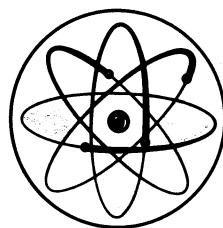


**CIVILIAN
NUCLEAR
POWER**

... a Report to the President — 1962

U.S. ATOMIC ENERGY



COMMISSION



UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON 25, D. C.

OFFICE OF THE CHAIRMAN

November 20, 1962

Dear Mr. President:

I am pleased to submit herewith the report resulting from our "new and hard look at the role of nuclear power in our economy," as requested by you on March 17, 1962. In preparing this report, we have had the benefit of comments and advice from interested offices and individuals within and without the Government. However, the Commission takes full responsibility for the conclusions and recommendations of the report.

The Commission, of course, has concentrated on issues related to the development and use of nuclear power; it has not attempted to appraise the possible effect of major research efforts on the economics of non-nuclear energy sources or on improved transmission methods for either source of energy. However, the study has been greatly aided by the information furnished by the Department of Interior, the Federal Power Commission, and the National Academy of Sciences Committee on Natural Resources.

Those who have participated in the study you requested are agreed that it has proved to be very timely. While the Commission has been proceeding on a considered course in general accord with its 10-year civilian power program adopted in 1958, that program is now on the threshold of attaining its primary objective of competitive nuclear power in high-fuel-cost areas by 1968. However, it became evident with the passage of time that our attention had probably for too long remained focused narrowly on short-term objectives. This restudy made it apparent that, for the long-term benefit of the country, and indeed of the whole world, it was time we placed relatively more emphasis on the longer-range and more difficult problem of breeder reactors, which can make use of nearly all of our uranium and thorium reserves, instead of the less than one per cent of the uranium and very little of the thorium utilized in the present types of reactors. Only by the use of breeders would we really solve the problem of adequate energy supply for future generations.

We believe that it still is necessary for the Government as a interim measure to maintain a substantial program of research and development on advanced types of reactors other than breeder reactors, which are some years away. It appears from the projections made that efficient converter reactors will be required in conjunction with breeder reactors to meet the rapidly growing national demands for electrical power. This Government program over the next several years is also important since it provides the national means for "bridging the gap" between the infancy and maturity

of nuclear power. This interim aid will allow the consolidation of the gains made to date and will permit the national nuclear program to proceed in an efficient and sensible manner toward the development of more efficient and economical converter reactors and eventually breeder reactors.

Furthermore, a vigorous national nuclear power program can be pursued without interfering with a growing coal industry; in fact, all our projections indicate that, even assuming an optimistic forecast of nuclear power development, the use of coal by the rapidly expanding electric generating industry will increase severalfold over the next 40 years.

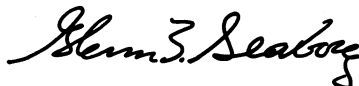
It should be recognized that, largely as a result of early optimism, we have, in a short space of time, developed a competitive nuclear equipment industry which is over-capitalized and under-used at the present time. This optimism has had some good results in terms of bringing many able technical men, manufacturers, and utility executives into the field, and assuring Congressional and industrial support during the development years.

The optimism has also brought about some difficulties in that unless there are new starts on atomic power plants, the atomic equipment industry will probably dwindle down to fewer manufacturers than would be desirable for a healthy and competitive nuclear industry. Fortunately, it now appears that only relatively moderate additional governmental help will be necessary to insure the building of a substantial number of large, water-type power reactors that will be economically competitive in the high-fuel-cost areas of this country and the world. This would increase public acceptance, keep the nuclear industry healthy, and help to furnish the plutonium necessary for a breeder reactor economy as soon as it can be adequately developed.

In summary, nuclear power promises to supply the vast amounts of energy that this Nation will require for many generations to come, and it probably will provide a significant reduction in the national costs for electrical power.

The Commission unanimously concurs in this report.

Respectfully yours,



Glenn T. Seaborg
Chairman

The President
The White House

Enclosure

THE WHITE HOUSE
Washington

March 17, 1962

Dear Mr. Chairman:

The development of civilian nuclear power involves both national and international interests of the United States. At this time it is particularly important that our domestic needs and prospects for atomic power be thoroughly understood by both the Government and the growing atomic industry of this country which is participating significantly in the development of nuclear technology. Specifically we must extend our national energy resources base in order to promote our Nation's economic growth.

Accordingly, the Atomic Energy Commission should take a new and hard look at the role of nuclear power in our economy in cooperation with the Department of the Interior, the Federal Power Commission, other appropriate agencies, and private industry.

Your study should identify the objectives, scope, and content of a nuclear power development program in the light of the Nation's prospective energy needs and resources and advances in alternate means for power generation. It should recommend appropriate steps to assure the proper timing of development and construction of nuclear power projects, including the construction of necessary prototypes. There should, of course, be a continuation of the present fruitful cooperation between Government and industry—public utilities, private utilities, and equipment manufacturers.

Upon completion of this study of domestic needs and resources, there should also be an evaluation of the extent to which our nuclear power program will further our international objectives in the peaceful uses of atomic energy.

The nuclear powerplants scheduled to come into operation this year, together with those already in operation, should provide a wealth of engineering experience permitting realistic forecasts of the future of economically competitive nuclear power in this country.

As you are aware, two major related studies are now or will soon be underway. The study being conducted at my request by the National Academy of Sciences on the development and preservation of all our national resources will focus on the Nation's longer term energy needs and utilization of fuel resources. The other study to be launched soon by the Federal Power Commission will determine the long-range power requirements of the Nation and will suggest the broad outline of possible programs of growth for all electric power companies—both private and public—to meet the great increase in power needs. Your study should be appropriately related to these investigations.

The extensive and vigorous atomic power development programs currently being undertaken by the Commission should, of course, be continued and, where appropriate,

strengthened during the period of your study. I urge that your review be undertaken without delay and would hope that you could submit a report by September 1, 1962.

Sincerely,

/s/John F. Kennedy

Dr. Glenn T. Seaborg
Chairman
Atomic Energy Commission
Washington 25, D. C.

*Civilian
Nuclear Power
a Report
to the President*

Contents

	Page
INTRODUCTION	1
SUMMARY	7
THE NEED FOR NUCLEAR POWER	16
Nuclear Energy as a Resource	16
Benefits of Nuclear Electric Power	23
THE ROLE OF GOVERNMENT	27
THE PRESENT SITUATION	29
REACTOR SYSTEMS	35
Converters	35
Breeder	37
Probable Trends	39
ASSESSMENT OF THE DEGREE OF URGENCY	42
STATEMENT OF OBJECTIVES	48
THE FUTURE PROGRAM	49
A Program for the Immediate Future	49
The Intermediate Program: Improved Converters	50
Program for the Long-Range Future	51
A Possible Construction Program	51
SUPPORTING TECHNICAL PROGRAMS	53
General Technology	53
Reactor Safety: Siting Problems	54
Waste Management	54
LEGAL, FINANCIAL AND ADMINISTRATIVE MATTERS	56
Policies Relating to Nuclear Materials	56
Ownership of Special Nuclear Materials	56
Toll Enrichment	57
Plutonium Prices	57
Uranium Procurement	58
Service Industries	59
Licensing and Regulation	60

Contents (Continued)

	Page
POSSIBLE INDUSTRIAL IMPACTS OF THE NUCLEAR POWER PROGRAM	61
The Coal and Transportation Industries	61
APPENDIX	65

FIGURES AND TABLES

FIGURES

1. Estimates of Future Rates of Energy Consumption in the United States	17
2. Cumulative Energy Consumption and Fossil Fuel Resources for the United States	18
3. Effect of Nuclear Power on Fossil Fuel Consumption	44
4. Fossil Fuel Consumption for Electric Power Generation During Initial Ex- pansion of the Nuclear Power Industry	62

TABLES

I Fission Energy Content of Domestic Nuclear Resources	23
II Nuclear Power Plants, Operable and Being Built	32



Introduction

As a result of successes achieved during World War II, it was widely recognized thereafter that nuclear energy could, if properly developed, have important civilian applications. In addition to unique applications in scientific research, in medicine, in agriculture and in industrial operations, it was believed by many that nuclear energy could yield large economic advantages in such massive applications as the generation of electric power. It was also recognized, though not emphasized, that over the long term it would be an important resource, whose timely introduction would help conserve for special uses our finite supply of fossil fuels.

The long-term availability of abundant and economic sources of energy and the development of new techniques and technologies of general applicability are matters of concern to all the people and therefore to the government. Federal responsibility for the peaceful development of civilian uses of nuclear energy—for

both short- and long-term ends—within our normal economic and industrial framework was clearly recognized by Congress in the Atomic Energy Act of 1946, and clarified and broadened in the Act of 1954. The latter states in Section 1 (Declaration):

“It is . . . declared to be the policy of the United States that—

* * *

“b. the development, use and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in private enterprise.”

And in Section 3—(Purpose):

“It is the purpose of this Act to effectuate the policies set forth above by providing for—

“a. a program of conducting, assisting, and fostering research and development in order to encourage maximum scientific and industrial progress;

* * *

“d. a program to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public;” and

“e. a program of international cooperation to promote the common defense and security and to make available to cooperating nations the benefits of peaceful applications of atomic energy as widely as expanding technology and considerations of the common defense and security will permit;”

Many sections of the Act and many other acts of Congress expand on the above provisions and provide means and mechanisms for implementing them.

In keeping with the responsibilities assigned it by the legislation, the Atomic Energy Commission has conducted vigorous programs of research, development, and exploitation, directed at realizing the many peaceful benefits potentially to be derived from nuclear energy. Included in the applications are many, such as those of radioisotopes, where nuclear phenomena have special characteristics that are uniquely useful. The major effort has, however, been directed at extraction of energy in large amounts, primarily to accomplish conventional tasks or extensions of them. The most promising, and hence the most vigorously pursued among the various applications, is that of generating electric power. It is with the power program that this report primarily concerns itself.

The Commission has conducted and encouraged a national program, aimed, first, at obtaining the basic scientific and engineering data needed for proof of technical feasibility and

safety of the more promising approaches to nuclear power generation and, second, at demonstrating the actual or potential economic feasibility of such approaches. This program has been strongly backed in both the executive and the legislative branches of the Government.

In its early phases the program was largely one of developing the technology. It leaned heavily upon, indeed it started from, knowledge gained from other reactor programs, notably "production" reactors for making plutonium, naval propulsion reactors and "research" and "test" reactors used for scientific purposes. In 1953 the Commission, with the encouragement of the Joint Committee on Atomic Energy, embarked upon a five-year "experimental" program to develop reactors giving promise for civilian power applications. Construction was started on several experimental power-producing reactors on Commission sites, and one "prototype" reactor on a utility grid.*

The revision of the Atomic Energy Act in 1954, which encouraged industrial cooperation, and associated policy decisions by the Government resulted in continued expansion of the program by both government and industry. An important step was the addition, in 1955, of a "Power Demonstration" program under which the Commission and industry have cooperated in building and operating a number of nuclear power plants on utility grids. In one segment of this program, Commission-built and -owned "prototype" reactors are operated by utilities that buy the steam; in another segment utilities are given research and development assistance in designing and constructing their own reactors and, for a few years no charge is made for the lease of Government-owned nuclear fuel.

In 1958, as the five-year experimental program ended, the Joint Committee on Atomic Energy of the Congress published a report, prepared by its staff with the advice of consultants, recommending objectives for an expanded program and various steps that might be taken in furtherance of the program. During that and the following year, the Commission conducted, at the national laboratories and through contracts with the nuclear equipment industry, a series of detailed studies and evaluations of all the reactor concepts believed to hold promise for the development of economic nuclear power. The results were carefully analyzed by the Commission staff and, on two separate occasions, by advisory committees. On the basis of these studies, analyses and recommendations, the Commission published a series of reports, known to the trade as the "Ten-Year Program", which established short-range economic targets as well as long-range goals in economics, resource

* This Commission-built and -owned reactor, at Shippingport, Pa., provides steam at a plant of an investor-owned utility, which built the power generating equipment and operates the reactor under contract with the Commission.

conservation and international leadership, and outlined a program for achieving these objectives. This has served as a general guide to the Commission during the intervening period.

Meanwhile, beginning with initiation of the "Atoms for Peace" program in 1954, and more intensively since the large International Conference on that subject in 1955, the Commission, in cooperation with the Department of State, has been very active internationally. The United States was the leader in the establishment of the International Atomic Energy Agency which conducts and sponsors cooperative programs throughout the world. The Agency will increasingly be responsible for administering safeguards against diversion of nuclear materials to military use and for developing and recommending international regulations on safety and waste disposal. Cooperation and assistance have been rendered by the United States through formal agreements with such international organizations as EURATOM, and with a large number of individual nations. Western Europe and, more recently, Japan have significant nuclear power programs in being as has the Soviet Union. Considerable interest in nuclear power has also been shown by many of the developing countries.

As a result of the various domestic programs, six sizeable reactors of the more highly developed types are in successful operation on utility grids (two of the largest and one other had no AEC assistance); seven more of small and medium size will be completed by the end of 1963; a few others are under construction or nearly so.

Sufficient developmental and operational experience has been accumulated to permit a reasonably accurate assessment of future possibilities. Nuclear electric power has been shown to be technically feasible, indeed, readily achieved. Power reactors can be reliably and safely operated. However, contrary to earlier optimism, the economic requirements have led to many problems—combining low capital cost with long life and assured reliability; lowering costs by improved efficiency; developing long-lived and, therefore, economic fuels. Attempts to optimize the economics by working on the outer fringes of technical experience, together with the difficulties always experienced in a new and rapidly advancing technology, have led to many disappointments and frustrations. Experiments have not always worked as planned. Many construction projects have experienced delays and financial overruns. Such difficulties led to considerable diminution of the earlier optimism regarding the early utilization of nuclear power, which in turn contributed to the withdrawal of some equipment and component manufacturers from the field.

Happily, more recently much progress has been made toward solutions of these problems. Expectations are being more nearly, and in some cases completely realized. Nuclear power is believed to be on or near the threshold of competitiveness

with conventional power for large plants, in areas of the country where fossil fuel costs are high. Further cost reductions are definitely in sight, provided an aggressive program is continued.

The developments to now have verified that, if extensively used, nuclear power could have important implications—as a means of exploiting a large, new energy resource; as an economic advantage, especially to areas where fossil fuel costs are high; as an important contributor to new industrial technology and to our technological world leadership; as a significant positive element in our foreign trade; and, potentially, as a contributor to the nation's defenses. Its potential benefits will actually be realized, however, only if it can be made economically attractive.

To surmount the economic hurdle is the most immediate program goal. Unfortunately the reactors that will do so can extract only about one percent of the energy potentially available in our reserves of nuclear materials. To utilize the rest, which must be done if nuclear energy is to be of lasting usefulness, requires the development to an economic status of more advanced and difficult reactors. This will be a rigorous and expensive task.

How best to pace the short- and long-term efforts, what relative emphasis to give to each, how diversified and intensive the total effort should be — these are the principal program questions.

The stage of development has also brought forward a number of important policy questions. Many of them relate to nuclear fuels. With extensive applications potentially in the offing, the question naturally arises as to the desirability of changing, at a reasonably early date, to private ownership of special nuclear materials. Its adoption would give rise to the corollary question of policy relating to the "toll" enrichment of privately-owned uranium in the government's diffusion plants, a service which private industry cannot economically provide for itself; this question arises internationally in any case. Action must be taken on the Commission's raw uranium procurement program, contracts for which expire in 1966, and on extension and adjustment of its schedule of guaranteed prices for plutonium produced in non-government reactors, which expires in 1963.

Clearly the time has come for a major review and reassessment — a review more of basic policies than of detailed technical activities; a review of where the nuclear electric power program should be headed, at what rate and with what amount of government participation. It is to these ends that this study has been made.

* * *

A study of this nature requires special knowledge in many fields outside the detailed cognizance of the Atomic Energy Commission. Among these are current and projected rates of