.1</u>	<u>2.8</u>
Federal Subtotal	27.9	35.5	32.5
ERDA Subtotal	14.9	25.5	28.3

*Does not include funds for FY 1976 Transition Quarter.

**Projects with other than ERDA funding.

ERDA is currently placing primary budgetary emphasis on long-term electricity generating technology; there are about twice as many dollars in the FY 1977 budget for long-term as for the near-and mid-term. Whether or not this emphasis will remain as federal programs proceed is hard to know. The Congressional Budget Office (CBO) has assembled some of the available 5-year projections (Figure VI-1) and the range is enormous--they indicate a possible doubling or tripling of federal energy RD&D expenditures. In assessing such projections one is in a situation a little like a horse race bettor attempting to predict the race's outcome by the horses' positions 100 yards out of the gate.

2. The Total Federal Picture

ERDA (now DOE) plays a leading role in federal energy RD&D, it does not play the only role. Other federal agencies which play a secondary role in energy RD&D are the Department of Interior (DOI), the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). DOI mainly provides funds for advanced coal mining RD&D and energy resource assessments. EPA concentrates its efforts for energy RD&D in environmental control technologies. The NRC provides RD&D support mainly for nuclear regulation and safeguarding. NASA receives funding (primarily indirectly through ERDA) in the solar energy area--for solar heating and cooling of buildings, photovoltaic and wind energy, while NSF performs basic research in many areas, particularly dealing with general systems studies. These five departments along with ERDA account for 98-99 percent of total federal RD&D. Tables VI-4 show the total federal energy RD&D funding (budget authority) levels for FY 1975, 1976 and 1977 for these secondary agencies.

In Appendix A we present a more detailed description of federal RD&D programs in 21 areas which are of particular concern to New York State.

3. Regional Federal RD&D Efforts

ERDA's RD&D efforts are conducted in locations across the nation but most are targeted toward national as opposed to regional problems. ERDA is not organized on a regional basis, although it does have a large field organization with operations offices, laboratories, energy research centers, production facilities, and various other types of offices.

*The CBO uses a definition of federal energy research which differs from that used in this analysis, primarily by ignoring most non-ERDA supporting R&D programs (see Table VI-4).

Figure VI-1. Alternative energy research budget paths, 1977-1986 Budget Authority (fiscal years, millions of 1977 dollars).

Table VI-4

Federal Energy R&D
(Authority in \$ Millions)

	<u>FY 75</u>	<u>FY 76*</u>	<u>FY 77</u>
<u>Direct Energy R&D</u>			
ERDA	\$1,317.0	\$1,657.0	\$2,435.0
DOI	89.9	104.0	98.3
EPA	80.8	56.8	55.4
NRC	58.9	87.5	104.0
NASA	<u>0.8</u>	<u>1.7</u>	<u>-0-</u>
Subtotal	1,547.4	1,907.0	2,692.7
<u>Supporting R&D</u>			
ERDA	362.0	403.0	430.0
DOI	33.2	59.0	66.8
EPA	53.2	43.2	41.6
NRC	2.3	9.6	5.3
NSF	<u>103.2</u>	<u>114.6</u>	<u>123.4</u>
Subtotal	553.9	629.4	667.1
TOTAL FEDERAL ENERGY R&D	<u>\$2,101.3</u>	<u>\$2,536.4</u>	<u>\$3,359.8</u>

*Funds for FY Transition Quarter are not included.

Source: Reference (4).

ERDA: Energy Research and Development Administration

DOI: Department of the Interior

EPA: Environmental Protection Agency

NRC: Nuclear Regulatory Commission

NASA: National Aeronautics and Space Administration

NSF: National Science Foundation

The primary effort within ERDA to incorporate the regional needs consists of technical representatives in eight of ERDA's national laboratories attempting to match state needs with technology available at the laboratories. There is also a regional studies program being conducted for evaluation of socio-economic, human health, environmental and institutional impacts related to energy development. Six ERDA laboratories are involved in this program coordinating it on a regional basis with direct contact with state governments. The Brookhaven National Laboratory is responsible for this program in the Northeast.

4. Impact of the Department of Energy (DOE) on Federal RD&D Programs

The Department of Energy has recently been formed as a merger of the Federal Energy Administration, ERDA and the Federal Power Commission as well as of pieces of various other federal agencies. (See Figure VI-2) The new Department has over 19,000 employees and an annually authorized budget in excess of 10 billion dollars. The DOE was formed to minimize duplication, overlapping jurisdiction, and conflicting mandates, particularly among regulatory and resource development programs.

The formation of DOE is likely to have very little immediate effect on the federal energy RD&D effort since ERDA's programs will come into the new agency intact. The only structural change is to incorporate the coal mining programs from Interior. The merger of RD&D and policy elements of the National Energy Plan proposed by President Carter could, in the longer run, alter the direction of energy RD&D but this is an influence which is highly uncertain at the present time.

C. UTILITY RD&D PROGRAMS

Traditionally electric utilities have not carried out very much RD&D. They basically bought their RD&D already embodied in the equipment they bought from Westinghouse, General Electric and others. But with increased use of nuclear power requiring customizing each application and with regulatory demands for utilities to embrace technologies from non-traditional suppliers (e.g., pollution control equipment manufacturers), the utilities have significantly expanded their RD&D activities over the last 10 years.

Departments to be merged totally:

Federal Power Commission
Energy Research and Development Administration
Federal Energy Administration

Activities to be transferred to DOE:

<u>Activity</u>	<u>Current Department</u>
Energy Mineral Leasing	Interior
Emergency Power and Resource Activities	Interior
Power Marketing	Interior
Fuels Data	Interior
Coal Mining R&D	Interior
Energy Production on Public Lands	Interior
Thermal Efficiency Standards	Housing and Urban Development
Rural Electrification Administration Loans	Agriculture
Fuel Efficiency Standards	Transportation
Oil Pipeline Regulation	Interstate Commerce Commission
Voluntary Industrial Energy Conservation	Commerce
Petroleum and Shale Reserves	Defense

Figure VI-2. Composition of Department of Energy.

1. National Utility RD&D

Lacking a comprehensive survey of utility RD&D activities the best available overview is provided by a voluntary project reporting system which the Electric Power Research Institute (EPRI) introduced in 1976.⁽¹¹⁾ The results of an analysis of utility RD&D expenditures based on that source are contained in Table VI-6. Generally these data indicate that utilities are putting their primary focus on problems which are their relatively unique province such as transmission and distribution, in research on relatively conventional technologies (fossil power generation) or the light water reactor (which is quickly becoming conventional), and in major problem areas such as air pollution. Overall the amount of reported RD&D is substantial, even though the total contains some public cost-shared funds from federal and state governments. Although interesting and informative, these data will not support an in-depth examination. For that reason the remainder of this section deals with two well-coordinated and substantial utility efforts in the form of EPRI and ESEERCO RD&D programs.

2. The Electric Power Research Institute

The Electric Power Research Institute (EPRI) was created in 1972 to help coordinate and consolidate utility RD&D programs and capabilities. It now has over 500 members who aid in research project selection and contribute to the annual budget in proportion to the amount of power they produce/sell. In 1977 EPRI is expected to expend between \$150 and \$180 million. Generally EPRI is attempting to allocate about 90 percent of its budget to near- and mid-term RD&D. Tables VI-7 and VI-8 indicate the type of 5-year growth they are planning and the detailed allocation for FY 1977. Appendix A contains a more complete description of these programs. Both tables reiterate the very strong conventional fossil-conventional nuclear-environment focus of EPRI programs.

3. Empire State Electric Energy Research Corporation (ESEERCO) and New York State Utility RD&D

Following the national trend, in 1973 the New York utility systems decided to coordinate research efforts in all phases of electrical energy through creation of ESEERCO. The organization has three major functions: (1) directly funding RD&D activities out of a \$6.5 million budget in 1977 developed from New York State utility contributions; (2) assisting in plan-

Table VI-5

Federal Energy RD&D Budget
(Authority in \$ Millions)

	<u>FY 75</u>	<u>FY 76*</u>	<u>FY 77</u>
Energy Technology Programs			
Fossil	404.3	477.6	561.8
Solar	41.9	114.7	160.0
Geothermal	38.9	43.4	56.0
Conservation	40.6	80.3	121.2
Fusion	183.3	250.3	392.1
Nuclear Fuel Cycle R&D and Safeguards	124.0	187.3	371.6
Fission	624.7	681.0	921.9
Environmental Control Technology	89.1	70.3	72.0
Supporting Technology Programs			
Environmental Research	274.8	318.6	334.8
Basic Energy Sciences	274.6	304.2	327.8
Energy-Related Supporting Activities	<u>27.9</u>	<u>35.5</u>	<u>32.5</u>
Total Federal	2124.1	2563.1	3351.7
Total ERDA**	(1679)	(2060)	(2865)

* Funds for FY 1976 Transition Quarter are not included.

** From Table VI-1.

Source: Reference (10).

Table VI-6

Nationwide Utility RD&D Analysis

<u>Selected RD&D Program</u>	<u>Reported 1975-1976 Funding</u>
General R&D Support	\$ 27,123,683
Fossil Fuels	60,242,880
Advanced Power Systems	19,297,751
Transmission	24,460,445
Distribution	5,244,811
Stations & Substations	2,817,845
Environmental Assessment	8,670,927

Source: Reference (11).

Table VI-7

Electric Power Research Institute
Summary of Proposed 5-Year Program Plan
(\$ Millions)*

Program	1976	1977	1978	1979	1980	1981	Total
(1)							
Fossil fuels and Advanced Power Systems	58.6	83.7	103.9	133.2	149.2	164.5	664.5
Nuclear Power (2)	34.3	62.4	84.5	98.2	109.6	123.1	477.8
Electrical Systems (3) (Transmission & Distribution)	24.9	38.2	45.8	54.7	60.2	66.5	265.4
Energy Analysis (4)	11.2	19.7	23.8	28.9	35.0	41.9	149.3
Total Proposed Plan (May 1976 Guidelines)	129.0	204.0	268.0	315.0	354.0	396.0	1,537.0 **
Future Program Adjustments	--	(24.0)	(58.0)	(72.0)	(51.0)	(23.0)	(228.0)***
Revised Funding Guidelines (November 4, 1976)	129.0	180.0	210.0	243.0	303.0	373.0	1,309.0 ****

* Funding entries represent planned contractor expenditures stated in current dollars including an adjustment for inflation.

** The total program plan represents the proposed Institute funding as defined by the May 1976 Guidelines. Revised funding guidelines adopted in November 1976 will require an adjustment in the total proposed program during the 1977 planning cycle.

*** Future program adjustments required to satisfy the revised funding guidelines adopted November 4, 1976.

**** Revised funding guidelines adopted by the EPRI Board of Directors on November 4, 1976.

(1) Fossil Fuels and Advanced Systems

Technologies in this division include:

- Gasification
- Liquefaction
- Direct Utilization
- Environmental Control and Combustion
- Supporting Research
- Fluidized Combustion and Coal Cleaning
- Fossil Plant Performance and Reliability
- Electrochemical Energy Conversion and Storage
- Thermal-Mechanical Energy Conversion and Storage
- Fuel Cells
- Fusion
- Solar Energy
- Geothermal Energy

(2) Nuclear Power

Technologies in this division include:

- Water Reactor System Reliability
- Reliability, Availability and Economics
- Fuel, Waste, and Environment
- Developing Applications and Technology

(3) Electrical Systems (Transmission and Distribution)

Technologies in this area include:

- AC Overhead Transmission
- Underground Transmission
- DC Transmission
- System Planning, Security, and Control
- Distribution
- Rotating Electrical Machinery

(4) Energy Analysis and Environment

Technologies include:

- Environmental Assessment
- Energy Demand and Conservation
- Energy Supply
- Energy Systems Modeling
- Electric Utility Rate Design Study

Source: Reference (12).

Table VI-8

EPRI Program Funding for FY 1977

FOSSIL FUEL and ADVANCED SYSTEMS DIVISION

Fossil Fuel Power Plants Department

Fluidized Combustion and Coal Cleaning	\$ 4,000,000
Air Quality Control	9,500,000
Water Quality Control and Heat Rejection	1,500,000
Fossil Plant Performance and Reliability	<u>2,000,000</u>
	\$ 17,000,000

Advanced Fossil Power Systems Department

Clean Gaseous Fuels	\$ 9,500,000
Clean Liquid and Solid Fuels	10,600,000
Power Generation	5,100,000
Power Plant Requirements and Analysis	<u>700,000</u>
	\$ 25,900,000

New Energy Resources Department

Fusion	\$ 4,500,000
Solar	3,800,000
Geothermal	<u>2,000,000</u>
	\$ 10,300,000

Energy Management and Utilization Technology Department

Energy Storage	\$ 4,650,000
Fuel Cells and Chemical Energy Conversion	8,300,000
Energy Utilization and Conservation	<u>850,000</u>
	\$ 13,800,000
	\$ 67,000,000

NUCLEAR POWER DIVISION

Water Reactor Systems Technology	\$ 12,900,000
Reliability, Availability, and Economics	12,200,000
Fuels, Waste, and Environment	7,800,000
Developing Applications and Technology	<u>8,600,000</u>
	\$ 41,500,000

ELECTRICAL SYSTEMS DIVISION

AC Transmission	\$ 6,330,000
Underground Transmission	5,960,000
DC Transmission	7,790,000
System Planning, Security, and Control	1,770,000
Distribution	5,150,000
Rotating Electrical Machinery	<u>1,100,000</u>
	\$ 28,100,000

ENERGY ANALYSIS and ENVIRONMENT DIVISION

Environmental Assessment	\$ 7,900,000
Demand and Conservation	1,500,000
Supply	2,100,000
Systems	1,200,000
Electric Utility Rate Design Study	<u>700,000</u>
	\$ 13,400,000

	\$150,000,000
1976 Carryover of Unexpended Funds	<u>30,000,000</u>

Total	<u>\$180,000,000</u>
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Source: Reference (13).

ning and coordinating state utility RD&D programs; and (3) providing an interface between New York State electric utilities and other RD&D organizations (e.g., USERDA, NYSERDA). ESEERCO, like EPRI, chooses its projects with the active involvement of the scientific staffs of its member utilities. Energy RD&D goals are listed in Table VI-9

There are eight member systems in ESEERCO who together spend about \$53 million per year on energy RD&D activities. About half of these funds are spent on internally managed RD&D projects, one quarter is a contribution to EPRI, and the remaining quarter is split among ESEERCO, ERDA's LMFBR demonstration, and NYSERDA. As indicated in Table VI-10 these funds support a wide variety of RD&D efforts with an emphasis (over 60 percent of total funds) on environment, fossil fuels, and nuclear power. Table VI-11 lists the titles of the projects directly managed by ESEERCO and its member utilities in these three areas (a more complete listing is available in Reference (1)).

D. PRIVATE SECTOR ENERGY RD&D

It is very difficult to determine the details of private sector energy RD&D. Most companies do not report the amount of energy RD&D they are performing, and even if they do report it, it is usually a very rough representation. Private corporations are reluctant to reveal information about their RD&D activities in order to protect the competitive advantages such research affords them.

The National Science Foundation has done a study of industrial RD&D expenditures for energy and pollution abatement for the years 1974-1976. The NSF studies are based on Census Bureau data and thus represent a comprehensive and consistently defined data base. Unfortunately, proprietary considerations prevent the detailed presentation of the data. This study indicates that industrial energy related RD&D spending amounted to \$1.4 billion in 1975 (up 18 percent from 1974). In 1976 total industrial energy RD&D was approximately \$1.6 billion (a 10 percent increase from 1975). Table VI-17 shows the division by type of energy and by industry for energy related and pollution abatement RD&D (in the private sector). Note that in Table VI-17 wherever the company funding is not available, total (federal and company) funding is shown. Over 80 percent of industry's energy RD&D effort was in the nuclear and fossil fuels areas in 1976. The largest relative increases between 1975 and 1976 were in solar and energy conservation and utilization.

Table VI-9
ESEERCO R&D Goals

Energy Sources:

- To make coal available in forms that can be burned with acceptable environmental impacts.
Examples: Intensively cleaned coal
Coal gas/liquids
- To insure the availability of nuclear (fission) fuels.
- To make available new nuclear energy sources.
Example: Nuclear fusion
- To ensure that presently unused (within New York State) but renewable energy sources such as: wind, tidal and geothermal energy, and biomass are developed and used according to their expected benefits.
- To insure that the use of solar energy for supplementary heating and cooling for residential, commercial and industrial applications within all parts of New York State, is supported and developed according to the expected benefits.
- To insure the maximum effective use of solid and biological wastes as fuel.

Energy Conversion:

- To improve the availability and efficiency and reduce the costs of present nuclear (fission) generation in plants in New York State.
- To improve the availability and efficiency and to reduce the costs of present fossil-fueled generation.
Examples: Ash erosion and chemical attack on boilers
Fluidized bed combustion
- To make available new energy conversion systems that make better use of available fossil and uranium fuels.
Examples: Breeder reactors e.g., the liquid metal fast breeder reactors (LMFBR)
High temperature gas-coolant reactors
- To make available efficient and economical dispersed generation systems.
Example: Fuel cells

Energy Delivery, Storage, Conservation, and Use:

- To improve the reliability and the cost savings provided by ultra high voltage overhead AC and DC transmission lines.
- To minimize the cost and improve the power capability of underground transmission systems.
Examples: High voltage (345 kV) and more reliable extruded dielectric cables
High voltage DC cables
- To reduce the costs of size of AC/DC conversion equipment, and of DC filters.
- To make available DC breakers.
- To make available at minimum size and cost AC station equipment.
- To reduce system energy losses and fixed and operating costs by the development of methods of advanced system design, and system control and operation.
- To make available components and systems having reduced environmental effects.
Examples: Flue gas desulfurization systems for coal-burning plants
Nuclear waste transportation and storage systems
- To make available efficient and economical energy storage systems.
Examples: Batteries, superconducting magnets and flywheels.

Environmental Impacts:

- To have sufficient quantitative understanding of the ambient ecosystem to allow measurement of the effects of the energy system.
- To be able to measure the environmental effects of the energy system with sufficient detail for the construction of models valid for predictive purposes.

Source: Reference (14).

Table VI-10

Summary Distribution of
ESEERCO/Member System Funding
(\$,000)

	<u>All Projects</u>	<u>Company Projects</u>	<u>ESEERCO</u>
1.00 General R&D Support	\$ 4,060	\$ 1,583	\$ 1,437
2.00 Hydroelectric Power	50	10	--
3.00 Nuclear Power	10,065	3,401	850
4.00 Fossil Fuels	9,581	3,845	1,952
5.00 Advanced Power Systems	4,860	1,981	250
6.00 Transmission	3,740	2,154	212
7.00 Distribution	4,023	3,267	250
8.00 Stations and Substations	1,947	1,014	717
9.00 Customer Utilization	1,745	549	--
10.00 Economics	1,223	64	--
3.00 Environmental Assessment	<u>12,037</u>	<u>10,112</u>	<u>583</u>
TOTAL	\$ 53,331	\$ 27,917	\$ 6,500

Source: Reference (14).

Table VI-11

Energy RD&D Projects Directly Managed
by ESEERCO and Member Utilities

Environmental Assessment		1977 EXPENDITURES (Dollars)
ESEERCO AND MEMBER SYSTEMS		
ES	Right-of-way management case studies	\$ 57,264
ES	Geologic seismic study	50,000
ES	Meteorological diffusion short term models	22,832
ES	Lake Ontario - St. Lawrence River study	3,209
ES	Power plant construction noise	14,215
ES	Sulfate formation in plumes	75,000
ES	Entrainment sampling	2,150
ES	Fly ash in agriculture	37,500
ES	Fish protective systems	321,000
CE	Integrated Hudson River Study (capital)	3,200,000
L	Sulfur dioxide monitoring	10,000
L	Environmental Quality Control System operations	15,000
L	Holbrook environmental air quality studies	30,000
L	Ecological studies at existing power stations	28,000
L	Fish guidance study for Long Island Sound	500,000
L	Mathematical modeling of gas turbine plumes	25,000
L	Mathematical models for meteorological conditions	15,000
L	Total sulfate monitoring system	55,000
L	Expansion of environmental quality control system	50,000
L	Real-time diffusion model	50,000
L	Emission solids from fossil fuel boilers	12,000
L	Power station SO ₂ impact under unusual terrain conditions	15,000
L	Sulfate plumes from oil-fired power plants	70,000
L	Waste heat recovery	1,000
L	Maximum hurricane surge analysis model	12,500
L	Investigation of the effects of de-watering	75,000
L	Aquatic ecology and water chemistry	125,000
NM	Commercial utilization of flyash	2,000
NM	Fish movement and behavior studies south-east Lake Ontario	17,000
NM	Polynuclear aromatic hydrocarbon in natural water	1,000
NM	Effluent vs. agriculture production	100,000
NM	Fly ash use for agricultural purposes	8,000
NM	Slash burning	50,000
OR	IUCC - Integrated Hudson River Study	389,200
OR	Bowline - fish population	46,600
OR	Bowline - plankton	4,400
OR	Bowline - benthos	4,400
OR	Bowline - ichthyoplankton population	77,200
OH	Lovett - fish population	4,800
OR	Lovett - ichthyoplankton population	12,800
OR	Lovett - benthos	1,700
OR	Lovett - plankton	2,700
OR	Bowline ichthyoplankton population	63,340
OR	Lovett - impingement	9,340
OR	Lovett - ichthyoplankton population	16,480
PA	Impingement - Astoria 6	12,000
PA	Environmental studies - Hudson River	3,240,000
PA	Aquatic studies - FitzPatrick	500,000
PA	Environmental studies - Prattville Project	396,000
PA	Sedimentation transportation - Schoharie	200,000
PA	Terrestrial study along proposed transmission line	24,000
PA	Environmental studies for road access to Greene County	65,000
PA	Hydrothermal study - FitzPatrick	250,000
RGE	Alden Research Laboratories fish behavioral study	45,000
RGE	Fish entrapment	180,000
RGE	Ginna entrainment	36,000
RGE	Fish impingement vs. intake velocity	5,000
RGE	Fish migration patterns - Ginna	7,000
RGE	Fish survival after impingement	17,000
RGE	Benthos - Sterling	62,000
RGE	Benthos - Ginna	35,000
RGE	Underwater viewing instrumentation	5,000
RGE	Fish population - Ginna	15,000
RGE	Fathometric study - Ginna	5,000
RGE	Fish migration patterns - Sterling	14,500
RGE	Echo soundings - Sterling	13,500

Nuclear Power		1977 EXPENDITURES (Dollars)
ESEERCO AND MEMBER SYSTEMS		
ES	Vibration detection	18,750
ES	Leak detection in reactor primary system	24,375
ES	PWR decontamination	133,718
ES	BWR containment structure and equipment	511,927
ES	Acoustic emission interpretational techniques	144,500
ES	Radiation exposure reduction	17,000
CE	Advanced analytical capability for PWR systems	75,000
CE	Monitoring of nuclear noise for Indian Point No. 2 reactor core	40,000
CE	Decontamination of FWRs (contingency)	5,000
CE	PWR acoustic monitoring (contingency)	5,000
CE	Indian Point #1 Amortization	538,538
CE	LWR/LWR conversion	50,000
CE	PWR reliability program	250,000
L	Tornado missile barrier testing	120,000
L	Hydraulic model study	15,000
L	Prototype reactor containment structural testing	45,800
L	Pressure transients in large hydraulic systems	22,000
L	Suppression pool coating material	10,000
L	New procedures for astro arc welding	14,000
L	Electrical safety and reliability standards	5,000
NM	BWR water chemistry evaluation program	25,000
NM	Hydrogen embrittlement	74,000
NM	Uranium solution mining	50,000
NM	Radwaste incinerator	1,000,000
PA	Torus integrity study	1,000,000
PA	Systems analysis and operational transient methodology development for LWR's	50,000
RGE	Ginna turbine measurement (torsional oscillation study)	1,301
RGE	Steam generator control chemistry	5,093

Source: Reference (14).

Table VI-11 (continued)

Energy RD&D Projects Directly Managed
by ESEERCO and Member UtilitiesFossil Fuels

		1977 EXPENDITURES (Dollars)
ESEERCO AND MEMBER SYSTEMS		
ES	Cooling tower performance improvement	234,633
ES	Hydrogen sulfide removal from fuel gas	17,250
ES	Coal gasification pilot plant	125,000
ES	Flue gas desulfurization demonstration project	50,122
ES	Cooling tower drift environmental toxicity	88,896
ES	Electrofluidized beds for fly ash control	66,862
ES	Rotary kiln solid waste gasification	588
ES	Flue gas desulfurization demonstration project	1,200,000
ES	Front-end coal utilization	168,000
CH	Impingement survival, 1975D	1,500
CH	Ecological survey, 1975D	8,700
CH	Thermal effects studies-field, 1976D	5,300
CH	Impingement survival, 1976D	25,830
CH	Ecological survey, 1976D	22,840
CH	Impingement abundance, 1976D	18,964
CH	Tagging studies, 1976D	6,504
CH	Reimpingement studies, 1976D	1,938
CH	Thermal effects studies-field, 1977D	36,365
CH	Impingement survival, 1977D	87,314
CH	Impingement abundance, 1977D	84,212
CH	Impingement mitigation, 1977D	38,878
CH	Impingement survival, 1975R	800
CH	Ecological survey, 1975R	4,000
CH	Thermal effects studies-lab, 1976R	2,773
CH	Impingement survival, 1976R	9,272
CH	Entrainment survival, 1975R	4,636
CH	Ecological survey, 1976R	13,039
CH	Impingement abundance, 1976R	4,623
CH	Entrainment abundance, 1976R	3,867
CH	Reimpingement studies, 1976R	468
CH	Entrainment abundance (th), 1976	3,867
CH	Thermal effects studies-lab — 1977R	20,501
CH	Thermal effects studies-field, 1977R	6,834
CH	Impingement survival, 1977R	20,501
CH	Entrainment survival, 1977R	66,340
CH	Ecological survey, 1977R	106,390
CH	Impingement abundance, 1977R	18,298
CH	Entrainment abundance, 1977R	23,484
CH	Entrainment abundance (th), 1977	23,484
CH	Impingement mitigation, 1977R	5,245
CH	River mixing patterns, 1977R	5,245
CH	Boiler fuel residue reclamation	5,000
CH	IUCC Program	344,006
CE	Gas turbine generating unit exhaust reingestion	107,000
CE	Solid waste utilization	30,000
CE	Simplified plugging of heat exchanger tubes	100,000
CE	Installing inlet air filters to reduce sulfidation on gas turbine blading	186,000
CE	Stresses in feedwater heaters	11,000
CE	AGA coal gasification	70,000
CE	Alternate blade design for GE turbine	87,000
L	Refuse as a supplemental fuel	5,000
L	Fuel oil burner gun tests	5,000
L	New methods and materials for condenser cleaning	10,000
L	Fuel oil desulfurization	35,000
L	Reducing gas turbine maintenance	5,000
L	Sodium concentration test	5,000
L	Dilution pump tests	10,000
L	Incineration of spent citosolv cleaning solution	5,000
L	Jet engine turbine washing techniques	2,000
L	Modification for internal combustion gas turbines to accept a new type combustion chamber	270,000
L	Improve station heat rate at low loads	15,000
L	Heat rate meter	15,000
L	Carbon re-injection fan relocation	8,000
L	Precipitator wash header	29,000
L	Measurement of gas volumes in large ducts	4,200
L	Vanadium yield from leaching pond residues	50,000
L	New condenser tube material	250,000
L	Sodium hypochloride from sea water	12,000
L	AGA coal gasification	50,000
L	Conversion of circulating water pumps from fresh to salt water lubrication	20,000
L	Fuel oil spill recovery methods and equipment	1,000
L	Vanadium refining plant	45,000
L	Effect of magnesium fuel additive particle size on quality of vanadium recovery	24,000
L	Wear metal investigation	6,000

		1977 EXPENDITURES (Dollars)
ESEERCO AND MEMBER SYSTEMS		
NYS	Fuel selection studies	25,000
NYS	Precise fine coal cleaning circuit	11,000
NYS	Direct, on line sulfur, ash and BTU meter	57,500
NYS	Ultra fine cleaned coal pilot circuit	10,000
NYS	Coal preparation plant, start-up and test program (interim configuration)	20,000
NYS	Improved combustion characteristics	25,000
NYS	MCCS start-up and test program	10,000
NYS	Precipitator model and in-field test using deep-cleaned eastern coal	5,000
NYS	Fly ash utilization	13,000
NYS	Supplemental fuel analysis	10,000
NYS	Precipitator performance improvement program	20,000
NYS	Power plant waste heat utilization	5,000
NYS	Automated data acquisition & logging system	53,000
NYS	Upper air flow patterns & thermal stability in Lake Ontario & Hudson River	20,000
NYS	Water quality models	4,000
NYS	Optimization of preparation of Pennsylvania coals	26,000
NYS	Boiler implosion analysis	8,750
NYS	IDFPN - Blade edge materials development pro- gram for resistance to erosion and corrosion	20,000
NYS	Alternate & refuse derived fuels	10,000
NYS	Fault detection in boilers utilizing a remote non-destructive technique	10,800
NM	Boiler tube performance study	5,000
NM	Feasibility of burning solid waste for generation	5,000
NM	Aqueous carbonate advanced flue gas desulfurization process	100,000
NM	Use of limestone to modify boiler slag viscosity	30,000
NM	OGP-OTP	40,000
NM	Hydrogen combustor	50,000
NM	Fish guidance (water intake)	20,000
NM	Flyash characterization	50,000
OR	Bowline - impingement study	79,800
OR	Bowline - impingement recirculation	12,100
OR	Bowline - entrainment studies	36,300
OR	Bowline - viability studies	153,000
OR	Bowline - zones of intake withdrawal	500
OR	Bowline - stomach content analysis	1,000
OR	Bowline - thermal tolerance	36,800
OR	Bowline - fish net studies	1,900
OR	Bowline - water quality	1,100
OR	Bowline - automated entrainment	300
OR	Bowline - discharge water recirculation	1,200
OR	High for SO ₂ study	4,000
OR	Lovett - water quality	300
OR	Lovett - impingement study	45,100
OR	Lovett - impingement recirc.	800
OR	Lovett - entrainment study	43,000
OR	Lovett - viability study	47,800
OR	Lovett - zone of intake withdrawal	700
RGE	AGA coal gasification	50,000
RCL	Refuse fuel	108,224

Key:

The following abbreviations are used to identify companies:

ES	Empire State Electric Energy Research Corporation
CH	Central Hudson Gas and Electric Corporation
CE	Consolidated Edison Company of New York, Inc.
L	Long Island Lighting Company
NYS	New York State Electric and Gas Corporation
NM	Niagara Mohawk Power Corporation
OR	Orange and Rockland Utilities, Inc.
PA	Power Authority of the State of New York
RGE	Rochester Gas and Electric Corporation

Table VI-12

Industrial R&D Expenditures for Energy and
Pollution Abatement by Type: 1974-76
(Dollars in Millions)

Type of Energy	1974		1975		1976 Est.	
	Federal and Company Total	Company Total	Federal and Company Total	Company Total	Federal and Company Total	Company Total
TOTAL		\$ 731		\$ 803		\$ 883
Fossil fuel		494		518		542
Oil		322		330	\$ 353	338
Gas	\$ 74	*	\$ 76	*	75	
Shale	13	*	14	*	13	
Coal		56		76		96
Synthetic fuel	21	*	37	*	47	
Mining	4	*	8	*	9	
Other		33		38		43
Other fossil fuel	30	*	26	*	31	
Nuclear		157		161		165
Fission		147		156		164
Fusion		11		6		1
Geothermal	2	*	7	*	10	
Solar	7	*	18	*	35	
Conservation and utilization		12		45		78
All other		62		70		78
<u>Type of Pollution Abatement</u>						
TOTAL		606		607		608
Air		491		466		441
Automotive emission	383	*	345	*	361	
Water	60	*	71	*	76	
Solid waste	14	*	22	*	21	
All other		46		53		60

* Not separately available but included in total.

Source: Reference (15).

A survey of selected energy RD&D activities has been carried out recently by INFORM, Inc.⁽¹⁶⁾ A summary of that survey is presented in Appendix A.

E. REGIONAL AND STATE ENERGY RD&D PROGRAMS

Regional, state, and local governmental entities are becoming widely involved in a whole range of energy activities, including RD&D. The brief survey contained in Table VI-13 indicates that most organizations are funded at less than \$1 million per year and deal primarily in public information and energy policy analysis activities. New Mexico, Ohio, California, and New York appear to be the only states at present with substantial RD&D responsibility. California's energy RD&D activities, like New York's, are financed through utility taxes and are detailed in Table VI-14. California, as opposed to NYSERDA, spends most of its funds on new energy technologies whereas NYSERDA spends about equal amounts on new technologies and end-use efficiency/conservation RD&D. The current and proposed RD&D activities of NYSERDA are summarized in Table IV-15.⁽¹⁸⁾

Table VI-13
State and Regional Energy RD&D Activities
FY 1977-1978

	<u>Staff</u>	<u>Primary Area of Energy RD&D</u>	<u>Estimated R&D \$ (Approximately)</u>
Southern Interstate Nuclear Board Atlanta	8	Nuclear Power Plant Siting	\$280,000
Western Interstate Nuclear Board Denver	7	Education & Information in Energy Issues	\$200,000
Colorado Energy Research Institute Denver	Will be 7 Prof.	Planning & Analysis Education	\$400,000 Work with Univ. to get research grant for state
Division of Energy Illinois Dept. of Business & Economic Development Springfield, Illinois	24	EPCA - Solar Energy Waste Utilization Recycling Coal Conversion (\$70 Million Bond Issue)	\$375,000 \$2 million Federal
New Mexico Energy Resource Board	41	Energy Resource Development Energy Conserva- tion & Management (Special emphasis in solar)	\$2.5 million
Michigan Energy and Resource Research Detroit	6	*	\$300,000
New Solar Energy Institute Michigan	8	Solar Research	\$250,000
Arizona Solar Energy Research Commission	7 plus clerical	Solar energy research	\$700,000 (in FY 76)
Florida Solar Energy Center Cape Kennedy	40	Education & Info. Energy Systems & Analysis RD&D in Solar Equipment	\$1,000,000
Ohio Energy & Resource Develop. Agency, Columbus	8	Fossil fuel research conser- vation & utili- zation	\$2,000,000

*Not Available

Source: Private Communication with respective Offices.

Table VI-14

PROPOSED RESEARCH AND DEVELOPMENT BUDGET FOR FY 77/78

California Energy Resources Conservation and Development Commission

Program/Element	Staffing	Contract (Thousands of \$)		
	(Person Years)	State	Federal	Total
New Resources and Technologies				
Solar	16.9	855	-	855
Geothermal	6.9	490	100	590
Fuels	5.7	400	60	460
Nuclear	13.3	424	-	424
Siting and Utility Systems	-	-	-	-
Subtotal	42.8	\$2,169	\$160	\$2,329
Energy Resources Conservation				
Building and Appliances	.3	-	475	475
Utilities	.4	175	250	425
Industrial	1.8	-	40	40
Subtotal	2.5	\$ 175	\$765	\$ 940
Forecasting and Assessment				
Energy and Electricity Planning	2.3	397	-	397
Subtotal	2.3	\$ 397	-	\$ 397
Facility and Site Certification				
Compliance and Enforcement	.9	-	-	-
Subtotal	.9	-	-	-
Commission and Administration				
Program Planning and Management	4.1	15	42	57
Subtotal	4.1	\$15	\$42	\$57
Total - Commission	52.6	\$2,756	\$967	\$3,723

Source: California Energy Resources, Conservation and Development Commission. (17)

Table VI-15
LISTINGS OF PROJECTS IN EXPENDITURE PLAN FOR DOE
(\$ Omitted)

<u>FUEL UTILIZATION</u>	<u>FY 1976-1977</u>	<u>FY 1977-1978</u>		
	<u>COMMITTED</u>	<u>COMMITTED</u>	<u>PLANNING</u>	<u>POTENTIAL</u>
<u>Coal Combustion</u>				
Fluidized Bed Retrofit	70,730			250,000
Combustion Research Facility	47,427			50,000
Coal Fired Combined Cycle: Hot Gas				
Cleanup Diagnostics	224,580			200,000
Modeling Fluidized Beds	83,480			
Fluidized Bed Combustion Studies				225,000
<u>Solid Waste Utilization</u>				
Technology Review and Assessment	22,263			75,000
Demonstration of Fuel Gas Recovery From				
Landfill	208,775			
Simplex	48,465			100,000
Demonstration of Co-Firing Shredded Waste				
With Oil			175,000	
<u>Coal Utilization</u>				
New Project Development				245,000
Consulting (Combustion Processes)		14,684		
<u>NEW ENERGY TECHNOLOGIES</u>				
<u>Solar Energy</u>				
New York State Solar Atlas	106,000			
Solar Energy Meteorological Research and				
Training Site			50,000	
Heliostat Development	204,000	32,000	95,000	
Solar Energy Application Center	113,380		350,000	
<u>Wind Energy Conversion Systems (WECS)</u>				
Demonstration of Wind Power Utilization On				
A Working Dairy Farm	167,050		64,459	
WECS Application In Urban Settings				500,000
Vortex Augmentation Wind Energy System (Yen)			250,000	

Table VI-15 (cont'd)

LISTING OF PROJECTS IN EXPENDITURE PLAN

(\$ Omitted)

	<u>FY 1976-1977</u>		<u>FY 1977-1978</u>	
<u>NEW ENERGY TECHNOLOGIES (Continued)</u>	<u>COMMITTED</u>	<u>COMMITTED</u>	<u>PLANNING</u>	<u>POTENTIAL</u>
<u>Biomass</u>				
Assessment of Biomass Conversion Technology Applicable To New York State	74,840			
<u>Storage and Conversion</u>				
Assessment of Electric Energy Storage Application For New York State Utilities	99,737			
Fuel Cell Demonstration	380,000		350,000	
Regenerative/Inertial Energy Storage In Rapid Transit Transportation System				300,000
<u>Transmission and Distribution</u>				
600KV DC Cable Development	100,000			
Compressed Gas Insulation Transformer	200,000			
<u>Hydroelectric Power</u>				
Small Hydropower Restoration and Expansion In New York State	168,485			
<u>Laser Fusion Research</u>	340,000	726,500		
<u>END-USE EFFICIENCY AND CONSERVATION TECHNOLOGIES</u>				
<u>Buildings</u>				
Solar Assist Heat Pump Demonstration	22,293	9,267		
Demonstration of Energy Conservation Techniques In A Restaurant	162,000	15,759		
Ballston Spa Central School District Solar Heating and Hot Water Demonstration	200,000			
Solar Heating and Cooling In Non Residential Buildings	500,000			
Solar Energy Research and Demonstration At Wagner College Heating and Cooling System			550,000	

Table VI-15 (cont'd)
LISTING OF PROJECTS IN EXPENDITURE PLAN

(\$ Omitted)

	<u>FY 1976-1977</u>	<u>FY 1977-1978</u>		
<u>END-USE EFFICIENCY AND CONSERVATION</u> <u>TECHNOLOGIES - cont'd</u>	<u>COMMITTED</u>	<u>COMMITTED</u>	<u>PLANNING</u>	<u>POTENTIAL</u>
<u>Buildings</u>				
Westchester Solar Hot Water Heating Demonstration	149,586		22,389	
Citywide Energy Conservation Retrofit Demonstration	28,000	12,000		
Energy Conservation for NY State Schools	68,200	68,615		
Air-to-Air Solar Collector Demonstration	12,500			
Evaluation of Add-on Devices to Existing Gas Fired Equipment	161,300			
Solar/Heat Pump Demonstration - SUNY/ Albany Alumni House Conference Center	59,862		61,000	
Energy Management & Conservation in Office Buildings	2,000			
Energy Management in a High Rise Residential Building			150,000	
Energy Audit of Residential Buildings in New York City			148,000	
Demonstration of Energy Efficient New Construction			50,000	
Energy Conservation Demonstration in an Urban Public Utility Area		245,000		
Improved Boiler Efficiency Demonstration			78,525	
Energy Efficiency Construction Code/Manual		30,000		
Impact of ASHRAE Standards on New Office Buildings		45,000		
Investigation of NYS/NYC Codes Standards, Rules & Regulations			140,000	
Energy Conservation in a Public Sector NYC Fire Department				80,000
Safety & Hazard Evaluation of Retrofit Insulation-Organic Hazards				100,000
Retrofit Insulation Field Test Facility				125,000

Table VI-15 (cont'd)
LISTING OF PROJECTS IN EXPENDITURE PLAN

(\$ Omitted)

	FY 1976-1977	FY 1977-1978		
<u>END-USE EFFICIENCY AND CONSERVATION</u> <u>TECHNOLOGIES - cont'd</u>	<u>COMMITTED</u>	<u>COMMITTED</u>	<u>PLANNING</u>	<u>POTENTIAL</u>
<u>Transportation</u>				
Assessment of Energy Conservation Potential in the Transportation Sector	93,649			
<u>Industry and Utilities</u>				
Low Level Heat Recovery	78,953		80,000	
Combined Heat and Power Generation Technology Diffusion in New York Industrial Sector	20,501		25,000	350,000
<u>Transmission and Distribution</u>				
Automated Distribution/Remote Meter Reading			75,000	
<u>ENVIRONMENTAL, HEALTH AND</u> <u>SAFETY TECHNOLOGIES</u>				
<u>Power Plant Heat Rejection</u>				
Remote Sensing Research	74,466			90,000
Hydrological Analysis	66,750			
Thermal Discharge Evaluation	37,802		3,369	60,000
Cooling System Impacts - Power Plant Intake Structure	71,273			75,000
Cooling System Impacts - Condenser Tube Simulator	122,300			25,000
<u>Coal Waste Disposal</u>				
Coal Waste Disposal at Sea	17,475		35,000	
<u>Environmental Geology</u>				
Earthquake Hazards - Seismic Network	103,330			75,000
Stress Patterns - In Situ Strain Relief	82,428			25,000
Indian Point Seismic Hearings	49,304			
<u>Radioactive Waste Management</u>				
Low-Level Radioactive Waste Management	70,136		1,200	
<u>Air Quality</u>				
Coal Emissions - Air Quality Assessment	10,000			130,000

Table VI-15 (cont'd)
LISTING OF PROJECTS IN EXPENDITURE PLAN

(\$ Omitted)

	<u>FY 1976-1977</u>	<u>FY 1977-1978</u>		
<u>ENVIRONMENTAL, HEALTH AND SAFETY TECHNOLOGIES - cont'd</u>	<u>COMMITTED</u>	<u>COMMITTED</u>	<u>PLANNING</u>	<u>POTENTIAL</u>
<u>Environmental Audit</u>				
Environmental Audit	37,721		40,000	100,000
<u>R&D PLANNING AND ANALYSIS AND ENERGY SYSTEMS STUDIES</u>				
R&D Assessment	307,250			50,000
Electric Supply Alternatives Model for NY State	118,683			75,000
R&D Program Planning	80,000			
R&D Information Dissemination	61,000		135,000	
R&D Technical Consultants	15,000	15,000		

Source: New York State Energy Research and Development Authority. (18)

NOTES AND REFERENCES

Chapter VI

- (1) This chapter is drawn from a detailed analysis of available literature on energy RD&D activities reported in Donovan, Hamester & Rattien, Inc, "Analysis of National Energy RD&D Programs" Draft of August 17, 1977.
- (2) Budgets are expressed in terms of "funding authority". "Annual budget authority" is the amount of new authority to expend funds an agency receives. R&D agencies can usually accumulate authority from year to year if it is not completely used. The actual cash disbursements are called "outlays".
- (3) FY1975 and FY1976 ran from July 1 to June 30. Beginning in FY1977 the fiscal year runs from October 1 to September 30. The period July 1 to September 30, 1976 is referred to as the transition quarter.
- (4) U.S. Energy Research and Development Administration, A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future, 1976, ERDA-76-1, Volume 1: The Plan, p. 25.
- (5) Ibid., p. 6.
- (6) Ibid., p. 43 and Table VI-3.
- (7) Ibid., p. 43 and Table VI-3.
- (8) Developed from A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future, 1976, ERDA-76-1, Volume 2: Program Implementation. ERDA subtotals were calculated by DHR from information available in this report.
- (9) Congressional Budget Office, Federal Energy Research on Analysis of Fiscal Year 1977 Program Funding Levels and Alternative Budget Paths Through Fiscal Year 1986, Technical Staff Working Paper-9/10/76, page 52.
- (10) USERDA, A National Plan for Energy RD&D: Creating Energy Choices for the Future, 1976, Volume 2, p. xvii.
- (11) Electric Power Research Institute, Digest of Current Research in the Electric Utility Industry, Palo Alto, California, May 1976.
- (12) This table was developed from "EPRI-Proposed Research and Development Program 1977-1981", Working Draft--12/1/76, p. 70 and "EPRI--A Summary of Program Emphasis for 1976", p. 20.
- (13) EPRI Facts, February, 1977.
- (14) Report of Member Electric Systems of the New York Power Pool and the Empire State Electric Energy Research Corporation, Pursuant to Article VIII, Section 12a-b of the Public Service Law, Volume 3A.

- (15) National Science Foundation, Science Resources Studies Highlights, 10/27/76 (NSF 76-324), p. 3 ad DHR estimates for 1976.
- (16) S. W. Herman, J. S. Cannon, with J. Malefatto, editor L. H. Orr, Energy Futures: Industry and the New Technologies, Copyright 1976 by INFORM, Inc.
- (17) California Energy Trends and Choices, Volume 6, Energy Research and Development Program, 1977, Biennial Report and Development Program, 1977, Biennial Report of the State Energy Commission, p. 23.
- (18) New York State Energy Research and Development Authority, "Quarterly Report to the Director of the Budget," July 1, 1977.

VII. PRIORITIES FOR NEW YORK STATE R&D ACTIVITIES

A. INTRODUCTION

The purpose of this project is to develop expenditure priorities for current and future NYSERDA RD&D activities and thus an RD&D "strategy". This strategy development is based on a top-down analysis of New York's energy and socioeconomic needs and contributions that might derive from NYSERDA action in various RD&D areas. Figure VII-1 depicts the overall logic of the study. It involves the consideration of many factors, the major elements being:

- Determination of eventual contributions of RD&D efforts to New York State's energy supply and demand situation in a particular future circumstance (i.e., in a particular scenario). Determination of the significance of non-technological factors/barriers to the adoption of technological change.
- Estimation of the type, magnitude and likelihood of contributions from RD&D activities ongoing outside of NYSERDA; that is, an estimate of the marginal impact of NYSERDA's efforts.
- Elucidation of the appropriate roles that NYSERDA can take in accomplishing RD&D and facilitating technological change in New York.

The overall logic is complex enough to provide a fairly strong and complete rationale for the derived strategy but it can also lead to correct, but non-obvious results. For example, a particular RD&D area could make a substantial contribution to an important need and not be addressed by federal or private efforts, but still receive a low level of funding relative to other projects. This could be the case if the particular RD&D activity is highly cost effective and thus requires only a small amount of funding.

To date, the study has not developed every step of the logic of Figure VII-1, but this interim report has addressed in a preliminary fashion the major elements listed above (see Chapters IV, V, and VI). This chapter integrates as much of the preliminary analysis as possible and uses the information to draw tentative conclusions as to the priority areas in which NYSERDA could direct its RD&D efforts. The conclusions as to priority areas are tentative because several important elements of the study are incomplete:

Figure VII 1. Development of NYSEERDA RD&D strategy.

- Only a limited number of RD&D areas have been evaluated (see Figure VII-2). Although they do cover a large proportion of NYSERDA's 1976-77 outlays, they are very aggregated and ignore other potentially important areas.
- The energy and socioeconomic needs of New York State and their relative importance have only been preliminarily addressed (e.g., impacts on industrial development or energy system reliability are not yet estimated).
- The quantification of RD&D impacts is very limited because only one scenario has been evaluated, and the evaluation contains very limited economic specification.
- Selected RD&D activities have not been subjected to any cost-effectiveness analysis.

In the course of finishing this study these items will be dealt with.

B. CONTRIBUTION OF RD&D TO NEW YORK NEEDS

Chapter IV has dealt at substantial length with a quantitative description of New York's energy situation and the possible future levels of energy use and the roles for new and existing energy supply and end-use technologies. This analysis indicates that New York has a clear need both now and in the future to (1) reduce its reliance on imported oil and scarce natural gas; (2) shift energy use to abundant domestic resources; (3) use fuels, particularly depletable ones, as efficiently as possible; and (4) reduce environmental impacts of energy supply and use as much as possible. Consequently, these are the types of impacts on which this preliminary analysis of selected RD&D areas is primarily focused.

Figure VII-3 summarizes the type of impact expected from each of the selected RD&D areas and the preliminary judgement as to the overall importance of this impact in New York. Five of the RD&D areas are thought to be highly important because of the scope and magnitude of their possible impacts:

- Building end-use conservation--ranks high in overall importance because of the breadth and major magnitude of its impact. For example, failure to attain efficiency increases of 50 to 75 percent in space heating by 2000 could increase gas consumption

<u>Abbreviated Designation</u>	<u>Energy Sector(s) Impacted</u>	<u>Generic Energy Technology</u>	<u>Example(s) of Specific Technologies</u>
<u>SOLAR ENERGY</u>			
Solar Heating and Cooling	Residential, Commercial, Government Buildings	Solar Heating and Cooling	Fixed absorber hot water system.
Process Heat	Manufacturing, Agriculture, and Industry	Solar Process Heat	Solar ponds. Fixed mirror concentrators.
Wind Electricity	Agriculture, and Residential (very low density)	Wind mills	Darius wind mill. NASA-1.
Biomass Fuels	All	Biomass combustion/conversion	Fuel farming. Wood waste-to-oil conversion.
<u>CONSERVATION</u>			
Building End-Use Efficiency	Residential, Commercial, and Government	Building end-use conservation	Heat pumps. Insulation. Window glazing. Load management. District heating.
Industrial End-Use Efficiency	Manufacturing, Agriculture, and Industry	Industrial conservation	Steam boiler maintenance. Waste heat utilization. Cogeneration. Process changes.
Transportation End-Use Efficiency	Transport	Transportation	High-efficiency IC engines. Diesel. Rankine cycle.
Electricity Generation/Distribution Efficiency	Electric Utilities	Energy Conversion (i.e., fuel to electricity)	MHD. Fuel cells. High voltage transmission lines. Electric storage. Bottoming and topping cycles.
<u>FOSSIL ENERGY</u>			
Coal Liquids	All	Coal liquefaction	SRC. Donor Solvent. H-Coal.
Coal Combustion	Industry and Utilities	Direct combustion	Atmospheric fluidized-bed. Pressurized fluidized-bed. Coal-oil slurries.
Coal Gasification	All	High- and low-Btu gasification	Wellman-Galusha. Winkler. Lurgi. Hygas. Combined cycle systems.
<u>NUCLEAR FUEL CYCLE</u>			
Waste Management	Utilities	Waste storage/disposal	Underground storage. Waste recycle.
<u>ENERGY/ENVIRONMENT INTERACTION</u>			
Control Technology	All	Pollutant control technology	Scrubbers (SOX). Cooling Towers. Catalytic mufflers. Fluidized bed combustion.
Environmental Impact Assessment	All	--	--
<u>ENERGY-RELATED SUPPORTING ACTIVITIES</u>			
Manpower/Education and Training	--	--	--
Information Services	--	--	--
General System Studies	--	--	--

Figure VII-2. RD&D areas selected for preliminary evaluation.

RD&D Area	TYPE OF IMPACT ^{a/}				Overall Importance of Impact in NY ^{b/}
	Reduction in Total Fuel Demand	Facilitates Switching from Oil	Facilitates Switching from Gas	Reduces Overall Environmental Impacts	
<u>SOLAR ENERGY</u>					
Solar Heating & Cooling	++	++	++	++	M
Process Heat	++	++	++	++	M
Wind Electricity	++	0	0	++	L
Biomass Fuels	++	++	++	0	M
<u>CONSERVATION</u>					
Building End-Use	++	++	++	++	H
Industrial End-Use	++	++	++	++	H
Transportation End-Use	++	0	0	++	H
Electricity Generation/Distribution Efficiency	++	++	++	++	L
<u>FOSSIL ENERGY ^{d/}</u>					
Coal Liquids	0	++	?	--	L
Coal Combustion	0	++	++	--	M
Coal Gasification	0	?	++	--	M
<u>NUCLEAR FUEL CYCLE</u>					
Waste Management	0	++	++	++	H
<u>ENERGY/ENVIRONMENT INTERACTION</u>					
Control Technology	--	++	++	++	H
Environmental Impact Assessment	?	?	?	?	c/
<u>ENERGY-RELATED SUPPORTING ACTIVITIES</u>					
Manpower/Education and Training	?	?	?	?	c/c/
Information Services	?	?	?	?	
General System Studies	?	?	?	?	

a/ Type of impact: ++ impact is as stated.
 -- impact opposite of stated.
 0 small or no impact of this type.
 ? impact direction and magnitude depend on many factors.

b/ Overall importance: H highly important.
 M moderately important.
 L least important.

c/ See following section on non-technical barriers to technological change.

d/ The environmental impacts of using coal are definitely negative particularly if coal substitutes for oil or gas, thus "--" has been entered. But contributions of RD&D could result in an overall environmental impact reduction if cleaner coal technology results, thus a "++" would also be appropriate for some specific technologies.

Figure VII-3. Summary of preliminary analysis of impacts of RD&D on New York energy situation.

27% over the reference case values. There are many different specific technologies in the building end-use conservation RD&D area: some which increase the efficiency of use of a particular fuel (e.g., heat pumps save electricity) and some which increase efficiency and facilitate shifting away from oil and gas (e.g., district heating). Specific technologies can differ substantially in their technical and economic attractiveness and the overall priority designation is unlikely to apply to each uniformly.

- Industrial end-use conservation, like building conservation, is of high overall importance. But even more so than in buildings, industrial efficiency improvements may require such a diversity of technological change that no single technology is of high overall importance.* This may be so even though industries in only 5 of the two-digit SIC codes comprise 80 percent of New York's industrial energy consumption. Such a situation could result in such low cost-effectiveness for RD&D on any one technology that despite the overall importance of the RD&D area, a low priority results.
- Transportation conservation--derives its high overall importance from the fact that the transport sector uses a very substantial portion of New York oil and generates significant pollution. Inability or delay in achieving projected transportation efficiencies could increase oil consumption in transport sector 20 to 40 percent by the year 2000.
- Nuclear waste management--is of high overall importance because of the significant likelihood that a major portion of electricity generation capacity in New York will be nuclear and that solving problems of nuclear waste management are vital to the functioning of this capacity.
- Pollution control technology--despite its energy use characteristics, is vital to allowing the continued or expanded use of all fossil fuels, particularly coal. Without adequate pollution control

* This is a case where disaggregation of the RD&D area will be important in further strategy development.

technology any shift away from oil and gas to coal is almost impossible, given the currently poor status of environmental quality in the Northeast. This RD&D area also encompasses thermal pollution control which is important to nuclear as well as fossil electricity generating plants.

The remaining eight RD&D areas, for which overall importance was assessed, were judged to be of only moderate or "least" importance for one or more of the following reasons:

- Potential application was quite limited (e.g., solar process heat, wind electricity, biomass fuels).
- Growth rate of utilization is limited over the next 15 to 25 years. Both coal gasification and solar heating and cooling will eventually have very widespread utilization, but the likelihood of widespread use in the near- or mid-term is low.
- Impact of RD&D only affects New York indirectly. In the case of both coal liquids and biomass fuels there is a good chance they will have substantial impact on other geographic locations (e.g., near mine-mouth or where agricultural waste is plentiful). Remote impact could have positive, negative, or no effect on New York, such as the case where coal liquids are produced cheaply enough to attract away industry but not so cheaply as to lower the cost or increase the availability of fuels in New York.

It is important to re-emphasize three points in interpreting these judgements: (1) they are preliminary in the sense that later analysis to be included in the study may alter the results, (2) the RD&D areas are not sufficiently disaggregated to distinguish between specific technologies within each group having different priorities, and (3) NYSERDA's budgetary priorities also must depend on considerations other than those included in this study.

C. NON-TECHNICAL BARRIERS TO TECHNOLOGICAL CHANGE

Technological improvements alone often are not sufficient to insure increased utilization. Frequently, barriers arise which slow or halt the

adoption of improved technologies or processes despite their ability to meet state needs. NYSERDA's strategy must allow for identification of barriers to utilization as well as technical improvements. Such analysis of non-technical barriers, moreover, is essential to making a proper assessment of the overall importance of environmental impact assessments and other energy-related support activities.

Figure VII-4 presents a brief listing of major non-technical factors/barriers influencing the utilization of selected energy technologies. There appears to be four major barriers on a state/local level which NYSERDA must factor into its priority setting decisions and its program design process:

- The dissemination of accurate performance and cost information to investors, sellers, and buyers. This appears to be a critical factor in the commercialization of certain types of solar energy systems and fossil-based advanced systems.
- The availability of capital through conventional or special markets for "non-traditional" borrowers appears necessary for the widespread adoption of solar and conservation technologies.
- Resolution of overlapping responsibilities/jurisdictions between government agencies and between labor unions appears to be necessary to reduce costs and decrease restrictions on the use of many conservation and solar technologies.
- Data on the system-wide environmental advantages and disadvantages of various advanced technologies needs to be better established in order to permit more rational public discussion and the development of the most sensible regulatory environment.

Consideration of these factors suggests that of the RD&D areas unevaluated in Figure VII-3, two, the environmental impact assessment area and information services are, or will be, highly important to achieving the projected impacts of most fossil, solar and conservation technologies.

D. IMPLICATIONS OF OTHER NON-STATE RD&D ACTIVITIES FOR NYSERDA

The energy RD&D efforts exclusive of NYSERDA are hundreds of times the size of the NYSERDA's total budget. Whether or not NYSERDA expenditures will have a large or small marginal impact, and what direction (in terms of specific

SELECTED ENERGY TECHNOLOGY AREA

FACTORS/BARRIERS

SOLAR ENERGY

Solar Heating and Cooling

- Technical and cost data must be more widely disseminated and understood by lenders, builders and buyers.
- Governmental and labor union jurisdiction over system design, construction, safety and operation must be clarified and, where appropriate, standardized.
- Appropriate utility rate structures must be developed for the operation of electric/gas backup systems.
- Development of a system for assuring capital availability to small solar users is needed.

Process Heat

- Governmental and labor union jurisdiction (see above).
- Appropriate utility rate structures (see above).
- Policy and legal framework need to be developed as regards zoning for solar power structures and the appropriateness of access to sunlight (sun rights akin to property rights).

Wind Electricity

- Better information on the energy density and variability of wind in the state needs to be developed as well as a credible methods for specific site evaluation.
- Policy and legal framework needs to be developed as regards zoning for wind power systems and the appropriateness of access to wind currents (wind rights akin to property rights).
- System for assuring capital availability to small users who wish to switch to wind power is needed.
- Appropriate utility rate structures for sale of excess wind power and purchase of backup power are needed.

Figure VII-4. Regional and New York State non-R&D factors/barriers effecting technological change.

SELECTED ENERGY TECHNOLOGY AREA

Wind Electricity (continued)

Fuels from Biomass and Solid Waste

FACTORS/BARRIERS

- Standardization of wind generator-utility system interface is needed to assure safety, reliability and optimal economic choice.
- Clarification is needed of institutional mechanisms for coordinating collection, conversion and use of biomass/waste fuels.
- Development of public land use policy for production of biomass is needed.
- Development of a consistent policy for environmental protection as regards effluent disposal runoff, sanitation, erosion and control options.

CONSERVATION

Conservation in Buildings

High Industrial End-Use Efficiency

- Development of utility rate structures which contain the appropriate load leveling incentives.
- Modernization of building codes and inspection system to aid commercialization of high performance technologies.
- Development of environmental policies and data which recognize tradeoff between indoor and outdoor air quality brought about as a result of increased building conservation.
- System for assuring capital availability (since industrial conservation usually involves a capital-energy tradeoff).
- Development of appropriate labor union policies vis-a-vis tradeoff between increased job security brought about by energy conservation and numbers/type of jobs in a particular industrial plant.
- Development of environmental policies and data which recognize the tradeoff between increased impacts at end-use site in saving energy versus added impacts at energy supply site if savings do not occur.

Figure VII-4 (continued).

SELECTED ENERGY TECHNOLOGY AREA

FACTORS/BARRIERS

High Efficiency Transport

- System to assure capital and land use patterns that are necessary for development of an energy efficient transport system.

Electricity Generation/Distribution Efficiency

- More accurate and inexpensive methods and data for evaluation of benefits of using high efficiency conversion systems (new or retrofit) is needed.
- Public policy toward the development of infrastructure (service and maintenance) for stored energy vehicles is needed. Policy on utilization of such vehicles by governmental agencies is also needed.
- Development of appropriate electricity rate structures for the use of power for storage.
- Consistent environmental and safety policy toward use of toxic, high temperature, or very low temperature storage systems is needed.
- Policy on land use for large scale storage systems (e.g., pumped hydro storage) is needed.

FOSSIL ENERGY

Coal Liquids

- Development of environmental policies to deal with disposal water resource and air pollution problems is needed.

Coal Gasification

- Public policy toward water use needs to be developed.
- System to assure capital availability for commercial size plants is needed.

Coal Combustion

- Development of environmental policy and data which will allow for advanced direct combustion technologies which contribute to environmental objectives.

Figure VII-4 (continued).

technology or role) a NYSERDA program could pursue most significantly, is tied up with these federal and private sector RD&D. Chapter VI and related reports contain a preliminary analysis of information available on non-NYSERDA RD&D efforts. This information is summarized in Figure VII-5. When combined with the New York energy supply-demand situation described in Chapter IV, this leads to a number of conclusions:

- On a national level ERDA and EPRI are providing substantial support in all time frames for the development of technologies for central station nuclear, fossil and renewable electric power production. Even within New York, utilities and ESEERCO are focusing relatively large amounts of money into this area. The problems of availability of conventional fossil fuels (oil, gas) are receiving the major share of private RD&D funds and a significant amount of public resources.
- On the other hand, two areas of the electric sector--conservation (e.g., electric storage, high efficiency use) and advanced central station power systems (e.g., fuel cells, bottoming/topping cycles)--are receiving significantly less federal and private attention. Also, relatively fewer resources are being put into efforts dealing with fossil fuel conservation through high efficiency end-use technologies or alternative resource replacement or back-up (e.g., solar heating/cooling, wind, biomass).
- In environment and energy-related RD&D areas, one finds environmental impact control and assessment RD&D activities receive little private funding and relatively little public funding (compared to resource supply and use efforts); and the public education, training, and technology transfer efforts of the Federal Government are very small.

Applying these conclusions to the activities listed in Figure VII-3 we can obtain a preliminary analysis of the extent to which non-NYSERDA RD&D activities will influence the likely marginal impact of NYSERDA efforts. As summarized in Figure VII-7, the likely marginal impact is judged to be high in five of the selected NYSERDA activities.

- Solar heating and cooling--is judged to be an area of high marginal impact for NYSERDA. The rather modest objectives of federal and private programs must be viewed in light of wide regional variations in conditions for applying solar heating and cooling technologies.

Figure VII-5

PROPOSED 1977 EXPENDITURES (ESTIMATED)
(Thousands of Dollars)

<u>RD&D Areas</u>	<u>USERDA</u>	<u>EPRI</u>	<u>ESSERCO and Member Systems</u>
General R&D Support	\$ 80,600	\$ 1,800	\$ 3,020
Hydroelectric Power	--	640	10
Nuclear Power	1,633,700	53,800	4,251
Fossil Fuels	419,000	52,000	5,797
Advanced Power Systems	459,600	24,700	2,168
Transmission	24,500	19,700	2,366
Distribution	--	7,200	3,517
Stations and Substations	--	3,100	1,731
Customer Utilization	73,200	2,200	798
Economics	--	4,600	64
Environmental Assessment	<u>203,000</u>	<u>10,260</u>	<u>10,695</u>
TOTAL	\$2,893,600	\$180,000	\$34,417

RD&D Area	Estimate of Non- NYSERDA Annual Funding ^{1/} (\$millions)	Major Non-NYSERDA ^{2/} Program Objectives	Likely Marginal Impact of NYSERDA Efforts
<u>SOLAR ENERGY</u>			
Solar Heating and Cooling	45	The primary objective of the federal program is to conduct state-of-the-art demonstrations in as many building types and localities as possible. Ultimately, program will conduct hundreds of demonstrations.	H
Process Heat	2	Primary program objectives technology development in the agricultural and food processing industries.	M
Wind Electricity	17	Major program objectives involve construction of several experimental windmills ranging in size from 100 KW to 1.5 MW.	M
Biomass Fuels	4	Primary objectives are completion of system studies and construction of agricultural residue processing plants (feedlot, dairy farm, crop waste).	M
<u>CONSERVATION</u>			
Building End-Use Efficiency	22	Primary objectives are in developing integrated community energy systems, energy conservation methods for commercial buildings, and retrofit conservation technologies for residences.	H
Industrial End-Use Efficiency	12*	Primary objectives are in developing more efficient boiler fuel use, heat recuperators, industrial waste utilization, and industrial information technology transfer.	M
Transportation End-Use Efficiency	24*	Major program objectives are development of gas turbine Sterling cycle and electric engine systems, studies of alternative transport fuels and development of ways of increasing efficiency of existing transport engines.	L
Electricity Generation/Distribution Efficiency	52	Primary federal program objectives involves battery development and testing and large scale utility storage. Utility RD&D focuses primarily on generation technology and high voltage transmission systems.	M
<u>FOSSIL ENERGY</u>			
Coal Liquids	84	Primary emphasis is being placed on development and demonstration of H-coal, SRC, and indirect liquefaction techniques.	L
Coal Combustion	56	Major objectives are small-scale demonstrations of atmospheric fluidized bed boilers; development and testing of large-scale systems; and development of pressurized fluidized bed systems.	M
Coal Gasification	88	Emphasis is on combined cycle systems and operation of small-scale units to test alternative gasification processes.	L
<u>NUCLEAR FUEL CYCLE</u>			
Waste Management	90	Emphasis is on waste treatment and storage site selection and preparation.	L
<u>ENERGY/ENVIRONMENT INTERACTION</u>			
Control Technology	82*	^{3/}	H
Environmental Impact Assessment	344	^{3/}	M
<u>ENERGY-RELATED SUPPORTING ACTIVITIES</u>			
Manpower/Education and Training	8	Primary objectives are coordination of federal educational aid programs and training workshops for high school and college instructors.	H
Information Services	12	Emphasizes mass media educational materials aimed at general public.	H
General System Studies	17	Efforts cover policy analysis; economic, environmental and energy system modeling; analysis of constraints on energy system development (labor, materials, equipment).	M

^{1/} Non-NYSERDA annual funding estimates are based on 1977 funding estimates for federal agencies and electric utilities. Private sector data is not detailed or quantitative enough to be added to these estimates; the asterisks indicate the RD&D areas in which private sector investments are considered to be equal or greater than public and utility sector investments.

^{2/} Major program objectives refers to objectives to which major amounts of listed funding is committed; thus most objectives refer to the federal effort.

^{3/} Program objectives are too numerous to summarize in this table, further detail is provided in Appendix A.

Figure VII-6. Implications of non-NYSERDA RD&D.

RD&D Area	Promote RD&D	Execute RD&D	Analyze Technical Economic & Social Factors/Issues	Disseminate Information
<u>SOLAR ENERGY</u>				
Solar Heating & Cooling	M	H	H	H
Process Heat	H	M	L	M
Wind Electricity	M	H	L	M
Biomass Fuels	M	H	L	L
<u>CONSERVATION</u>				
Building End-Use	H	H	M	H
Industrial End-Use	M	M	H	H
Transportation End-Use	H	L	L	L
Electricity Generation/Distribution Efficiency	H	L	M	M
<u>FOSSIL ENERGY</u>				
Coal Liquids	H	L	H	L
Coal Combustion	H	M	H	L
Coal Gasification	H	L	H	M
<u>NUCLEAR FUEL CYCLE</u>				
Waste Management	H	L	H	M
<u>ENERGY/ENVIRONMENT INTERACTION</u>				
Control Technology	M	H	M	M
Environmental Impact Assessment	M	M	M	H

a/ Table should be read across rows, not down columns. Every RD&D area could be assigned a high, moderate, and least appropriate roles.

Key:

H = Highly appropriate.
M = Moderately appropriate.
L = Least appropriate.

Figure VII-7. Appropriateness of NYSERDA roles^{a/}.

- Building end-use conservation--is judged as a high NYSERDA impact area because federal and private funding/objectives in the retrofit applications area (the major area for New York) are likely to have a very small impact in New York.
- Pollution control technology--despite significant private efforts, the problems and opportunities in this area are so pervasive as to imply that NYSERDA activities could result in a high marginal impact. This is particularly true of fluidized bed coal combustion technologies which are included under this heading because of their environmental advantages.
- Manpower education and information services--non-NYSERDA efforts in these areas are small and on a per capita basis NYSERDA could have a significant marginal impact.

In four of the selected RD&D areas, NYSERDA was judged to have a low marginal impact. This result is due primarily to the existence of a very large and comprehensive non-NYSERDA RD&D programs. Also, in these areas there are relatively few technical problems which are regionally unique. These include coal liquifaction and gasification areas. Major federal and joint private-public efforts also exist in increasing transport efficiency and nuclear waste management. Again there is relatively little regional uniqueness associated with either.

E. THE APPROPRIATE NYSERDA ROLES

Determination of the appropriate NYSERDA role in each RD&D area is an important step in the "logic" of developing a NYSERDA RD&D strategy. As discussed in Chapter V, NYSERDA can and does function in many roles. It could be given further responsibilities in the future where need and/or opportunities can be identified. NYSERDA's current activities can be roughly categorized into four separate roles:

- Execute and manage RD&D programs in New York utilizing normal NYSERDA budgetary resources or through receipt of funds from federal or other sources.
- Conduct or participate in analyses of economic factors, technological aspects, and institutional elements of the state's energy system.
- Promote RD&D programs in or out of New York by bringing together potential performers and funders, publicly advocating research efforts, and/or partially supporting efforts in order to catalyze larger efforts.

- Disseminate information to assure the widest possible use of energy RD&D results by the public, other RD&D organizations, and energy policy decision-makers.

To help develop a basis on which to decide which of these roles is both appropriate and beneficial, in each RD&D area we have listed several relevant factors :

- Adequacy of resources and expertise available outside NYSERDA.
- Necessity for RD&D to be performed in New York in order for results to be used in New York.
- Existence of complex or poorly understood energy issues with a major technological component.
- Existence of barriers to technological change attributed to lack of sufficient or credible information.
- Expertise of NYSERDA staff.

The preliminary results of attempting to evaluate these factors for each RD&D area and to reach a judgment as to the highly, moderately, and least appropriate NYSERDA roles are given in Figure VII-7. The conclusions can be grouped by the role(s) determined to be most highly appropriate:

- Promoting the conduct of RD&D outside NYSERDA is shown to be most highly appropriate where adequate RD&D resources outside are available and the results of such RD&D would be applicable in New York despite relatively little specific regional input. This was designated a highly appropriate role in building conservation, transportation, electricity generation, coal utilization, and nuclear waste management.
- Execution, in part or totally, of RD&D by NYSERDA is most appropriate when programs funded and carried out elsewhere are inadequate to meet New York's needs, when NYSERDA has the expertise necessary to design/ manage a program, and budgetary resources are available. RD&D execution was deemed a highly appropriate role in solar energy, building conservation, and pollution control technology.
- Analyses of technical, economic and social factors would appear most appropriate where circumstances are complex, poorly understood, and where such analysis would aid in either internal NYSERDA decision making or critical decision making elsewhere within the State Government. Such analyses can also be useful in attracting federal

RD&D programs into the state. This role appears to be applicable to areas of solar heating and cooling, industrial end-use conservation, coal utilization, and nuclear waste management.

- Information dissemination is highly appropriate in areas where lack of such information contributes to a substantial barrier to technological change and/or where NYSERDA's credibility is an important aid in utilization of information. This appears to be the case in solar heating and cooling, industrial conservation, building conservation, and environmental impact assessments.

It must be emphasized once again that these judgments are not necessarily applicable to every specific technology falling within the selected RD&D areas.

Although we have not yet performed cost/benefit analyses of any programs, it should be pointed out that, relative to the actual performance of hardware RD&D, the latter two types of activities are inexpensive. Furthermore they are, by their nature, oriented to state-specific problems.

F. CONCLUSIONS AND RECOMMENDATIONS

Because vital elements are still missing from this analysis, the preceding material can best be characterized as "benefit" oriented. Without more analysis directed to assessing the relative and absolute costs attached to the listed activities, it is very difficult to draw conclusions regarding expenditure priorities. Nevertheless, one can attempt to use the preceding materials to indicate what will come out of the study once it is completed. Figure VII-8 lists "preliminary priority predictions" leading to the following conclusions:

- High priority RD&D areas for NYSERDA activity lie in the areas of solar energy, energy conservation, and energy/environment interaction. Lower priority is assigned to fossil and nuclear energy. This result follows in large part because of comprehensive federal and private programs in the coal and nuclear areas. In the case of coal, the control technology RD&D area has, however, received a high priority on the basis of its being able to achieve clean coal use with such technologies as fluidized-bed combustion. Coal clean-up appears to be much more important in New York State than increasing coal utilization efficiencies or reducing costs. Despite receiving less than top priority NYSERDA appears to have a moderate priority role in promoting RD&D in coal combustion.

RD&D Area	Overall Importance of Impact in NY	Likely Marginal Impact of NYSERDA Efforts	Most Highly Appropriate NYSERDA Role(s)	Overall Preliminary Priority Predictions a/
<u>SOLAR ENERGY</u>				
Solar Heating and Cooling	M	H	Execute RD&D Analysis Information	H
Process Heat	M	M	Promote RD&D	M
Wind Electricity	L	M	Execute RD&D	L
Biomass Fuels	M	M	Execute RD&D	M
<u>CONSERVATION</u>				
Building End-Use Efficiency	H	H	Promote RD&D Execute RD&D Information	H
Industrial End-Use Efficiency	H	M	Analysis Information	H
Transportation End-Use Efficiency	H	L	Promote RD&D	M
Electricity Generation/ Distribution Efficiency	L	M	Promote RD&D	L
<u>FOSSIL ENERGY</u>				
Coal Liquids	L	L	Promote RD&D Analysis	L
Coal Combustion	M	M	Promote RD&D Analysis	M
Coal Gasification	M	L	Promote RD&D Analysis	L
<u>NUCLEAR FUEL CYCLE</u>				
Waste Management	H	L	Promote RD&D Analysis	M
<u>ENERGY/ENVIRONMENT INTERACTION</u>				
Control Technology	H	H	Execute RD&D	H
Environmental Impact Assessment	H	M	Information	H
<u>ENERGY-RELATED SUPPORTING ACTIVITIES</u>				
Manpower/Education and Training	L	H	--	M
Information Services	H	H	--	H
General System Studies	L	M	--	L
a/ H = high priority M = moderate priority L = low priority				

Figure VII-8. Overall NYSERDA RD&D preliminary priority predictions.

- In conservation NYSERDA has high priority roles in the building and industrial RD&D area. In the building area, the most appropriate roles are promotion and execution of RD&D; in the industry area NYSERDA needs extensive analysis to aid internal decision making. The electricity generation/distribution area received a low priority primarily because widespread utilization of new technologies seems unlikely and there is an extensive non-NYSERDA RD&D effort (even within New York). But, as Chapter IV has indicated, there may be some technologies such as fuel cells which have such ubiquitous applications and benefits that a higher priority may be appropriate. Throughout the conservation area it appears that more disaggregation of RD&D areas are needed to allow more exact conclusions.
- In the solar energy area, NYSERDA has high priority roles (execution, analysis, and information) in solar heating and cooling, and moderate priority roles in solar industrial process heat and biomass fuels. Wind electricity received a low priority primarily because of the low overall importance such generation capacity is likely to have for New York.
- Although both RD&D groups included in the energy/environment interaction received high priority, different roles are anticipated for each. The execution of control technology RD&D is given priority as is the information dissemination of environmental impact assessments.
- The provision of information services was the only activity to receive a high priority in the area of energy related supporting activity. The low priority for general system studies is somewhat misleading because "analysis" appears as the most highly appropriate NYSERDA role in six RD&D areas, leading one to the conclusion that what is needed are very specific as opposed to general system studies.
- Although not falling directly out of the logic of the analysis, it is clear that NYSERDA has an important role in attracting federal (and other funding sources) RD&D programs of the state. As shown in Chapter V the funds for energy research are substantial and major RD&D

projects within the state are of benefit in creating jobs and state revenues even if the technology is no more applicable to New York than other states. If, however, NYSERDA's contribution to the overall RD&D cost of such efforts becomes significant, then relevance to New York's energy future must become a more important consideration.

As a final conclusion we would note that, despite the preliminary nature of our work so far, it has become clear that NYSERDA can make an important contribution to achieving a viable energy system for New York State. Indeed, our analysis of the energy problems that will face the state over the next ten to twenty years indicates an increasingly important role for the types of activities for which NYSERDA has been given responsibility.

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Appendix A

U.S. Energy RD&D Activities

In Chapter VI we presented a summary of energy RD&D activity funded by the Federal Government and by other agencies including NYSERDA. We present further details on those programs in this appendix.

A. Discussion of Selected Federal RD&D Projects

From a seemingly infinite list of RD&D efforts conducted by the federal government, 21 RD&D technologies have been selected which are of particular interest to New York State. (The method of selection of technologies is detailed more fully in Chapter VII of this report.) The 21 technologies by ERDA classification are:

1. Solar Energy/Thermal Applications/Solar Heating and Cooling of Buildings
2. Solar Energy/Thermal Applications/Agricultural and Industrial Process Heat
3. Solar Energy/Technology Support and Utilization/Information Dissemination and Commercialization
4. Solar Energy/Solar Electric Applications/Wind Energy
5. Solar Energy/Fuels from Biomass
6. Conservation/Technologies to Improve Efficiency and End-Use Conservation/Buildings Conservation
7. Conservation/Electric Energy Systems and Energy Storage/Energy Storage Systems
8. Conservation/Technologies to Improve Efficiency and End-Use Conservation/Industrial Conservation
9. Conservation/Technologies to Improve Efficiency and End-Use Conservation/Energy Conversion
10. Conservation/Technologies to Improve Efficiency and End-Use Conservation/Transportation Energy Conservation
11. Fossil Energy/Coal/Liquefaction
12. Fossil Energy/Coal/Direct Combustion
13. Fossil Energy/Coal/Low- and High-Btu Gasification
14. Fossil Energy/Resource Appraisal
15. Nuclear Fuel Cycle R&D and Safeguards/Waste Management (Commercial)
16. Environmental Control Technology
17. Biomedical and Environmental Research/Assessment
18. Energy-Related Supporting Activities/Manpower/Education and Training
19. Energy-Related Supporting Activities/General Technology Transfers
20. Energy-Related Supporting Activities/Information Services/Public Awareness
21. Energy-Related Supporting Activities/General Systems Studies

A brief synopsis of each of the related federal programs included in this section. (1, 2) Each RD&D technology program is described by the principal objective sought, the subprograms or projects involved, milestones and accomplishments related to important subprograms, and funding. This information is important in assessing

Solar Energy/Thermal Applications/
Solar Heating and Cooling of Buildings

Objective: The primary objective of this program is to promote the development and commercialization of solar heating and cooling of buildings where economically and socially viable thereby reducing demand for exhaustible fuel resources currently used in the residential and commercial sectors.

*/
Description of Projects and Funding:

Total budget outlay for this program is \$40,200,000, corresponding to a budget authority of \$45,300,000. Projects conducted under this program include:

	1977 Funding (\$ Thousands)
● Commercial Demonstrations	\$ 12,200
-- At least 40 commercial demonstration projects were conducted during 1976 ranging from systems analysis to retrofitting to installation of new collection systems.	
-- Work continues during 1977 in the areas of technical viability of solar heating in wide variety of commercial building types, information gathering for support of economic viability of solar systems, and establishment of certification procedures in equipment manufacture.	
● Residential	6,300
-- Activities in this area include granting of funds to contractors, development of location matrix, and outlining performance standards for solar energy industry.	
● Research and Development	8,200
-- In addition to providing support for private sector research and development, increased funding will be available in high-risk areas such as:	

* Whenever possible funding for 1977 is given in terms of budget authority for each technology RD&D effort and subprograms which support that effort. Where information is not available for subprograms the total budget authority for operating expenses and capital equipment expenses is given. In instances where budget authority cannot be determined, figures are derived from budget outlays and are so noted.

the types of marginal impact NYSERDA efforts will have in a particular area where Federal Government sponsored RD&D is already being performed.

1977
Funding
(\$ Thousands)

- (1) air heating collectors, high performance collectors and liquid heating collectors,
- (2) solar air conditioning (e.g., Rankine vapor compression machine),
- (3) thermal storage subsystems (i.e., rock bed, phase-change and seasonal storage),
- (4) heat pump, and
- (5) market analysis (including retrofit and passive systems markets).

● Development in Support of Demonstration \$ 7,800

-- Contract procurement of marketable subsystems and systems requiring further development prior to marketing as well as contract system integration, design and development aid in increasing technical capabilities of solar energy systems.

● Capital acquisitions associated with demonstrations 5,700

Milestones:

Solar Energy/Thermal Applications/ Agriculture and Industrial Process Heat

Objective: The overall objective of this program is to develop technologies which use solar energy in an economically competitive manner in grain drying, crop curing, animal shelters, and/or food processing and which supply a sufficient amount of the industry's energy requirement.

Description of Projects and Funding:

The Agriculture and Industrial Process Heat Program budget outlay is \$1,300,000. Subprograms include:

- **Agricultural Program**
 - A wide range of projects from small-scale field to laboratory studies cover research and development in areas such as drying of grains and crops and heating of animal shelters.
 - Information dissemination is provided through USDA bulletins combining solar expertise and agricultural experience of the USDA.
 - Private sector manufacture of viable solar systems is supported by federal funds wherever possible.
- **Industrial Process Heat Program**
 - RD&D efforts are carried out in the technical development of a cost-competitive solar energy system.
 - Federal incentive programs for commercialization and utilization of solar systems are being investigated.

Milestones:

Solar Energy/Technology Support and Utilization/
Information Dissemination and Commercialization

Objective: The purpose of this program is to provide communication and market support of solar energy RD&D efforts and commercialization.

Description of Projects, Milestones and Funding:

The total budget outlay for this program is \$700,000.
Work in this area includes:

- PL 93-473 and PL 93-409 (enacted in 1976) provide for data base (located at ERDA Technical Information Center in Oak Ridge, Tennessee) for national solar energy technical information.
- In 1977 public information projects were started using mass media, seminars, workshops, the Division of Solar Energy, NBS and the Interagency Panel on Terrestrial Application of Solar Energy (IPTASE)
- Studies are being conducted with regard to constraints associated with solar energy and possibilities for incentive programs (legal, economic, or regulatory) to overcome constraints.

Solar Energy/Solar Electric Application/
Wind Energy

Objective: The objective of this program is to stimulate the development of economically viable and dependable wind energy systems capable of providing a significant portion of the nation's energy requirement.

Description of Project and Funding:

Total budget outlay for the wind energy conversion program is \$12,500,000. The following is a sample of projects being conducted in order to meet the objective of this program:

	1977 Funding (\$ Thousands)
● Program Development and Technology	\$ 5,800
-- Based on systems analyses determining user and application requirements as well as cost goals performed in 1975-76, this project will investigate advanced concepts from laboratory tests to field tests in an effort to decrease overall energy output costs.	
● Farm and Rural Systems	1,200
-- This project includes laboratory and field testing of wind systems for heating, refrigeration and irrigation for application studies of small systems for individual farm or rural homes.	
● 100 KW Scale Ssytems	600
-- Construction has been completed and testing begun on a 100 KW unit (the largest windmill in existence) designed by ERDA and NASA Lewis Research Center.	
-- Two units, upgraded to 200 KW ratings, are being fabricated and site selection is being investigated.	
● MW Scale System	3,600
-- Preliminary designs of systems from a few hundred kilowatts to 3 MW have lead to a selection of a contractor, fabrication and site selection for two 1.5 MW systems.	

1977
Funding
(\$ Thousands)

● Large Scale Multi-Unit Systems

\$ 800

- This project includes research to determine the technical and economic feasibility of off-shore systems as well as study of electric stability and aerodynamic interference between wind systems.

Milestones:

Solar Energy/Fuels from Biomass

Objective: It is the objective of this program to develop the photosynthetic production, collection, storage and conversion of organic substances (biomass) into clean, useful fuels.

Description of Projects and Funding:

The budget outlay for this program totals \$3,000,000.

1977
Funding
(\$ Thousands)

● Terrestrial and Marine

\$ 1,300

- Studies encompass analysis of agricultural production methods, silviculture, and marine applications.
- Systems studies are currently being conducted; pilot plant operations are scheduled for FY79; and large scale demonstration facilities are slated for FY86.

● Agricultural and Forestry Residues

1,700

- Systems studies are underway and demonstration facilities are scheduled to be operating between FY82-FY89.

Milestones:

Conservation/Technologies to Improve Efficiency
and End-Use Conservation/Buildings Conservation

Objective: The Buildings Conservation Program is directed at increasing efficiency of energy utilization and providing options for substitute energy forms and technologies which will decrease need for energy without curtailment or further regulation while maintaining the current standards of living.

Description of Projects and Funding:

	1977 Funding (\$ Thousands)
● Total Budget Outlay	\$ 18,410
● Commercial Buildings	3,310
-- FY76 projects initiate development and implementation of energy conservation technologies and methodologies in the following categories: (1) office and retail buildings, (2) development of Model Energy Council, (3) energy conservation in restaurants, and (4) techniques for retrofit in municipal buildings.	
-- FY77 shifts interest to the verification and evaluation of data gathered during the previous fiscal year. Some categories are also expanded along with the gathering of energy conservation data. Bench scale projects involving new technologies will begin.	
● Residential Buildings	2,700
-- FY76 established a data base leading to the commercialization of new retrofit technologies. TVA and HUD conducted an evaluation of the Annual Cycle Energy System (ACES) which explores the use of heat pump and water/ice storage for summer cooling.	
-- FY77 shifts from development to implementation with regard to the retrofit program. Research projects will begin to analyze waste heat technologies application in residential buildings.	

1977
Funding
(\$ Thousands)

- Performance Standards \$ 1,200
 - Consists of legislation initiated during FY76 and includes development of energy efficiency performance standards, model training programs for states and localities, analysis of State Energy Codes and development of low cost computer program for public domain for energy analysis.
- Community Systems 5,700
 - Analysis to determine technology mixes capable of providing most efficient and economic integrated utility system includes such projects as: Integrated Utility System (IUS) Application Project, Campus-Community IUS Project (CCIOUS), Community Utility/Energy Program Systems (CEUS) and Modular Integrated Utility System (MIUS) as well as study of feasibility of substitution of coal for gas and fuel oil and load leveling.
 - FY 77, the City of Pasadena and Pasadena Power Company undertook application of a grid connected system where a total energy system is operated as part of large electric generating and operating system and controlled on thermal demand.
- Urban Waste 1,200
 - FY76 assessment for use of urban waste as fuel for electricity or large central heating systems (including evaluation of power production and heating systems already in existence). The Pompano Beach Project continued work on waste to methane process.
 - FY77 continued methane and methanol production studies and accelerated efforts at community aid.
- Appliances 1,000
 - Program directed at identification and evaluation of technology opportunities for increasing energy efficiency of building components--lighting, insulating, window control and conditioning equipment--includes mandatory labeling and development of operations standards for equipment, study of integrated appliances.
- Technology 2,800
 - Covers the development and evaluation of materials used for thermal control of buildings from standard development, component

1977
Funding
(\$ Thousands)

and systems evaluation, and consumer behavior research related to efficient utilization of energy.

- FY77 demonstration, evaluation and commercialization of a newly designed fluorescent bulb which results in both increased savings by the consumer and reduced impact on the environment.

● Technology Dissemination and Transfer \$ 500

- FY76 develop brochures, guides, seminars, and histories on the various ERDA projects related to buildings conservation for dissemination through outreach programs, extension services, schools and information transfer programs.
- FY77 implement dissemination and technology transfer information programs.

Milestones:

Conservation/Electric Energy Systems and Energy
Storage/Energy Storage Systems

Objective: The overall objective of this program is to improve energy storage systems in power generation (electric utilities, residential, commercial and industrial sites), automotive propulsion systems and inexhaustible energy generation systems (e.g., solar, wind, geothermal) and thereby promote reduced costs of electricity.

Description of Projects and Funding:

Total budget authority for this program is \$22,300,000. Specific projects being conducted are presented below.

- Electrochemical study includes:
 - development of high-performance batteries (e.g., sodium/sulfur, lithium/sulfur, redox, zinc/chlorine and advanced lead-acid batteries) for electric utilities and transportation systems, and
 - identification of electrochemical processes useful in industry conservation of gas and oil (such as involved in the production of chlorine and aluminum).
- Chemical Storage methods are being investigated:
 - study of hydrogen production (including hydrochemical production and high current density water electrolysis) storage distribution and use, and
 - system study related to solar energy, nuclear energy, central station electric storage, transportation, use as an additive to natural gas or as a substitute for natural gas.
- The Thermal Energy Systems Project seeks to develop and demonstrate thermal storage techniques for electric energy systems and transportation applications. It includes seasonal and load leveling storage; thermochemical storage for solar thermal power and heating; retrofitting thermal storage for peaking power to electrical generating plants and high temperature storage for advanced solar thermal power, electrical peak power generation and automobiles.
- Mechanical Energy Storage projects include:
 - the design and fabrication of components for integrated testing of flywheel design to capture energy lost during braking in urban driving;

- field testing of aquifer site, rock formation or salt dome for compressed air storage; and
 - development of technological or non-technological methods of solving environmental problems linked with mechanical energy storage.
- Magnetic Storage is being investigated and design is underway on a 100 MJ model to demonstrate superconducting magnetic energy storage. It is hoped that this system will provide 90-95 percent efficiency for electric utility applications.

Milestones:

Conservation/Technologies to Improve Efficiency
and End-Use Conservation/Industrial Conservation

Objective: The industrial/agricultural sector consumes 42 percent of the annual quantity of energy consumed throughout the United States. The focus of the industrial conservation program is to accelerate and augment industries' incentive toward decreasing energy consumption.

Description of Projects and Funding:

	<u>1977 Funding (\$ Thousands)</u>
● Total Budget Outlay	\$ 9,260
● Unit Operations and Equipment Efficiency	1,800
-- Fuel Combustion: Two projects which are currently underway test the catalytic combustion boiler and the use of multi-sensor instruments for excess air control on industrial boilers. The object of these tests is to increase the operating efficiency of current industrial furnace systems above the standard average (70%).	
-- Heat Exchange: Studies are being conducted on both a high temperature recuperator system and a heat pump system to recover heat lost as stack (flue) discharge.	
● Process Analysis and Modification	1,400
-- Some experiments being conducted on energy balances and materials flow in high energy consuming industries and techniques to reduce energy consumption during such processes include: boiler efficiency program, blended cement program, paper fiber optical imaging program, and oxygen blow blast furnace program among others.	
● Alternative Energy Fuels, Materials and Processes	1,760
-- Determination of the technical feasibility of using coal or waste matter (directly or as derived substances) as fuel for use in industrial processes is an important issue.	
-- Research in methods for waste reduction and recycling waste materials and the use of energy intensive chemical processes to produce energy promise to aid the effort to determine alternate energy sources.	

1977
Funding
(\$ Thousands)

● Agriculture and Food Industries

\$ 2,250

-- This project proposes to increase energy efficiency in agricultural productivity (in planting, tilling, harvesting, and processing) through analysis of structure of agricultural and food processing industries. Major efforts include: textile processing changes, improving fertilizer, and use of microwaves and vacuum in grain drying.

● Industrial Information Technology Transfer and Analysis

2,050

-- Here the emphasis is toward the acceptance of new and unused energy efficient technologies alien to an industry. Dissemination of information has begun through industrial and trade outreach programs, seminars, and interfacing with other federal information transfer programs, e.g., FEA, DOC, DOA, NBS and national laboratories.

● Capital Equipment Obligations (not related to construction)

1,000

-- This category includes the purchase of controls and instruments to maintain, monitor, or improve energy efficiency in various industrial processes.

Milestones:

Conservation/Technologies to Improve
Efficiency and End-Use/Energy Conversion

Objective: The principal objective of this program is to improve existing or develop new technologies or techniques for use in electric energy storage systems, transportation, buildings and industry for energy conversion.

Description of Projects and Funding:

The total budget outlay including capital and operating expenses is \$4,800,000.

- Heat utilization projects investigate the economic and technical feasibility of using low-grade waste heat from industry and utilities in bottoming cycles. Demonstration of feasibility of using high-grade waste heat and high-temperature topping cycle is scheduled for 1980.
- Improved Component Efficiency: Results of initial research necessary to improve efficiency and reliability of components such as compressors, heat-exchangers, pumps, motors, and generators are scheduled to be available in FY77.
- Combustion Technology: Advanced equipment design concepts are being investigated and development begun on the supporting data base from research. Technology utilization and continued assessment of impact on environment, economy and general public well-being will be promoted in the near term.
- Materials and Fabrication Technology
 - Research and development of techniques involving high temperature materials and fabrication technologies (e.g., plastic and metal reclamation processes, use of ceramic components, corrosion resistant materials) is being conducted.
 - Design and development of a catalyst for fuel cells continues.
- Advanced Cycles: The development and demonstration of advanced conversion cycles such as the steam Rankine cycle, the closed Brayton cycle gas turbine, ultra high-temperature conversion machines and fuel cells is being cost-shared by industry.
- Alternative fuels: Programs in this area include research on wood waste conversion, use of methanol in gas turbine combustors, and analyses of low Btu gas available from coal gasification..

Milestones:

Conservation/Technologies to Improve Efficiency and
End-Use Conservation/Transportation Energy Conservation

Objective: The transportation sector is the largest single consumer of petroleum derived products. It is the objective of this program to decrease energy consumption in this sector by increasing end-use efficiency or altering consumption patterns in a timely manner.

Description of Projects and Funding:

	<u>1977 Funding (\$ Thousands)</u>
● Total operating costs plus plant and capital equipment (budget outlay)	\$ 20,690
● Implementation	1,180
-- This subprogram will outline key economic factors which influence the production of energy saving devices by the private sector and will suggest incentives to increase industry participation.	
-- Major component manufacture demonstrations include truck drag reduction devices, retro-fit auto engine electronic computer, Stirling cycle systems and electric vehicles.	
● Heat Engine Highway Systems	12,800
-- Heat Engine Systems: RD&D continues on the gas turbine and the Stirling cycle system, two of the most promising internal combustion engines. Development activities on these engines is being conducted on a cost-sharing basis with industry.	
-- Vehicular Systems: Work in this category encompasses design and testing of engine accessory drive systems, key component fabrication, and waste heat utilization system.	
-- Alternative Fuels: Completed studies in this area include testing of pure methanol, methanol/gasoline blends, and hydrogen use as a fuel for highway vehicles. Work will continue in these areas as well as testing of synthetic gasoline and distillants.	

1977
Funding
(\$ Thousands)

- Electric and Hybrid Highway Systems \$ 3,940
 - The focus of this subprogram is on RD&D in the area of electric propulsion systems (i.e., battery powered electric vehicles or hybrid systems such as a flywheel). The development stage of this project includes compiling performance and cost objectives as well as guideline specifications.
- Non-Highway Transportation Systems 500
 - In conjunction with other federal agencies, ERDA is conducting reserach toward reducing energy consumption in air, rail, water and pipeline transportation systems.
- Technology Studies 1,770
 - This subprogram seeks to identify and evaluate both technology and non-technology oriented methods of reduction of energy consumption. This is principally an information compiling project.
- Improved Conversion Efficiency 4,300
 - Increased efficiency and reliability, use of alternate fuels and waste heat and reduced petroleum use are the principal factors in improved energy conversion. Specific goals of this subprogram include development of material and fabrication techniques, increasing efficiency of combustion devices, use of high and low grade waste heat and increasing efficiency of key components such as pumps, generators and heat exchangers.

Milestones:

PROGRAM ACTIVITY	Fiscal year														1985	BEYOND
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION																
Complete Economic Analysis for New Transport Aircraft			▲													
Complete Economic Analysis and Detail Design of Pipeline Pumping Station with Waste Heat Recovery				▲												
Complete Operational Analysis of Transport Aircraft					▲											
Complete Study of Coal Transport R&D Needs						▲

Fossil Energy/Coal/Liquefaction

Objective: The overall objective of this program is to provide the technical know-how to convert coal to liquid for electric power generation in an economical and environmentally sound manner.

Description of Projects and Funding:

Total federal funding for the liquefaction program is \$73,946,000. Some of the projects described below will be cost-shared with the federal government but private is not included in program cost estimate. Industry's contribution in the form of cost-sharing totals \$15,950,000. Major projects in this category are:

- | | 1977
Funding
(\$ Thousands) |
|--|-----------------------------------|
| ● <u>Direct Hydrogenation</u> - The projects described below differ in reactor design and type of catalyst used to liquefy coal. They are similar in that they all add hydrogen to coal and then catalytically convert it to fuel oil and remove the sulfur. | |
| -- Ebullated-Bed Pilot Plant (H Coal) | \$21,000 |
| -- This project is being cost-shared with a consortium of industrial firms and is scheduled for completion in FY78. | |
| -- Fixed-Bed Hydrogen (Synthoil) | 8,000 |
| -- Operations by Bethlehem Steel began in FY77. | |
| -- Zinc Chloride Catalyst PDU | 2,500 |
| -- Operation is scheduled for FY77 and is cost shared with two major oil companies. | |
| -- Disposable Catalyst Hydrogenation | 500 |
| ● <u>Solvent Extraction</u> uses a hydroaromatic solvent to extract solid or liquid product from coal. In turn, the solvent acts as a host to transfer hydrogen to the coal to increase liquefaction. | |
| -- Solvent Extraction of Lignite | 1,000 |
| -- Costeam Process | 400 |
| -- Chemicals from Coal | 450 |
| -- Donor Solvent Liquefaction | 2,000 |
| ● <u>Pyrolysis</u> involves form of pyrolysis or carbonization which, through destructive distillation, yields a liquid and a char. | |

1977
Funding
(\$ Thousands)

-- Clean Metallurgical Coke/Liquids Three such systems are in operation and data is being gathered to serve as base for future plant design.	\$ 2,500
-- Entrained Pyrolysis	600
-- Flash Liquefaction Bench scale tests are being utilized to help develop larger units. This process appears to be a good option since it employs high feed rates and results in reduced cost.	1,000
-- Hydrocarbonization	1,000
-- Fluid Coke	600
• <u>Indirect Liquefaction</u> - Coal is converted into synthetic gas (carbon monoxide and hydrogen) and then into liquid fuel by catalytic reaction.	13,000
• <u>Supporting Studies & Engineering Evaluations</u>	10,341
-- Engineering supports provide review of projects to evaluate technical and economic practicability.	
-- Other support includes refining methods and two-stage methods of liquefaction.	

Milestones:

Fossil Energy/Coal/Direct Combustion

Objective: It is estimated that the use of coal indirect combustion systems can reduce oil and gas consumption by 6 to 8 quads/year by 2000. In line with this estimation, the objective of this program is to design and develop and utilize fluidized-bed combustion systems fueled by high-sulfur coal, to increase efficiency of existing systems and develop retrofit technologies, and to increase or improve alternatives for direct coal use.

Description of Projects and Funding:

Total budget for direct combustion program is \$52,416,000.
Specific projects under this program are:

	<u>1977 Funding (\$ Thousands)</u>
● <u>Fluidized Bed Boilers, Atmospheric</u>	
-- Fluidized Bed Boiler, 30 MW	\$ 3,000
-- Industrial Applications High- and low-pressure steam generation and air and industrial product heaters will be studied to determine economic and technical feasibility. This project is being cost-shared throughout construction and operation stages.	10,000
-- Modular Integrated Utilities System (MIUS) Authorized by PL 91-609, this program demonstrates combined processing plants using residual or recycled energy to provide heat, air conditioning, and electricity within a community.	1,700
-- Component Test and Integration Facility (CTIF) This project will test intermediate sized fluidized-bed combustion system components. Fabrication and field construction are scheduled for FY77 and operation will begin the following year.	9,000
-- Plant conversion	1,100

● Pressurized Systems

- Fluidized Bed Combined Cycle Plant, 13 MW \$ 6,500
This project will be cost-shared and is designed so that operating, engineering, economic and environmental data can be evaluated through the prototype module.
- Pressurized Fluidized Bed Component Test and Integration Facility (CTIF) 8,000
- Granular Bed Filter 1,500

● Support Studies and Engineering Evaluations

11,616

- Engineering studies will be conducted on emission characteristics and slagging and corrosion characteristics at Morgantown and Pittsburgh Research Centers.
- Systems analyses and feasibility studies will be conducted as a preliminary step toward establishing an analytical model of the elemental processes involved in fluidized-bed combustion in boilers.
- Coal-based fuel combustion will be investigated as a near-term method of reducing oil use.
- ERDA is cooperating with the International Energy Agency (IEA) to test a pressurized industrial boiler in the United Kingdom.

Milestones:

Fossil Energy/Coal/Low-
and High-Btu Gasification

Low-Btu Gasification

Objective: The overall objective of this program is to provide technologies for the design and demonstration of conversion of domestic coal resources to low-Btu gas for electric power generation, industrial and process heat applications and chemical feedstocks and to support the commercialization of this process toward market saturation by the mid-1980s.

Description of Projects and Funding:

Total budget authority for this category is approximately \$33,052,000.

	1977 Funding (\$ Thousands)
● Fixed-Bed PDU* (Atmospheric)	\$ 2,700
-- Preliminary design and economic assessment is scheduled for completion in FY 1976. This is an extension of work begun previously in Morgantown, West Virginia.	
-- At Grand Forks Energy Research Center a fixed-bed producer will be reactivated and slagging mode studies resumed.	
● Fluid-Bed PDU (Pressurized)	1,700
-- One ton per day PDU is scheduled to be completed in FY 1976. PDU operations will be conducted for two years and followed by a performance review.	
-- A two-stage pressurized fluidized-bed gasifier with integral sulfur removal (limestone injection as the solvent for hydrogen sulfide) is underway at Westinghouse Laboratory.	
● Entrained-Bed PDU (Atmospheric)	500
-- Final design is scheduled for completion in FY 1977. Fabrication systems will start in that fiscal year for the test facility. This project is shared on a ratio of two to one, government to industry, respectively.	

* Process Development Unit (a research unit slightly larger than laboratory scale).

1977
Funding
(\$ Thousands)

- Combined Cycle Pilot Plant \$ 16,500
 - A pilot plant to test combination of the gasification and gas purification units with gas turbine electrical generating units will be constructed during FY 1977. This project is being cost shared--two-thirds government and one-third industry.
- Molten Salt PDU (Pressurized) 1,000
 - The project involved is being cost shared on a two-thirds government, one-third industry basis. Development and pilot gasifier work have been initiated.
- Hydrogen Production 5,000
 - Under a program of co-funding this project's principal goal will be design, construction and operation of a developmental unit to produce hydrogen from coal.
- Support Studies and Engineering Evaluations 5,652
 - Engineering support includes assistance in proposal evaluations, process selection, budgeting, engineering designs and collection, evaluation and transfer of data.
 - Hot Gas Cleanup include cleanup with molten salt (scrubber system for the removal of fly ash and sulfur compounds) and iron oxide (for the removal of hydrogen sulfide and particulates).

Milestones:

High-Btu Gasification

Objective: The objective of this program is to improve those technologies required to produce high-Btu gas from coal in order to create substitute natural gas at decreased costs and greater efficiency.

Description of Projects and Funding:

	1977 Funding (\$ Thousands)
● Total budget authority (approximate)	\$ 45,054
● HYGAS Process - increases yield of methane from coal within hydrogasifier operating at high pressure.	3,000
-- Pilot plant was completed in 1971.	
-- Steam-oxygen system for generation of heat and hydrogen during the hydrogasification of coal was fitted during 1974.	
-- Long-duration tests were conducted during 1975. Testing should be completed during FY 1977, providing data to establish feasibility for gasification of lignite, sub-bituminous and bituminous coals.	
● Carbon Dioxide Acceptor Process	2,333
-- Pilot plant which uses the exothermic heat of calcium oxide and carbon dioxide reaction to fuel the gasification reaction was developed and completed in 1971.	
-- A methanation unit was constructed next to the gasification plant during FY 1975. Testing of these operations should be completed in FY 1977.	
● BI-GAS Process - is the only slagging-type gasifier being tested under this program.	10,000
-- A large-scale, 5 ton-per-hour pilot plant was built in FY 1975 and FY 1976. Experimental operations will begin during FY 1977.	
● Self-Agglomerating Fluidized Bed, Two Stage Process	2,227
● Synthane Process	10,500
-- This process has several attractive features. First, it can handle any rank of coal; second, the high degree of simplicity results in good	

1977
Funding
(\$ Thousands)

operations with high reliability; and third, 60 percent of the methane is formed in the gasifier, reducing both oxygen required and additional cost for methanation equipment.

-- A pilot plant was built during FY 1975; experimentation will be continued through FY 1977.

- Hydrane Process - currently at bench-scale development, this process produces about 95 percent of the methane in the hydrogasification reactor from coal. This is a very economical process for coal conversion to substitute natural gas. \$ 1,800

- Steam-Iron Process - investigates economical production of hydrogen necessary for the HYGAS Process. 4,800

- Support Studies and Engineering Evaluation 10,394

-- Engineering evaluation includes gathering data necessary to determine pros and cons of competing processes, to determine combinations of processes which are most economical, and to determine development areas which will make available technical data, materials and equipment necessary to construct a commercially viable high-Btu gasification plant.

-- Hydrogen generation studies are being conducted to determine the operational parameters on the generation of hydrogen through steam gasification of residual char, including bed depth, geometric ratios, steam/oxygen ratios, temperature, and pressure.

-- Equipment required for the various tasks involved in gasification is being developed. Much of this equipment does not currently exist and therefore new designs must be tested and proven before commercialization. Grinders, pumps, valves, filters, separators, power recovery turbines and many others are among the equipment currently being tested.

-- Materials are also being developed and tested which are capable of withstanding the stringent conditions of the gasification process.

Milestones:

Fossil Energy/Resource Appraisal

Objective: In an effort to expand the domestic supply of recoverable raw materials capable of producing energy (e.g., coal, petroleum, natural gas, oil shale, etc.), this program seeks to develop reliable and economical methods for evaluation, detection, and recovery of these resources.

Description of Projects and Funding:

Total federal energy RD&D budget authority for this program is \$17,200,000. Projects being conducted in this area include:

- U.S. Geological Survey conducts on-going appraisal of coal resources including geology, geophysics, geo-chemistry and hydrology.
- In cooperation with the U.S. Geological Survey, 16 of 37 coal states have participated in resource assessment and environmental impact studies.
- Study of sedimentary basins, on and offshore, provide data for oil and gas resource appraisal. Seismic reflection recording equipment and digital computers are used to detect oil and gas.
- Maps are being compiled by the U.S. Geological Survey to depict resource areas for oil shale and related minerals.
- Water supply and environmental impacts of coal and oil shale mining are being studied.

Milestones:

Nuclear Fuel Cycle R&D and Safeguards/
Waste Management (Commercial)

Objective: In order to insure and enhance the general health, safety and welfare of the public and to protect the environment, the DOI and NRC are actively participating in this program. The NRC has as its principal goal the development of sound regulations for the handling and disposal of waste from nuclear fuel processes. The DOI must, on the other hand, investigate and determine optimal land-fill sites for low level radioactive waste.

Description of Projects and Funding:

The criteria for government acceptance and storage of radioactive waste materials from commercial sources is delineated in 10/Code of Federal Regulations 50, Appendix F. Total funding for this program is \$82,300,000.

- Technical information exchange is maintained by ERDA and NRC with a large number of international nuclear energy organizations..
- Field investigation (at 4 sites) of migration of low-level solid radioactive waste is being conducted (DOI).
- DOI is compiling hydrologic data on the Nevada Test Site.
- Site selection is being investigated in the areas of disposal of low-level liquid radioactive waste and terminal storage of commercial nuclear waste materials.
- Criteria (or recommended criteria) for waste form and packaging is scheduled to be completely delineated by 1978.
- Industrial plant-scale testing of vitrification techniques for high-level waste is slated to begin in 1978.

Milestones:

U.S. DEPARTMENT OF THE INTERIOR

ENERGY RESEARCH AND
DEVELOPMENT ADMINISTRATION

NUCLEAR REGULATORY COMMISSION

Key to symbols:

▽ Significant milestones	△ Estimated completion date of program activity	◇ Slippage	→ Continuing activity	C : Construction start	R : Research start
* Administrative decision point		Date of Information	--- Completed activity	D : Demonstration start	S : Studies start
					T : Test start

Environmental Control Technology

Objective: The environmental control technology program serves as a protector of the environment and the general well-being of the public while increasing energy efficiency and reliability of conversion and delivery systems by the continuing evaluation of environmental control technologies.

Description of Projects and Funding:

The total budget authority for this program (including EPA and DOI) is \$72,000,000.

- **Environment-Energy Information Systems:** The following matrix represents a preliminary inventory of environmental control technology programs in ERDA and other federal agencies.

TECHNOLOGY	FOSSIL	NUCLEAR	CONSERVATION	SOLAR/GEOTHERMAL
Agency: Activity				
DOI (Bureau of Mines, USGS)	<ul style="list-style-type: none"> • Demonstrate effectiveness of citrate process for scrubbing sulfur oxides from High-Sulfur Coal Burning Power Plants 	<ul style="list-style-type: none"> • Conduct nuclear hydrology programs to deal with disposal of high-level and low-level radioactive waste 		
EPA	<ul style="list-style-type: none"> • Physical and Chemical Coal Cleaning-Assess environmental impacts and develop advanced processes and associated control equipment (DOI support) • Identify impacts and propose means to quantify and control effects of advanced energy conversion cycles (MHD, open and closed cycle gas turbines, etc.) • Determine impacts of Synthetic fuel production as a basis for control technology, performance requirements (with ERDA) • Develop thermal pollution control options for fossil-fueled power plants (with TVA) • Assess impacts of utility and industrial combustion as a basis for standard setting and development of flue gas control technology for fine particulates, sulfur oxides, 	<ul style="list-style-type: none"> • Develop Thermal Pollution control technology for Nuclear Power Plants (with TVA) • Assess environmental impacts of nuclear cycle wastes and effluents 	<ul style="list-style-type: none"> • Assess impacts and develop control support process development activities for: <ul style="list-style-type: none"> —waste recovery —indoor air quality —energy conserving industrial processes —advanced energy conversion cycles • Develop technology to convert municipal and industrial waste to usable energy 	<ul style="list-style-type: none"> • Assess environmental effects to support development of standards, control technology, and siting guidelines for geothermal • Characterize both indirect and direct impacts of solar systems

TECHNOLOGY	FOSSIL	NUCLEAR	CONSERVATION	SOLAR/GEOTHERMAL
Agency: Activity				
EPA	<p>nitrogen oxides and hazardous pollutants and controls for water and solid waste effluents from these systems</p> <ul style="list-style-type: none"> Determine and assess the land and water impacts of commercial mining operations for coal, oil, gas and oil shale 			
ERDA	<ul style="list-style-type: none"> Assess and minimize environmental impacts of coal gasification, liquefaction through development of process modification, hot-gas cleanup systems and other control technology systems Demonstrate the environmental acceptability of coal and oil shale conversion processes prior to commercialization Investigate environmentally attractive technologies such as MHD and fluidized bed: Develop stack gas cleanup technologies Develop analytical tools to measure trace elements and to characterize by products of coal conversion as a basis for control technology development 	<ul style="list-style-type: none"> Define environmental impact and develop standards for construction and operation of various nuclear concepts Develop large-scale dry cooling systems for nuclear reactors Minimize impacts from power plants supplying power to separation facilities Identify and develop safe technology for nuclear fuel cycle Investigate reactors such as thermal reactors which are environmentally attractive Develop methods for safe transport and disposal of radioactive wastes 	<ul style="list-style-type: none"> Assess environmental impact of alternative high capacity transmission systems and develop environmental criteria Develop environmental controls for systems designs to convert wastes to fuel Insure end-use conservation options are environmentally acceptable 	<ul style="list-style-type: none"> Determine environmental impacts of geothermal systems and develop control technology for gaseous emissions subsidence and other identified problems Identify potential environmental effects of <ul style="list-style-type: none"> large multi-unit wind energy conversion units solar thermal power plants ocean thermal energy conversion systems production of fuel from biomass solar heating and cooling minimize impacts in technology developments
TVA	<ul style="list-style-type: none"> Evaluate methods to reduce thermal impacts at fossil fueled power plants (with EPA) Characterize and/or reduce volume of wastewater and develop more efficient waste handling systems for coal-fired utility boilers Assess and develop concepts for NO_x, fine particulate control at fossil plants. Characterize trace elements impacts Develop and demonstrate both regenerative and non-regenerative flue gas desulfurization systems 	<ul style="list-style-type: none"> Evaluate methods to reduce thermal impacts at nuclear power plants (with EPA) Develop techniques for prediction and control of shut-down radiation levels in boiling water reactors 		

TECHNOLOGY	FOSSIL	NUCLEAR	CONSERVATION	SOLAR/GEOTHERMAL
Agency: Activity				
TVA	<ul style="list-style-type: none"> • Investigate strip mine reclamation techniques and monitor sites for recovery 			
DOA	<ul style="list-style-type: none"> • Develop reclamation technology and land management in potential mining areas • Develop technologies for reclaiming lands affected by mining including overburden analysis; redeposition; control of run-off, sedimentation and chemical pollution of surface and subsurface waters; soil amendments; development of plant materials for revegetation; and field demonstrations of the total reclamation process-planning, extraction, reclamation. • Develop criteria for environmentally and economically feasible systems for development 			

- Environmental Control and Waste Management Survey and Assessment
 - Survey energy development activities and maintain balance between environmental control function and health/environmental standards criteria.
 - Evaluate Environmental Impact Assessments and Statements and supplement energy technology programs where necessary.
 - Identify and develop alternative control systems.
- Energy Systems Materials Transport Survey and Assessment
 - Evaluate fuel and waste transport safety (in terms of environmental impact and risk analyses) including packaging and transporting nuclear materials.
 - Determine energy system materials transport standards and criteria.
- Disposal of Surplus Contamination Facilities

Milestones:

Biomedical and Environmental Research/Assessments

Objective: The Environmental and Safety Assessments program consists of four basic functions: policy analysis, overview management, EIS monitor, and review and integrated assessment. The emphasis of the program is on the environmental, health, and safety considerations pertaining to all ERDA activities.

Description of Projects and Funding:

The total budget authority for this program is \$26,400,000. Projects being conducted under this program are:

- Environmental Policy Analysis: This project compiles analyses of energy policy with regard to toxic substances, pollutants, water and air quality and radiation standards.
- Overview Management
 - Technical liaison agreements between federal agencies for data exchange, systems monitoring and RD&D support exist under this subprogram. One of the goals is to expand liaison to include state and local governments.
 - Environmental Development Plans are being prepared through interagency review in order to identify and suggest solutions to environmental issues for each energy technology.
- EIS Monitor and Review: This project includes preparation of guidelines and review and approval criteria.
- Integrated Assessment
 - Technical requirements documents to establish annual assessment priorities will be developed under this project.
 - An assessment of cost/risk/benefit factors of alternate energy development programs in the areas of fossil fuels, nuclear, solar/geothermal and conservation on a national and regional level is being conducted. The National Coal Assessment program is the first such study to be produced.
 - An evaluation of national scenarios which include alternative energy development on the basis of cost/risk/benefit is being made. In FY 1977 methodology for developing alternative energy approaches will be finalized. This methodology will include consideration of the effects of technical, legal, and environmental controls. In FY 1978 and FY 1979 recommendations for alternate energy approaches, increased or revised RD&D, policy changes will be finalized on both local/regional and regional/national levels.

The following matrix depicts the preliminary integrated assessment activities of federal agencies other than ERDA.

TECHNOLOGY	FOSSIL	NUCLEAR	CONSERVATION	SOLAR/GEOTHERMAL
Agency:	Activity:			
DOI	<ul style="list-style-type: none"> • Assess coal and oil-shale mining related hydrological problems and water-control measures in specific situations • Model physical and social impacts of western coal developments 			
DOC	<ul style="list-style-type: none"> • Investigate impacts of petroleum importation and outer continental shelf development 			
EPA	<ul style="list-style-type: none"> • Examine interactions between public and private sectors in assessing and mitigating environmental impacts and identify R&D and commercial gaps. • Evaluate environmental impacts of both energy-related and non-energy-related activities as a basis for determining necessary standards and control measures. • Disseminate information which has been developed on the costs, benefits, and risk of energy activities through symposia, manuals and conferences. • Evaluate existing regional studies in order to correlate health effects with ambient pollutant levels. • Coordinate the design of a national environmental R&D information system. • Develop economic projection models, electric power system models and computer simulations of site specific environmental impact data. • Evaluate economic, social, and cultural consequences of coal and oil shale development. 			
FPC	<ul style="list-style-type: none"> • Develop more effective procedures for identifying environmental impacts of energy facilities 			
TVA	<ul style="list-style-type: none"> • Develop computer model to predict residual outputs from the power system on a plant/plant basis 			
WRC	<ul style="list-style-type: none"> • Assess water requirements and supply availability • Identify water and land resource problems on a state/regional basis 			
DOA	<ul style="list-style-type: none"> • Evaluate costs of alternative reclamation technologies and uses of mined land • Assess current coal and oil shale resource use • Determine the impacts of energy development on employment, income, population, local government and services • Assess impacts of site selection on land and water resources and prepare guidance for state and local authorities on methods of mitigating impacts 			

Milestones:

Energy-Related Supporting Activities/Manpower/
Education and Training

Objective: The overall objective of this program is to aid in the education and training of sufficient manpower to support energy RD&D in both the skilled and the professional job areas.

Description of Projects and Funding:

Total funding for this program including plant and capital equipment as well as operating expenses is \$3,100,000. This figure represents budget outlay. Specific projects included in this program are listed below.

- An energy and environmental training program for managers of nuclear power projects is being conducted on an international basis with the support of the International Atomic Energy Agency.
- Federally supported education programs are being coordinated through interagency agreements to assure uniform and cooperative planning.
- Workshops are being conducted for the continuing education of high school and college instructors.
- The Puerto Rico Center for Energy and Environmental Research (University of Puerto Rico and Division of Biomedical and Environmental Research and Physical Research) offers training and research sharing opportunities for scientists, engineers and other professionals.

Energy-Related Supporting Activities/
General Technology Transfer

Objective: As an extension of basic RD&D in development of energy-related technologies, this program will seek to provide through government support a link to assure rapid absorption and utilization by the private sector.

Description of Projects and Funding:

Total budget outlay funding for this program (including both plant and capital equipment and NASA funding) is \$3,400,000. Examples of individual projects are given below.

- Information transfer programs such as Public Awareness and Technical Information Services make federal RD&D results available to the private sector.
- A Task Force on Demonstration Projects has been established in ERDA to recommend specific structures for demonstration projects in order to maximize speed of commercialization process.
- Incentive programs are being investigated, implemented and evaluated to identify those incentives which will best serve the interest of all parties toward the end of benefit to the public.
- Six ERDA laboratories are manned with Technology Utilization (TU) representatives who assist state and local governments and industry in the utilization of federally developed technologies or techniques.
- The National Bureau of Standards (NBS) provides a screening and evaluation of all invention proposals from the private sector dealing with energy-related technologies.
- NASA (budget outlay \$1,400,000) identifies energy-related technologies within their program activities (e.g., ground propulsion, fuel cells, hydrogen, gas turbines, etc.) and, if appropriate, develops plans and forwards them to the federal agency with responsibility for that particular area of the energy field.

Energy-Related Supporting Activities/
Information Services/Public Awareness

Objective: The objective of this program is to enhance public awareness and comprehension of federal RD&D efforts in the energy field, of the energy crisis and of alternatives available in the resolution of energy related problems.

Description of Projects and Funding:

The total funding for this program is \$3,200,000.

● Department of Agriculture

- Prepares and distributes brochures, fact sheets, publications, press releases, radio and television announcements and slide and film shows on energy use and conservation methods applicable in agriculture, rural communities and households.
- Coordinates education and demonstration programs with other federal, state, and private agencies.

● ERDA

- Informs public of issues relative to energy research and development policy, plans, programs, contracts, decisions, etc. through a wide variety of media. For example, it is estimated that 2.5 million elementary and secondary school students receive ERDA literature in the course of their studies; that over 350,000 people participate annually in ERDA sponsored workshops and seminars; that over 7 million people visit ERDA exhibits or demonstrations each year; and that radio, television or film clips are viewed by over 29 million people.
- Participates in cooperative programs with civic, labor, environmental and other groups to exchange information on energy issues.

● FEA

- A public service advertising campaign is currently being conducted to inform the public of the energy crisis and alternative solutions.
- A concentrated effort is being directed toward youth education through school systems and youth organizations.

Energy-Related Supporting Activities/
General Systems Studies

Objective: The principal objective of this program is to compile the data required and to develop the techniques necessary to support national energy RD&D planning, decision making, resource allocation, assessment and program evaluation.

Description of Projects and Funding:

Total budget outlay for this program is \$13,000,000.

- An international forum for the exchange of ideas and program data exists between ERDA, the International Energy Agency (IEA) and the International Institute for Applied Systems Analysis.
- The Department of Agriculture's program, through the use of the Department of Commerce's input/output model can assess the energy-related activities in over 65 subsectors of food, fiber, and forest products thereby enabling proper policy evaluation of supply/demand of food and fiber and the impact of policy decisions on the rest of the economy.
- ERDA
 - In relation to budget commitments cost/risk/benefit judgements are made to establish priority projects.
 - Documentation is prepared of all ERDA planning and program areas for review by Congress and the public.
 - Several analytical tools are used in order to implement decision-making. Two such projects are:
 - (1) Energy/Economic/Environmental Modeling and Interfuel Substitution Studies - to examine alternative energy RD&D and policy and to project demand/supply by type of energy and end-use.
 - (2) Constraint Analysis - to determine resource input problems associated with a given energy technology and to compile a data base of necessary resources (i.e., labor, materials, equipment, etc.)

- Department of Interior
 - Bureau of Mines - provides histories and current data which depict the quantities and areas of energy needs.
 - Geological Survey - records types and quantities of non-energy materials needed by the energy industry.
- National Science Foundation
 - Energy Resource Analysis - evaluates the current supply of domestic energy resources in light of demand projections and potential impact on domestic and international, environment, employment, productivity and resources.
 - Comparative Systems Analysis - evaluation of technical and economic options available in the production of electricity and impact of pricing schedule on energy sector.
- Federal Energy Administration -- The FEA activities focus on those energy problems which potentially endanger the national security and/or general welfare. A demographic modeling system which depicts industrial location, population and state/local government activity as a function of energy price and supply, an end-use consumption data base and a data base of international energy flow systems are three examples of FEA projects.
- Federal Power Commission - produces reports and publications which assess sources and uses of energy, analyse the effectiveness of regulation, and explain the energy issues relating to public utilities as part of its function as a regulatory agency.

B. Programs of the Electric Power Research Institute (EPRI)

The programs of EDRI were summarized in Chapter VI. A more complete description is given in Table A-1.

Table A-1⁽³⁾

EPRI Program Objectives and Milestones

<u>Technology Approach</u>	<u>Program Milestones</u>
Objective: Increase environmentally acceptable use of coal for electric power generation.	
Water treatment/solids disposal:	
Scrubber Sludge Landfills	Prepare guidelines for disposal site selection/preparation (1979)
Bifouling Control	Demonstrate preferred alternatives to chlorination (1979)
Scaling and Corrosion Control	Demonstrate trace element control (1979)
Particulate control:	Develop a device which is 99.5% efficient with low conductivity ash (1979)
NO_x combustion controls:	Develop technologies for NO _x removal to meet 100-200 ppm requirements (1980)
SOX controls:	
Intermittent Control	Develop technical basis for applying intermittent controls (1977)
Throwaway Scrubbing	Full scale testing to improve reliability (1978)
Regenerable Scrubbing	Construct 20-50 MW pilot scale plant (1980)
Fluidized Bed Combustion	Construct demonstration plant (1982)
Coal Cleaning:	
Mechanical Cleaning	200 T/D demo (1980)
Chemical Cleaning	200 T/D demo (1980)
Coal Liquefaction:	
Solvent Refined Coal (solidfaction)	6 T/D Wilsonville pilot plant process evaluation (1977)
H-Coal Process	Construct 250-600 T/D Cattleettsburg pilot plant (1978)
EDS Process (Exxon)	Construct 250 T/D pilot plant (1979)
Technology Improvements	Develop improved catalyst (1978); Upgrading of coal liquids (1978)
Coal Gasification:	
Fuel Grade Methanol/CDF	Construct 25 T/D pilot plant (1978)
Lurgi with Gas Turbine	Construct 25 MW Powerton combine cycle (1978)
Slagging Fixed Bed	Complete Westfield pilot program (1977)
Entrained Gasification	Complete testing at Texaco 15 T/D pilot plant (1978)
Entrained Gasification	Construct 5 T/hr Combustion Engineering pilot plant (1977)
Objective: Ensure efficient use of fossil fuels.	
Improved Gas Turbines	Provide guidelines for improved operation and control (1979) Demonstrate engine which will operate at 2600-3000° F range (1983)
Improved Steam Turbines	Evaluate and demonstrate subsystems for steam turbine driven power plants (1976-1981)
Advanced Fossil Fuel Cycles such as MHD	First generation OCMHD Test Facility and equipment tests complete (1980) Complete market assessment for advanced, dispersed generating units (1977)
Fuel Cells	Demonstrate FCG-1, 4.8 MW module (1979); Verify technology, 100 KW level (1980)

Table A-1 (cont'd)

EPRI Program Objectives and Milestones

<u>Technology Approach</u>	<u>Program Milestones</u>
Objective: Develop technologies to use essentially unlimited resources.	
Solar:	
Solar Heating and Cooling of Buildings	Construct residential houses (1977-1980); Demonstrate commercial applications (1979-1981)
Solar Electric:	
Solar Thermal Conversion	Construct 10 Mwe (equivalent) gas cooled central receiver pilot plant (1981)
Photovoltaic Energy Conversion	Requirement and impact analyses complete (1977)
Solar Related Systems	Environmental and impact analysis complete for wind, ocean, thermal gradient, biomass (1977)
Geothermal:	
High/Low Salinity Hydrothermal Resources	Construct 50 MW demonstration plant (1980)
	Complete evaluation of high salinity technologies (1981)
Dry Steam Resources	Prove concept for selective removal of non-condensable gas from geothermal steam (1980)
Geopressure Resources	Complete design of geopressure demonstration plant (1981)
Fusion:	
Fission-Fusion Systems	EPRI/USSR program for testing hybrid blanket modules (1980)
Electromagnetic	Design of pilot plant (1982)
Laser	Assess technologies (1977-1982)
Objective: Provide systems that permit economic storage of energy.	
Mechanical Energy Storage:	
Compressed Air	Complete preliminary design (1979); Utility decision (1980); Evaluate advanced CAS (1979)
Underground Pumped Hydro	Complete preliminary design (1979); Utility decision (1980)
Thermal Energy Storage:	
Before Meter	
Latent Heat	Complete assessment (1977)
Sensible Heat	Complete preliminary design (1979); Utility decision (1980)
After Meter	
Heat Pump/Solar/Storage HVAC System	Develop improved design for Northern climates (1979)
Chemical Energy Storage:	
Lead-Acid Battery	Determine economic viability (1977)
Zinc-Chlorine Battery	Full scale cells (1978); BEST prototype (1980)
Sodium-Antimony Chlorine Battery	Full scale cells (1978); BEST prototype (1981)
Sodium-Sulfur Battery	Full scale cells (1978); BEST prototype (1981)
Lithium-Metal Sulfide Battery	Full scale cells (1977); BEST prototype (1980)
Zinc-Bromine Battery	Determine Technoeconomic Prospects (1977)
Battery Energy Storage Test Facility	Design (1976); Complete construction (1979); Start first advanced battery tests (1980)

Table A-1 (cont'd)

EPRI Program Objectives and Milestones

<u>Technology Approach</u>	<u>Program Milestones</u>
Objective: Develop efficient electrical systems and equipment designed to conserve resources.	
Overhead Transmission Lines AC/DC:	
Line Design and Improvements	Demonstrate compact transmission lines for right of way conservation (1979)
Advanced Overhead Systems	Complete UHV electrical research to 1500 kv (1979) (UHV)
	Publish preliminary design studies on +600 to +1200 kv overhead dc lines (1979) (DC)
Transmission Substations AC/DC:	
Switchgear	Field test prototype 230 kv fault current limiter (1978)
Transformers/Reactors	Develop in-place hot-spot detectors (1978)
Capacitors	Complete study of large tank-type capacitors for use in reactive power sources (1979)
Insulation Systems	Lab test 500 kv, 4000 a, heat-pipe cooled epoxy bushing (1977)
Controls and Protection	Fabricate prototype 500 kv instrumentation for gas-insulated substation
Gas Insulated Equipment	Develop alternative dielectric gases (1980)
AC/DC Converter Terminals	Demonstrate compact, gas insulated, ac/dc terminal (1978)
Arrestors	Demonstrate improved surge arrestor to reduce BIL on lines (1981)
Underground Transmission AC/DC:	
Cable System Improvements (Taped, Extruded, Gas, DC)	Laboratory testing finalized for 800 kv semi-synthetic tape cable (1978)
	Laboratory testing of 345 kv extruded dielectric cable (1977)
	Demonstrate flexible, gas-insulated, 345 kv cable (1979)
Advanced Underground Systems (Superconducting)	Completion of 10 meter lengths NB ₃ GE tape to operate at T greater than 12°K
Installation, Operation and Maintenance Methods	Increased cable pulling length criteria available (1977)
Distribution:	
Overhead Lines	Develop two synthetic materials as a replacement for wood power poles (1979)
Substation Equipment	Develop hybrid (vacuum and gas) breaker (1977); Develop transformer with advanced cooling/insulation (1979)
Underground Systems	Define thermal limit for cable insulation (1978)
System Development:	
System Control and Automation	Complete demonstration of communication systems for automatic meter reading, load management and fault detection (1978)
Improved Planning Methods	Complete distribution load forecasting study (1978)
Transient and Fault Management	Complete measurement and analysis of transients and fault currents in distribution networks (1978)
Rotating Electrical Machinery:	
Conventional Large Generators and Motors	Improve metallurgy for large casting and forgings (1978)
Superconducting Machines	Complete two competitive designs for a 300Mva superconducting generator (1977)
Objective: Ensure environmental protection and public safety in the transmission and distribution of electric power.	
Line and Substation Design	Demonstrate use of low voltage underbuild to modify UHV electric fields (1978); Publish data on RI, TVI and audible noise for +1200kv (dc) lines (1979); Report design criteria for 138kv compact transmission lines (1976)
Construction and Maintenance Methods	Complete research on chemical treatment as an alternative to tree trimming (1978)
Substitute Materials	Develop non-flammable substitute for PCB insulating fluids in distribution transformers (1980)

Table A-1 (cont'd)

EPRI Program Objectives and Milestones

<u>Technology Approach</u>	<u>Program Milestones</u>
Objective: Develop technology to maintain reliable electric service.	
System Simulation Tools	Demonstrate a computer code for simulating the dynamic response of an electric network (1978)
Computational Technology	Develop new computing methods based on micromachines (1985)
System Reliability Analyses	Develop data base and methods for composite system analysis (1980)
Component Modeling	Develop new synchronous machine and boiler models (1980)
System Dynamic Testing	Provide for system dynamic testing (1981)
Objective: Minimize the environmental and health effects of electricity production and use without prohibitive economic burden.	
Assessment of environmental and health effects:	
Identification, Characterization and Monitoring of Pollutants	
Remote Sensory Systems	Demonstrate remote sensory systems (1976)
Analytical Procedures	Sulfate and nitrate evaluation (1976); Organic compounds analysis (1979)
Compound Identification	Polycyclic organic materials identification study (1980)
	Sulfate monitoring demonstration (1978); Particulate identification (1976)
Transport and Interactions	
Regional Analysis	Complete regional sulfate experiment analysis (1979)
Individual Plant Analysis	Complete laboratory and field experiments on power plant plumes (1978)
Formation Mechanisms	Determine major mechanisms for the formation of sulfates, nitrates, and oxidants (1978)
Modeling and Supporting Studies	Link environmental and economic models (1978)
Effects on Ecological Systems	
Water Pollution	Identify effects on aquatic systems of cooling towers (1976)
	Acidic inputs (1979)
Land Pollution	Investigate acid rain effects (1979)
Transmission Effects	Initial investigation of high voltage field effects (1977)
Effects on Human Beings	
Fossil Fuel Combustion Products	Complete fly ash toxicant testing (1976); and trace element studies (1977)
High Voltage Electric Fields	Evaluate effects on primates and swine (1978)
Cost/Benefit and Cost Effectiveness Analysis	
Advanced Systems	Complete environmental assessment of 2 solar power systems (1977)
	Environmental and social cost of advanced technologies (1977-1982)
Fossil Fuel Plants	Evaluate health effects associated with coal conversion and combustion (1977-1980)
Beneficial Uses of By-Products of Electricity Generation	Pilot studies of scrubber sludge, fly ash and waste heat utilization (1981)
Data Bases	Develop data bases for health effects, (thermal pollutants, high voltage) field effects (1976-1981)
Improve Environmental Impact of Utility Systems	Coal plant modification; Coal processing T&D
Objective: Promote the efficient use of energy and the conservation of irreplaceable resources.	
Assess Impact of Conservation on Demand	Evaluate impact of conservation oriented technical change and public policy on electric power use
Improve Energy Efficiency in End-Use Devices	Assess potential research needs in industrial processes and climate control of buildings (1977)
Develop Technologies for Load and Supply Management	Identify potential approaches in demand control and customer energy storage (1977/78)
Develop Efficient Systems to Affect Energy Substation Displacement	Assess applications and initiate work in climate control, industrial processes and electric vehicles (1977/78)

Table A-1 (cont'd)

EPRI Program Objectives and Milestones

<u>Technology Approach</u>	<u>Program Milestones</u>
<u>Objective:</u> Supply data, information and analyses to aid in the design and management of hardware R&D programs.	
Energy Demand Analysis	
Residential	(1) Develop methods to improve forecasts of national and regional energy and power demand, explicit consideration being given to technological change and inter-fuel substitution; (2) Use research results to produce forecasts in-house
Materials Processing	
Commercial	
Transportation	
Energy Supply Analysis Resource	
Natural Resources	Develop initial resource information categorization (1976)
Supporting Resources	Complete initial review of supporting resource constraints (1976)
Energy Production and Delivery	
Energy Production	Develop initial supply curves at point of production (1977)
Transportation, Transmission, Distribution and Storage	Complete assessment of potential transportation bottlenecks (1976)
Assessment of Supply from New Technologies	Develop analytic tools required to assess supplies from new technologies (1976)
Applications and Analysis	
Model Assessments	Critique and compare major models being used in national energy decision making (1977-1981)
Energy Problem Analysis	Study key energy questions using a range of models, i.e., the cost of a nuclear moratorium (1977-1981)
Energy Conversion Analysis	
Plant Productivity	Provide analysis data to assess R&D needs (1977-1981)
Component Reliability	
Safety Performances	
Energy System Modeling	
Synthesis	
Economy-wide Relationships	Evaluate the effects of reduced energy consumption and higher energy prices on national output and employment (1977-1981)
Integration of Supply, Demand and Environmental Factors	
Applied Methodological Research	
Modeling Techniques	Improve selected energy modeling methodologies (1977-1981)
Decision Procedures	Critically examine discount roles and risk analysis in R&D decision making (1977-1981)

Table A-1 (cont'd)
EPRI Program Objectives and Milestones

<u>Technology Approach</u>	<u>Program Milestones</u>
<u>Objective:</u> Improve viability of nuclear fission option.	
Improve Water Reactor System Technology	
LOCA-ECCS	
LWR System Behavior and Control	Provide industry with a verified LWR system code
Structural Integrity	Provide methods and data for tornado, seismic and fluid structure design (1979)
Probabilistic Safety Analysis	Complete full plant probabilistic models to support utility licensing efforts (1981)
Primary and Secondary Pressure Boundary	Provide 3 dimensional finite element FOL mechanics code (1978)
Improve Reliability, Availability and Economics	
Component Technology	Complete development of better engineered components for high reliability plants (1981)
Plant Operations and Engineering	Provide designs incorporating highly reliable system and better techniques (1981)
Plant Chemistry and Corrosion Diagnostic and Evaluation	Complete in-plant chemistry characterization (1979)
	Provide non-destructive inspection systems and fault diagnostic methods (1980)
Instrumentation and Control Engineering	Complete evaluation of on-line monitoring system (1980)
Plant Materials and Processes	Complete assessment of materials compatibility in secondary system reliability (1981)
Radiation Monitoring and Control	Complete plant radio nuclide source terms and environmental monitoring techniques (1979)
Developing Applications and Technology	
LMFBR Technology	Complete PLBR design (1978)
Gas-Cooled Reactor	Complete evaluations of different options, e.g., high conversion ratio reactors (1980-1981)
Advance Water Reactor Technology	Assess feasibility of commercial application of HTGR (1979)
<u>Objective:</u> Improve the use of available fissionable material,	
Fuel Cycle	
External Fuel Cycle	Provide reactor waste monitoring and disposal systems (1980)
Plutonium Recycle	Complete data base on performance of Pu recycle fuels in large operating power reactors (1981)
Fuel Performance	
Fuel Performance	Complete integration of comprehensive fuel rod reliability model into power reactor fuel management scheme (1981)
Core Performance	Complete analytical methodology for fuel management and operational analysis (1979)
Halden Fuel Test Program	Complete experiments to verify fuel rod reliability and performance model(s) (1981)
Breeder and Advanced Nuclear Reactors	Conduct fuel studies in conjunction with LMFBR Design Study (1981)
	Initiate program directed to close LMFBR fuel cycle loop by 1990
	Complete studies for Thorium utilization (1981)

Fifteen companies participated in the survey; three of which have main offices in New York City: Coalcon, Exxon Corporation, and Union Carbide. The total R&D expenditures of those reporting their investment in this technology comes to approximately \$185,300,000. Research is primarily at the laboratory research and small scale levels.

Steam Electric - Bottoming Cycles

Due to rising energy costs, various engineering and manufacturing firms have proposed different means of capturing waste heat for energy utilization. The technique known as a "bottoming cycle" involves removing the heat from the lower-temperature "bottom" of an industrial process or engine. The heat is recycled to generate electricity or to do other mechanical work. Two possible alternatives for machinery to convert waste heat into useful work are: turbines using steam or turbines using fluids--usually organic but sometimes non-organic fluids, including freon.

Four companies conducting research and development of bottoming cycles are included in this survey. Substrand, beginning research in 1960, has invested ten million dollars in developing this technology. Thermo Electron Corporation, which now sells bottoming cycle equipment, has contracted with ERDA and New England Electric Company for a two million dollar project to demonstrate a 500-kw organic fluid system. ERDA is also funding the construction of a 500-kw system by Mechanical Technology Inc. of Latham, New York. Based on incomplete information, the private industries reporting their R&D funding for this technology show an investment of approximately \$10,030,000. It should be emphasized that this figure is low because complete information is not available.

Steam Electric - Topping Cycles

Numerous techniques known as topping cycles are designed to convert fossil energy, primarily coal, to electricity more efficiently than conventional power plants do. These topping cycles are generally installed in a conventional plant in front of the standard steam turbine generator cycle of producing the electricity. Magnetohydrodynamic (MHD), thermionic, and potassium-turbine conversion are three alternate topping cycles now undergoing research. Eight firms are included here which are conducting research into one of these techniques, except for GE which is involved in both MHD and Potassium-Turbine topping cycles. None of these efforts are taking place within New York State.

MHD is highest in the ERDA priority list, of these three techniques. Current research is focused on developing magnetic channels which are resistant to the corrosion caused by extremely hot combustion gases, and on developing air preheaters with sufficiently high temperatures (3100° F). All research is occurring on the laboratory or small-scale development level for MHD as well as for Thermionic and Potassium-Turbine Conversion.

Some of the participating companies have invested their own funds (more than \$6 million to date) for topping cycle research, but this occurred mostly in the past when these power-generating concepts were of interest to the space program. The federal government (ERDA and NASA) are funding almost all private sector research into these three topping cycles, with MHD receiving the greatest amount.

C. INFORM Study

In order to gain a more detailed view of private sector activities, a recently completed set of interviews was utilized, despite its not being comprehensive or completely consistent. A summary of selected energy R&D activities within American corporate research centers was compiled by the researchers of the INFORM group. INFORM developed a fairly comprehensive view of new technologies now available based on interviews with employees of 135 corporations. For each area the study identifies which companies play major roles in energy RD&D as well as describes some of the effects (environmental, economic, etc.) of these companies' actions. The value of the INFORM study is found in its qualitative description of range of energy RD&D. However, the study does not provide complete information and may underestimate the level of expenditures on RD&D. Therefore, although the study provides information on the range of RD&D currently underway, it does not provide a complete or accurate picture of energy RD&D in the private sector. The results of some of the INFORM interviews are summarized in the following eleven generic^{*/} technology areas:

- Solar Heating and Cooling
- Solar Photovoltaic
- Solar Thermal Electric Conversion
- Solar Wind Power
- Biomass and Solid Waste Utilization
- Coal Gasification

* Of the 21 R&D areas identified in Chapter VI only eleven were covered in the INFORM study.

Coal Gasification--Combined Cycle Power Generation
Coal Liquefaction
Steam Electric--Bottoming cycles
Steam Electric--Topping cycles
Fuel Cells

Solar Heating and Cooling

Twenty-four companies were found to be performing solar heating and cooling RD&D. Two of these, Corning Glass Works and Grumman Aerospace are conducting their solar activities within New York State at their Corning and Bethpage headquarters, respectively. Many other companies, as well as some utilities, are producing solar systems or components for use in domestic water heating, space heating and cooling, and industrial process heating.

Many different collector and whole system designs are currently undergoing research, testing and production throughout the private sector. These range from low-temperature (150-200° F) air-type systems to high temperature (to 600° F) fluid systems. Current emphasis is on bringing down the cost of collector manufacture while increasing their efficiencies to make them useful for various functions, including absorption-type air conditioners. In general, the larger corporations are waiting for an assured market before developing a product line. By contrast, smaller solar firms are already producing and distributing solar heating and cooling systems in local markets, thus avoiding the substantial distribution and mass production investments usually faced by large, national corporations.

Those firms which have disclosed financial data report approximately \$10.5 million invested in solar heating and cooling RD&D to date. This figure represents a floor for the amount of RD&D spending in this area. Many firms will spend much more in solar heating and cooling in the future, though many appear to be waiting until the federal government assures the technology and its market through research grants, tax incentives, demonstrations, etc.

Solar Photovoltaics

Eighteen companies were found to be conducting RD&D in the area of solar photovoltaics. Only IBM, at its Yorktown Heights laboratories is conducting solar cell research within New York State.

The primary research thrust is aimed at how to balance the need for an efficient cell against the need to drastically reduce the cost of producing them. Automated production should accomplish this goal partially, but mass markets at current prices do not yet exist for solar cells. Using less expensive materials (cadmium-sulfied or less pure silicon) as the conductive material should also bring down the cost, and much research is directed at increasing the efficiency of these cheaper materials.

On the basis of very limited financial information from this survey, approximately \$11.5 million (a low estimate) has been spent on solar cell research to date. Obviously more private investment has taken place but the data is not available. At

least another \$1.5-2 million is allocated for further solar cell research in the private sector, and probably much more. Many of the larger companies surveyed employ from 5 to 20 full-time researchers, indicating significant continued investment. Many of the companies said, however, that their photovoltaics programs are dependent on federal contract work.

Solar Thermal Electric Conversion

Six corporations are performing research in the field of solar thermal electric conversion, or collecting the sun's energy as heat and using it to drive conventional powerplant equipment. The participants are primarily large aerospace firms such as Boeing, McDonnell Douglas and Martin Marietta, none were identified in New York State. Research is primarily at the laboratory research and small-scale levels, with the federal government providing much of the funding and guidance.

The main RD&D effort in solar thermal electric conversion is focused on proving the technical and economic feasibility of Central-Tower powerplants, emphasized by ERDA grant programs. Improvements in heliostat (pivotal mirrors which reflect the sun's energy onto an elevated central steam tower) design are part of the Central-Tower research effort. Some companies are also studying the Mirror Trough-Collectors for powerplants, as well as the feasibility of using gas instead of steam turbines, eliminating the need for cooling water in arid regions.

Approximately \$3.85 million (probably under estimated) has been invested by the private sector to date, a figure based on incomplete information. Private sector investment is dependent on ERDA involvement in developing this technology. ERDA's interest is currently perceived to be serious, and participating companies employ anywhere from 2 to 25 full-time researchers in their solar thermal electric divisions. The National Science Foundation and the Electric Power Research Institute are also dispensing funds to private firms for these programs, but nowhere near ERDA levels.

Solar Wind Power

Five companies who are conducting research, testing and production of wind electric conversion machines are included in this survey, one of which, Grumman Aerospace, is operating within New York State. A number of smaller companies are currently producing wind machines for electricity production, but their efforts are largely in the commercial arena after having conducted earlier technical research. Large firms are generally interested only in applying their high-technology skills to develop large machines capable of generating hundreds of kilowatts or more, and they depend on the federal government for project grant money. At the same time, the handful of smaller companies are already marketing home-size wind machines (Zephyr Wind Dynamo).

There are no real technical barriers to building wind generators, and the technology has greater potential for being economically competitive than many complex conversion technologies. Current research is directed at building durable and economic machines with blades over 200 ft. in diameter, how to store energy for windless periods, and how to bring the cost within range of conventional power sources. Grumman is working on some advanced wind generator designs, such as the "Tornado Machine" and open some accelerators to increase the efficiency of conventional generators.

Practically all wind electricity RD&D money has come from ERDA through its program administered by NASA, but governmental and industrial interest is still embryonic. No private firms are interested in investing heavily in the large machines until the government displays a strong commitment to the technology. Funding is expected to increase across the board in the future, although present research levels are very low compared to other emerging energy technologies.

Biomass and Solid-Waste Utilization

There are basically four major technological approaches being developed for converting trash to energy. The first, "waterwall incinerators" are specially designed combustors for direct incineration. The second technique involves separation and shredding of waste to produce a "refuse-derived" solid fuel for steam generating boilers. Another approach, pyrolysis, involves partial burning of waste in anaerobic conditions--resulting in liquid, solid or gaseous fuels. The fourth technique known as "bioconversion" uses bacteria or enzymes to decompose waste into fuels.

There are currently about sixteen major projects underway in trash-to-energy conversion. Certain difficulties such as capital investment, mistrust between local government and industry, technical difficulties, and various institutional obstacles are inhibiting further utilization of this technology. Despite these difficulties research and development of trash conversion systems has grown particularly due to the shortage of landfill sites in urban areas, both ERDA and the EPA support programs in waste conversion. The Resource Recovery Act of 1970 authorized the EPA to provide up to two-thirds funding for demonstration plants.

Of the twenty-two companies involved in this survey, Babcock and Wilcox, Black Clawson, Combustion Equipment Associates, Continental Can Company, and Union Carbide, all have central offices in New York City. Of those offering information concerning R&D spending, the approximate total investment in R&D for waste conversion would be approximately \$33,696,000.

Coal Gasification

Thirty-four corporations are performing research in the field of coal conversion, specifically coal gasification. The participants are primarily large industrial process and engineering firms, producers and distributors of natural gas, and major oil companies.

The main R&D effort in coal conversion is developing the technology necessary to provide a "high Btu" synthetic gas, useful as a supplement to presently dwindling natural gas supplies.

Synthetic "low-Btu gas", product of a simpler technical process, would be uneconomical to ship through existing pipelines. However, if produced at or near the usable site, it could prove adequate for meeting many industrial needs, in addition to providing power generation.

The government is presently dominating the program in coal gasification, stressing development of advanced systems in both low-Btu and high-Btu gasification. The private sector, however, is providing increased support for the development of the various technologies involved. Of the thirty four corporations performing research, many have invested heavily in large-scale demonstration, requiring formation of industrial consortiums to provide the necessary capital. Based on incomplete information, the total R&D investment by the private sector is approximately \$318,930,000. Of particular interest, may be those firms located in New York (main office--New York City). These include: Babcock and Wilcox, Chem Systems, Coalcon, Exxon Corporation, General Electric (Research Center based in Schenectady), and Union Carbide.

Coal Gasification-Combined Cycle Power Generators

To increase the efficiency of powerplants, a "topping cycle" is used to intercept some of the energy in fossil-fuel combustion gases. The oil or gas fuels a combustion turbine generating electricity before passing the hot gases on to fuel, a conventional steam boiler and steam turbine.

Approximately thirty large "gas-turbine/steam-turbine" power plants have been sold by General Electric, (whose gas-turbine division is in Schenectady), Westinghouse, and United Technologies,

the major producers. The problem with present "gas-turbine/steam-turbine" plants is that they can only run on natural gas and oil. Experiments to drive gas turbines on coal have been unsuccessful because dirty fuel corrodes vital parts of the machinery. GE and Westinghouse estimate that the engineering problems of developing systems relying coal gasification will take at least ten years to overcome. The efforts will cost hundreds of millions of dollars, which the companies expect the government to provide.

United Technologies, the only corporation reporting their R&D expenditures, has invested seventy five million dollars since 1970 in developing an advanced gas turbine to run on coal gasification products.

Coal Liquefaction

Coal liquefaction presents major obstacles for development by the private sector. The main factor discouraging development of this technology is the very high cost involved. Coal liquefaction also involves difficult technical problems such as very high temperatures and pressures, additional chemical processing (to convert a portion of the coal to a liquid), and difficulties in separating the liquid from the ash and unconverted coal. Commercial liquefaction facilities even at minimum scale would require large amounts of coal and thus would present added environmental problems from additional mining. Coal liquefaction itself consumes large quantities of water, and generates air and water pollution.

Most of companies interviewed in this survey agree that future investments are heavily dependent on stabilization of oil prices or technological breakthroughs which lessened the capital.

Fuel Cells

Three companies developing the fuel-cell technology have been surveyed in this study. Englehard Minerals and Chemicals, whose main office is in New York City, presently produces a small and extremely expensive device which is used for specialized industrial needs. Exxon, another corporation based in New York City, hopes to develop a somewhat larger device. The third, United Technologies, has been developing an even larger device, investing one hundred million dollars over the last twenty years. With federal assistance United Technologies hopes to develop a utility sized multi-megawatt device that will be economically competitive by 1980. NYSERDA's budget has \$380,000 committed for FY 1976-77 and a planned \$350,000 for FY 1977-78 going to United Technologies for a fuel cell demonstration.

Two major problems must be overcome in the development of fuel cell technology. One being the fuel supply--hydrogen. This fuel is currently derived from natural gas and oil. Proponents of this technology expect that this dependence can be shifted to coal. Secondly, the cost of manufacturing the fuel cell must be dramatically cut. An economically viable technology is yet to be developed. Nevertheless both ERDA and EPRI are confident that with their financial support the United Technologies fuel cell will prove an economical source of electricity in the next decade. The three companies have invested approximately \$118,700,000 over the past 20 years in the development of fuel-cell technology.

Footnotes

1. A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future, Volume 2: Program Implementation.
2. U.S. Energy Research and Development Administration Budget Estimates, Fiscal Year 1977 (Submission to Congress).
3. Adapted from "EPRI--Proposed Research and Development Program 1977-1981", Working Draft--12/1/76, pp.37-57.