ESTIMATED BUDGETARY EFFECTS OF ALTERNATIVES FOR PRODUCING TRITIUM

Tritium gas (a radioactive isotope of hydrogen) is used to enhance the explosive yield of nuclear warheads. Scientists generally produce tritium in nuclear reactors by bombarding target rods containing lithium with neutrons (because the fissioning of a reactor's uranium fuel generates lots of neutrons). More recently, scientists have produced small quantities of tritium in a particle accelerator by bombarding helium 3 gas with neutrons. The Department of Energy (DOE) formerly produced tritium in nuclear reactors located at its Savannah River site in South Carolina. The last reactor there was shut down in 1988, and since then no tritium has been produced in the United States. Tritium decays relatively rapidly, so its levels in the nuclear stockpile are being maintained by using the tritium from dismantled warheads. That recycling process can continue for only a limited time, however. Eventually, tritium production will have to be resumed.

In response to Congressional requests, the Congressional Budget Office (CBO) has estimated the budgetary impact of three options for producing tritium. All of the options assume that DOE must make enough tritium to support a nuclear stockpile of the size allowed by the START I treaty. One option calls for producing tritium with a proton accelerator built and owned by DOE. The second option calls for completing the Bellefonte light-water reactor owned by the Tennessee Valley Authority (TVA) and producing tritium there. The third option calls for DOE to buy tritium from one or more of TVA's existing nuclear plants, a method referred to as purchasing irradiation services.

Those alternatives involve different patterns of costs and receipts over time. In order to compare the options on an equal footing, CBO has converted the estimated future costs and receipts to their present discounted value. Present value expresses a flow of current and future income (or payments) in terms of an equivalent lump sum received (or paid) today. A present-value calculation adjusts for the opportunity cost of delaying a payment or receipt, as measured by the interest rate. That is, the cost of a dollar tomorrow compared with that of a dollar today is the forgone interest that would be earned on the dollar.

To analyze the alternatives for tritium production, the opportunity cost (or discount rate) may be measured by the yield on government securities because that yield reflects the cost of borrowing by the federal government. CBO uses a real (inflation-adjusted) discount rate of 3.2 percent—the projected interest rate on 30-year Treasury bonds, 5.7 percent, minus the expected rate of inflation, 2.5 percent.

In present-value terms, CBO estimates that the accelerator option would cost a total of about $6.0 billion over 40 years (see Table 1). The Bellefonte reactor option would cost $2.3 billion, and the option to purchase irradiation services would cost about $1.1 billion.

TABLE 1. FEDERAL BUDGETARY COSTS OF ALTERNATIVES FOR PRODUCING TRITIUM (In millions of dollars)

Option	Initial DOE Design and Construction Costs	40-Year DOE Operating Costs	40-Year DOE Offsetting Receipts	Total Costs
As a Present Value in 1999				
Producing Tritium with an Accelerator	3,530	2,690	-230	5,990
Using the Bellefonte Reactor	2,340	540	-570	2,310
Purchasing Irradiation Services	430	630	0	1,060
In Constant 1999 Dollars				
Producing Tritium with an Accelerator	3,930	6,180	-590	9,520
Using the Bellefonte Reactor	2,590	1,120	-1,200	2,510
Purchasing Irradiation Services	460	1,320	0	1,780

SOURCE: Congressional Budget Office based on data provided by the Department of Energy and the Tennessee Valley Authority.

NOTES: The estimates include revenues from the sale of electricity and medical isotopes. They exclude sunk costs of $385 million for the accelerator option, $4.6 billion for the Bellefonte reactor, and $100 million for the tritium extraction facility that would be necessary under the second or third option.

DOE = Department of Energy.

To indicate the nature of the underlying assumptions, the table also shows those costs measured in constant 1999 dollars (which are adjusted to remove the effects of inflation but are not discounted to reflect the time value of money). Substantial changes in the assumptions underlying the estimates would be necessary to alter the relative cost of the three options.

In the discussions of the options that follow, numbers are presented in constant 1999 dollars unless otherwise indicated. For purposes of its estimates, CBO assumes that funds will be appropriated for DOE's expenses as needed. Those costs would fall under discretionary spending, whereas TVA's expenditures and receipts are classified as direct spending. TVA's power program is financed by a combination of operating income and borrowing, but all costs are ultimately recovered by income from the sale of electricity. In other words, TVA's ratepayers ultimately pay for any additional expenditures by the authority; conversely, those ratepayers benefit (by paying lower electricity prices) for any reduction in TVA's costs.

OTHER CONSIDERATIONS

CBO's analysis focuses on the cost of three options that DOE could use for its primary source of tritium. But several other factors must be considered to place CBO's cost estimates in context. For instance, those costs could be changed by a number of factors: the consequences of deregulating the utility industry, breaches of the contracts to build tritium production facilities, and changes in tritium requirements caused by arms reductions beyond those specified under START I. All of those areas of uncertainty could affect the cost estimates presented here.

DOE has stated that it may finance a secondary source of tritium as a backup in case the primary source fails to perform as expected. For example, if the accelerator is selected as the primary option, DOE may choose a reactor as a backup, complete a facility to extract tritium from the reactor, and fabricate target fuel rods. Alternatively, if DOE chooses to use the Bellefonte reactor or purchase irradiation services as its primary method, it may continue to develop the accelerator as a backup, stopping short of construction. In either case, if DOE does pursue a two-track approach, developing the secondary source will add to the costs of the primary options.

Using a civilian nuclear reactor for military purposes could have direct implications for U.S. policy on the nonproliferation of nuclear weapons and technology. For years the United States has strongly urged other countries not to put civilian reactors to military uses. In a recent report, DOE argues that those concerns can be managed, but some outside experts disagree.

In addition, pending arms control treaties could significantly affect the amount of tritium that DOE must produce and the necessary timing of any decision to select a source. Until Russia ratifies the START II treaty, U.S. policy requires DOE to produce enough tritium to support a START I stockpile. But if START II is ratified, DOE’s requirements will change: it will not need tritium until 2011 and can cut its necessary production by roughly one-third. Those lower requirements would reduce the cost of all three options to some extent. Furthermore, the United States and Russia have already agreed to negotiate a third START treaty as soon as START II is ratified, which would cut their strategic arsenals and tritium requirements even further.

Finally, other sources of tritium have been suggested that DOE is not currently considering. They include purchasing a reactor, using the Fast Flux Test Facility at DOE's Hanford site (which would produce only enough tritium to support a smaller START III stockpile and raises proliferation issues of its own because it uses plutonium fuel), and buying tritium from Russia, which can produce large quantities of the gas.

PRODUCING TRITIUM WITH AN ACCELERATOR

According to information provided by DOE, the particle accelerator under consideration would be one mile long and part of a 170-acre complex. The proposed plant would be similar in some respects to the continuous electron beam accelerator facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (the Jefferson Lab) in Newport News, Virginia, and the linear accelerator at the Los Alamos Neutron Science Center. The machine would require about 450 megawatts (MW) of power to deliver a high-power proton beam at 100 MW. That would be about two orders of magnitude greater than existing research accelerators, such as the one at Jefferson Lab. In addition to building the accelerator and related buildings at the Savannah River site, DOE would upgrade the existing tritium-recycling facilities there to support the accelerator plant. Assuming all went as planned, the plant would deliver the first tritium by 2008 and operate for 40 years. CBO estimates that construction and 40 years of operation would cost a total of $9.5 billion in 1999 dollars (see Table 1).

Design and Construction Costs

Out of the $9.5 billion price tag for this option, design, construction, and other activities associated with building the accelerator would cost $3.9 billion, CBO estimates. That $3.9 billion figure is made up of four main components. First, completing plans for the accelerator and starting construction designs would require spending about $500 million over the next several years.

Second, constructing the accelerator plant would cost an estimated $2.9 billion. Some $900 million of that would pay for the linear accelerator and associated equipment, according to information that the potential manufacturer of the accelerator provided to DOE. Another $1.2 billion would cover such things as utilities and plant buildings ($400 million), the mile-long tunnel ($300 million), targets ($100 million), the tritium separation plant ($100 million), and construction management and support ($300 million). CBO included another $750 million, or about 35 percent, to account for contingencies. A 1996 study by the General Accounting Office (*Opportunity to Improve Management of Major System Acquisitions*, GAO/RCED-97-17) found that cost overruns averaged about 50 percent for 15 large construction projects completed during the 1980-1996 period. Those projects included two accelerators—CEBAF at Jefferson Lab and the advanced photon source accelerator—as well as the tritium loading facility, the photon synchrotron, and other large capital projects similar to the accelerator. Schedule delays and slippages were the primary reason for the cost overruns. In contrast, 11 accelerators experienced average cost growth of only 20 percent. CBO used an intermediate rate because there is no experience with operating an accelerator continuously for the production of tritium.

Third, start-up costs for the accelerator would total $350 million, CBO estimates, assuming that Savannah River has enough heavy water and helium 3—key ingredients for producing tritium with an accelerator. Last, management and support costs would add $150 million to the total cost of design and construction.

Operating Costs

CBO estimates that operating costs for the Savannah River accelerator would total about $155 million a year. Utility costs would come to about $90 million a year, assuming that DOE paid about $28 per megawatt-hour of electricity (a figure based on industry averages over the past three years), operated the accelerator at 486 MW per hour, and kept the accelerator on-line for an average of nine months per year. Other operating and maintenance costs would add $65 million annually, CBO estimates, evenly split between personnel and other costs. Over 40 years, operating costs would total nearly $6.2 billion.

Offsetting Receipts

Based on information from DOE, CBO estimates that a small part of the accelerator's capabilities could be used to produce new therapeutic medical isotopes. A significant market for such isotopes may develop in the next 10 to 20 years, and the accelerator could be designed and operated to capture a share of that market. Although the medical effectiveness of new therapeutic isotopes is uncertain at this time, as is the government's role in producing them, CBO estimates that DOE could generate net receipts of $10 million to $20 million annually from the sale of these products beginning in 2010. (DOE's current isotope production and distribution program spends more than it generates in annual sales.) Additional infrastructure needed to produce therapeutic isotopes with the accelerator would add about 2 percent to the project's initial cost.

USING THE BELLEFONTE REACTOR

The Tennessee Valley Authority has offered to begin supplying tritium in 2005 if DOE pays it to complete its Bellefonte nuclear reactor—a project that TVA suspended in 1988. In 1997, TVA proposed that DOE pay $1.9 billion to complete construction of the reactor. CBO's estimate assumes that the proposed agreement between the two agencies would be updated to reflect the delay in reaching contract terms and that the payment would be $2.1 billion. If the Bellefonte reactor is brought on-line and is used to produce tritium, TVA has offered to pay DOE at least $16 million a year under a revenue-sharing agreement. If for some reason the Bellefonte unit does not produce tritium (for example, if the plant does not become operational for economic, technical, or regulatory reasons), TVA would make tritium using one or more of its other nuclear reactors, such as its Watts Bar or Sequoyah plant. The proposal does not obligate TVA to produce tritium for a specified period of time; rather, the supply would be contingent on TVA's continued operation of its nuclear power plants. To carry out this option, DOE would also have to construct and operate facilities for manufacturing replacement rods and extracting the tritium.

For the purposes of this estimate, CBO assumes that TVA would pay for any cost overruns experienced in completing the Bellefonte unit and that the plant would produce all of DOE's tritium over the 40-year life of the reactor. Under those assumptions, the option would cost about $2.5 billion over the construction period and 40-year operating life of the plant, CBO estimates (see Table 1). If conditions differed from those assumed here, the estimated budgetary impact would differ. For example, federal outlays would be higher if DOE had to pay more than $2.1 billion for completion of the plant or if TVA had to use plants other than Bellefonte to produce tritium (because revenues would be shared only in years in which the Bellefonte plant was operational).

Design and Construction Costs

This option involves constructing two facilities: the partially complete Bellefonte nuclear power plant and a facility to extract the tritium from the target rods. In its estimate, CBO assumes that DOE will pay $2.1 billion for the first of those two. The actual cost of completing the Bellefonte plant could be more or less than that, but CBO does not expect any difference to show up in the federal budget. If the cost exceeded $2.1 billion, TVA presumably would invest its own funds to complete the plant; if the cost was less than $2.1 billion, TVA would most likely keep the savings. Either way, CBO expects that any costs or savings accruing to TVA as a result of its agreement with DOE would be passed on to TVA's electricity customers in the form of higher or lower electricity prices. (Under current law, TVA is required to recover all of its power-related costs through its charges for electricity while keeping those prices as low as reasonably possible.) Hence, although finishing the Bellefonte plant could affect TVA's outlays in specific years, it should have no net impact on the agency's outlays in the long run.

The second component, building a facility to receive irradiated target rods from Bellefonte and extract their tritium, would cost DOE an estimated $500 million. Of that amount, $100 million would pay for construction of the facility, another $100 million would pay for the initial rods, and $300 million would cover the costs of labor and utilities to start up the facility, various licensing and regulatory expenses, and management and support. Costs for additional target rods are included in CBO's estimate of operating costs.

Operating Costs

To use the Bellefonte reactor, DOE would have to pay for shipping the target rods from the reactor to the tritium extraction facility in Savannah River, operating that extraction facility, and manufacturing replacement target rods. According to information provided by DOE, those activities would cost an average of about $28 million a year, beginning in fiscal year 2005—or $1.1 billion over 40 years.

For its part, the Tennessee Valley Authority would pay the routine costs associated with running the Bellefonte reactor and the additional cost of handling the target rods during the refueling process. Those expenditures would have no net budgetary impact, CBO estimates, because TVA would recover the costs from its electricity customers on an annual basis.

If successful, this agreement would result in significant savings to TVA and its customers. The marginal cost of electricity from Bellefonte is likely to be lower than the cost of acquiring the same amount of electricity through leases or new construction, because the plant would be completed at no additional capital cost to TVA's customers. Based on current market trends, CBO estimates that the agreement would reduce TVA's operating costs by $70 million to $100 million per year (net of its payments to DOE). If Bellefonte's production continued to be cost-effective over the 40-year license term of the plant, the agreement would save TVA a total of $3 billion to $4 billion. CBO estimates that those savings would have no net effect on the federal budget over time because TVA would pass them on to its customers.

Offsetting Receipts

Under the proposed agreement, DOE would receive some portion of the difference between the Bellefonte plant's revenues and operating costs—but no less than $16 million in any year in which the plant produced tritium. The likelihood that DOE would be paid more than that minimum amount would depend on several factors: the formula used to calculate prices and operating costs for electricity produced by Bellefonte, the plant's output in a given year, and trends in future electricity prices. If the Bellefonte reactor was never completed or if TVA shut it down after completion, the agency would not make annual payments to DOE.

In the absence of information about the specific terms of the agreement, CBO estimated DOE's share of the Bellefonte proceeds on the basis of several assumptions. It assumed, for example, that the prices used to calculate revenues would not exceed TVA's average revenue per kilowatt-hour and that the formula for operating costs would not include TVA's interest and depreciation expenses for the Bellefonte plant. CBO also assumed that DOE would receive 50 percent of the net revenues (as measured by a formula) and that those funds would be deposited in the Treasury as miscellaneous receipts. In keeping with current law, CBO expects that TVA would set its electricity prices at a level that was high enough to recover the cost of any payments to DOE.

Based on those assumptions, CBO estimates that TVA's payments to DOE would reduce federal outlays by an average of about $30 million a year (about double TVA's minimum guarantee) if the Bellefonte reactor was used to produce all of the tritium over a 40-year period. If the terms of the final agreement differed from those assumptions, or if the plant did not operate as TVA anticipates, the estimated budgetary effects would be different. However, current projections of electricity prices suggest that TVA's annual payments to DOE are likely to be much less than DOE's $2.1 billion up-front payment to TVA on a present-value basis.

PURCHASING IRRADIATION SERVICES

The Department of Energy could also acquire tritium through a service agreement with TVA to use reactors that are already operating to irradiate target rods. As under the Bellefonte option, TVA would own and run the reactors and sell the electricity they generated. DOE would be responsible for constructing a tritium extraction facility, manufacturing the target rods, shipping the rods from the nuclear reactors to the extraction facility in Savannah River, and extracting the tritium. The estimate assumes that DOE would compensate TVA for the actual cost of the irradiation services.

Such an irradiation-services contract with TVA would cost nearly $1.8 billion over a 40-year period, CBO estimates (see Table 1). In practice, the service contract might span fewer years, because the licenses for the Sequoyah and Watts Bar units are set to expire in 2020 and 2035, respectively. As in the Bellefonte option, the supply of tritium could be cut short if TVA chose to shut down its nuclear power plants before the end of their license terms.

Design and Construction Costs

Like the previous option, this alternative would require the construction of a tritium extraction facility at Savannah River. CBO estimates that designing, building, equipping, and licensing that facility would cost almost $500 million, the same as under the Bellefonte option.

Operating Costs

The estimated costs of shipping irradiated rods to Savannah River, operating the tritium extraction facility, and manufacturing replacement target rods would be $28 million a year, the same as under the Bellefonte option. In addition, providing irradiation services would cost TVA an average of about $5 million a year, CBO estimates, based on information provided by government and private-sector analysts. CBO assumes that DOE would compensate TVA for the cost of the services as they were provided, presumably when TVA refueled its reactors. For the purposes of this estimate, CBO also assumes that the agreement between DOE and TVA would be consistent with the terms of the Economy Act, which directs federal agencies to buy goods or services from other federal agencies on the basis of the actual cost of the goods or services provided. If TVA charged DOE more than the actual cost of the irradiation services, taxpayers would pay more for tritium, and TVA's customers would pay correspondingly less for electricity.

Offsetting Receipts

Unlike the other options, this alternative would produce no offsetting receipts.