

ATOMS FOR PEACE INITIATIVE FOR THE 21ST CENTURY

BY

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ATOMS FOR PEACE INITIATIVE FOR THE 21ST CENTURY

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Eisenhower's Atoms for Peace speech to the UN in 1953 outlined U.S. policy to share peaceful uses of nuclear power with the rest of the world and provided the theoretical foundation of the nuclear technology control regime that has governed for over 50 years. With an impending energy crisis due to increased demand for fossil fuels, the U.S. must consider alternative energy sources that are environmentally friendly. Increased use of nuclear energy can provide the needed power not only domestically, but worldwide. Advances in the design of light water reactors have enhanced the safety, security and proliferation-resistance of new nuclear power plants. A closed nuclear fuel cycle concept in which the U.S. controls enriched and spent fuels may be the answer to the materials proliferation issue. The earthquake and tsunami in Japan on March 11, 2011 have propelled discussion of the safety and security of the world's nuclear power plants to the forefront of public dialogue. The time is right for the President to announce a new policy in an "Atoms for Peace Initiative for the 21st Century" speech to highlight a paradigm shift in the Nation's attitude to the increased use of nuclear power not only in the U.S. but throughout the world.

ATOMS FOR PEACE INITIATIVE FOR THE 21ST CENTURY

INTRODUCTION

In his seminal Atoms for Peace speech given December 8, 1953 to the United Nations, President Dwight D. Eisenhower outlined U.S. policy to share peaceful uses of nuclear power with the rest of the world. Eisenhower called for the creation of an international, multilateral institution aimed at enhancing nuclear cooperation, safety, and security which became the impetus for the International Atomic Energy Agency (IAEA). At the same time, this policy called for non-proliferation with the ultimate goal of a worldwide disarmament and elimination of nuclear weapons.

With an impending energy crisis on the horizon, the U.S. must find ways to increase its domestic production while trying to reduce its reliance on diminishing foreign fossil fuels supplies. Current National strategic guidance identifies the importance of energy for the security of the Nation and calls for alternative solutions to the problem. Nuclear power is one source of energy that can fill the gap in the Nation's resources.

One of reasons why the U.S. does not currently have a thriving nuclear energy program is due to political and social apprehension about the safety and security of nuclear power plants. This apprehension is based primarily on public ignorance and fear of nuclear processes and radiation in general. Public fear is exacerbated by the fact that the same power that can be used for peaceful purposes can also be used for the destruction of cities through the use of nuclear weapons.

The fact is that, even with the recent disaster in Japan in which six nuclear reactors were affected by an earthquake and subsequent tsunami, nuclear power

remains a safe source of energy and one of the most environmentally friendly in terms of greenhouse gas emissions. Additionally, with advances in the safety features of emerging nuclear technologies and new reactor designs, next generation nuclear power plants will be even safer. Some new reactor designs are also inherently proliferation-resistant which will reduce the ability of adversaries to acquire plutonium to be potentially used in nuclear weapons.

Given the fact that the world will need an energy supply that is safe and environmentally friendly and given new advances in the safety features and proliferation-resistance of future nuclear power systems, the U.S. should reduce its reliance on foreign fossil fuels by increasing the number of nuclear power plants domestically. Additionally, the U.S. should become the world's leading exporter of nuclear energy technologies to developing nations while maintaining control of the nuclear fuel cycle to prevent weapons material proliferation. Finally, the President should announce this new policy in an "Atoms for Peace Initiative for the 21st Century" speech to highlight a paradigm shift in the Nation's attitude to the use of nuclear power not only in the U.S. but throughout the world.

This paper provides a brief historical perspective about the significance of Eisenhower's Atoms for Peace speech. It investigates the potential future energy crisis that the world may face and outlines U.S. strategic guidance as it pertains to nuclear energy. The paper then examines the use of nuclear energy as a safe and secure energy source and outlines a few emerging technologies which enhance the safety of nuclear power while also making the weapons-usable isotopic byproducts proliferation-resistant. Finally, this paper discusses a closed fuel cycle concept that will ensure that

the U.S. controls spent nuclear fuel to ensure that potential nuclear weapons material remains secure.

HISTORICAL PERSPECTIVE

President Harry Truman planted the seeds that later bloomed as Eisenhower's Atoms for Peace speech in an October 3, 1945 message to Congress. This address contained the first official reference to the control and use of nuclear energy when the President said, "The hope of civilization lies in international arrangements looking, if possible, to the renunciation of the use and development of the atomic bomb, and directing and encouraging the use of atomic energy and all future scientific information toward peaceful and humanitarian ends."¹ He also proposed the establishment of a U.S. Atomic Energy Commission (AEC) which would essentially control the materials necessary to develop nuclear energy.² At the time, the U.S. had a monopoly on nuclear weapons but on August 29, 1949, the Soviets tested their first fission weapon (nearly a replica of the "Fat Man" implosion-type bomb design first detonated at the Trinity Site and later used at Nagasaki due to stolen blueprints of the U.S. design by Klaus Fuchs³), and a nuclear arms race had begun.⁴

In his Atoms for Peace speech Eisenhower said, "the United States knows that if the fearful trend of atomic military buildup can be reversed, this greatest of destructive forces can be developed into a great boon for the benefit of all mankind."⁵ His original idea was to have a "uranium bank" in which the U.S. and Soviet Union would contribute a share of their fissile materials from their nuclear stockpiles to be used for peaceful purposes and to encourage the development of nuclear energy.⁶

Eisenhower's speech outlined three basic themes of his historic proposal to the United Nations General Assembly.⁷ The first theme was one of having a strong commitment to international agreements aimed at pursuing worldwide peace and security. As part of this theme, Eisenhower proposed establishment of an international atomic energy agency (IAEA) which was established in 1957 by the UN. This agency would "be made responsible for the impounding, storage and protection of the contributed fissionable and other materials."⁸ A more important responsibility "would be to devise methods whereby this fissionable material would be allocated to serve the peaceful pursuits of mankind...to apply atomic energy to the needs of agriculture, medicine, or other peaceful activities...to provide abundant electrical energy in the power-starved areas of the world."⁹

The second theme in Eisenhower's speech was that he wanted to achieve a level of transparency for the knowledge of the nuclear fission process which would aid nations in developing their own peaceful nuclear energy programs. Critics of the Eisenhower's concept believed that this concept actually increased the danger of weapons proliferation by promulgating dual-use technologies around the world¹⁰ and because plutonium is a byproduct of the fission process, more fissile material, not less, would become available to nuclear weapons use.¹¹ Additionally, it is likely that some of the current nuclear weapons states (particularly India and Pakistan) did achieve nuclear arsenals sooner than they would have done due to the U.S. and other countries sharing information which was encouraged by the Atoms for Peace speech.¹²

The third theme that Eisenhower outlined was the need for a general disarmament of nuclear weapons with the ultimate elimination of those weapons

worldwide. In 1946, before the Soviets had detonated their own nuclear weapon, they proposed to outlaw the production and use of nuclear weapons worldwide and to destroy all existing nuclear weapons.¹³ So their response to Eisenhower's proposal in 1953 was to point out that they had at one time proposed to outlaw nuclear weapons and as a result indirectly rejected his plan.¹⁴ Ultimately, the Soviets supported the establishment of the IAEA and pledged a small amount of fissile material to contribute to the international bank.

Eisenhower's speech did promote and inspire many other peaceful uses of nuclear processes in terms of medicinal, agricultural, and industrial technologies. Medical techniques are so prevalent in today's hospitals that "one out of three patients who enter a U.S. hospital or medical clinic ... benefit directly from nuclear medicine."¹⁵ Agricultural uses include using gauges to measure hydrogen content in scarce water supplies, improving crop production through irradiating crops, improved animal health, food processing, and eradication of pests to name only a few.¹⁶ Industrial uses include process control and plant diagnostics using different irradiation techniques which can be used for materials inspection, development, and testing. Additionally, the oil industry uses nuclear techniques to find economically viable oil deposits in test wells.¹⁷ Peaceful uses of nuclear technologies have proliferated throughout the world. If public and political leaders can make populations similarly aware of the benefits and safety of nuclear energy, the nuclear energy renaissance will become a worldwide reality which may allow mankind to avert a global energy crisis.

THE ENERGY CRISIS AND NATIONAL STRATEGIC GUIDANCE

Rising energy demands and diminishing fossil fuel resources are already having a significant impact on global politics. These increasing demands for energy are due to economic growth in developing countries, especially China and India, and the subsequent increase in consumption of resources. Considerations for energy security and evolving competition for resources are increasingly being supported by military capabilities which lead to heightened tensions and potential conflict.¹⁸ Growing dependence on imported carbon-based energy products by major energy consumers - most notably the United States and China - result in strategic vulnerabilities and will constrain “their ability to pursue a broad range of foreign policy and national strategic objectives.”¹⁹

The world’s total annual energy consumption, including oil, gas, coal, nuclear, and renewable, has increased significantly in the last 30 years and is projected to continue to increase within the next 30 years. For example, the total world’s annual energy consumption increased from 104 billion barrels of oil equivalent in 1970 to 192 billion barrels of oil equivalent in 2000 and is projected to increase to 338 billion barrels by 2035.²⁰ Nearly 74 percent of this projected growth in demand comes from developing countries of which 45 percent comes from China and India alone.²¹ The importance of China in future global energy markets cannot be overstated because they surpassed the United States as the world’s largest energy user in 2009 in aggregate (the U.S. is still the world’s largest per capita energy user).²²

Another important aspect pertaining to the world’s energy problem is the perceived relationship between energy consumption and the environment.²³ Of today’s

total energy usage, approximately 63 percent is oil and 24 percent is coal²⁴ while nuclear energy supplies approximately 6 percent of the total.²⁵ Fossil fuel use has been identified as a major contributor to the release of greenhouse gases (GHGs).²⁶ Because the United States uses approximately 25 percent of the world's oil,²⁷ they have historically been the lead contributor to the problem. "The United States was the world's lead emitter of GHGs every year until 2007, when Chinese emissions surpassed the U.S. emissions."²⁸ Nuclear power provides an alternative energy source that does not emit GHGs. For example, a 1000 mega-Watt electric (MW_e) nuclear power plant operating at 90 percent capacity can annually displace approximately 2.1, 1.6 and 1.0 metric tons of carbon equivalents released to the environment due to the same energy production from coal, petroleum and natural gas fueled plants respectively.²⁹

Nuclear energy is an attractive alternative to fossil fuel-based energy sources that will become increasingly expensive and scarce in the future. Nuclear power is projected to increase from 6 percent in 2008 to 8 percent in 2035.³⁰ The Council for Foreign Relations commissioned an independent task force to examine national security consequences of U.S. oil dependency. This task force concluded that "the world will need more nuclear power in the future."³¹ They also expressed concern about the fact that, with more nuclear power plants worldwide, there will be an increased risk of proliferation of nuclear materials.³²

A Report of the Center for Strategic and International Studies Commission on China echoed the need to explore opportunities for commercial nuclear power. China is planning a major expansion of nuclear power and the commission recognized the need for the U.S. to collaborate with them to develop nuclear technologies that are less prone

to proliferation. The commission also recognized the need to develop a plan to prevent proliferation of nuclear weapons material and proposed development of “a concrete plan for managing a global nuclear fuel cycle.”³³

Strategic guidance also supports the idea of expanding nuclear energy production to satisfy the nation’s increasing demand for energy. In his remarks at the U.S./China Strategic and Economic Dialogue, President Obama said, “...we can cooperate to advance our mutual interest in a clean, secure, and prosperous energy future.”³⁴ He also recognized the fact that the U.S. and China are the two largest emitters of GHGs and both countries should seek new sources of energy. President Obama also highlighted a mutual interest in stopping the spread of nuclear weapons and that the two countries should cooperate to secure vulnerable nuclear materials and strengthen the Nuclear Non-Proliferation Treaty with its basic tenets that “countries with nuclear weapons move towards disarmament, countries without nuclear weapons will not acquire them, and all countries can access peaceful nuclear energy.”³⁵

The National Security Strategy (NSS) highlights the fact that since the end of the Cold War, the risk of nuclear attack has increased and that more nations have acquired nuclear weapons. The NSS also addresses the need to secure nuclear materials and that one way to do so would be to have “cradle-to-grave nuclear fuel management.”³⁶ Additionally, it supports peaceful use of nuclear energy “by promoting safety through regulatory bodies and training of operators, promoting physical security to prevent terrorist acts, and assuring safe and secure handling of fuel at the front and back ends of the nuclear fuel cycle.”³⁷

The Department of Defense's Nuclear Posture Review also addresses the aspiration to "promote peaceful uses of nuclear energy without increasing proliferation."³⁸ The review outlines support for the Global Nuclear Energy Partnership (GNEP) which is an international arrangement of 25 partner and 31 observer nations aimed at improving nuclear energy and security collaboration. One of the major aims of this partnership is to reduce developing nation's ambition to pursue their own fuel enrichment facilities. To that end, GNEP has established international nuclear fuel banks that will supply enriched nuclear fuel to developing countries with the promise to take the spent fuel assemblies back to place in repositories. This concept allows for a "cradle-to-grave" nuclear fuel management cycle to preclude developing nations from having to build their own fuel cycle industry.

THE NUCLEAR ENERGY ALTERNATIVE: SAFE AND SECURE

Over its 60 year history, nuclear power has proven to be one of the safest sources of energy when compared with other energy industries. Even though there have been three nuclear power incidents significant enough to gain the attention of the public worldwide: Three Mile Island (TMI), Chernobyl and, recently, Fukushima; only Chernobyl resulted in fatalities. After each incident, the impact on the nuclear power industry has been to improve redundancies in safety systems. It is important to stress that while TMI was clearly an accident, Chernobyl was due to operator error and poor reactor design and Fukushima was clearly caused by a natural disaster. A summary of each incident and consequences follows.

The accident at Three Mile Island occurred on 28 March 1979 was the only serious commercial nuclear power accident in the U.S. Even though the accident

resulted in no deaths and minimum release of radiation to the environment, the event brought about many changes in the nuclear industry to increase safety to include new emergency response procedures, reactor operator training, radiation protection practices and changes in nuclear plant operations. Additionally, the Nuclear Regulatory Commission (NRC) increased its regulatory oversight over nuclear power plants across the Nation.³⁹

Commercial nuclear reactors in the U.S. are light water (H₂O) reactors in which the energy from the fission process is transferred to pressurized water which is then used to generate steam that turns a turbine to generate electrical power. There are two types of reactors in the U.S.: the pressurized water reactor (PWR) and boiling water reactor (BWR).

The primary difference between the two types is the pressure at which each operates which results in the amount of boiling in the reactor core reactor. PWRs are operated at higher pressures to suppress bulk boiling of the water, fed in a primary, “contaminated” loop and the heat is transferred to a secondary, “clean” loop of water to create steam. A BWR operates at a lower pressure which allows the reactor to boil the water directly which means that the water in the entire loop is “contaminated.” Unit 2 at TMI was a PWR.

The accident occurred at 4:00 a.m. when the main feedwater pump malfunctioned which caused the reactor to shut down automatically. The nuclear fission process is shut down using control rods comprised of material that absorb neutrons which are necessary to maintain the nuclear chain reaction. Even after the fission process is shut down, coolant water must continue to flow through the reactor core

because radioactive fission particles (the byproduct of the fission process) continue to generate heat as they decay to more stable nuclei.

At TMI, when the main pump shut down, the pressure in the reactor core began to increase at which time the operators activated a relief valve to relieve the pressure. The valve should have closed at a set pressure but it, too, malfunctioned and remained opened which resulted in a loss of coolant accident ultimately leading to approximately 50 percent of the core melting.⁴⁰

The resulting radiation release to the environment was minimal and controlled. In order to relieve pressure in the primary system and prevent additional damage, operators released radiation from the plant's auxiliary building. The estimated average dose above background radiation to the public in the surrounding community (about 2 million people) was approximately 1 millirem (mrem) which is less than the amount of radiation one would receive from a chest x-ray (approximately 6 mrem). A mrem is a measure of dose equivalent and quantifies the effect of radiation on the body. As a preventative measure, authorities ordered the evacuation of a three mile radius for those people most susceptible to radiation damage, pregnant women and children. This evacuation caused widespread fear about radiation.

Due to the increased use of radiation in medicine along with the natural background radiation from the earth and sun, the estimate of the average annual amount of radiation that the population is exposed to was recently increased to 620 mrem.⁴¹ It was also estimated that at the TMI site boundary the maximum dose would have been less than 100 mrem. Comparing a dose equivalent of 100 mrem to 50,000

mrem, the dose equivalent radiation necessary to start causing changes in the human body, and one can see relative significant of the small release of radiation from TMI.

In addition to sweeping reforms in safety and regulatory procedures for nuclear power, the most significant impact of the TMI accident was spreading fear throughout the U.S. and subsequently made nuclear power socially and politically unpopular. As a result of the incident, “no nuclear power plant has been ordered [in the U.S.] since the accident at Three Mile Island in 1979.”⁴²

The accident at Chernobyl, Ukraine was the most severe radiological accident in human history and highlights the need for international controls for nuclear reactor designs. Put simply, the reactor design at Chernobyl was flawed and the accident was exacerbated by reactor operator errors. The Chernobyl reactor was a graphite-moderated, water cooled design which means that graphite is used to slow down fast neutrons born in fission and water is used to cool the reactor core and to generate steam as outlined previously.

The Chernobyl reactor was recognized to have a design flaw, even before the accident took place, which made the reactor difficult to control under specific circumstances. The circumstances included having to closely control the fission reactions in the core when the plant operated at lower power. Without positive control, the coolant in the reactor could rapidly turn to steam which would increase the temperature in the core to dangerous levels. This increase in temperature would cause more steam resulting in a positive feedback loop that would eventually cause a run-away reactor.

Another design flaw at Chernobyl was that the containment building that housed the reactor had only a corrugated metal roof that separated the reactor from the environment. This roof was ruptured due to a hydrogen explosion and allowed the release of a large amount of radiation to the environment. In the U.S. the typically dome-shaped containment buildings are massive structures of steel and concrete designed to separate the reactor from the environment and, in an accident, prevent a release of radiation to the environment.

The April 26, 1986 accident occurred at Unit 4 during a test of the turbine generator which was conducted to ascertain if it could continue to provide power after a reactor shutdown during the time it took emergency diesel generators to come online. The written test procedures were flawed in that the operators were directed to operate the plant at low-power, “coolant flow and cooling conditions that could not be stabilized by manual control.”⁴³ Additionally, the operators deliberately violated safety rules by withdrawing most of the control rods completely from the core and switched off other safety systems.⁴⁴

After the control rods were removed, large steam voids occurred in the reactor core due the resulting rapid increase in power. This caused a power excursion estimated at 100 times the nominal power within approximately 4 seconds. As a result, a steam explosion ruptured the containment structure and the influx of air caused the graphite to catch fire which released large amounts of radioactive core materials to the environment.⁴⁵

Two of the 600 reactor workers present at the plant were killed as a result of the explosion.⁴⁶ Another 134 reactor staff and emergency workers received high enough

doses that they suffered from acute radiation sickness of which 28 of them died within 4 months due to the high gamma radiation doses that they had received.⁴⁷ The average doses to evacuees from Ukraine and Belarus was estimated to be 1700 mrem and 3100 mrem, respectively.⁴⁸ The majority of the population living in contaminated areas, estimated to be 5 million residents, received approximately 100 mrem which is a small radiation dose relative to the evacuees. Additionally, there was an increased incidence of thyroid cancer among children in Belarus from 1986 to 2002 with 1152 cases recorded in that time. With treatment, the survival rate was 98.8%.⁴⁹

The resulting changes in the U.S. nuclear power industry were minimal. After a detailed study of the incident, the NRC concluded that “no immediate changes were needed in the NRC’s regulations regarding the design or operation of U.S. commercial nuclear reactors.”⁵⁰ The NRC’s reaction illustrates that the cause of the accident at Chernobyl was due mainly to the reactor design and operator error which had little bearing on light water reactors used in the U.S.

The full impact of the natural disasters that affected the six Fukushima Daiichi nuclear power plants in northeast Japan on Friday, March 11, 2011 have yet to be fully understood. Some conclusions that can be drawn even at these early stages of the analysis of the effects from the radiological release caused by the incident are that, even with 6 different plants being affected, the release of radiation to the population was well below that of Chernobyl and no immediate deaths or incidences of acute radiation sickness have occurred to date.

The incident at the Daiichi complex began with an earthquake that registered 9.0 on the Richter scale.⁵¹ The design basis for the nuclear power plants at the Daiichi was

comparable to the ground accelerations experienced at the site except for at Unit 3 which exceeded the design basis by about 11 percent.⁵² At the time, three of the reactors (units 1, 2, and 3) were operating normally and the other three reactors were off-line for inspection and Unit 4 was completely defueled. All 6 reactors at the site are BWR-type reactors operated by Tokyo Electric Power Company. Recall from previous discussion that in BWR-type reactors, water from the primary coolant loop goes directly to the turbine which creates a potential pathway from the compromised reactor core to the environment.

The earthquake caused the three operating reactors to automatically shut down by inserting the control rods into the core. When electric power was lost to the plants, back-up diesel generators continued to provide power to the plant's cooling system⁵³ until approximately one hour after the earthquake when the tsunami hit. Fukushima Daiichi was originally designed to withstand a 3-meter tsunami but later the seawall offshore was increased to withstand a design basis 5.7 meter tsunami in 2000.⁵⁴ The tsunami that hit the Daiichi site was determined to be a staggering 14 meters high.⁵⁵

The tsunami disabled the diesel generators on site by sweeping the diesel fuel tanks out to sea. The second back-up power system of emergency batteries continued to operate the water injection system for 8 hours. Without the ability to recharge the batteries, the reactors went to total blackout after the 8 hours and cooling systems failed.⁵⁶ During the following days, each of the three operating reactors experienced hydrogen and other pressure explosions which eventually led to authorities pumping seawater into each of the three core pressure vessels in an attempt to maintain coolant in the core.

After 338 flight hours of aerial radiation monitoring of the site and 150,000 field measurements, the U.S. Department of Energy provided an estimated dose to people who did not evacuate the downwind area (generally to the northwest inland) and who remained in the area for one year to be 2000 mrem.⁵⁷ This value is the same order of magnitude as the NRC's annual limit of radiation exposure to nuclear industry workers in the U.S. which is 5000 mrem. Recall that 50,000 mrem is necessary to detect damage due to radiation in the human body, so the radiation effects to the general public are expected to be relatively small.

The social, political, and economic impact of the radiological release at Fukushima Daiichi are yet to be determined. However, given the fact that there were 6 separate nuclear power plants affected, all safety features apparently functioned properly and were only completely overwhelmed by the tsunami which was well above the design basis limit, and the projected relatively low-level release to the environment. In the end the final accident analysis will likely substantiate the fact that nuclear power remains one of the safest energy industries in the world.

Security of nuclear materials is another prominent issue when considering increased use of nuclear power. As previously stated, proliferation of nuclear materials is a strategic security concern due to the fact that the Nation's enemies are actively trying to gain weapons of mass destruction. The fact is that "there has been no known diversion of nuclear material from safeguarded nuclear power plants"⁵⁸ Of the current nuclear weapons states, all acquired the fissile material needed by making indigenous enrichment facilities or by diverting materials from reactors that were initially designed for other purposes. "In no case was the material obtained by diversion from a nuclear

fuel cycle that supported commercial electricity or by theft.”⁵⁹ Vigilance and international cooperation must always be maintained to ensure that the Nation’s enemies do not acquire fissile materials. The IAEA is a key component in monitoring and tracking civilian nuclear power activities to ensure fissile materials are not diverted to non-peaceful purposes.⁶⁰

EMERGING NUCLEAR TECHNOLOGIES

To be politically and socially acceptable, new nuclear power plants will have to be even safer than current designs. Several enhancements to light water reactors (LWR) have been proposed to improve passive safety features. New plants include the advanced boiling water reactor (ABWR), natural circulation boiling water reactor (NCBWR), and advanced pressurized water reactor (APWR) concepts. Additionally, new non-LWR concepts such as the modular pebble bed reactor and fixed bed nuclear reactor (FBNR) are being investigated at the experimental level and as such will not be discussed in detail here.

General Electric introduced the ABWR concept which includes increasing the power rating from 1,350 to 1,600 MW_e while improving safety and operations. These improvements include “relocating pumps, a more integrated reactor containment, modernized control systems, and improved fuel design.”⁶¹ Toshiba is also developing an ABWR concept called AB1600 with safety improvements including passive containment cooling to include two meters more coolant in the reactor pressure vessel which will protect against a loss of coolant accident.⁶²

A NCBWR concept is also being developed which has safety systems based on natural circulation of the water. In a natural circulation system “the primary pumps are

eliminated, and the necessary flow rates are achieved by locating the steam drums at a suitable height from the center of the core, taking advantage of the reactor building height.”⁶³ A water-steam mixture is present in the core and upper sections of the reactor and liquid water is in the lower section of the reactor vessel. The density difference between the two states of water allows for natural circulation of the water. General Electric has a similar natural circulation concept called the Economic Simplified BWR.

Westinghouse has an advanced pressurized water reactor concept called AP1000 which includes passive safety systems that do not require alternating current power or cooling water.⁶⁴ Another advanced PWR concept is called IRIS which was developed by an international consortium also led by Westinghouse. It was designed “to satisfy DOE requirements for the new generation reactors, that is, improved proliferation resistance, enhanced safety, improved economics and reduced waste.”⁶⁵

While some of the systems outlined above are designed to improve security, efficiency, and non-proliferation, some of the features are designed specifically to mitigate the effects of a loss of coolant accident (as had happened at TMI) and the loss of alternating current (AC) power as was seen in the reactors at the Fukushima Daiichi site. For example, had the reactors at Daiichi been the NCBWR design, the loss of AC power would not have affected the core as critically because the reactor is designed to continue to operate naturally. After control rods had been inserted, the steam-water cycle would have continued to flow naturally until the temperature of the core was reduced below the ability to make steam. Had some of this natural circulation concept been already inherent in the 6 reactors at the Fukushima Daiichi site, the severity of the

damage to the reactor cores may have been mitigated and less radiation would have been released to the environment.

New commercial nuclear power plants will necessarily have to be not only safer but also proliferation resistant due to concerns over fissile material being diverted by emerging nations with the intent to develop nuclear weapons programs. In an effort to increase the security and proliferation resistance of the new nuclear power concepts, “two recent developments – safeguards by design and security by design – are receiving increasing international attention and support as important elements in achieving integrated, balanced facility designs that optimally meet all requirements, including safety and operations.”⁶⁶

The safeguards by design concept includes designing facilities that minimize the safeguards efforts from the international community necessary to ensure nations are not diverting fissile material (primarily plutonium) or misusing nuclear facilities.

“Proliferation resistant measures of facility safeguarding may include (1) advanced measurement techniques for improved nuclear material accountancy, and (2) advanced additional measures related to containment and surveillance.”⁶⁷ One example of the safeguard by design concept is the Advanced CANDU Reactor which includes a spent fuel storage basket designed to allow easier inspection by the IAEA.⁶⁸

The security by design concept “is based on protecting nuclear materials and facilities from theft, sabotage, and terrorism using detection, delay, and response against a design basis threat (DBT).”⁶⁹ One example of the industry’s need to constantly evaluate the threat environment and develop designs to mitigate it is the NRC’s January 2010 Regulatory Guide “Cyber Security Program for Nuclear Facilities” which addresses

concerns about the threat of cyber-related attacks to the Nation's nuclear power plants.⁷⁰

CONTROL OF FISSILE MATERIALS: A CLOSED FUEL CYCLE CONCEPT

In addition to proliferation resistant technologies, safeguard by design and security by design concepts, the U.S. and the international community can positively control enriched uranium and plutonium used in commercial nuclear power plants by developing a closed fuel cycle. This concept can be used to dissuade developing nations from building their own indigenous enrichment facilities. Throughout the commercial nuclear energy industry, the U.S. has led the way in developing new technologies and has the capability to become the world's leading exporter of nuclear power technologies.

A U.S. nuclear power export program could include providing the expertise and manpower to build a power plant in a developing nation, supplying enriched fuel to that power plant, and after the fuel's lifetime in the reactor, and exchanging the spent fuel for new enriched fuel. One major shortcoming in a developing nation's ability to create their own nuclear power is that they do not have enough human capital with the expertise to do so. They also "lack of indigenous human infrastructure needed to safely and securely build, operate, and regulate nuclear power plants."⁷¹ The U.S. can fill this void while also ensuring the responsible and safe use of nuclear power.

The problem of spent nuclear fuel storage can be alleviated by the U.S. developing a reprocessing industry. Spent fuel is about 97 percent re-usable because it contains about one percent each of fissile uranium and plutonium, 3 percent highly radioactive fission products, and about 95 percent uranium-238 (the most abundant

natural uranium isotope). The uranium and plutonium can be extracted from the spent fuel and re-used in nuclear reactors as mixed oxide fuel (MOX). The high-level radioactive waste can be extracted and stored and the uranium-238 can be reused to make new fuel rods. The concept of reprocessing would reflect a paradigm shift in policy because it was made illegal in the U.S. due to proliferation concerns. Assuming the policy was shifted, the U.S. can reduce its own domestic spent fuel storage requirements by 97 percent.

The current global environment includes international nuclear fuel bank initiatives designed to provide countries developing nuclear power programs with enriched fuel. According to the IAEA, “about 60 countries are interested in building their first nuclear power plant. If these countries go forward, they will all need nuclear fuel, and they will get it in one of two ways: by making it themselves, or by buying it from someone else.”⁷² To that end, Russia is establishing a fuel bank of low enriched uranium (LEU) reactor fuel will be held until a country needs it in the event of a supply interruption.⁷³

In September 2006, a Nuclear Threat Initiative (NTI) was proposed by Warren Buffet to give the IAEA \$50 million to help create a similar stockpile of LEU. The pledge included a condition that one or more countries pledge an additional \$100 million in matching funds. So far the U.S. (\$50 million), Norway (\$5 million), the United Arab Emirates (\$10 million), the European Union (\$32 million), and Kuwait (\$10 million) have pledged to fill the matching funds.⁷⁴

Given the global energy environment, the establishment of international fuel banks to ensure secure stockpiles of LEU fuels, and the U.S.’s expertise in the nuclear power industry, the time is right for a policy change to aggressively export necessary

technologies and assistance to ensure that developing countries build their own safe and secure plants.

CONCLUSION

“Today, the Atoms for Peace program seems to have prevailed. Fission is used largely to generate electricity.”⁷⁵ Additionally, it has done so safely for nearly 60 years. The truth is that only one accident has ever occurred in the U.S. which resulted in a minor radiation leak (less than naturally-occurring background radiation) and intense public fear of radiation mainly due to ignorance. Current events in Japan have brought the discussion of nuclear power to the forefront of public consideration. Now is the time for U.S. policy makers to educate the public about the safety record, benefits, and necessity of nuclear power to gain energy independence.

The future of civilian nuclear power technology is linked to the future of international and domestic security.⁷⁶ New designs in nuclear reactors will not only make nuclear power safer, but they will also include inherent proliferation resistant technologies to impede the spread of nuclear weapons. Instead of being one of the world’s leading importers of fossil fuels, the U.S. can become the world’s leading exporter of nuclear technologies while maintaining positive control over spent fuel containing fissile materials.

The bottom line is that proliferation-resistant technologies cannot entirely stop a state from acquiring nuclear weapons. “Stopping a determined proliferator is a political act: Proliferation resistance can raise hurdles, slow progress, and provide alarm signals of proliferation activity, but it is not, in its own right, a sufficient nonproliferation strategy.”⁷⁷ A closed nuclear fuel cycle in which the U.S. controls spent fuel may be the

most powerful way to keep the increasing amount of plutonium out of the hands of its enemies.

Eisenhower's Atoms for Peace speech "brought together concepts that furnished the theoretical underpinnings of the nuclear technology control regime that has governed for [over] 50 years."⁷⁸ President Obama has a unique opportunity to influence the next 50 years by taking this opportunity to dispel the myth that nuclear energy is dangerous and by promoting not only the use of nuclear energy domestically but throughout the world.

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