
PURPOSE

The effort that resulted in this report was conducted by three subpanels of the Basic Energy Sciences Advisory Committee (BESAC) of the Department of Energy (DOE). The first subpanel, chaired by Robert Birgeneau, Dean of Science at Massachusetts Institute of Technology, was charged with considering upgrades to the High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory and the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory. The second subpanel, chaired by Gabriel Aeppli of AT&T Bell Laboratories, was charged with considering upgrades to the Los Alamos Neutron Science Center (LANSCE) and the Intense Pulsed Neutron Source (IPNS) at Argonne National Laboratory. The third subpanel, chaired by Thomas Russell of IBM Research Laboratories,
was charged with considering the technical specifications of the
next-generation spallation neutron source.¹

The first two BESAC subpanels addressed the following questions: (1) Is there a need to operate both sources (the HFBR and the HFIR in the case of the first subpanel, and the LANSC and IPNS in the case of the second subpanel) until after the completion of the next-generation spallation neutron source? (2) If so, what, if any, upgrades would be necessary to meet research needs? (3) Should both sources in either case be upgraded?

BACKGROUND

Following the termination of the Advanced Neutron Source in 1995, the fiscal year 1996 Energy and Water Development Appropriations Conference Report² directed the DOE’s Office of Basic Energy Sciences to evaluate opportunities to upgrade existing reactors and spallation sources as cost-effective means of providing neutrons in the near term for the scientific community while the next-generation source is developed. This evaluation was needed prior to the appropriations committee’s hearings on the department’s fiscal year 1997 budget submission. In response, three subpanels of the Basic Energy Sciences Advisory Committee were convened.

METHODS/APPROACH

The three BESAC subpanels were tasked to provide advice to the DOE within a very short period of time. The request to create the subpanels (along with a notice about budget constraints) was made on November 9, 1995. The subpanels met for several days in January 1996 and heard proposals from individuals operating with or interested in the sources under study. The results of the meetings were presented to BESAC on February 5–6, 1996. The report from that presentation³ contains the findings and recommendations of the sub-

¹For complete lists of committee and subpanel members, see Office of Basic Energy Sciences (1998).
panels and the resulting recommendations by BESAC. The Birgeneau subpanel findings were much more extensive (43 pages) than the 6-page Aeppli subpanel and 5-page Russell subpanel findings. A comprehensive report,\(^4\) including the report of the subpanels with introductory letters and preface material, was published in March 1998.

**FINDINGS AND RECOMMENDATIONS**

**Birgeneau Subpanel Findings**

- The scientific and technological case for neutron science was as strong if not stronger in 1996 than in January 1993 when the case for neutron science was made in the Panel on Neutron Sources report (see Chapter Thirteen).\(^5\)

- The development of facilities in Europe and Japan in the previous five years puts the United States behind other countries in neutron source facilities.

- The proposed upgrades at the HFIR and HFBR can help close the gap in neutron source facilities and significantly enhance U.S. scientists' and engineers' access to world-class thermal and cold neutron instrumentation at HFIR and cold neutron research instrumentation at HFBR. The scope of work and cost estimates for the proposals were analyzed and appear to be reasonable, given some uncertainties. Both proposed upgrades are cost-effective and will guarantee U.S. prominence in neutron research well into the 21st century. Without the upgrades, the progression of research on new materials, radiation effects, and production of some isotopes is at risk.

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\(^5\)Panel on Neutron Sources (1993). The report contains an appendix with the recommendations from the Basic Energy Sciences Advisory Committee's Panel on Neutron Sources on this topic.
Birgeneau Subpanel Recommendation

- The subpanel recommended that the DOE proceed with both upgrades as proposed.

Aeppli Subpanel Findings

- Operation of both the LANSC and IPNS should continue. Recent successes have served as the foundation for near-term (over the next five years) high-impact research. Closing down either source would terminate ongoing world-class research efforts in the United States, even though in most respects neither source has had the required investment to enable it to perform as well as the Rutherford Appleton Laboratory Pulsed Spallation Source (ISIS) near Oxford, UK (the world’s most powerful pulsed spallation source).

- Upgrades are necessary to meet research needs. U.S. scientists and engineers need access to an ISIS-class source to perform certain leading-edge research. In addition, both the IPNS and LANSC are oversubscribed.

- Both the Los Alamos and Argonne upgrades are needed because they are qualitatively different and serve very different scientific needs.

- The upgrades cannot be performed within existing operating budgets because the budgets are simply too small relative to the upgrade costs to permit completion over a realistic time period. The IPNS proposal cannot be executed within the cost guidelines given to the subpanel, but the proposal is technically sound and, if the upgrades are completed, the IPNS would exceed the performance of the world’s best pulsed spallation source.

- The Los Alamos proposal is at a less advanced stage than the Argonne proposal. Although no operating experience with long-pulse spallation sources exists, the panel judged the project to be technically feasible and the current cost estimate to be conservative and within the given budgetary constraints. For many experiments involving cold neutrons that are well matched to large-scale structures and slow dynamics, the Los Alamos facility should perform better than any existing reactor or spallation
source. Therefore, the panel recommended that unless the new 1-MW-plus short-pulse source were to begin producing neutrons (at the ISIS level) within the first seven years, BESAC and the DOE should fund the IPNS upgrade.

Aeppli Subpanel Recommendation

- The United States should invest in a portfolio of sources defined not so much by the methods of neutron production as by the scientific capabilities. Maintaining a balanced portfolio of sources clearly mandates the IPNS upgrade or an accelerated construction schedule for the 1-MW-plus spallation source at Oak Ridge National Laboratory.

Russell Subpanel Findings

- The Russell subpanel found, as was discussed in the Panel on Neutron Sources (1993) report (see Chapter Thirteen), that present sources are inadequate and a combination of a pulsed source and a reactor source is necessary. There are technological uncertainties in the development of a 5-MW pulsed source with respect to the accelerator, target, and ion source designs and the instrumentation necessary to fully utilize the enhanced flux. These uncertainties would require time to overcome, but enhanced flux would be feasible at the 1-MW level. In each of these areas, research and development is deemed necessary.

- The subpanel also felt that a strong argument for the development of a next-generation pulsed spallation source was needed to accommodate the broad user base in academia and industry. This need also requires upgrading the existing reactor and spallation source facilities. However, these upgrades alone would not satisfy the nation’s needs in the next 10 to 20 years. Flux limitations and limited neutron beam availability at these upgraded facilities would still prevent the realization of the scientific and technical opportunities identified by the panel. Thus, development and construction of the next-generation pulsed spallation source are deemed to be crucial.
Russell Subpanel Recommendations

The subpanel recommended that the DOE develop a strategy to create the highest-power short-pulsed spallation source. Specifically, the subpanel recommended that the DOE

- build a short-pulsed spallation source in the 1-MW power range for neutron scattering with sufficient design flexibility to operate later at a significantly higher power level
- carefully select an initial set of instruments to maximize early scientific benefits, the design of which must rely initially on low-risk technology
- in parallel, conduct research and development on ion sources, beam chopping, low-energy beam transport, charge exchange injection, and moderator and target technologies to reduce risks to acceptable levels.

Keeping the cost of the initial project within the $1 billion limit demanded the exploitation of existing studies in the United States and abroad on the next-generation pulsed spallation source. Specifically, this dollar limit demands

- a broad-based collaboration on the design of source components and instrumentation
- continuous cost monitoring within the project.

Building on the subpanel recommendations, BESAC concluded that while the proposed upgrades were critically important, the upgrades and construction projects could not be done at the expense of the other research activities of the Office of Basic Energy Sciences.

Overall Findings and Recommendations

As a result of the subpanels’ findings and recommendations:

- The Russell subpanel’s recommendation for the construction of a 1-MW, upgradeable, short-pulse spallation source was adopted by BESAC.
• The Birgeneau subpanel viewed the two reactor upgrade proposals as part of a coherent plan to provide cold and thermal neutrons. While the upgrade project costs were uncertain, the sum of the two reactor upgrades fell within the $200 million cost guideline. BESAC concluded that the HFBR at Brookhaven National Laboratory must be upgraded to provide the essential neutron scattering facilities. BESAC also concluded that the more modest $50 million proposed upgrade of the High Flux Isotope Reactor (HFIR) would provide significant additional thermal neutron scattering capability for the United States and should be pursued, subject to verification of the cost estimates.

• The Aeppli subpanel made a compelling case for a short-pulse neutron source capability in the ISIS class within the next two to four years, and that the DOE’s Office of Energy Research should further explore other affordable options for providing short-pulse neutron capability. The subpanel documented the need for a short-pulsed spallation neutron source and described a proposed $450 million IPNS upgrade to a 400 kilowatt power level. Because the cost of this interim upgrade far exceeded the $100 million cost guidelines, BESAC did not recommend proceeding with the upgrade. The proposed long-pulse spallation neutron source at Los Alamos was in a less advanced stage than the Argonne proposal and did not meet the short-pulse needs of the community. BESAC recommended that the DOE’s Offices of Defense Programs and Energy Research jointly develop a plan to exploit the long-pulse spallation source.

• All of the proposed upgrades involve the development of major new experimental end stations as a part of the project. Construction of these major new instruments is critical if the upgrades are to be fully utilized. BESAC concluded that this instrumentation must not be sacrificed in order to reduce the total project cost of an upgrade.

OTHER ITEM OF INTEREST

As a result of the BESAC recommendations, the Office of Basic Energy Sciences initiated enhancements to the HFIR at Oak Ridge National Laboratory and joined with the DOE’s Office of Defense Programs to upgrade the short-pulse spallation source at the LANSC.
The cost of both efforts was modest, and the enhancements were thought to increase capacity to match the performance of current neutron sources in Europe.