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SUMMARY

Improved nuclear technology and a strong U.S. commercial nuclear program are key elements of global sustainable energy and improved U.S. non-proliferation strategy. No single nuclear technology can engage all the energy and proliferation issues. Hence, a broad nuclear technology and U.S. industry base are critically important. High Temperature Gas Cooled reactors (HTGRs) and the joint U.S.-Russian HTGR development program for surplus weapons plutonium disposal are valuable strategic elements of a broad U.S. approach to proliferation control. At the same time, HTGR development for production of commercial power and alternative transportation fuel provides an attractive pathway to sustainable global energy and domestic fuel independence.

Mr. Chairman and Members of the Subcommittee, my name is Mark Haynes and I'm Vice President of Energy Development for General Atomics (GA). Thank you for asking GA to testify about one part of the nexus of nuclear energy, non-proliferation and the need and opportunity to re-build a U.S.-owned nuclear industry.

By way of brief background, General Atomics is a high-end technology company with a primary focus on defense and energy applications. We are the originators and manufacturers of the Predator series of unmanned aircraft; we are also major participants in Navy ship electrification, fusion energy research, next generation nuclear reactor technology, defense lasers, radars, sensors, stealth materials, maglev transportation and many other advanced technology research and development activities.

Fifty-one years ago, GA was formed by leading scientists from Los Alamos laboratory and elsewhere to harness the atom for peaceful commercial purposes. Most relevant to today's hearing is the fact that GA's roots were planted squarely in the area of innovative nuclear reactor development with an emphasis on safety and non-proliferation. Our first product, the TRIGA reactor (there are over 64 deployed in the U.S. and abroad), is the most common test, research and isotope reactor throughout the world. Our second reactor type, the high temperature gas cooled reactor (HTGR), was not fully developed before the decline of the nuclear market in the 1970s and the subsequent reduction of investment in nuclear technology development in this country. More recently, GA's particular HTGR design and its close technological "cousins" are key elements of nuclear programs in many nations, including a joint non-proliferation development effort by the U.S. and Russia that I will describe in more detail later in my testimony. Its development is compatible with DOE initiatives in advanced reactor development, being a central feature of DOE's Next Generation Nuclear Plant (NGNP) and complementary to DOE's Global Nuclear Energy Partnership (GNEP).

It is very important for decision makers on nuclear energy and proliferation issues to be aware that the past and the future of nuclear energy are rich with technological options. The broad nuclear industry, including General Atomics, is in firm agreement that the near term deployment of the next generation of light water reactors in the U.S. and abroad is vitally important to reinvigorate nuclear energy. In addition, the ultimate deployment of fast reactors, as is contemplated in the President's Global Nuclear Energy Partnership (GNEP), will almost certainly be an essential element of nuclear fuel cycle management as nuclear energy becomes more and more relied upon around the world. Nuclear technology will and must continue to advance to meet what seems certain to be a huge worldwide demand for economic reactors that can provide electric power and other energy forms. Our belief is that this can and must be done in a manner that improves safety and nuclear waste management and that eases proliferation concerns.

General Atomics has been asked to testify today on a third type of reactor: the High Temperature Gas Cooled Reactor (HTGR) and its potential implications in the non-proliferation area.

HIGH TEMPERATURE GAS COOLED REACTORS

For the past several years, there has been a worldwide effort directed toward the development of a next generation of nuclear reactor technology. These so called "Generation IV" reactors are meant to substantially improve the existing generation of reactors in several areas. The Gen IV "vision" is to develop and deploy reactors that are safer, more efficient, more proliferation resistant, more economical, more secure and produce less waste. High Temperature Gas Cooled Reactors (HTGRs) are generally agreed to be the nearest term Gen IV reactors that squarely meet each of these Gen IV objectives. Indeed, in last year's Energy Policy Act, Congress authorized the Department of Energy to build a HTGR at the Idaho National Laboratory to demonstrate this reactor technology and its ability to produce hydrogen and/or electric power.

HTGRs have progressed beyond paper studies and paper designs to the construction and operation of test and evaluation devices. There are two test units currently in operation in Japan and China and in addition, there is an extensive base of historic HTGR experience in the U.S. and Germany. The past and present experience in these reactors has made clear their advantages. The state of the reactor core design has advanced to the point where no large development program is required for deployment and the costs and risks are well understood.

One primary type of HTGR is the Gas Turbine Modular Helium Reactor or GT-MHR. Without getting into unnecessary technical detail, suffice it to say that the GT-MHR, like other HTGRs such as the Pebble Bed reactor, is cooled with helium instead of water, is moderated by graphite, contains no metal in the core and uses extremely robust ceramic-coated fuel particles. These and other design features lead to a reactor design that is:

> **Melt-down Proof Safe –** Even with the complete loss of all coolant and emergency circulation, the reactor core cannot get hot enough to melt the fuel. Further, because HTGR reactor cores are relatively diffuse and have a large heat sink capability, reactor operators have days to understand and react to problems, not minutes or seconds.

Nearly 50% More Thermally Efficient Than Existing Reactors – In addition to improving the economics of the reactor, this particular characteristic leads directly to decreased cost of electricity, substantially decreased production of high level waste and less waste heat being dumped to the environment.

Very Flexible to Site – Because of their increased efficiency, HTGRs do not necessarily need to be located near a substantial body of water for cooling purposes. Hence, they can likely be deployed in arid areas of the world that are in need of nuclear energy. Moreover, inherent operational safety achieved by HTGR designs permits much reduced buffer zones between reactor sites and other activities.

Capable of Burning All Types of Nuclear Fuel – The particularly robust ceramic coated fuel form allows almost anything that is fissionable to be burned in an HTGR including uranium, plutonium, thorium, and nuclear fuel waste products. This same characteristic makes these reactors very effective burners of surplus weapons grade plutonium and capable of burning existing spent nuclear fuel inventories. They provide an important complementary technology to transmuting fast reactors (the Advanced Burner Test Reactor) proposed as part of GNEP

Capable of Providing High Temperature Process Heat for Central Plant Scale Hydrogen Production – Hydrogen seems certain to play an increasingly important role in reducing our dependence on fossil fuels as soon as adequate and affordable hydrogen production capabilities are developed. The present U.S. market for stationary hydrogen consumption is over 11 million tons per year, and is growing at about 10% per year. Over 180 million tons of hydrogen per year would be required to fuel the domestic light transportation fleet. It is likely that only efficient high temperature process heat from nuclear power reactors will be capable of satisfying such annual demand with no greenhouse gas emissions. The present development path to nuclear production of hydrogen requires process heat temperatures that exceed all reactor concepts except the High Temperature Gas Reactor.

THE INTERSECTION OF HTGRS AND NON-PROLIFERATION

We believe there are four ways in which HTGRs are relevant to non-proliferation:

1. Superior non-proliferation characteristics: The presence of significant quantities of fissile material in all reactor cores (HTGR or otherwise) and in spent nuclear fuel makes these sources susceptible to use for proliferation purposes. Enrichment of nuclear fuels to establish core criticality has the same, perhaps higher susceptibility. The highly visible signatures and difficult and expensive recovery and refinement processes necessary for proliferant materials extraction from reactor cores, enrichment processes and spent nuclear fuels provide the most important means of verifying non-proliferation compliance.

HTGRs have superior characteristics because their robust ceramic-coated fuel form increases processing and extraction difficulty and because the core of HTGRs is inherently more diffuse in terms of concentration of nuclear materials. Consequently, significant quantities of HTGR fuel would be more difficult to pilfer and more difficult to use for nefarious purposes. In addition, because the HTGR is designed to be built entirely underground, it will have arguably superior security and non-proliferation benefits compared to large, above-ground installations.

2. Joint Development Project with Russia: For the past several years, DOE's NNSA and several key Russian nuclear institutes and laboratories have been working to develop the Gas Turbine Modular Helium Reactor (GT-MHR) for the purpose of destroying surplus Russian weapons plutonium. The goal of this unique, 50 / 50 cost-shared program with Russia is to construct one or more GT-MHR modules to replace the existing plutonium production reactor at Seversk. The GT-MHR reactor(s) will burn Russian surplus weapons plutonium and produce electric power and heat for that city.

This program is successful for several reasons: First, there is a strong feeling of mutual respect and shared goals between U.S. and Russian personnel. Second, the Russians are genuinely interested in the HTGR as a potential commercial reactor because of its efficiency, safety, security and versatility, and particularly because of its ability to support efficient hydrogen production. This interest has been expressed at the highest levels of the Russian government. Third, because of the Russian interest in the technology, they are sharing half of the costs and hence, have a high degree of incentive. Finally, the business model mandates delivery and approval of work products before payment is made.

A valuable opportunity for U.S. non-proliferation efforts and international nuclear cooperation exists as the Russian non-proliferation program proceeds simultaneously with other gas reactor efforts in the U.S.: the Next Generation Reactor Project at the Idaho National Lab and the High Temperature Test and Teaching Reactor (HT3R) at the University of Texas Permian Basin. A parallel and collaborative development path in the U.S. and Russia for this reactor provides early implementation of technology that contributes to non-proliferation, global energy security and revitalization of the U.S. nuclear power industry.

Almost needless to say, we are extremely pleased to see the recent news that the President wants to move forward with a civilian nuclear energy agreement with Russia. Our own experience with our Russian counterparts has been very productive and we believe has served to strengthen the ties between our nations and lessen nuclear proliferation concerns. There is every reason to suppose that other similar arrangements could expand these positive impacts and serve to mutually benefit our industrial bases.

3. The Importance of Rebuilding a U.S. owned Nuclear Technology and Supply Industry: The U.S. nuclear technology and supply industry, once the clear world leader, has suffered a steep decline in the past 30 years and has been substantially eclipsed by the industries of other countries who maintain and nourish their commitments to nuclear growth. In most cases, these foreign nuclear capabilities are either owned outright or substantially supported by their respective governments.

The loss of U.S.-owned capability and technology is almost certainly very damaging to U.S. non-proliferation interests, especially in the context of growing world interest in expanded nuclear power capabilities. When the U.S. government goes to the international negotiating table, it should have a menu of “carrots” in addition to “sticks” to encourage favorable outcomes. Lack of a diverse U.S. owned industry and the relative scarcity of attractive products will no doubt drive some negotiating parties to develop their nuclear relationships with other nations that have stronger nuclear industries and valuable products. A strong U.S. nuclear technology and supply industry working around the world provides added value by strengthening foreign relationships and helping establish a more favorable balance of trade.

If true Generation IV reactors are the way the world will ultimately go, then the U.S industry needs to be positioned to compete in this arena. As I mentioned before, HTGRs are the most near term, most flexible and likely the most economic of the next generation (“Generation IV”) reactors. There seems to be little doubt that importers of nuclear capability will seek out the most cost-effective and safest reactors available. Therefore, exporters must offer efficient and safe systems that are as proliferation resistant and secure as possible. HTGRs look very good in all these measures and should be regarded as a prime competitive opportunity by our country.

4. Nuclear Waste Management: The proper and secure management of spent nuclear fuel has important non-proliferation implications particularly because of its plutonium content. In fact, the President’s Global Nuclear Energy Partnership (GNEP) is, in large measure, directed at addressing the long-term proliferation implications of nuclear waste through recycling and the burning of the plutonium and other waste products in fast-spectrum Advanced Burner Reactors. Because of the nuclear characteristics of the core and their extremely robust ceramic coated fuel, HTGRs have excellent and unique characteristics in terms of their ability to burn almost any kind of fissionable material, including plutonium and the other most long-lived and toxic components of nuclear waste. Further, once waste products are substantially or completely burned in an HTGR, the ceramic fuel cladding serves as a built in and very long-lived waste package. So, our belief is that HTGRs can and should play an important role in the GNEP because in addition to their ability to economically produce electric power, hydrogen and high quality process heat, they might also provide another waste management option in addition to the proposed Advanced Burner Reactor.

SUMMARY

Improved technology, including the GT-MHR, is of course not a one-stop solution to the complex array of proliferation issues that exist today and will continue to persist for an indefinite period. But many nations around the world including China, India, Russia, Canada, France, South Africa, South Korea, Lithuania, and Estonia, are moving quickly in the direction of substantially increasing their nuclear energy generating capacity.

There seems to be little doubt that nuclear power will grow substantially worldwide whether or not the U.S. participates. As this growth happens, it is vitally important that the technology choices are the right ones. Reactor concepts that provide the most proliferation resistant power system and fuel cycle will make substantial contributions to inhibiting proliferation and assuring non-proliferation compliance on the part of user nations. Rebuilding a U.S. industry that can provide such systems to other nations is one of the best ways to discourage proliferation and assure compliance with non-proliferation protocols.

We believe that the U.S. government should implement a development plan with U.S. industry to address a variety of safe and economically attractive nuclear technology options. In the face of a steep increase of worldwide nuclear generating capacity, to do otherwise would be penny wise and pound-foolish. Such a plan would help assure that the U.S. was the major "player" in world non-proliferation negotiations and would increase our ability to respond to future uncertainties.

Thank you again for asking General Atomics to testify on this subject.