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Usefulness of Space Power Research to Ground-Based Nuclear Reactor Systems

Statement of
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Before the Energy Research and Development
Subcommittee
Committee on Science, Space and Technology
House of Representatives

Madam Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss the methodology and results of our review of the potential usefulness of the Department of Energy's (DOE) space nuclear power systems research to developers of advanced terrestrial (ground-based) nuclear power systems.

Our review was performed in response to a request from the Chairman and Ranking Minority Member of the House Committee on Science, Space and Technology. Specifically, the Committee requested that we obtain opinions from experts in nuclear power and related technologies on the potential for technology transfer from DOE's space reactor research and development (R&D) programs to its terrestrial reactor R&D program. My testimony today is based on our December 1988 report that resulted from our review.[1]

In the mid-1980s, DOE adjusted its nuclear reactor research and development efforts to meet the growing need for nuclear power in potential civil and military space missions, including the Strategic Defense Initiative (SDI). In making these adjustments, DOE officials stated that some results of their SP-100 and

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[1]Nuclear Science: Usefulness of Space Power Research to Ground-Based Nuclear Reactor Systems (GAO/RCED-89-17, Dec. 6, 1988).

Multimegawatt space nuclear power programs may be useful in the development of civilian terrestrial reactors.[2]

Overall, the nuclear power systems experts that we surveyed expect that knowledge gained from much of DOE's space nuclear power systems research may also be useful in the development of advanced liquid metal- and gas-cooled terrestrial reactors. Furthermore, knowledge gained in generic areas, such as reactor instrumentation and control, may be useful for improving water-cooled terrestrial reactors.

STUDY METHODOLOGY

To learn if DOE's space nuclear power systems research might also benefit the development of civilian terrestrial nuclear power systems, we (1) identified a frame of reference for comparing nuclear space power systems and nuclear terrestrial power systems, (2) identified a group of experts to query, (3) developed a data

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[2]DOE is participating in two programs to research and develop technology for space nuclear power systems. The SP-100 Space Power Program, which was initiated in 1983, is a joint effort of DOE, the Department of Defense's Strategic Defense Initiative (SDI) Organization, and the National Aeronautics and Space Administration to develop and demonstrate technology capable of providing up to 1 megawatt (1,000 kilowatts) of electric power for potential future civilian and defense space missions. The Multimegawatt Space Nuclear Power Program, which is funded by DOE and the SDI Organization, was initiated in 1985 to specifically develop and demonstrate a nuclear power system that will meet SDI's requirements for electric power ranging from tens to hundreds of megawatts.

collection instrument to gather information from these experts, and (4) analyzed the results.

We selected 11 major systems and components of space nuclear reactor power systems as a frame of reference for making our inquiries. These 11 major systems and components are also common to all terrestrial nuclear reactor power systems. They include fuel and fuel systems, materials, heat transport, energy conversion, instrumentation, control methodology, safety, reliability, fabrication, facilities, and modeling and analysis.

To identify a group of experts to query we requested that DOE, the Department of Defense, the National Aeronautics and Space Administration, nuclear industry associations, and nuclear engineering departments at selected universities recommend individuals with expert knowledge in 1 or more of the 11 major systems and components. Next, we called these experts to confirm their area of expertise and asked them to recommend other individuals with appropriate expertise. Then, we asked a consultant to review the list of prospective respondents to ensure a proper mix of expertise and to ensure that both the space reactor and terrestrial reactor communities were fairly represented. We thus identified 139 experts for our survey.

We used two questionnaires to survey the opinions of these 139 experts. The first questionnaire was open-ended, permitting

spontaneous, somewhat unguided responses. We asked the experts to comment on the potential for research advances in each of the 11 major component and system areas to produce technology that might be useful to terrestrial power systems. Potential usefulness was rated on a progressive scale, from little or no usefulness to somewhat, moderately, very, or extremely useful. We analyzed the responses to this first questionnaire and then developed a similar, but more detailed and specific, second questionnaire with closed-ended quantifiable responses. We used mainly the responses to the second questionnaire to report the quantitative results of our survey.

Of the 139 experts surveyed, 118 (85 percent) responded to our two questionnaires--72 percent to the first and 76 percent to the second.[3] Most of the respondents to our questionnaires have experience in both space and terrestrial power systems and their affiliations cover the range of scientific communities--government, private industry, and colleges and universities. Similarly, they are diverse in their experience with nuclear power systems: they write R&D proposals, approve and/or manage R&D projects, conduct or review research, provide technical advice, or are involved with terrestrial power plant operations. About 80 percent of these experts conduct or review research results. Twenty-one respondents work for companies that are vendors responsible for marketing the

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[3]Some respondents returned one survey questionnaire but not the other.

results of reactor systems research. Seventy-six percent of the respondents are involved with SP-100 and/or Multimegawatt and the remaining 24 percent focus exclusively on terrestrial projects.

STUDY RESULTS

The experts surveyed identified various areas in which space reactor systems technology is expected to be useful in the development of advanced terrestrial nuclear reactor system technology. Most of these experts believe that knowledge gained from the following research areas may be useful: fuel and fuel systems, materials, heat transport, instrumentation, control methodology, safety, reliability, and modeling and analysis techniques. Although the other areas--energy conversion, fabrication, and facilities--were rated lower, most respondents expect that research advances in these areas will be somewhat useful for future terrestrial reactor development.

Instrumentation and control research may prove the most fruitful for designers of terrestrial systems. Those surveyed believe that instrumentation and control technology from space power systems research may be very useful for improving reactor systems' safety and efficiency, not only for future terrestrial reactors but also for existing reactors. Nuclear power plants contain elaborate instrumentation networks consisting of sensors (measuring devices) and cables for transmitting measured

information, such as temperature and power intensity, back to the power plant operations room. Respondents said the space power program is expected to develop sensors that respond faster, are more resistant to temperature and radiation, and last longer than sensors currently used in terrestrial reactor systems. They also said that the space power program is exploring improved cabling and other means, such as fiber optics and telemetry, for transmitting sensor data. In addition, respondents stated that space power research in advanced computer systems to control reactor operations may be very useful to terrestrial designers seeking to improve reactor safety and efficiency.

However, survey respondents also identified limitations to the technology that can be transferred. They cautioned that while space power research knowledge can be useful to terrestrial reactor development, little one-for-one transfer of space power hardware components is likely because of different design requirements. In addition, space power technology, which involves liquid metal- and gas-cooled systems, is less likely to benefit existing commercial reactors, which employ water-cooled systems. The respondents also stated that the SP-100 program will be less likely than the more advanced Multimegawatt program to produce technology that will be useful to designers of terrestrial reactors. The Multimegawatt program is longer-term, with more demanding design and performance requirements than the SP-100 program, and thus has a much greater potential for technology advancements.

The opinions of the experts that we queried varied slightly as a result of each respondent's particular space program affiliation and role within the nuclear R&D industry. In general, those affiliated with SP-100 and/or Multimegawatt were a little more optimistic about potential commercial applications than were the others. In addition, those involved directly in space or terrestrial power research were more optimistic about the terrestrial application of space power research than vendors who have to market such systems. However, we believe it is significant that the vendors were very optimistic about the potential use of instrumentation research results by terrestrial reactor system designers.

The respondents to our survey also identified a number of constraints that will affect the extent to which space power technology is successfully transferred. For example, DOE plans to classify as restricted or national security data key information from the space nuclear power systems research programs. In addition, institutional problems--including industry regulatory and licensing issues, financial and economic concerns, and public perception problems--may discourage investors and developers from accepting and using new technology. Finally, the extent of transfer will depend on the continuance of a space power research program to develop the new technology and the maintenance of a viable advanced terrestrial reactor program to accept the technology.

Madam Chairman, this concludes my summary. We would be pleased to answer any questions that you and other subcommittee members may have.