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The Department of Energy's Spallation Neutron Source Project: Description and Issues

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Kai-Henrik Barth
Analyst in Science and Technology Policy
Resources, Science, and Industry Division

ABSTRACT

This CRS report focuses on the Spallation Neutron Source (SNS), a new Department of Energy-funded research facility, which is scheduled for construction at the Oak Ridge National Laboratory in eastern Tennessee. The facility is intended to generate and use pulsed neutron beams to study the structural properties of a wide range of materials. The report describes the SNS's management, project costs, schedule, site selection, and funding, and discusses issues raised by some congressional critics of the project, such as management problems, potential cost overruns, and schedule delays. Technical information about the project as well as excerpts from relevant legislation are appended. The report will be updated as appropriate.

The Department of Energy's Spallation Neutron Source Project: Description and Issues

Summary

The U.S. Department of Energy (DOE) is preparing construction of the Spallation Neutron Source (SNS), a new $1.36 billion research facility at the Oak Ridge National Laboratory in eastern Tennessee. The project is a collaboration of five national laboratories: Oak Ridge (ORNL), Argonne (ANL), Brookhaven (BNL), Lawrence Berkeley (LBNL), and Los Alamos (LANL). The facility is intended to generate and use pulsed neutron beams to study the structural properties of a wide range of materials. After its scheduled completion in December 2005, the facility would be the world's most powerful neutron source of its kind. Many scientists argue that the SNS will provide U.S. science and industry with an essential tool to compete with Europe and Japan in broad areas of the physical, chemical, and biological sciences, as well as in the development and testing of new materials.

In FY1999, Congress gave DOE permission to begin some design and construction work and appropriated $130 million. During FY2000 budget negotiations, congressional critics of the SNS's management threatened to withhold further authorization for construction funds unless DOE would take significant steps to strengthen project management. In conference, Congress appropriated $117.9 million, including $100 million for construction. Although significantly less than the DOE's FY2000 SNS budget request of $214 million, the appropriated amount permits the project's continuation during FY2000.

While most scientists contend that the SNS's scientific merits are undisputed, some critics have pointed to weaknesses in the project's management. DOE states that SNS project management has been strengthened in recent months with the selection of a new and experienced leadership team. However, two problems remain that might jeopardize further congressional support: difficulties in developing one of the project's pivotal technical components, its linear accelerator; and a Tennessee tax imposed on the project's construction. Concerned about potential cost overruns and schedule delays, some in Congress are arguing for close congressional oversight to help ensure the SNS's successful completion on schedule and within budget.

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Introduction

The Spallation Neutron Source (SNS), a new research facility funded by the Department of Energy (DOE), is scheduled to be constructed at the Oak Ridge National Laboratory in east central Tennessee.[1] The project is the collaboration of five DOE national laboratories:

- Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee
- Argonne National Laboratory (ANL), Argonne, Illinois
- Brookhaven National Laboratory (BNL), Upton, New York
- Lawrence Berkeley National Laboratory (LBNL), Berkeley, California
- Los Alamos National Laboratory (LANL), Los Alamos, New Mexico

Each of the five laboratories is responsible for developing and constructing one of the major components for the SNS. With a projected total cost of $1.36 billion, the SNS would be the most expensive civilian DOE facility under construction since the cancellation of the Superconducting Super Collider (SSC) in 1993. The DOE developed the SNS concept beginning in the mid-1990s, after it abandoned a more ambitious neutron source project at Oak Ridge, the Advanced Neutron Source (ANS).[2]

The SNS, which is scheduled to become operational by December 2005, is designed to be the world's most powerful neutron source of its kind.[3] Neutrons are subatomic particles that have become essential tools in studying broad areas of the

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[1] For general information about the Spallation Neutron Source see Department of Energy, *Spallation Neutron Source: The next-generation neutron scattering facility for the United States* (1998); see also the project's website [http://www.ornl.gov/sns/].

[2] The Advanced Neutron Source, a reactor-based facility, faced congressional opposition primarily because of its high price, estimated to be $3 billion. In addition, nonproliferation advocates criticized the project for its planned use of highly enriched uranium. See Barbara Goss Levi, "The Advanced Neutron Source Knocks at the Door of Congress," *Physics Today* (November 1994), 17-19; Daniel Clery and Andrew Lawler, "The Looming Neutron Gap," *Science* (17 February 1995), 952-954; Faye Flam, "Panel Hopes Compromise Will Bail Out Neutron Source," *Science* (18 November 1994), 1160-1161.

[3] Neutron beams can be produced in two different ways, either by a particle accelerator or by a nuclear reactor (see Appendix A). The SNS is an accelerator-based facility. Currently, the most powerful operating accelerator-based neutron source is ISIS at the Rutherford Appleton Laboratory near Oxford, England. SNS, with an expected beam power of 2 megawatts, will have more than 10 times the beam power of ISIS.

physical, chemical, and biological sciences, as well as aiding the development and testing of new materials. Much like x-rays or electrons, neutron beams can be used to probe the structure of physical and biological materials, acting like a high-resolution "microscope." Experiments conducted with the SNS are expected to advance scientific disciplines such as materials science, solid state physics, engineering, chemistry, and structural biology. Many scientists expect that the SNS will lead to a wide range of improved materials used in every day products such as cars, airplanes, computers, and drugs [see Appendix A for additional information on the technology and applications of the SNS].

Many leading U.S. scientists have long called for a new neutron source in the United States.[4] Currently, six neutron sources operate in the United States,[5] but most scientists have pointed out that these sources are out-of-date and inferior to facilities in Europe and Japan.[6] DOE evaluated three possible approaches to remedy the situation: upgrading existing facilities, buying access time at European facilities, and constructing a new powerful neutron source in the United States. While some upgrades of existing facilities are planned, they will not reach the beam power required for some essential research areas. Access for U.S. researchers to European facilities is limited since the best sources are already oversubscribed by the host nations. In addition, some foreign facilities might not be inclined to support U.S. research involving neutron sources, which is directly linked to industrial competitiveness. Many scientists agree that the SNS could help U.S. science and

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[4] National Research Council, *Neutron Research on Condensed Matter* (1977); National Academy of Sciences, *Major Facilities for Materials Research and Related Disciplines* (1984); Department of Energy, Basic Energy Sciences Advisory Committee (BESAC), *Neutron Sources of America's Future* (January 1993), DOE/ER-0576P; BESAC, *Neutron Sources and Applications* (January 1994), DOE/ER-0607P; BESAC, *Report of the Basic Energy Sciences Advisory Committee on Neutron Source Facility Upgrades and the Technical Specifications for the Spallation Neutron Source* (March 1998).

[5] Neutron sources in the United States: LANSCE (Los Alamos) and IPNS (Argonne) are spallation neutron sources; HFIR (Oak Ridge), NBSR (National Institute of Science and Technology), MURR (University of Missouri), and MIT (Massachusetts Institute of Technology) are reactor neutron sources. The four reactors were designed and constructed in the 1950s and 1960s. The most recent U.S. reactor for neutron scattering research, NBSR, began routine operation in 1969. On November 16, 1999, Secretary of Energy Bill Richardson closed the High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory, which had provided scientists with a neutron beam since the mid-1960s. For a list of present and future neutron sources worldwide see DOE, *Construction and Operation of the Spallation Neutron Source Facility, Final Environmental Impact Statement*, Volume 1, DOE/EIS-0247, p.1-5.

[6] European countries, including France, England, Germany, and Italy, among others, are designing a European Spallation Source (ESS), with an expected average beam power of 5 megawatts, more than double the SNS's 2 megawatts. However, the ESS is only in the research and development phase and will not be completed, if constructed at all, in the near future. No site for the facility has been selected yet. In contrast, the SNS was designed to become operational as soon as possible. Therefore, the design mostly relies on proven technologies that avoid costly and time consuming research and development of components. For the ESS see [http://www.kfa-juelich.de/ess/].

industry to regain a competitive position in research and development areas that depend on powerful neutron beams.[7]

Management

The Spallation Neutron Source is a collaborative effort of five national laboratories: Oak Ridge, Los Alamos, Brookhaven, Lawrence Berkeley, and Argonne, all of which have participated in the SNS's design. Oak Ridge National Laboratory, which leads the collaboration, is currently managed by Lockheed Martin Energy Research Corporation. In April 2000, Lockheed Martin will be replaced by a new contractor, the University of Tennessee in cooperation with Battelle Memorial Institute.

The SNS management structure involves the DOE Office of Science, which provides overall guidance, DOE's Oak Ridge Operations Office, the SNS Project Office, and the five participating national laboratories and their local DOE operations offices.[8] Unlike the other four laboratories involved in the SNS, Los Alamos National Laboratory reports to DOE's Defense Programs and not directly to the Office of Science. Interactions between various DOE agencies and the participating laboratories are guided by Memoranda of Agreement (MOAs).[9] Following a critical review of the SNS management in January 1999,[10] DOE selected a new leadership team, including a new SNS Executive Director, Dr. David E. Moncton. On November 18, 1999, Secretary of Energy Bill Richardson assigned primary authority and responsibility for project execution to Moncton.[11]

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[7] Department of Energy, *Report of the Basic Energy Sciences Advisory Committee on Neutron Source Facility Upgrades and the Technical Specifications for the Spallation Neutron Source* (March 1998).

[8] For a detailed description of SNS management structure see Department of Energy, *Spallation Neutron Source: Project Execution Plan*, approved by Secretary of Energy Bill Richardson on November 18, 1999, Appendix C.

[9] *Memorandum of Agreement between the Office of Science and Defense Programs for the Spallation Neutron Source*, signed February 26, 1998; *Memorandum of Agreement between Oak Ridge Operations Office, Spallation Neutron Source Project Office, and the Argonne Group, Berkeley Site Office, Brookhaven Group, and Los Alamos Area Office*, signed July 9, 1999; *Memorandum of Agreement between the Spallation Neutron Source Project and Argonne National Laboratory, Brookhaven National Laboratory, Lawrence Berkeley National Laboratory, Los Alamos National Laboratory, and Oak Ridge National Laboratory*, signed October 18, 1999. These three memoranda are included in Department of Energy, *Spallation Neutron Source: Project Execution Plan*, approved by Secretary of Energy Bill Richardson on November 18, 1999.

[10] Department of Energy, *Technical, Cost, Schedule, and Management Review of the Spallation Neutron Source Project* (January 1999).

[11] Department of Energy, *Spallation Neutron Source: Project Execution Plan*, approved by Secretary of Energy Bill Richardson on November 18, 1999.

Project Cost and Schedule

Conceptual design activities for the SNS began in November 1995. In June 1997, a DOE review validated the project's design. The expected total cost of $1.266 billion was judged to be credible, but the reviewers felt that the construction schedule of six years, with completion scheduled for September 2004, was too optimistic.[12] Since February 1999, total project cost has remained level at $1.36 billion. The SNS is now scheduled to become fully operational in December 2005.

Site Selection

In April 1999, the DOE issued an Environmental Impact Statement (EIS), which discussed potential environmental consequences of the SNS's construction and long-time operation.[13] Possible sites for the project included Oak Ridge, the DOE's preferred location, and alternative sites at Los Alamos, Argonne, and Brookhaven. While the EIS did not determine any unacceptable environmental consequences at any of the four sites, it concluded in favor of Oak Ridge. Following this assessment, Secretary Richardson announced in June 1999 that the DOE would construct and operate the SNS at Oak Ridge.[14] On November 19, 1999, DOE approved the beginning of construction. DOE officials expect that site preparation activities such as clearing timber and the construction of permanent roads will begin in early December 1999.[15]

DOE preferred to build the SNS at Oak Ridge primarily because of the laboratory's existing infrastructure and experience in neutron science. Oak Ridge's High Flux Isotope Reactor would complement SNS research and make Oak Ridge the nation's center for materials science research with neutron sources. In addition, the availability of low cost skilled labor and the support of the State of Tennessee as well as the local community in Oak Ridge were cited in support of the DOE's decision. The State of Tennessee has committed to constructing a guest user facility and to initiating a neutron science program at the University of Tennessee.

Budget

From FY1996 to FY1998, Congress appropriated a total of $38.5 million for conceptual design work. For FY1999, DOE requested $157 million for the SNS to begin design activities and to continue research and development work. While the Senate suggested appropriating the requested amount (S. 2138, S.Rept.105-206) , the

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[12] Department of Energy, *Department of Energy Review of the National Spallation Neutron Source Project*, June 1997. Secretary of Energy Pena approved the SNS technical, cost, and schedule baselines on December 23, 1997.

[13] Department of Energy, *Final Environmenal Impact Statement, Construction and Operation of the Spallation Neutron Source Facility*, DOE/EIS-0247 (April 23, 1999), [http://nepa.eh.doe.gov/eis/eis0247/eis0247.html].

[14] Department of Energy, *Record of Decision for the Construction and Operation of the Spallation Neutron Source* (June 18, 1999), [http://www.ornl.gov/sns/Rod.pdf].

[15] Personal communication, Jeffrey Hoy, DOE-SNS Program Manager, November 23, 1999.

House cut the SNS budget to $100 million, citing severe budget constraints (H.R. 4060, H.Rept. 105-581). In conference, the Congress appropriated $130 million and gave permission to begin some design and construction work (H.R. 4060, H.Rept. 105-749). The appropriated amount included $28.6 million for project research and development and $101.4 million for construction. The President signed the bill (H.R. 4060) October 7, 1998 (P.L. 105-245).

For FY2000, DOE requested $214 million for the SNS, an increase of 64.6% over FY1999 appropriations. The request included $196.1 million for construction and $17.9 million for research and development to confirm the SNS's technical design. While the Senate approved $186.9 million for the SNS in its version of the FY2000 Energy and Water Development Appropriations Bill (S. 1186, S.Rept. 106-58), including $169 million for its construction, the House cut appropriations for the SNS to $67.9 million in its version of the bill (H.R. 2605, H.Rept. 106-253), a reduction of $146.1 million from the requested amount. In conference, Congress followed the recommendation of the House-passed DOE R&D authorization bill (H.R. 1655, H.Rept. 106-243) and appropriated $117.9 million for the project, including $100 million for construction (H.Rept. 106-336). The amount is $69 million less than suggested by the Senate and $50 million more than suggested by the House. In total, Congress appropriated about 50% of the DOE's FY2000 budget request for the SNS's construction. The bill was signed into law on September 29, 1999 (P.L. 106-60). Commenting on the bill, the President expressed disappointment that Congress did not fully fund the Spallation Neutron Source.[16] However, Representative Zach Wamp reportedly is working to secure additional funding for the SNS as part of a possible supplemental appropriation bill, expected early in 2000.[17]

Issues

While internal and external reviews have emphasized the project's scientific merits, many observers have expressed concerns about the project's cost and schedule, its management, and the difficulties of effectively integrating the efforts of the five participating laboratories.[18] Dissatisfied with the project's progress, critics in the House in 1999 threatened to withhold authorization for further construction funds until DOE significantly strengthened SNS management. In March 1999, House Science Committee Chairman Sensenbrenner recommended that no FY2000 funds for SNS construction be appropriated because the project's —

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[16] "Statement by the President," White House Press Release, September 30, 1999.

[17] Ron Bridgeman, "OR [Oak Ridge] funding nearly level, despite SNS," *The Oak Ridger*, September 30, 1999.

[18] DOE, *Department of Energy Review of the National Spallation Neutron Source Project*, June 1997; Department of Energy, *Technical, Cost, Schedule, and Management Review of the Spallation Neutron Source*, January 1999; EG&G Service, *External Independent Review of the Spallation Neutron Source (SNS) Project*, Final Report, March 15, 1999; Victor S. Rezendes, Testimony before the Subcommittee on Energy and Environment, Committee on Science, House of Representatives, *Department of Energy: Challenges Exist in Managing the Spallation Neutron Source Project*, GAO/T-RCED-99-103, March 3, 1999.

> management is in turmoil, spending is lagging, Project [sic] cost and schedule estimates have not been fully developed (nor will they be until much later this year), the Department of Energy's (DOE's) complex management approach requires further simplification and current memorandums [sic] of agreement (MOAs) should be substantially strengthened.[19]

These concerns shaped legislation, in particular the Department of Energy Research, Development, and Demonstration Authorization Act of 1999 (H.R. 1655). The bill passed the House but was not taken up in the Senate in the 1st Session of the 106th Congress. Concerning the SNS, the bill included seven conditions for the obligation of appropriated funds for the SNS (see excerpts of H.R. 1655 in Appendix B):

1. that senior management positions be filled by qualified individuals;
2. that an external review validate the project's cost baseline and project milestones;
3. that the duties and obligations of each participating laboratory be defined in legally binding terms;
4. that the project director have direct supervisory responsibility over the SNS staff based at the collaborating laboratories;
5. that the Secretary delegate primary authority of the project to the project director;
6. that the Tennessee sales tax for the construction of the SNS not exceed taxes in states where the SNS could have been constructed, i.e., California, Illinois, New Mexico and New York; and
7. that the DOE Secretary report on the project's progress annually.

DOE responded to criticism of SNS's management with the appointment of a new Executive Director, Dr. David E. Moncton, in February 1999. The choice of Dr. Moncton has been widely applauded, based on his professional accomplishments as a physicist and project manager. Moncton's career includes fundamental research with neutron sources, industrial experience at AT&T Bell Laboratories and Exxon Research Corporation, and large project management. He was Associate Director at the Argonne National Laboratory, where he directed the completion of the Advanced Photon Source on schedule and under budget.[20] Within weeks of his appointment, Moncton provided a project assessment and a reorganization plan, addressing concerns about weaknesses in the project's management.[21] In November 1999,

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[19] F. James Sensenbrenner, Jr., *Trip Report on the Spallation Neutron Source (SNS)* (March 5, 1999), [http://www.house.gov/science/106thpress/106-24.htm].

[20] Larisa Brass, "Moncton named new SNS head," *The Oak Ridger* (February 22, 1999); Oak Ridge National Laboratory, "Dr. David Moncton to become SNS Project Director," Oak Ridge Press Release (February 23, 1999), [http://www.ornl.gov/Press_Releases/archive/mr990223-00.html].

[21] David E. Moncton *et al., Spallation Neutron Source: Project Assessment Report and Action Plan* (April 13, 1999).

Secretary of Energy Richardson strengthened the Executive Director's authority by assigning him full responsibility for the execution of the project.[22]

Cost and Schedule Baseline

Reviewers have criticized the cost and schedule estimates for the SNS as not being fully developed. Some argue that the project leadership lacked the necessary skills to produce a reliable baseline, which is regarded as essential for the project's completion on time and within budget. In particular, reviewers pointed out that SNS managers included insufficient allowances for unforeseen costs and construction delays in their cost and schedule estimates, leading to unrealistic expectations about the project's total cost and its completion date. The new leadership team reviewed the project's cost and schedule baseline and increased the contingency budget from 19% to 28% of the total project cost, without increasing the project's total cost.[23]

Appropriations, Total Costs, and Completion Date

According to SNS Executive Director Moncton, the FY2000 funding cuts of $96 million could increase total costs by $20 million and delay completion of the SNS by a year.[24] SNS officials pointed out that the project would require $281 million for FY2001 and $272 million for FY2002 to be completed as planned by December 2005. However, critics in Congress contend that the project requires close congressional oversight to guard against cost overruns and time delays.

Vacant Management Positions

In 1997, a DOE internal review found that key management positions were unfilled.[25] In early 1999, both an internal and an external review concluded that these positions were still vacant and that the management lacked the necessary determination to successfully complete the project in time and within budget. In March 1999, the lack of qualified managers, in particular a technical director and an operations manager, were highlighted by the General Accounting Office (GAO) and by Chairman Sensenbrenner of the House Science Committee.[26] SNS Executive

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[22] Department of Energy, *Spallation Neutron Source: Project Execution Plan*, approved by Secretary of Energy Bill Richardson on November 18, 1999.

[23] Department of Energy, *Spallation Neutron Source: Project Execution Plan*, approved by Secretary of Energy Bill Richardson on November 18, 1999.

[24] Larisa Brass, "SNS cut may delay schedule," *The Oak Ridger* (September 28, 1999).

[25] DOE, *Department of Energy Review of the National Spallation Neutron Source Project*, June 1997, p. ii.

[26] Victor S. Rezendes, *Challenges Exist in Managing the Spallation Neutron Source Project* (March 3, 1999) GAO/T-RCED-99-103; Sensenbrenner, *Trip Report on the Spallation Neutron Source (SNS)* (March 5, 1999).

Director Moncton recently pointed out that all key positions have now been filled, including a construction manager.[27]

Integration

As a collaborative effort of five laboratories, the SNS poses potentially significant management difficulties. According to DOE, the collaborative structure was chosen to incorporate the expertise of each participating laboratory. Critics argued, however, that this level of collaboration between five national laboratories is unprecedented and risks schedule delays and cost overruns.[28] Reviewers stressed that this collaboration can only succeed with the strongest possible leadership. In response to this concern, DOE, under Executive Director Moncton's leadership, negotiated detailed Memoranda of Agreement, which govern the interaction between the participating laboratories and the SNS management.[29]

Key Issues

According to DOE officials, five of the seven conditions specified in H.R. 1655 have been met. The two remaining conditions are the independent review of the cost baseline and project milestones, and a satisfactory solution to the Tennessee tax problem. While the independent review, by the engineering and construction company Burns and Roe, appeared in final form on December 10, 1999,[30] no immediate resolution of the Tennessee tax problem is in sight. Furthermore, management differences between the SNS Project Office and the Los Alamos National Laboratory, which designs and constructs one of the SNS's pivotal components, could lead to project delays. The remainder of this report focuses on these two issues, which could threaten the project's completion on time and within budget.

Los Alamos's Linac. Since the initial planning for the SNS, the design and production of the project's linear accelerator, or Linac, was the responsibility of Los Alamos National Laboratory. Technical and management problems, however, led to schedule delays and uncertain cost estimates for this pivotal component.[31] As part of Executive Director Moncton's reorganization efforts, a new Accelerator Systems

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[27] Larisa Brass, "SNS cut may delay schedule," *The Oak Ridger* (September 28, 1999).

[28] See for example Victor S. Rezendes, *Challenges Exist in Managing the Spallation Neutron Source Project* (March 3, 1999) GAO/T-RCED-99-103.

[29] Moncton et al., *Spallation Neutron Source: Project Assessment Report and Action Plan* (April 13, 1999).

[30] Private communication, Jeff Hoy, December 10, 1999.

[31] The January 1999 DOE review highlighted the Linac's unresolved technical issues as well as management problems. The reviewers recommended that the SNS Project Office should take ownership of the Linac design, cost estimate and schedule. Department of Energy, *Technical, Cost, Schedule, and Management Review of the Spallation Neutron Source Project* (January 1999), p. 9.

Division was established at Oak Ridge.[32] The new division is responsible for "integration and review of component and system designs, prepare [sic] for facility operations, and guide [sic] procurement, fabrication, installation, testing and commissioning strategies."[33] Relations between the SNS Project Office and the Los Alamos Linac team reportedly have been strained since.[34] It remains to be seen to what extent SNS Executive Director Moncton and his team will be able to accelerate and control Los Alamos's Linac development and ultimately its timely integration into the SNS.

Tennessee Sales and Use Taxes. The State of Tennessee imposes sales taxes on certain items sold in the state as well as use taxes on items purchased elsewhere by non-governmental entities (i.e., contractors) and brought into the state for use. These taxes affect the costs of federal construction projects, since the Department of Energy generally reimburses its contractors for such taxes. DOE estimated that these Tennessee taxes would add about $30 million, or about 2%, to the SNS's total cost.[35] In March 1999, House Science Committee Chairman Sensenbrenner rejected this tax as unacceptable.[36] In addition, one of the seven conditions for the authorization of funds for the SNS, included in H.R. 1655 (see above), dealt with the Tennessee sales tax. According to this condition, no funds could be obligated until it is guaranteed that the Tennessee sales tax for the construction of the SNS would not exceed taxes in California, Illinois, New Mexico or New York, the states of alternative sites for the facility. Action on the bill is pending in the Senate.

On November 1, 1999, at the opening of a special session on taxes of the Tennessee Legislature, Tennessee Governor Sundquist proposed a tax plan that included an exemption from the states sale tax for the construction of the SNS until the year 2009. However, on November 18, 1999, the Tennessee legislature voted to adjourn the legislative session, leaving tax legislation, including the sales tax issue, unresolved.[37] Nevertheless, it is possible that another tax plan will be discussed in the next few months.[38]

In the meantime, the GAO has determined that at least in one state under consideration, New York, virtually no taxes would be imposed on the project's

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[32] David E. Moncton *et al., Spallation Neutron Source: Project Assessment Report and Action Plan* (April 13, 1999).

[33] Ibid., p. 4.

[34] Department of Energy, *Review Committee Report on the Baseline Review of the Spallation Neutron Source (SNS) Project* (July 1999), p. 21.

[35] Ron Bridgeman, "Tax bill would excempt SNS," *The Oak Ridger* (October 27, 1999). DOE's original cost estimate for sales and use taxes amounted to $35.4 million. In July 1999, this figure was reduced to $28.3 million.

[36] Sensenbrenner, *Trip Report on the Spallation Neutron Source (SNS)* (March 5, 1999).

[37] Phil West, "General Assembly adjourns special session on tax reform," *The Oak Ridger* (November 18, 1999).

[38] "Income tax is gone for now, but expect issue to re-surface," *The Oak Ridger* (November 22, 1999).

construction, since Brookhaven National Laboratory is managed by a tax-exempt, not-for-profit organization.[39] In contrast, neither Oak Ridge's current managing contractor, the Lockheed Martin Energy Research Cooperation, nor the partnership of the University of Tennessee and the Battelle Institute, which will manage Oak Ridge beginning in April 2000, are tax-exempt. Therefore, the cost of taxes will likely be higher if the SNS is built at Oak Ridge, Tennessee, than at Brookhaven, New York. These taxes would violate one of the conditions for obligation of SNS construction funds as detailed in H.R. 1655.

Despite the unresolved Tennessee sales tax issue, DOE has begun to release $68 million of the SNS's total appropriations of $117.9 million.[40] DOE managers have argued that since five of the seven conditions in the House-passed authorization bill have been satisfied and the other two are progressing, it was justified to go ahead and release SNS construction and operating funds. DOE managers expect that the rest of the FY2000 SNS funds, about $50 million, will be available by February 2000.

Conclusion

DOE officials suggest that the SNS is back on track, largely as a consequence of the new leadership team. Yet, supporters of the project also contend that the FY1999 and FY2000 cuts in the SNS construction budget have made it difficult to meet the scheduled completion date. They argue that further cuts might lead to the project's termination.

At this time it is uncertain to what extent Congress agrees with DOE's decision to release funds before all seven conditions included in the House-passed authorization bill were met. The Tennessee tax issue is likely to be raised again during the FY2001 budget negotiations. In addition, problems with the integration of Los Alamos's component for the SNS, could result in significant construction delays. Congress may closely watch DOE's efforts to solve SNS management problems, to get the project back on track, and to successfully begin operation in December 2005. There are those in Congress who stress that the SNS requires close oversight to guard against cost overruns and schedule delays. The recently issued cost and schedule baselines should offer a measure to evaluate the project's progress.[41]

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[39] U.S. General Accounting Office report to House Committee on Science, *Laboratory Research: Sales and Use Tax Costs to Build DOE's Spallation Neutron Source Project* (November 19, 1999), GAO/RCED-00-33R SNS Tax Costs.

[40] Larissa Brass, "Partial funding comes through for SNS," *The Oak Ridger* (November 19, 1999).

[41] Spallation Neutron Source, *Project Execution Plan*, approved by Secretary of Energy Bill Richardson on November 18, 1999; see also Department of Energy, *Review Committee Report on the Baseline Review of the Spallation Neutron Source (SNS) Project* (July 1999).

Appendix A: Technical Description

Neutrons and Neutron Beams[42]

Neutrons and protons are subatomic particles of about the same size and mass. While protons have a positive charge, neutrons are electrically neutral. Neutrons can penetrate matter more easily than protons, because they are not deflected in the electromagnetic fields of atoms. This property makes neutrons ideal sources for probing the structure of materials. A high-intensity neutron source can be used as a high-resolution "microscope" to investigate the structure of materials.

Neutron beams can be produced either by a nuclear reactor or a particle accelerator. A nuclear reactor produces a continuous flux of neutrons, whereas an accelerator can generate short pulses of neutrons. Most of the world's nineteen operating neutron sources are nuclear reactors, often 30 to 40 years old, but the majority of recently designed sources are accelerator-based. DOE officials emphasize that for many research problems a pulsed source is more desirable, because higher neutron intensities and energies can be reached. In addition, an accelerator is environmentally significantly less controversial than a nuclear reactor.

The Spallation Neutron Source[43]

The SNS is an accelerator system consisting of five major components: a particle source, a linear accelerator, an accumulator ring, a beam target, and an area for experimentation. The particle source produces negatively charged hydrogen ions (a proton orbited by two electrons), which are then accelerated to high energies in a large, 465-meter long, linear accelerator. Leaving the accelerator, these ions are stripped of their electrons and thereby converted to protons. Within a small fraction of a second, the accumulator ring, a structure of about 220 meters circumference, collects many billions of these high-energy protons into a bunch, which is then released onto a target of liquid mercury. When high-energy protons bombard a heavy metal target such as mercury, every proton knocks between 20 to 30 neutrons out of a target (e.g., mercury) atom. This process, known as neutron spallation, gives the project its name. Finally, the high-energy neutrons are slowed down before they are directed to various experimental setups.

The pulsed neutron beam will be directed to experimental setups where scientists use the beam to investigate the arrangement and motion of atoms in materials. Instruments measure how the material under investigation scatters the incoming neutrons. A detailed analysis of the scattering patterns allows researchers to determine a material's atomic structure. In many ways the SNS is a high resolution "microscope," comparable to X-ray or electron microscopes. While scientists use a

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[42] For general information on neutrons and neutron beams see Department of Energy, *Spallation Neutron Source: The next-generation neutron scattering facility for the United States* (1998); see also the project's website [http://www.ornl.gov/sns/].

[43] For SNS technical parameters see David Olsen et al., *SNS Parameter List* (July 8, 1999); [http://www.ornl.gov/sns/paralist070899.pdf]

variety of techniques to investigate the structure of materials, neutron scattering offers insights not obtainable with any other procedure. DOE officials expect many benefits from neutron scattering research, ranging from improved magnetic materials to better plastics and superconductors which have applications in every day life.

Each of the five participating national laboratories is responsible for the design and construction of one of the SNS's major components. Lawrence Berkeley is responsible for the ion source, Los Alamos for the Linac, Brookhaven for the accumulator ring, Oak Ridge for the target, and finally, Oak Ridge and Argonne for instrumentation and experiment facilities. After a number of reviews, DOE decided in 1999 that the SNS would be constructed at the DOE's preferred site at Oak Ridge, where it will occupy an area of about 100 acres.

DOE expects that the SNS will operate for about 40 years. Each year between 1,000-2,000 scientists and engineers, primarily from U.S. academic institutions, industry, and government laboratories, will use the new facility.

Appendix B: Excerpts from H.R. 1655

H.R.1655: Department of Energy Research, Development, and Demonstration Authorization Act of 1999 (Passed House on September 15, 1999, pending in the Senate)

Sec. 3. Authorization of Appropriations

[...]

(b) SCIENCE- There are authorized to be appropriated to the Secretary for Science scientific and civilian energy research, development, and demonstration operation and maintenance and construction programs, projects, and activities for which specific sums are not authorized under other authority of law $2,657,761,000 for fiscal year 2000 and $2,691,465,000 for fiscal year 2001, to remain available until expended, of which–

[...]

(10) $17,900,000 for fiscal year 2000 and $13,100,000 for fiscal year 2001 shall be for Spallation Neutron Source research and development; and

(11) $100,000,000 for fiscal year 2000 shall be for construction of Project 99-E-334, Spallation Neutron Source, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

[...]

Sec. 10. Limits on Use of Funds

(a) CONSTRUCTION OF SPALLATION NEUTRON SOURCE PROJECT- None of the funds authorized by section 3(b)(11) may be obligated until—

(1) the Secretary certifies in writing to the Committee on Science of the House of Representatives and the Committee on Energy and Natural Resources of the Senate that senior project management positions for the project have been filled by qualified individuals; and

(2) the Secretary provides the Committee on Science and the Committee on Appropriations of the House of Representatives, and the Committee on Energy and Natural Resources and the Committee on Appropriations of the Senate, with—

(A) a cost baseline and project milestones for each major construction and technical system activity, consistent with the overall cost and schedule submitted with the Department’s fiscal year 2000 budget, that have been reviewed and certified by an independent entity, outside the Department and having no financial interest in the project, as the most cost-effective way to complete the project;

(B) binding legal agreements that specify the duties and obligations of each laboratory of the Department in carrying out the project;

(C) a revised project management structure that integrates the staff of the collaborating laboratories working on the project under a single project director, who shall have direct supervisory responsibility over the carrying out of the duties and obligations described in subparagraph (B); and

(D) official delegation by the Secretary of primary authority with respect to the project to the project director; and

(3) the Comptroller General reports to the Congress, on the basis of available information, that the tax reimbursements that the Comptroller General estimates the Department would pay to its contractors as a cost of constructing the Spallation Neutron Source at Oak Ridge National Laboratory in Tennessee would be no more than the tax reimbursements it would pay if the same project were constructed at the Lawrence Berkeley National Laboratory in California, the Argonne National Laboratory in Illinois, the Los Alamos National Laboratory in New Mexico, or the Brookhaven National Laboratory in New York.

The Secretary shall report on the Spallation Neutron Source Project 99-E-334 annually, as part of the Department's annual budget submission, including a description of the achievement of milestones, a comparison of actual costs to estimated costs, and any changes in estimated project costs or schedule.
[...]

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