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97002: The Department of Energy's Tritium Production Program

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FOR ADDITIONAL READING

SUMMARY

Tritium is a radioactive isotope of hydrogen used to enhance the explosive yield of every thermonuclear weapon. Tritium has a radioactive decay rate of 5.5% per year and has not been produced in this country for weapons purposes since 1988 when the K Reactor at Savannah River Site in South Carolina was shut down for safety reasons.

To compensate for decay, tritium levels are being maintained in deployed warheads in the near term by recycling and reprocessing tritium recovered from dismantled nuclear weapons. To maintain the nuclear weapons stockpile at the level called for in the Strategic Arms Reduction Treaty (START) II (not yet in force), however, a new tritium source would be needed by the year 2011. If the higher stockpile levels set by START I remain the target, as is presently the case, tritium production would be needed by 2005.

The Department of Energy (DOE) looked at a number of options for a long term tritium source as part of its Stockpile Stewardship and Management program. Following the release in October 1995 of a final Programmatic Environmental Impact Statement on Tritium Supply and Recycling, DOE on December 6, 1995, issued a Record of Decision to pursue a dual-track approach to develop the two options it considered most promising. The first is to investigate the purchase of the services of an existing commercial reactor or the reactor itself to supply radiation for transforming lithium into tritium. The second is to design, build, and test a particle accelerator to drive tritium-producing nuclear reactions. The Savannah River Site was selected as the location for an accelerator, should one be built.

Both options could meet the 2011 deadline but only the commercial reactor option could be ready by 2005. If tritium is needed sooner, an interim source may be necessary. One such possibility is the DOE Fast Flux Test Facility (FFTF) in Hanford, WA. Two recent studies provided support for this option, and DOE recently decided to maintain the FFTF as a backup tritium source.

Several issues remain to be resolved before a long term source can be built. Included are technical uncertainties with the accelerator and target development for the reactor option, the wide range of possible costs of the various options, regulatory actions particularly with the reactor option, environmental consequences of producing additional radioactive materials, and nuclear proliferation concerns that may arise if civilian and defense nuclear operations are combined on a single facility. DOE's decision to keep the FFTF available as an option has also generated opposition over environmental concerns, and whether there should be defense production at Hanford.

Congress has expressed other concerns about the program. Report language with FY1997 appropriations stated that DOE is not proceeding at a fast enough pace in developing a tritium source. In its FY1997 appropriation, Congress added $50 million to the DOE request of $100 million to accelerate the program. Recently, a report by the House National Security Committee reiterated this concern about the lack of concrete plans by DOE for resuming tritium production.

MOST RECENT DEVELOPMENTS

In the Energy and Water Development Appropriations Act for FY1997, Congress appropriated $150 million for tritium production and related activities, compared to DOEþs request of $100 million. The conference report accompanying the bill directed DOE to inform the House and Senate Committees before it began any tests involving tritium targets within a commercial light water reactor. The Chairman of the House National Security Committee, in a recent report, stated that DOE is not moving fast enough to ensure a tritium production capability when needed. In a related development, in December the Clinton Administration announced a two-track plan to get rid of 50 tons of *weapons-grade plutonium, including its use as mixed oxide to be burned as fuel in commercial nuclear power plants. The impact of this decision on tritium production remains to be seen. DOE recently announced its intention to maintain the Fast Flux Test Facility (FFTF) as an interim tritium source option while it continues to pursue its two-track strategy for a long term source. While supported by some, the decision has also drawn opposition, primarily on environmental grounds.*

BACKGROUND AND ANALYSIS

Role of Tritium

Why It Is Needed

Tritium is a crucial component of thermonuclear weapons. Tritium gas is used in every U.S. nuclear warhead to enhance its explosive yield. A typical thermonuclear device consists of two stages, a primary where the explosion is initiated, and a secondary where the main thermonuclear explosion takes place. The yield of the primary stage, and its effectiveness in driving the secondary to explode, is increased (boosted) by tritium gas which undergoes a nuclear fusion reaction with deuterium, and generates a large amount of neutrons to `boost' the nuclear burn up of the plutonium or highly enriched uranium.

Tritium is radioactive and has a relatively short half-life of a little over 12 years. As a result, the supply of tritium in a newly manufactured weapon would decay by 5.5% per year to less than 1% of its original amount in seven half-lives or 87 years without replenishment. In the past, tritium for replenishment in existing weapons was produced in a nuclear reactor, called the K reactor, at the DOE Savannah River Site (SRS) in South Carolina. In 1988, the reactor was shut down for safety reasons, and no additional tritium has been produced in the U.S. for weapons purposes. Replenishment of tritium in the stockpile has continued, however, by recycling tritium from existing nuclear weapons as they are dismantled. In 1991, President Bush signed the Strategic Arms Reduction Treaty II (START II) which committed the major nuclear powers to a large reduction in their nuclear weapons stockpiles. As a result of this reduction, the stockpile's tritium levels have been maintained primarily by recycling the tritium from deactivated warheads without new tritium production.

By 1993, based on the annually updated Nuclear Weapons Stockpile Plan (NWSP), DOE and DOD determined that tritium production would need to be resumed by the year 2011 if the United States were to maintain its weapons stockpile at the levels set by START II. The NWSP is the blueprint by which DOE proposes to manage the nation's nuclear weapon's stockpile in the absence of testing. Because of the long lead time required to set up a tritium production facility, it was realized that development of preferred production options begin immediately. In the 1996-2001 NWSP, the President directed DOE to fully support the higher START I nuclear weapons level until START II is ratified by all parties and implemented. At present, the United States Senate gave its advice and consent to ratify the treaty in January 1996 but Russia has not ratified START II, and has no plans to do in the foreseeable future. The higher START I level requires that new tritium production start in the year 2005.

What Is Tritium and How Is It Made?

Tritium is a radioactive isotope of hydrogen. Atoms of a particular element have a specific number of protons, but may have different numbers of neutrons in their nuclei. All the different forms, called isotopes, have that element's basic chemical properties but may differ in their atomic properties. A normal hydrogen atom has one proton. An atom with one proton and one neutron is called deuterium, and an atom with one proton and two neutrons is called tritium.

Normal hydrogen and deuterium atoms are stable and not radioactive. But tritium atoms are radioactive with a half-life of 12.43 years. When tritium undergoes radioactive decay, it converts to a stable, non-radioactive form of helium, helium-3. The half-life is the time it takes for half of a given number of radioactive nuclei to be converted to helium-3.

Although tritium occurs naturally in the environment, the amount is too small for practical recovery. Therefore tritium for nuclear weapons must be produced artificially. There are two ways of producing tritium, both involving nuclear reactions using neutrons. In the first way, neutrons are made to strike a target consisting of a lithium/aluminum material. The neutrons react with the lithium, producing tritium and other byproducts. This technology has been used to produce tritium for several decades at the Savannah River Site (SRS) in South Carolina. In the second method, neutrons react with an isotope of helium, helium-3, to produce tritium and normal hydrogen as by-products. Although this process has been proven by various experiments, the helium-3 method has not yet been used in any tritium production system.

Tritium Production Technologies

The production of tritium requires the generation of energetic neutrons. There are two suitable ways of producing such neutrons: nuclear reactors and accelerators. In an accelerator, neutrons are produced by a process called spallation. Protons accelerated in a particle accelerator to very high energies strike a target made of tungsten. The energetic protons then knock neutrons and more protons off of the tungsten atoms like billiard balls. These neutrons and protons then knock off more neutrons, in a cascade fashion. In a nuclear reactor, energy is produced by nuclear fission, or splitting, of uranium and plutonium atoms. Neutrons are used to produce the fission in the first place, and a byproduct of this reaction is more neutrons. Most of these neutrons are used to create more fission reactions -- a chain reaction -- but some neutrons leave the reaction region -- the reactor core -- without initiating a fission reaction. These neutrons are available for other nuclear reactions including those that produce tritium. In both cases, the quantity of neutrons produced can be controlled by adjusting parameters inherent to the accelerator or nuclear reactor.

Congressional Considerations

DOE Activities

The responsibility of maintaining the countryþs nuclear weapons stockpile is assigned to the Department of Energy (DOE). The signing of the Comprehensive Test Ban Treaty (CTBT) by President Clinton on September 24, 1996, banning further testing of nuclear weapons, contemplates that the U.S. nuclear weapon stockpile is to be maintained primarily with a science based approach using laboratory experiments and computer simulations. Weapons activities fall within DOEþs Office of Defense Programs and consist of two major components: stockpile stewardship and stockpile management. The first of these is charged with research and development on ways to ensure the safety and reliability of the existing stockpile, and to preserve a core of weapons-related technical and scientific expertise. The stockpile management component is responsible for stockpile surveillance activities -- those activities designed to ensure the safety, reliability and performance of the existing stockpile, including remanufacture of existing weapons, and for all tasks related to the production of nuclear weapons. Tritium activities lie within the stockpile management program.

Historically tritium has been produced at the K Reactor and other reactors at the Savannah River Site (SRS). As the reactors were shut down, tritium production declined and halted altogether in 1988 when the K Reactor was shut down for safety upgrades. In the same year, DOE started the New Production Reactor (NPR) project to develop a long term source of tritium to replace the aging K Reactor. In September 1992, the Bush Administration, under pressure from Congress and citing reduced tritium demands, decided to defer any further work on the NPR until 1995 and stopped all the reactor design efforts. With the signing of START II by President Bush in 1993, the number of active nuclear warheads and the need for tritium were dramatically reduced. At that time, the Department of Defense (DOD) and DOE concluded that recycling the existing tritium from the deactivated warheads could supply the needed tritium until a new source was ready.

By 1993 DOD and DOE both declared that due to the long lead time for construction and the depletion of tritium by radioactive decay, a tritium production development program must be started immediately. During the FY1993 budget process, Congress directed DOE to prepare and submit a report on tritium supplies and the necessary schedule to resume tritium production. Again in the FY1994 Defense Authorization Act, Congress directed DOE to study tritium production and identify the selected technology by March 1995. A part of the decision making process is the issuance of the Programmatic Environmental Impact Statement (PEIS). In March 1995 DOE released the draft PEIS, without making a decision on the selected technology. In October 1995 DOE issued its final PEIS for Tritium Supply and Recycling.

The PEIS evaluated the alternatives for siting, construction, and operation of tritium supply and recycling facilities at each of five candidate sites: the Idaho National Engineering Laboratory, the Nevada Test Site, the Oak Ridge Reservation, the Pantex Plant, and the Savannah River Site. Idaho National Engineering Laboratory (INEL) is one of DOEþs primary research and development centers on reactor performance and breeder reactor development. The Nevada Test Site (NTS) is the site for conducting underground nuclear tests. The Oak Ridge Reservation (ORR) Y-12 plant is the primary location for certain defense program missions, including the dismantling of some nuclear weapons components returned from the stockpile, producing some weapon components, providing stockpile support for uranium and lithium, storing special nuclear materials, and providing special manufacturing support to DOE programs. The Pantex Plant near Amarillo, TX at present is the only active site for nuclear weapons disassembly and for storage of certain components. The Hanford Site near Richland, WA, is the location of the Fast Flux Test Facility (FFTF) which can be used to produce tritium on a limited scale. The Savannah River Site (SRS) is the nationþs primary facility for tritium recycling to provide tritium for weapons in the nuclear stockpile. Evaluation of the environmental impacts considered the impacts on land resources, site infrastructure, air quality and acoustics, water resources, geology and soils, biotic resources, cultural and paleontological resources, socioeconomics, radiological and hazardous chemical impacts during normal operation and accidents to workers and the public, waste management, and transport between sites. The PEIS also compared the impact when no action (to implement new tritium production) is taken.

Based on the analysis of the PEIS and other considerations, on December 6, 1995 the DOE issued the Record of Decision, Tritium Supply and Recycling Facilities, which committed DOE to pursue a dual track strategy to ensure an adequate tritium production capability. The dual track approach is to: (1) initiate the purchase of an existing commercial reactor or irradiation services with an option to purchase the reactor and convert it to a defense facility; and (2) design, build, and test critical components of an accelerator system for tritium production (called Accelerator Production of Tritium of APT). According to DOE, the reactor approach would be available by 2005 while the accelerator would be operational by 2007. The Savannah River Site (SRS) was selected as the location for an accelerator, should one be built. Furthermore, the tritium recycling facility at SRS will be upgraded and consolidated to support both options. On September 5, 1996, the Secretary of Energy selected Burns and Roe Enterprises, Inc., to demonstrate the APT concept at Los Alamos National Laboratory, and to design the accelerator at the SRS site.

At the time of the decision, the target date for completion of the long term tritium source was still that set by START II requirements, the year 2011. With the shortening of the schedule as a result of the President's decision to use the START I stockpile numbers, the DOE has announced that an interim tritium source might be necessary if the accelerator option is selected. No decision, however, about the nature of this interim source has been made at this time.

Total funding for DOE weapons activities amounted to $3.46 billion in 1996. For FY1997, Congress appropriated $3.91 billion compared to a request of $3.71 billion. The appropriation provides $1.66 billion for stockpile stewardship, $1.93 billion for stockpile management, and $0.33 billion for program management. The tritium source program first appeared as a budget line in FY1996 at which time it received $75 million. For FY1997, DOE requested $100 million. Congress, however, appropriated $150 million. From 1993 to 1995, DOE spent $30 million for research and development on the APT concept at the Los Alamos National Laboratory (LANL).

For FY1997, DOE plans to spend the largest fraction of its tritium activity appropriation ($125 million) on the APT project. It will continue its efforts to demonstrate tritium production with accelerator technology using the existing linear accelerator at LANL. The remaining $25 million will go to developing the commercial light water reactor option. Major activities will include development of targets and the capability to extract tritium from them, and initial efforts to acquire a reactor and begin tritium operations. DOE plans to make a conditional selection of a reactor either for purchase or for providing irradiation services in 1998. According to DOE at a January 1996 informational meeting with the nuclear power industry, at least 13 U.S. utility companies have expressed an interest in providing irradiation services for the production of tritium. These include the Arizona Public Service Co. (Palo Verde 1, 2 and 3 power plants); Centerior Energy (Perry 2); Florida Power and Light Co. (St. Lucie 2); Georgia Power Co. (Vogtle 1 and 2); Houston Lighting and Power (South Texas 1 and 2); Illinois Power Co. (Clinton); Niagara Mohawk Power Co. (Nine Mile Point 1 and 2); N.C. MPA and Piedmont MPA (Catawba 2); S.C. Electric and Gas (Summer); Tennessee Valley Authority (Bellefonte 1 and 2); Virginia Power (North Anna 1 and 2, Surry 1 and 2); Wisconsin Public Service Co. (Kewaunee); and WPPSS (WNP-1). At most two reactors will be needed to meet the tritium production needs.

Recently, DOE announced that it will reconsider using the Fast Flux Test Facility (FFTF) at Hanford as a back-up source for tritium production. In particular, the facility will remain open for at least two more years in a "hot standby" mode. In other words, it will be capable of starting up without the need to re-fuel. The FFTF had been scheduled for shut down, but recent reports by an independent study group, JASON, and a consulting firm indicated that the reactor could be used for interim production of tritium over the period 2006 to 2016.

Current thinking by DOE is that the FFTF could serve as an interim source until a permanent source is built. If tritium requirements were to drop because of a new arms reduction agreement, it is possible that the FFTF could become the primary source of tritium. According to DOE officials, the added cost to keep the FFTF as a tritium source option would be about $7 million over the next 2 years. This figure compares with $88 million already budgeted for FFTF operations over that period. Extensive development work and additional testing would be needed before the FFTF could be producing the necessary quantities of tritium.

In related matters, DOE announced it will issue a request for proposals from utilities interested in providing commercial reactor services or selling a reactor to DOE for tritium production. A contract to one or more utilities is expected to be awarded by early 1998.

Program Issues

Although DOE has decided on the dual track course toward selection of a technology for production of tritium, the program remains controversial. Most of the controversy concerns the choice of technology. Indeed, before the Record of Decision there were some indications that DOE had already decided upon accelerator production of tritium (APT) as the primary choice. Several reasons were behind this decision including a desire to continue operation of the linear accelerator facility at the Los Alamos Neutron Science Center (LANSCE) where much of the development work for the APT targets would take place. In addition, concerns may have been expressed by some in the Administration about the need to construct a new nuclear reactor probably contributed to the decision. Congressional action (primarily a task force set up by the Speaker -- see below), however, caused DOE to reconsider and to add the existing commercial reactor option when the Record of Decision was issued.

Target Date. Although current policy is set to meet the 2005 target for a new tritium production source, there are those who believe that completion of that source can be extended well beyond that deadline. If and when START II is ratified by Russia, the need for tritium production would be extended to the year 2011 because the number of strategic warheads remaining in the stockpile would be substantially lower than the START I limits which define the 2005 target. The START II calls for a stockpile of 3,500 nuclear strategic warheads.

Many argue that further nuclear weapons reduction beyond the START II limits is possible with the result that additional years would be available to recycle tritium from dismantled warheads since the tritium production schedule included an additional 5- year reserve. Recently a number of nuclear arms control advocates have argued for further reductions to around 1,000 deployed warheads. In that case, the need for new tritium production could be pushed back to the year 2035 by the recycling of the tritium from the deactivated warheads. In December 1996 retired Air Force General George Lee Butler, former Commander in Chief of Strategic Air Command (CINCSAC), together with retired General Andrew J. Goodpaster and 60 other generals and admirals around the world, called for additional reduction in nuclear arms and the phased elimination, with verification, of all nuclear arms. Defense Secretary William Perry however has rejected further unilateral cuts in U.S. nuclear weapons until the Russians have ratified START II. At this time, there have been no official proposals, either from Congress or the Administration, for additional nuclear weapons stockpile reductions. But more calls for nuclear arms reduction, possibly leading to elimination of nuclear arsenals, are likely in the next few years.

Interim Sources - Fast Flux Test Facility (FFTF). If there is no change in the current target date, however, then the question of an interim source becomes important. One option is to upgrade existing DOE reactors. Currently four DOE research reactors are operational: the High Flux Isotope Reactor at ORR; the High Flux Beam Reactor at Brookhaven National Laboratory; the Experimental Breeder Reactor II at the Idaho National Engineering Lab (INEL); and the Advanced Test Reactor also at INEL. However, none of these facilities have the capacity to meet the projected stockpile tritium requirements.

Of the non-operational DOE reactors, only one is capable of producing a significant amount of tritium, the Fast Flux Test Facility (FFTF) at the Hanford Site, WA. A recent study by JASON (a non-government, scientific group advising DOE on Defense matters) expressed þreasonable confidenceþ that the FFTF could be made to produce about 1.5 kg of tritium per year, nearly 75% of the projected 2 kg requirement. The JASON group, in its final report, expressed concern about whether the FFTF could be restarted to meet the 2005 target date due to significant testing requirements and "formidable bureaucratic barriers" such as regulatory requirements. They did not, however, identify any major technical barriers. Recently a private company offered to assume operation of the FFTF and make the necessary modifications for the reactor to produce tritium. The company proposed to lease the reactor and contract with DOE to provide tritium for 10 years starting in 2000.

A consulting firm hired by DOE recently completed an examination of the use of the FFTF as an interim source. The study found that the reactor would be a "cost-effective backup" for tritium production, and concluded that under certain conditions, the FFTF could be cheaper than the other two options even over a more extended period. As described above, DOE decided to add the FFTF as an option for am interim tritium production source. If needed, the FFTF would supply tritium for a period of about 10 years and convert to the production of medical isotopes at the end of that period. Right now, however, the production of medical isotopes from the FFTF could not compete with lower cost sources. The DOE action could provide more time for it to develop one of its two long term options, the accelerator production of tritium facility or the commercial reactor.

Nevertheless, there is still considerable opposition to using the FFTF. In particular, the Governor of Oregon has joined other Northwest political leaders and environmental activists in opposing the restart of FFTF. These groups argue that DOE should not be spending money to restart the reactor when there is so much cleanup work to be done at the Hanford site. Other arguments are that using the reactor for the weapons program would be illegal and not consistent with the current cleanup mission of Hanford. There is also likely to be opposition from those who are concerned that restarting the FFTF would divert resources from the Savannah River Site which has been selected for the accelerator production of tritium facility. They already contend that the FFTF will not be able to supply the necessary tritium.

In its decision to retain the FFTF option, DOE stated that the additional cost would be small -- about $7 million over 2 years -- and would not divert funds from cleanup. Some supporters of this decision argue that using the FFTF as an interim source could permit construction of the accelerator facility at a slower pace and at lower annual appropriations. Whether this reduction is possible depends on the course of inflation over that period.

Another interim option is the possibility of purchasing tritium from a foreign source. Tritium has been produced in reactors for defense purposes in several countries such as Russia, Britain, and France. Tritium has also been produced as a by-product in Canada although Canada prohibits its use in weapons. There are no treaty prohibitions, however, to foreign purchases. The purchase of tritium from foreign sources was considered by DOE, but rejected largely because of concerns it could place U.S. national security at risk. In view of the changed target date from 2011 to 2005, however, DOE may reconsider this option as a temporary measure, particularly if the FFTF option does not develop for whatever reason.

Long Term Sources. Of the two tracks being considered by DOE for a long term source, the commercial reactor option -- either purchase of radiation service or purchase of a commercial reactor -- probably involves the least technical risk, although the APT concept also appears relatively straightforward. Presently there are 110 nuclear power plants operating in the United States. These reactors could be used to produce tritium by placing lithium-6 target rods within the reactor core. This may require the redesign and evaluation of the neutron absorbing control rods, but the impact on electricity power production should be minimal. The tritium production target rods can be removed at the same time the reactor is refueled, about every 18 months. The quantity of irradiation services can be scaled according to the amount of tritium needed for the stockpile. Target rod development thus far has demonstrated feasibility, but development and qualification have not yet been completed. In addition, additional facilities would be required to extract the tritium for use in weapons. DOE has selected Southern Company's Vogtle nuclear plant and Tennessee Valley Authority's Watts Bar reactor to test tritium production assemblies.

A significant potential concern with this option is that a commercial reactor would not be under the control of DOE. It is possible that future changes in the electric utility industry could cause the utility owner/operator to decide that the reactor was no longer economic to operate. If DOE had to take over the reactor at that point and could not obtain a þsubsidyþ from the sale of electric power from the plant, its operational costs might suddenly grow substantially. In addition, there are potential regulatory and environmental problems that could arise in the option. These possible issues are discussed in more detail below.

The purchase of a commercial nuclear reactor by DOE would eliminate potential uncertainties connected with the utility owner/operator. Most of the existing commercial nuclear reactors, however, are in the middle or tail-end of their designed life-cycle. The conversion of a commercial reactor for the 40 years of tritium production may require substantial investment in upgrading the facility as well as insuring the safety of the reactor. The purchase of a partially completed reactor might be preferred, depending on the cost for completion, although the reactor may not be in a suitable location. The cost of decommissioning the reactor at the end of the tritium production life-cycle is highly uncertain, but is likely to be very high based on current site cleanup experiences. Finally, there would be some regulatory, environmental and non- proliferation issues as discussed below.

Construction of a new reactor has also been considered by DOE but was not part of the Record of Decision. If purchase of radiation services does not prove to be feasible, however, DOE may once again consider this option. There are several reactor designs which DOE could consider. The reactor for producing tritium would be fueled with enriched uranium rods similar to those used in existing light water reactors (LWR). The small light water reactor, in the range of 600 MW, might face fewer regulatory delays than other candidates because it is a proven technology although it has not been used in tritium production. A large light water reactor, which would produce electricity in the range of 1,100 to 1,300 MW, would have a production rate well above that required by the DOE stockpile management program and, therefore, could compensate for unexpected down time.

Another possibility is the heavy water reactor which is the technology previously used for tritium production at the Savannah River Site (SRS). Such a reactor may cost more than an equivalent LWR and be subjected to more regulatory uncertainty. In this connection, the K Reactor at SRS may be a candidate. It is the only DOE reactor specifically designed to produce nuclear materials capable of returning to operation. The K Reactor is presently in þcold standbyþ after it was shut down in 1988 for safety upgrades. However, the reactor was designed in the 1940s, and, according to the DOE PEIS, it may not be possible to upgrade it to the level needed to meet the nation's long term tritium requirements regardless of the level of investment made in the facility.

The construction of a multipurpose reactor which could be used to produce tritium, generate electricity, and burn off excess weapons grade plutonium has been recommended by some including most of the Members of the Speakerþs task force headed by Representative Graham (see below). The Task Force report recommended that the missions of tritium production and plutonium disposal be combined in the multipurpose reactor. Presently these functions are managed by two different offices within DOE, the DOE Tritium Production Office and the Fissile Materials Control and Disposition Office. The Task Force argued that combining the two missions would result in the highest assurance of a reliable tritium source and lowest cost to the taxpayer. One Member of the task force, however, argued that the decision of tritium production technology, whether it be a reactor or accelerator or multipurpose reactor, should be based on the best science and technology available, and that such an evaluation was not yet at the stage where a decision could be made.

While there is private sector interest in building a multipurpose reactor, there are uncertainties regarding future electricity markets, regulatory actions, and environmental concerns which could delay this reactor or even cause project cancellation if it is started. For example, the deregulated environment in which the nationþs electric utilities are entering may make a new nuclear reactor uncompetitive even if it is partially subsidized by federal funds for tritium production.

In a related development, the Clinton Administration announced in December 1996 a two-track approach to the disposition of 50 tons of weapons grade plutonium, including its use as mixed oxide (MOX) fuel in commercial nuclear power reactors. At least 18 U.S. utility companies have expressed interest in using the plutonium /uranium MOX in their power plants. Although no mention of tritium production was made, as just discussed, there is a potential that disposition of the surplus plutonium could be also be used for that purpose.

The second option in DOEþs dual track approach, accelerator production of tritium (APT), is a significant departure from previous approaches. Existing DOE particle accelerators are capable of producing only a small amount of tritium. The research accelerators were designed for pulsed, and not continuous, operation at low power levels (about 800 KW). A production accelerator would be required to deliver a high power proton beam at 100 MW, or two orders of magnitude greater. While the APT process has yet to be demonstrated on anything approaching the scale required for the stockpile, research and development is being conducted at Los Alamos National Laboratory (LANL) to demonstrate its feasibility. The accelerator facility which is part of the Los Alamos Neutron Science Center, is being used for this R&D. As mentioned above, DOE has contracted to begin this phase of APT development.

The advantages of APT are that it does not create additional high-level nuclear waste, and that safety concerns are not a major problem since it does not use fissionable material. The quantity of tritium to be produced can be adjusted by the schedule of operation. In addition, the accelerator could be available for scientific experiments since tritium production is not likely to demand all of its time. A major disadvantage with this approach is that the APT requires a substantial amount of electrical power -- about 500 MW -- to produce the high energy proton beam. The proposed accelerator at SRS is approximately 0.7 mile long, and is a part of the APT complex covering approximately 173 acres of land.

Costs. The estimated cost of these options varies substantially. The DOE has carried out extensive cost analyses and determined a mean value for the discounted life cycle costs (both construction and operating costs over the life of the project and accounting for the cost of money) of several candidate technologies. For the options which involve government purchase or construction of a reactor, the mean value estimates range from $1.4 billion to $6.3 billion including revenues gained from sale of electricity. Purchase of irradiation services from an operating commercial reactor yields the lowest cost estimate of all the options, a mean value for the discounted life cycle cost of $1.2 billion. The same kind of analysis for an APT facility gives a mean value of discounted life cycle cost of $5.1 billion. Of course, the APT facility would not produce any electricity but would require a substantial amount to power the accelerator. The apparent cost advantage of the commercial reactor route is the primary reason for DOEþs choice of that option as part of the dual track approach.

The cost estimates are highly variable. For each candidate, cost can range from 30% below the mean to as much as 55% above. Important factors contributing to this large uncertainty are the location of the facility, the amount of tritium production, the cost/revenue of electricity, construction, operation, maintenance, and decommissioning the site at the end of the production cycle.

Environmental and Safety Concerns. Important factors influencing the decision about tritium production technology are the potential impact of the candidate technologies on the environment, and the safety level of the production facility. Common to all the reactor options are concerns about reactor safety and the generation and management of radioactive waste. Since the 1970s, no new commercial nuclear reactor has been built in the United States. The major reasons have been the high cost of nuclear power compared to other electric power generation technologies, and the slowdown in the growth of electric power demand which left substantial excess generation capacity. In addition, there have been concerns about reactor safety. While the U.S. nuclear power industry has a generally excellent safety record, the memory of Three Mile Island and foreign accidents has contributed to the resistance by the public toward more nuclear power plants.

Finally, there are environmental concerns about the creation and disposal of high level nuclear waste. The additional waste produced by a production reactor would be quite small in comparison to the waste already produced. Nevertheless, the difficulty in disposing of such waste remains and this fact has also contributed to the resistance toward construction of additional nuclear reactors. The public is concerned about the storage of nuclear wastes, and the high cost of cleanup upon the decommissioning of the reactor or in case of an accident. The APT is not a reactor and would not generate any spent fuel nor would there be any significant safety concerns. Because nuclear reactions would take place in the APT facility, some radioactive waste material would result. It would be a small amount, however, and all of it would be low level waste (waste whose radioactive byproducts emerge at low energy and are far less dangerous than byproducts from nuclear reactors). The principal environmental consequence of an APT facility would likely be the large amount of electric power which would be required. This power would very likely be generated by the burning of fossil fuels which would add to air quality concerns and produce additional carbon dioxide.

Regulatory and Proliferation Concerns. Regulation is also an issue for the choice of production technology since any reactor option would likely be subjected to the current nuclear power plant regulatory process. Presently commercial reactors are licensed and regulated by the Nuclear Regulatory Commission (NRC). The DOE assumes that an existing facility used to make tritium for the department would remain licensed by the NRC, with license amendments for insertion of tritium target rods. Furthermore, similar NRC licensing and regulatory process and structure would be employed for the construction and operation of new reactors. In June 1996, DOE and NRC signed a Memorandum of Understanding (MOU) concerning DOE's future use of NRC-regulated facilities to produce tritium for nuclear weapons. The agreement established a basis for NRC review and consultation on DOE's possible purchase of commercial light water reactors or of irradiation services from commercial reactors. This MOU will smooth out some of the obstacles to the licensing of commercial reactors for tritium production. For the APT, regulatory delay appears to be less likely since the accelerator would not have to undergo the same safety and licensing process as a reactor.

Another issue which has been raised is the possible nuclear proliferation consequences of using civilian facilities for weapons tritium production. The separation of civilian and military use of atomic energy is a long-standing U.S. policy, partly to protect against unauthorized use of weapons grade nuclear materials. Since tritium is not considered to be special nuclear material, however, tritium production would not come under the provisions of the Atomic Energy Act (AEA). A possible statutory impediment is section 57e of the AEA, which forbids special nuclear material produced in a commercial reactor from being used "for nuclear explosive purposes." That section was intended to prevent plutonium created in commercial nuclear power plants during normal operation from being separated for weapons use. DOE officials have raised the possibility that section 57e could be interpreted as prohibiting plutonium created in commercial reactors from being used to produce tritium for nuclear weapons. Production of substantial quantities of tritium in a commercial nuclear reactor likely would call attention to the appropriate uses of commercial nuclear reactors. Indeed, this possibility was cited by DOE as one of the reasons it selected the APT concept as a candidate tritium source.

On March 29, 1996 the environmental group Greenpeace issued a statement opposing DOE's proposal to use commercial reactors for tritium production or plutonium disposition. Greenpeace contended that DOE's use of a commercial reactor to produce tritium or to burn plutonium would effectively force consumers to support nuclear programs opposed by many U.S. citizens. This opposition is likely to intensify as DOE's decision on a commercial reactor for a tritium source nears, although according to the Nuclear Non-proliferation Treaty (NPT) the production of tritium in a commercial reactor is not a proliferation issue. There is concern, however, that the use of civilian nuclear reactors for the production of weapons material may set a bad precedent. Again, an APT facility would not have this difficulty since the accelerator would be a dedicated defense facility in its tritium production mode. If also used for scientific research, however, it is possible that such concerns would be raised.

Schedule. According to DOE analyses, all of the options presented here have high probability of meeting a 2011 tritium production date, the original target set by START II weapon levels. Some options, however, could not meet a 2005 deadline. In particular, an APT facility would not be available until 2007. The quickest way to secure a long term source appears to be purchase of irradiation services from the civilian nuclear power industry, in which case the production of tritium could occur as early as 2004. The purchase of an existing or partially completed commercial reactor could result in tritium production by the year 2005 after the target development and construction of a tritium extraction facility. It is likely that a new reactor, including the multi-purpose option, would not be ready by 2005. Except for the existing reactor option (including purchase of radiation services), an interim source would be needed to meet the 2005 deadline.

These schedule assessments are based on the assumption that everything would go smoothly, including construction in the case of new reactor or accelerator, contract negotiation in the case of the existing commercial reactor, regulatory review and licensing, and environmental impacts analysis. There are those who feel that DOE is not proceeding quickly enough to meet the shorter deadline. In particular they are concerned that DOE has not adequately accounted for the environmental, regulatory, proliferation and costs uncertainties as discussed above. The Congress expressed this concern in the Conference Report of the FY1997 Defense Authorization Bill. Recently, an unnumbered report from the House National Security Committee also stated that DOE is not moving fast enough to make the decisions needed to ensure a tritium production capability when needed. In particular it criticized DOE for not providing adequate funding for the program. The DOE, however, feels that its stockpile management program will be able to meet its objectives.

Congressional Actions

In the spring of 1995, the Speaker of the House, feeling that DOE was slow in responding to congressional directions about tritium production, established a Task Force on Nuclear Cleanup and Tritium Production, chaired by Representative Lindsey Graham of South Carolina. The charge to the Task Force was to review the DOE efforts to carry out remediation of nuclear and hazardous wastes at federal sites and to develop and construct a new source of tritium production. The task force's recommendations are discussed above.

The conference report accompanying the National Defense Authorization Act for FY1997 directed DOE to accelerate its þphased approach to restoring the tritium production capacity of the United States, including proceeding in parallel with site preparation for a new tritium production facility.þ The conferees stated that the þtritium production program must be accelerated to meet the requirements of the Nuclear Weapons Stockpile Memorandum, which identified a new tritium production date of 2005 if a reactor is selected or 2007 if an accelerator option is chosen.þ The conferees recognized þthe need to enhance the ongoing accelerator research and development and testing programs at LANL in conjunction with SRS personnel.þ The conferees þstrongly supported the full consideration of all technically feasible tritium production options, including accelerator, existing commercial reactor, and multipurpose reactor options.þ The latter was a result of action by the House which, in the report accompanying its version of the bill, had expressed disappointment that DOE has excluded a new multipurpose reactor option from further consideration.

In the Energy and Water Development Appropriations Act for FY1997, Congress appropriated $150 million compared to DOEþs request of $100 million. The conference report accompanying the bill directed DOE to inform the House and Senate Committees before it began any tests involving tritium targets within a commercial light water reactor. No mention of an accelerated timetable appeared in the report.

In the first session of the 105th Congress, the tritium program is likely to receive considerable scrutiny during proceedings for authorization of defense programs at DOE and the energy and water development appropriations. The report cited above from the House National Security Committee suggests that this review will be contentious as the Committee appears concerned about the level of effort DOE is making to carry out the stockpile stewardship and management program. In addition, it is possible that the Senate may receive, for advice and consent for ratification, the Comprehensive Test Ban Treaty signed by the United States in September 1994. If so, it is very likely that a review of the entire stockpile stewardship and management program, including the tritium program, will take place.

Legislation from the 104th Congress

P.L. 104-201, H.R. 3230 and S. 1745 National Defense Authorization Act for Fiscal Year 1997. H.R. 3230 passed House May 7, 1996; authorized $100 million for tritium production and related activities. The Committee encouraged DOE to consider FFTF at Hanford as an option for interim production of tritium. Passed Senate May 13, 1996; authorized $160 million to accelerate its phased approach to the tritium production needs of the United States, including proceeding in parallel with site preparation for a new tritium production accelerator. House and Senate agreed to conference report (H.Rept. 104-724) authorizing $160 million for tritium production. Signed into law September 23, 1996.

P.L. 104-206, H.R. 3816 and S.1959 Energy and Water Development Appropriations Act of 1997. Reported by Committee on Appropriations July 16, 1996 (H.Rept. 104-679). Recommends $100 million for activities related to tritium production. Passed House July 25, 1996 by a vote of 391 - 23. Reported as S. 1959 to Senate by Committee on Appropriations July 16, 1996 (S.Rept. 104-320). Recommends $150 million for activities related to tritium production. Substituted H.R. 3816 as an amendment; passed Senate July 30, 1996 by a vote of 93-6. House and Senate agreed to conference report (H.Rept. 104-782) providing $150 million for tritium production. Signed into law September 30, 1996.

CONGRESSIONAL HEARINGS, REPORTS, AND DOCUMENTS

U.S. Congress. Committee on Commerce. Subcommittee on Energy and Power. Oversight Hearing on Tritium Production. November 15, 1995. Serial No. 104-47.

FOR ADDITIONAL READING

U.S Department of Energy. Office of Reconfiguration. *Technical reference report for tritium production supply and recycling*. October 1995.

----- *Final programmatic environmental impact statement for tritium supply and recycling*. Executive Summary. October 1995.

----- Record of Decision. *Tritium supply and recycling programmatic environmental impact statement. Federal Register*, v. 60. No. 238: December 12, 1995.

The MITRE Corporation. JASON Program Office. *Accelerator production of tritium; 1995 review*. June 27, 1995.

CRS Reports

CRS Report 92-827. *Tritium production alternatives; Transcript of a CRS seminar*, by Jonathan Medalia.

CRS Report 96-11. *Nuclear weapons stockpile stewardship: Alternatives for Congress*, by Jonathan Medalia.