AD HOC GROUP

on

THE ARMY NUCLEAR POWER PROGRAM

Final Report
June 1969

CONTENTS

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II. Summary and Recommendations

The Ad Hoc Group on the Army Nuclear Power Program was formed in January 1969, under the auspices of the Army Scientific Advisory Panel, to assess the applicability of nuclear power technology to military energy needs and to recommend to the Army an appropriate nuclear technology R&D program to meet these needs. Naval nuclear propulsion and space nuclear power needs were not considered by the Group.

The Ad Hoc Group met in Washington, DC from 10-13 February 1969, and from 2-3 April 1969, to review the past history and current status of relevant DOD and AEC nuclear power programs, to discuss these and possible future programs, and to make recommendations concerning the future R&D programs under the Army Nuclear Power Program. The final report of the Group was circulated to the members of the Group in June 1969, and is presented here.

The Group came to two primary conclusions:

1. Aside from naval propulsion and possible applications in the polar regions and in space, there are no current military requirements for power sources for which nuclear power systems offer clear overall advantages over fossil fueled power systems.

2. With varying degrees of conviction among its members, the Group also concluded that thorough and creative examination of the opportunities for using nuclear power for military purposes may reveal ways that the DOD can achieve new basic capabilities that will greatly improve the wartime effectiveness and peacetime utility of US military forces in the future, and that would be impossible or are more difficult or expensive without the use of nuclear power.

Accordingly, the Group makes the following recommendations:

1. The present R&D efforts of the Army Nuclear Powered Program (ANPP) should eliminate any further experimental work and hardware development until firm requirements for nuclear power sources is established.

2. The R&D effort within the ANPP should be reoriented toward a study group effort of approximately ten man years/year with an operating budget of approximately $800,000. This group should undertake extensive technical studies of future weapons systems concepts and Army mission requirements that could conceivably use nuclear power sources to determine if their use would result in a more effective system than competitive power sources. Examples of studies that could be undertaken are:

a. high power laser systems; large ground effects vehicles;

b. barge-mounted power plants;

c. "buttoned-up," hardened, underground power plants for support of long term surveillance activities in demilitarized zones;

d. and power plants for post-attack civil defense applicators.

Initial emphasis should be on short term (5 years or less) requirements in order to determine of there is a need to continue operation of the current PNR plants for R&D purposes.

3. The Army should undertake concurrent studies to determine whether the unique characteristics of nuclear power sources can, in the context of future land force operations, provide the Army with new capabilities that could lead to changed military doctrine, tactics and organization. The analysis should consider:

a. the capability for the Army to operate for extended periods of time without logistic support

b. the use of possible future weapons and propulsion systems requiring large blocks of power but small masses of expended material (chemical fuel or ammunition).

c. hardened power units that require neither air nor constant resupply of fuel.

4. Periodic reviews of the results of the study efforts recommended above should be used as the basis for determining the extent and nature of the Army Nuclear Power Program beyond that recommended now by this Panel.

III. Objectives and Terms of Reference for Ad Hoc Group

A. The objectives of the Group were to assess the applicability of nuclear power technology to military energy needs and to recommend an appropriate R&D program to meet these needs.

B. Background.

The background information cited in the following paragraphs was presented to the Group at the opening of its first meeting:

In 1954, the Secretary of Defense designated the Department of the Army as the cognizant agency of the Department of Defense in developing nuclear power plants to supply heat and electricity at remote and relatively inaccessible military installations. The US Army Chief of Engineers, in turn, was assigned DA responsibility for the establishment and direction of the Army Nuclear Power Program (ANPP). The mission of the ANPP was broadened in 1963 to include research and development of nuclear devices for generating mechanical power and energy conversion systems. The ANPP is also assigned responsibility for training of nuclear power plant crews, technical support to military users of nuclear power, operation of nuclear power plant, and nuclear health and safety.

Several R&D prototype nuclear plants have been constructed and operated. One field plant, the MH-1A floating nuclear power plant, has been constructed and has now been deployed to the Panama Canal Zone for service. There are no new reactors under design or construction, nor are there any documented Army requirements for nuclear power plants. Research and development efforts in the past few years have been focused on attempts to overcome the economic stumbling blocks which so far have prevented nuclear power (in the small-size range of Army interest) from being cost-effective when compared with conventional electric power sources.

Through the ANPP, the Atomic Energy Commission and the Department of Defense have made significant advances in the technology of small pressurized water reactor systems, mobile gas-cooled reactors and their associated power conversion subsystems, and a compact, high power, mobile reactor concept for providing electric power to dispersed tactical forces. Eight operating power reactors and two test facilities have been developed for an investment of approximately $200 million, divided almost equally between the AEC and the DOD.

Since 1963, the RDTE funding for this program has steadily decreased from $7,580,000 to $1,400,000 for FY 69. The Chief of Engineers has advised that this level of funding is below the sustaining point for a minimal R&D effort and that he is forced to seriously consider recommending cancellation of the program or reduction to a small study group effort.

The future success of nuclear power in Army applications depends in large measure on achieving significant technological advances in small reactors (less than 75 MWe) that will make them competitive in cost with conventional fuel systems. The likelihood of such achievements in the foreseeable future is not obvious; a comprehensive analysis by experienced people competent in reactor technology, industrial capabilities, economics, and reactor operating problems is required.

C. Terms of Reference - In its study of the problem, the Group was asked by the Army to:

1. Assess the ANPP technology developed to date in the following fields, together with its applicability to current and future energy needs of the Army, and recommend appropriate further effort, if any, in these fields:

a. small (< 75 MWe) pressurized water reactor systems.

b. gas-cooled reactors and their associated power conversion systems.

c. energy depot systems for distributing energy from a mobile, compact, high power reactor.

2. Identify new reactor system technology which might offer potential benefits in meeting Army energy needs, and define appropriate Army objectives for RDTE effort to realize these benefits.

3. Define appropriate guidelines and effectiveness measures for cost-effectiveness analysis of possible applications of nuclear power to meet Army energy needs.

4. Define an appropriate level of effort (in terms of manpower and facilities) for the ANPP during FY 1970-74.

IV. Summary of Ad Hoc Group Proceedings

On November 14, 1968, Theodore B. Taylor accepted the invitation of Assistant Secretary of the Army (R&D) R. D. O'Neal to be chairman of an ad hoc group, to be organized under the auspices of the Army Scientific Advisory Panel, to study the Army Nuclear Power Program and recommend an appropriate R&D program for the Program. Subsequently the other members of the Group accepted invitations to participate in the activities of the Group, and the first series of meetings of the Group were held in Washington, DC, on February 10, 11, 12 and 13.

A summary schedule of the briefings and discussions during the first set of meetings is presented below: (The content of the OCE briefings is given in Appendix A to this report.)

10 February 1969

Introductory Remards	Dr. Taylor
Welcoming remarks and objectives for the Ad Hoc Group	LTG Betts
Background Briefings History of ANPP, Current Status Current R&D Program	OCE
Future Energy Needs	OCE
ANPP Technology Developed to Date Small PWR, gas-cooled reactors, energy depot systems	OCE

11 February 1969

New Reactor Concepts	OCE
Cost-effectiveness analyses	OCE
Summary and Conclusions	OCE
Discussions with Mr. Milton Shaw and Staff, Division of Reactor Development, AEC	

12 February 1969

Informal discussion among members of the Group, primarily in seeking to uncover some well defined military requirements for nuclear power

13 February 1969

Electric vehicle propulsion systems and fuel cell development	MERDC
Further Group discussion	

Between 13 February and 2 April 1969, the members of the Group individually reviewed information provided to them by the military staff assistant to the Group. The second series of meetings of the Group was held in Washington, DC, on 2 and 3 April 1969. A summary schedule of the briefings and discussions held during those meetings is below:

2 April 1969

Costs of POL fuel	OCE
Minuteman Power Sources	LTC Purple
Hardrock Silo Program	Mr. Thomas
Group discussion of conclusions	

3 April 1969

Group discussion of conclusions and recommendations

A draft of the Final Report of the Group was prepared between 2 April and 26 May, circulated to members of the Group for comment and signature between 28 May and 13 June.

V. Conclusions.

The first six of the following conclusions and related discussions correspond to the consensus of the Ad Hoc Group regarding the specific tasks that the Group was asked by the Army to undertake as indicated in the Terms of Reference given on page six of this report. The additional conclusions are presented here in the hope that their statement and the related discussion will assist the Army in understanding the reasons why the Group has chosen to make the recommendations that it has.

1. Pressurized water reactor systems

PWR power plants in the power range from 1 to 100 MWe could be made available for military applications without extensive further research and development, assuming that no unusual new operating or performance characteristics would be required for any specific military application. It is questionable, however, whether PWR plants could be cost competitive with fossil fueled plants at power levels below 100 MWe if the cost of fossil fuel is assumed to be as low as 5¢ per gallon. At POL costs of 8¢ per gallon, PWR plants might be cost competitive at power levels as low as about 50 MWe. Further R&D on PWR plants might conceivably lower the power level for cost competitiveness with 8¢ per gallon POL plants to 10 or 20 MWe. the R&D cost of such PWR plant cost reductions are likely to be several tens of millions of dollars, and might exceed $100 million to achieve safe, reliable operation for periods of ten years or more.

For comparison purposes, we note that current "Worldwide New DOD Standard" costs per gallon of conventional fuels are as follows: Arctic Diesel, 14¢; Marine Diesel, 7¢; Navy Special or Bunker A, 5.9¢.

2. Gas-cooled reactors

Gas-cooled reactor power plants for producing up to several MWe

are very unlikely to be competitive with power plants that use POL that costs as much as $1 per gallon. Considerable further R&D would be required to make low powered gas-cooled reactors simultaneously acceptably safe, reliable and inexpensive for military portable power systems. They are likely to be good candidates for power production at levels from several hundred KWe to several MWe, compared to other types of nuclear power plants, for applications in places where POL is not available. Gas-cooled reactors operating at high temperatures offer the attractive possibility of discharging waste heat from a portable plant as hot air, either by using forced air as a coolant for the low temperature side of the system, or by using air as a working fluid in an open cycle turbine.

3. Nuclear energy depot systems

None of the nuclear energy depot systems concepts we have reviewed appear likely, even with considerable R&D effort, to be cost competitive with POL sources, as long as POL can be delivered to the site of a nuclear energy depot at costs less than about 20¢ per gallon. The factors of cost, system vulnerability to enemy action, "political" and operational problems associated with using nuclear power systems under battle conditions, and the need for changes in the propulsion systems of many (or all) army vehicles for which the depot might supply fuel (hydrogen or ammonia), all contribute to making such systems non-competitive with conventional sources of electrical energy and fuel for vehicles, as long as POL is available. We have not seen any studies of the use of the nuclear energy depot for the specific purpose of allowing large scale Army field operations in situations where the POL supply has been completely cut off for an extended time.

Although all members of the group expressed considerable enthusiasm

about electrification of army vehicles, we found no reason to expect that a nuclear energy depot would be a better source of energy--by charging batteries or providing ammonia or hydrogen for fuel cells--than POL used to fuel electrical generators or, conceivably, fuel cells.

4. Foreseeable new advances in nuclear power technology.

Although advances in nuclear technology in the future could reasonably be expected to lead to major increases in the safety, reliability, versatility of possible applications, simplicity of operation, compactness, resistance to attack, and overall cost effectiveness compared to present nuclear power systems, we have been unable to find any clear-cut, present military requirements for which nuclear power appears to offer overall advantages over fossil fuel power sources. We can identify no reasons to believe that new reactor system technology, even if vigorously pursued, would lead to cost competitiveness with fossil fuel power sources, at power levels below about 10 MWe (with the exception of those applications noted above that were excluded from this study.). Even at a power level of several hundred MWe, the possible cost advantages of nuclear power appear unlikely to be large.

No firm requirements that were presented to the Group specify a need for characteristics that nuclear power sources uniquely possess (such as long-time independence on a fuel and oxygen supply, or a very high energy density in the fuel). In making its own search for applications requiring the special characteristics of nuclear power, the Group considered the following possible cases:

a. power supplies for the Sentinal for Safeguard ABM system components.

b. power supplies for hard Silos.

c. portable power sources for use by the field army.

d. barge mounted plants for delivering up to 50 MWe.

The characteristics of nuclear power systems qualitatively appear to offer some advantages in the above cases. But it is our understanding that current Army long range planning doctrine assumes that supplies of POL are always available. As long as this assumption holds, there is not much incentive for developing technologies that lead to independence of POL supplies. We therefore reached the overall conslusion that further R&D effort in the nuclear power field is unwarranted on the basis of existing, specific military requirements.

5. Cost-effectiveness analysis guidelines

A major deficiency in the cost-effectiveness comparisons between nuclear and conventional power sources that were presented to the Group is the narrowness of the context in which comparisons were made. Comparisons were generally strictly on the basis of power costs alone, without taking into account changes in requirements for logistic support, safety, political problems, ease or difficulty of hardening against a variety of weapons, etc. These and other factors that affect "effectiveness" are often very difficult to take into account quantitatively, yet some account must be taken of them if comparisons are to be considered to be realistic. For example, the cost of using the Sturgis nuclear barge for power for coastal bases in Southeast Asia compares very favorably (now that the plant exists) with using conventional power sources, yet political and operational considerations have prevented its use altogether.

This deficiency is obviously not restricted to nuclear power cost-effectiveness studies. Perhaps one of the most urgent and difficult problems facing the Federal Government is to develop ways to compare alter-

native solutions to problems that involve many variables that are difficult to define quantitatively in terms of costs. As long as this general problem is not satisfactorily solved, we believe that pure cost comparisons alone should not be the basis for choices of power systems.

6. Future R&D.

Since, in spite of a concerted effort to do so, the Group was unable to identify any definite military requirements for nuclear power for the Army, the Group sees no logical way to define the details of any further R&D programs related to future DOD needs for nuclear power. The Group also concludes that, without further definition of the characteristics and constraints applicable to future military applications of nuclear power, the present and planned AEC nuclear power R&F programs would be more likely to be an effective use of Federal funds than general R&D supported by the Army.

7. The lack of persuasive definitions of military requirements for nuclear power.

No compelling rationale for the use of nuclear power for military applications (other than for naval propulsion and some space applications) appears to have been constructed. The Group spent a considerable fraction of its time unsuccessfully trying to construct such a rationale, without at the same time proposing new types of military systems that the Group was in no position to analyze. There have been (as far as the Group is aware) no studies of the advantages that might accrue to US military ground forces if they were able to operate for extended periods without logistic lines of support; and the intuitive argument that nuclear power plants, though more costly than conventional plants, offer a big advantage by reducing fuel logistics problems in such situations is not currently supported.

Without thorough examinations of the new options for tactics and strategy, and of overall possible changes and definitions of the roles and missions of the defense establishment that would be made possible by use of the qualitative potential advantages of nuclear power--low fuel costs, very high power density, compact and long lifetime fuel, a large variety of specific forms of released energy, etc.--it is difficult to imagine that a strong case for nuclear power will be made. The majority current opinion in the DOD appears to be: "If we can't do what we're already doing with conventional power more cheaply with nuclear power, we don't need nuclear power at all."

8. New basic capabilities that depend on the use of nuclear power.

With varying degrees of conviction among its members, the Group also concludes that thorough and creative examination of the opportunities for using nuclear power for military purposes is likely to reveal ways, so far not yet identified, that the DOD can achieve new basic capabilities that could greatly improve the wartime effectiveness and peacetime utility of US military forces in the future, and that are not possible or are much more difficult or expensive without the use of nuclear power. Among such opportunities that were tentatively identified by the Group as warranting further study are the following:

a. maintenance of a capability to hold and take ground by army field units, without requiring logistic lines of support to provide POL or ammunition or both.

b. use of large Army or Marine Corps nuclear powered water or la land-surface vehicles. These might be heavily armored and equipped with active defensive and offensive weapons, such as lasers, that require large amounts of power but do not expend large quantities of material.

c. use of transportable (e.g. barge mounted) nuclear power plants in the intermediate power range (10-several hundred MWe) to provide power for US military bases, as well as for developing countries or small industrialized countries that do not have sufficient power needs to make economic use of very large (greater than 500 MWe) nuclear power plants of the types that are now clearly cost-competitive with plants that use fossil fuels.

d. use of underground, hardened nuclear power plants for production of power to sustain military or civil defense operations in the areas that have been or are likely to be subjected to nuclear or conventional attacks. Such areas might include parts of the United States or demilitarized zones.

Since the Group did not explore any of these concepts in detail, they should be taken as illustrative examples only.
